Environmental Impact
Assessment Report

NISA
North Irish Sea Array

Volume 3: Offshore Chapters

Chapter 14
Marine Mammal Ecology

Statkraft CIP Copenhagen Infrastructure Partners GoBe APEM Group ARUP

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14.1 Introduction

This chapter of the Environmental Impact Assessment Report (EIAR) presents an assessment of likely significant effects from the North Irish Sea Array (NISA) Offshore Wind Farm (hereafter referred to as the 'proposed development') in relation to marine mammal ecology during the construction, operation and decommissioning phases.

This chapter sets out the methodology followed (Section 14.2), describes the baseline environment (Section 14.3) and summarises the main characteristics of the proposed development which are of relevance to marine mammal ecology (Section 14.4), including any embedded mitigation. Potential impacts and relevant receptors are identified, and an assessment of likely significant effects on marine mammal ecology is undertaken, details of which are provided (Section 14.5).

Additional mitigation measures are proposed to mitigate and monitor these effects if required (Section 14.6) and any residual likely significant effects are then described (Section 14.7). Transboundary effects are considered (Section 14.8), and cumulative effects are considered in Section 14.9 and are summarised in Chapter 38 Cumulative and Inter-Related Effects (hereafter referred to as the 'Cumulative and Inter-Related Effects Chapter'). The chapter then provides a reference section (Section 14.10).

The EIAR also includes the following:

- Detail on the competent experts that have prepared this chapter is provided in Appendix 1.1 in Volume 8
- Detail on the extensive consultation that has been undertaken with a range of stakeholders during the development of the EIAR is set out in Appendix 1.2
- A glossary of terminology, abbreviations and acronyms is provided at the beginning of Volume 2 of the EIAR; and
- A detailed description of the proposed development including construction, operation and decommissioning is provided in Volume 2, Chapter 6: Description of the Proposed Development – Offshore (hereafter referred to as the 'Offshore Description Chapter'), Volume 2, Chapter 8: Construction Strategy – Offshore (hereafter referred to as the 'Offshore Construction Chapter').

The assessment should be read in conjunction with the following linked EIAR chapters within Volume 3:

- Chapter 11: Marine Water and Sediment Quality; and
- Chapter 13: Fish and Shellfish Ecology (hereafter referred to as the Fish and Shellfish Chapter).

This chapter should also be read alongside the following appendices:

- Volume 9, Appendix 14.1: Underwater Noise Modelling Report (hereafter referred to as the Underwater Noise Report)
- Volume 9, Appendix 14.2: Marine Mammal Baseline Characterisation (hereafter referred to as the Marine Mammal Baseline Characterisation); and
- Volume 9, Appendix 17.1: Navigational Risk Assessment.

The Marine Mammal Baseline Characterisation report provides detailed information on the marine mammal study area and the wider management units (MUs) based on existing literature and survey data and includes information on marine mammal species of ecological importance and of commercial and conservation value. The Underwater Noise Modelling Report provides detailed methodologies in relation to the underwater noise modelling and presents the results of this modelling.

All figures within this Chapter are provided in Volume 7A.

14.2 Methodology

14.2.1 Introduction

The assessments of marine mammal ecology are consistent with the EIA methodology presented in Volume 2, Chapter 2: EIA and Methodology for the preparation of an EIAR (hereafter referred to as the EIAR Methodology chapter).

14.2.2 Study Area

The marine mammal ecology study area was initially identified at the proposed development scoping stage, in line with Department of Communications, Climate Action and Environment (DCCAE) (now the Department of the Environment, Climate and Communications; DECC) Guidance (DCCAE, 2017) (See Appendix 2.1: Scoping Report).

The marine mammal study area for the proposed development varies depending on the species, considering individual species ecology and behaviour. For all species, the study area covers the offshore development area which is the proposed development seaward of the High Water Mark (HWM) consisting of the Offshore export cable corridor 'ECC' and array area. The study area is extended over an appropriate wider area considering the scale of movement and population structure for each species (see Section 14.3).

The marine mammal species identified as present in the study area from the site specific surveys and existing baseline data are: harbour porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops truncates*), Risso's dolphin (*Grampus griseus*), short beaked common dolphin (*Delphinus delphis*), minke whale (*Balaenoptera acutorostrata*), harbour seal (*Phoca vitulina*), and grey seal (*Halichoerus grypus*).

For each species, the area considered in the assessment is largely defined by the appropriate species MU which is a defined spatial scale for highly mobile marine mammals. The study area for marine mammals has been defined at two spatial scales: 1) the marine mammal survey area to obtain local density estimates of each species and 2) the MU scale for species specific population units.

The marine mammal survey area is the site-specific survey area that was surveyed to characterise both the marine mammal and the offshore ornithology baseline. The survey area consisted of the wider Maritime Area Consent (MAC)[1] boundary for the proposed development (which is larger than the offshore development area), plus a 4km buffer. Primary vessel surveys were conducted in November 2019, January 2020 and March 2020 with supplementary surveys in June 2020 and July 2020. Digital aerial surveys (DAS) were conducted monthly between May 2020 and October 2022 (Natural Power 2021, 2022). The survey methods and results and fully are described in the Marine Mammal Baseline Characterisation.

The proposed development is located within the following MUs for each species (Figure 14.1):

- 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 and South-east regions of Ireland and Northern Ireland; and
- Harbour seal: East and South-east regions of Ireland and Northern Ireland.

[1] the MAC is a State consent which allows the Developer the right to occupy a part of the maritime area and the ability to subsequently apply for development consent within that maritime area

14.2.3 Relevant Guidance, Policy and Legislation

This section outlines guidance, policy and legislation specific to marine mammals, including best practice guidelines. Overarching guidance on EIA is presented in the EIAR Methodology Chapter. Furthermore, policy applicable to the proposed development is detailed in Volume 2, Chapter 3: Legal and Policy Framework.

The assessment of likely significant effects upon marine mammal ecology has been made with specific reference to the following identified relevant legislation and guidance:

- Department of Arts, Heritage and the Gaeltacht (DAHG) (2014): Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters
- Department of the Environment, Climate and Communications (DCCAE) (2017): Guidance on EIS and NIS Preparation for Offshore Renewable Energy Projects
- DCCAE (2018a): Guidance on Marine Baseline Ecological Assessments & Monitoring Activities
- Environmental Protection Agency (EPA) (2011): Assessment and Monitoring of Ocean Noise in Irish Waters
- Irish Whale and Dolphin Group (IWDG) (2020): Policy on Offshore Windfarm Development
- Irish Wind Energy Association (IWEA) (2012): Best Practice Guidelines for the Irish Wind Energy Industry
- Joint Nature Conservation Committee (JNCC) (2010a) Guidelines for minimising the risk of injury to marine mammals from using explosives
- JNCC (2010b) Statutory Nature Conservation Agency Protocol for Minimising the Risk of Injury to Marine Mammals from Piling Noise
- JNCC (2020) Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs
- JNCC et al. (2010): The protection of marine European Protected Species from injury and disturbance. Guidance for the marine area in England and Wales and the UK offshore marine area
- Marine Notice No. 15 (2005): Guidelines for correct procedures when encountering whales and dolphins in Irish coastal waters
- National Parks & Wildlife Service (NPWS) (2010): Appropriate Assessment of Plans and Projects in Ireland Guidance for Planning Authorities
- Sustainable Energy Authority Of Ireland (SEAI) (2017): Guidance on EIS and NIS Preparation for Offshore Renewable Energy Projects
- SEAI (2018): Guidance on Marine Baseline Ecological Assessments and Monitoring Activities for Offshore Renewable Energy Projects Part 1
- SEAI (2018): Guidance on Marine Baseline Ecological Assessments and Monitoring Activities for Offshore Renewable Energy Projects Part 2
- Sea Mammal Research Unit (SMRU) Ltd (2010) on behalf of The Crown Estate: Approaches to Marine Mammal Monitoring at Marine Renewable Energy Developments Final Report
- Southall et al. (2019): Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects; and
- Thomsen et al. (2011) (Centre for Environment, Fisheries and Aquaculture Science; CEFAS) Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects.

14.2.3.1 *Habitats Directive 92/43/EEC*

All cetaceans in Northern European waters are listed under Annex IV of the European Union (EU) Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (the Habitats Directive) as European Protected Species (EPS) of Community Interest and in need of strict protection. It is an offence to injure or significantly disturb EPS. The harbour porpoise, bottlenose dolphin, harbour seal and grey seal have protection under Annex II as species of Community Interest whose conservation requires the designation of Special Areas of Conservation (SACs).

The Habitats Directive was initially transposed into Irish law in 1997 by the European Communities (EC) (Natural Habitats) Regulations, 1997 (S.I. No. 94 of 1997). This was later amended with regulations S.I. No. 233 of 1998 and S.I. No. 378 of 2005. This requires the designation of SACs to conserve habitats and species listed on Annex I and II respectively of the Habitats Directive. To ensure effective conservation of protected habitats and species in SACs, all activities within or adjacent to SACs that are likely to have a significant effect, require an appropriate assessment.

Article 6(3) of the Habitats Directive requires that any plan or project that is not directly connected with or necessary to the management of the Natura 2000 site concerned but is likely to have a significant effect on it, on its own or in combination with other plans and projects, is to be authorised only if it will not adversely affect the integrity of that site.

Assessment of the potential to injure and disturb marine mammals is provided in the impact assessment section (see Sections 14.5.1, 14.5.2 and 14.5.3).

14.2.3.2 *Wildlife Acts 1976 to 2021*

The Wildlife Act 1976 (as amended) (hereafter 'the Wildlife Act') gives protection to a wide variety of birds, animals and plants in Ireland. The Wildlife Act also provides a mechanism to give statutory protection to Natural Heritage Areas (NHAs). The amendment in 2000 of the Wildlife Act extends protection under this legislation to most species, including the majority of fish and aquatic invertebrate species which were excluded from the 1976 Act.

The Wildlife Act provides specific protection to seal, whale, dolphin, and porpoise species. Under the Act and it's amendments, it is an offence to hunt (except in some instances under licence or Ministerial permit), injure (except when hunting under such licence) or wilfully interfere with or destroy the breeding place of a protected species(except under license or permit). The act applies out to the 12nm limit of Irish territorial waters.

Assessment of the potential to injure and disturb marine mammals is provided in the impact assessment section (see Sections 14.5.1, 14.5.2 and 14.5.3).

14.2.3.3 *Bonn Convention*

The Convention on the Conservation of Migratory Species of Wild Animals (the Bonn Convention) requires signatories to conserve migratory species and their habitats by providing strict protection for endangered migratory species (Appendix I of the Convention) and lists migratory species which would benefit from multilateral agreements for conservation and management (Appendix II of the Convention). There are 16 cetacean species listed under Appendix I of the Bonn Convention. The Ireland is a party member of the Bonn Convention.

14.2.3.4 *Bern Convention*

The Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention) aims to ensure conservation and protection of wild plant and animal species and their natural habitats (listed in Appendices I and II of the Convention). There are 19 species of cetacean listed under Annex II of the Bern Convention ('strictly protected fauna'), including harbour porpoise, bottlenose dolphins, common dolphins, Risso's dolphins, white-beaked dolphins (*Lagenorhynchus albirostris*) and minke whales.

All other cetacean species as well as both grey and harbour seals are listed under Annex III of the Bern Convention ('protected fauna'). Ireland is a member of the Bern Union and thus the Bern Convention applies.

14.2.3.5 *Whale Fisheries Act, 1937*

Under the Whale Fisheries Act, 1937, the hunting of all cetaceans is banned within the fisheries limits of the State (out to 200 miles from the coast). Following this, in 1991, Ireland declared its waters a whale and dolphin sanctuary, the first European sanctuary within the fishery limits of an entire country.

14.2.3.6 *National Marine Planning Framework*

The key National Marine Planning Framework (NMPF) policies that are applicable to the assessment of marine mammal ecology is summarised in Table 14.1. NMPF policies are addressed in their entirety in Appendix 3.1: NMPF Compliance Report.

Table 14.1 Key NMPF policies relevant to the assessment

Policy Name	Policy Description	Where addressed
National Marine Planning Framework (2021)	Biodiversity Policy 1 Proposals incorporating features that enhance or facilitate species adaptation or migration, or natural native habitat connectivity will be supported, subject to the outcome of statutory environmental assessment processes and subsequent decision by the competent authority, and where they contribute to the policies and objectives of this NMPF. Proposals that may have significant adverse impacts on species adaptation or migration, or on natural native habitat connectivity must demonstrate that they will, in order of preference and in accordance with legal requirements: a) avoid, b) minimise, or c) mitigate significant adverse impacts on species adaptation or migration, or on natural native habitat connectivity.	The significance of effects associated with UXO clearance, pile driving, other construction activities, disturbance and collisions with vessels, prey availability and distribution and increased concentration of suspended solids are all assessed to be minor or negligible for all species, post mitigation, as outlined in Section 14.7. The mitigation to be used is a Vessel Management Plan (VMP; Volume 9, Appendix 17.2), and a Marine Mammal Mitigation Protocol (MMMP; Volume 9, Appendix 14.4), as outlined in Section 14.6.
	Biodiversity Policy 2 Proposals that protect, maintain, restore and enhance the distribution and net extent of important habitats and distribution of important species will be supported, subject to the outcome of statutory environmental assessment processes and subsequent decision by the competent authority, and where they contribute to the policies and objectives of this NMPF. Proposals must avoid significant reduction in the distribution and net extent of important habitats and other habitats that important species depend on, including avoidance of activity that may result in disturbance or displacement of habitats.	The significance of effects associated with UXO clearance, pile driving, other construction activities, disturbance and collisions with vessels, prey availability and distribution and increased concentration of suspended solids are all assessed to be minor or negligible for all species, post mitigation, as outlined in Section 14.7. The mitigation to be used is a VMP and a MMMP, as outlined in Section 14.6.
	Biodiversity Policy 4 Proposals must demonstrate that they will, in order of preference and in accordance with legal requirements: a) avoid, b) minimise, or c) mitigate significant disturbance to, or displacement of, highly mobile species.	The significance of effects associated with UXO clearance, pile driving, other construction activities, disturbance and collisions with vessels, prey availability and distribution and increased concentration of suspended solids are all assessed to be minor or negligible for all species, post mitigation, as outlined in Section 14.7. The mitigation to be used is a VMP, and a MMMP, as outlined in Section 14.6.
	Underwater Noise Policy 1 Proposals must take account of spatial distribution, temporal extent, and levels of impulsive and / or continuous sound (underwater noise) that may be generated and the potential for significant adverse impacts on marine fauna. Where the potential for significant impact on marine fauna from underwater noise is identified, a Noise Assessment Statement must be prepared by the proposer of development. The findings of the Noise Assessment Statement should demonstrably inform determination(s) related to the activity proposed and the carrying out of the activity itself.	As the effects cannot be avoided, the proposed development will have a dedicated MMMP to ensure potentially adverse effects are minimised so far as is practicable to be no higher than minor adverse (not significant) or negligible adverse (not significant) for each potentially affected species.

14.2.4 Data Collection and Collation

The baseline characterisation for marine mammals is described in detail in the Marine Mammal Baseline Characterisation. The characterisation of the receiving environment has been informed by numerous data sources comprising a desk-based review of existing data sources together with consideration of site-specific survey data (Table 14.2).

Table 14.2 Data sources examined to inform the baseline characterisation for marine mammals

Data source	Type of data	Temporal and spatial coverage
Site-specific surveys	Combination of visual boat-based surveys and digital aerial surveys	The original site specific DAS survey extent mirrored the array area within the foreshore licence plus a 4km buffer. The DAS survey extent was updated in November 2020 to include the entire MAC boundary (which included the small area beyond 12nm that was not within the original DAS survey extent. Surveys conducted between November 2019 and October 2022.
ObSERVE (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. The offshore development area is entirely located within ObSERVE survey Stratum 5.
SCANS III & 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. The offshore development area is located in block E (western Irish Sea) for SCANS III surveys. This block was renamed to block CS-D for SCANS IV.
SCANS II (Hammond et al. 2013)	Aerial and vessel visual surveys	June & July 2005. All European Atlantic waters. Proposed development located in block O (entire Irish Sea).
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, including the whole Irish Sea.
Irish marine mammal atlas (Wall et al. 2013)	Collation of data from IWDG, the ISCOPE I and II projects, ferry survey programme and the PReCAST surveys.	2005-2011. Irish EEZ.
IWDG Irish Sea surveys (Berrow et al. 2011)	Visual and acoustic survey	2 surveys in August 2011. Inshore surveys in 2 blocks: Block A (northern Irish Sea – including the proposed development) and Block B (southern Irish Sea).
IWDG SAC surveys (Berrow and O'Brien 2013, O'Brien and Berrow 2016, Berrow et al. 2021)	Visual and acoustic line transect surveys	1 survey in 2013. 4 surveys in 2016. 6 surveys in 2021. Rockabill to Dalkey Island SAC.
IWDG Irish coastal water surveys (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 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.
MERP maps (Waggitt et al. 2020)	Collation of data from JCP (aerial and vessel)	1980 and 2018. European Atlantic waters.

Data source	Type of data	Temporal and spatial coverage
Seal counts 2017-2018 (Morris and Duck 2019)	Aerial survey	August 2017 and 2018. Entire coastline of Ireland.
Seal at-sea density (Carter et al. 2020)(Carter et al. 2022)	Seal habitat-use derived from telemetry data	2005 – 2019 UK and Ireland
Seal telemetry (Cronin et al. 2016)	Telemetry tags	Strangford Lough: 33x harbour seals (2006, 2008 & 2010). Raven Point (Co Wexford): 19x grey seals 2013 & 2014. Great Blasket Island: 8x grey seals 2009.
Seal counts 2005 (Ó Cadhla et al. 2007)	Aerial survey	Spring & summer 2005. Entire coastline of the Republic of Ireland.
Seal counts 2017-18 (Morris and Duck 2019)	Aerial survey	August 2017 and 2018. Entire coastline of Ireland.
Seal telemetry (Cronin et al. 2016)	Telemetry tags	Strangford Lough: 33x harbour seals (2006, 2008 & 2010). Raven Point (Co Wexford): 19x grey seals 2013 & 2014. Great Blasket Island: 8x grey seals 2009.
Codling surveys (Codling Wind Park Limited 2020)	Visual vessel surveys	April 2013 – March 2014 and again in Oct 2018 – Oct 2019. Codling Wind Park array area.
Arklow surveys (RPS 2020)	Visual vessel surveys Digital aerial surveys	Monthly vessel surveys: July 1996 and March 1997, and June 2000 and June 2009. Arklow Bank wind farm array area plus a 5km buffer. Monthly aerial surveys between March 2018 and February 2020. Lease Area plus a 4km buffer.

14.2.5 Site-specific Surveys

Site-specific surveys for the proposed development included a combination of vessel-based and digital aerial surveys. Vessel surveys began in November 2019 and were conducted through to March 2020. For the remainder of the surveys, due to the COVID-19 pandemic, the primary survey method switched to digital aerial surveys, which were conducted monthly from May 2020 to October 2022 resulting in 29 surveys. Vessel-based surveys were also conducted again in August 2020 and June/July 2021 to help apportion the unidentified sightings from the digital aerial surveys. The original site-specific DAS survey extent mirrored the array area within the foreshore licence plus a 4km buffer. The DAS survey extent was updated in November 2020 to include the entire MAC boundary (which included the small area beyond 12nm that was not within the original DAS survey extent..

14.2.6 Desk-Based Review

Additional baseline data were available from a variety of sources, including previous baseline surveys ObSERVE, IWDG surveys, SCANS, Irish marine mammal atlas, survey information (available in the public domain) from other wind farm areas in close proximity, MERP maps, aerial seal surveys and seal telemetry data. These data are limited by the lack of fine spatial and temporal scales surveyed, with many of the areas surveyed not directly overlapping with the offshore development area. However, they do provide a good indication of the species present in the vicinity of the proposed development and are complimented by the proposed development’s site-specific surveys which provide a more contemporary estimate at both fine temporal and spatial scale.

14.2.7 Data Limitations

The key data limitations with the baseline data and their ability to materially influence the outcome of this EIAR are the high spatial and temporal variation in marine mammal abundance and distribution in any particular area of the sea. For this reason, a precautionary approach has been taken, where the higher of the density estimates is recommended to be used in the impact assessment.

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 on these uncertainties is presented in Appendix 14.3.

These data limitations and uncertainties are typical in offshore wind impact assessments. Where possible, uncertainty has been minimised. The assessment presented here uses the science and methods available at the time of writing.

14.2.8 Methodology for Assessment of Effects

EIA significance criteria for marine mammal ecology follows Environmental Protection Agency (EPA) guidance:

- EPA (2022) Guidelines on the information to be contained in Environmental Impact Assessment Reports.

The criteria for determining the sensitivity of the receiving environment and the magnitude of impacts for the marine mammal ecology assessment are defined in Table 14.3 and Table 14.4 respectively. A matrix was used for the determination of significance in EIA terms (Table 14.5). The combination of the magnitude of the predicted impact with the sensitivity of the receptor determines the assessment of significance of effect.

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

From the assessment of these potential impacts, the significance of the effect upon the receiving environment/receptor can then be determined against predetermined criteria (Table 14.5).

14.2.8.1 Sensitivity criteria

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 are outlined in Table 14.3.

However, 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 14.3 Sensitivity of the receiving environment

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

14.2.8.2 *Magnitude of Impact criteria*

The magnitude of potential impacts is defined by a series of factors including the spatial extent of any interaction, the likelihood, duration, frequency, and reversibility of a potential impact. The criteria for defining magnitude in this chapter are outlined in Table 14.4.

Table 14.4 Magnitude of the impact

Magnitude of impact	Definition
High	Duration: The effect is expected to result in behavioural changes that last for years. Frequency: The impact 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.
Medium	Duration: The effect is expected to result in behavioural changes that last up to a year. Frequency: The impact 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 impact 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 impact 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.

14.2.8.3 *Defining the significance of effect*

The significance of effect associated with an impact will be dependent upon the sensitivity of the receptor and the magnitude of the impact. The assessment methodology for determining the significance of likely significant effects is described in Table 14.5. There are no guidelines on whether a "moderate" effect should be considered significant in EIA terms or not, and different EIARs have used different approaches. In this EIAR chapter it has been conservatively assumed that "moderate" is significant in EIA terms. Therefore, in this EIAR chapter, effects defined as moderate, significant, very significant or profound are considered significant in EIA terms. An effect that has a significance of slight or imperceptible is not considered to be significant in EIA terms.

Table 14.5 Matrix to determine effect significance

			Existing Environment – Sensitivity			
			High	**Medium**	**Low**	**Negligible**
Description of Impact Magnitude	**Adverse impact**	**High**	Profound or very significant	Significant	Moderate	Slight
		Medium	Significant	Moderate	Slight	Slight
		Low	Moderate	Slight	Slight	Imperceptible
		Negligible	Slight	Slight	Imperceptible	Imperceptible

Where relevant, mitigation measures that are incorporated as part of the proposed development design process and/ or can be considered to be industry standard practice (referred to as 'embedded mitigation') are considered throughout the chapter and are reflected in the outcome of the assessment of effects, described in Section 14.4.5. Additional mitigation measures that are not embedded are considered as part of the residual effects assessment and are described separately (Section 14.6).

14.2.9 Auditory Injury

For marine mammals, the main impact from the proposed development will be as a result of underwater noise produced during construction. Therefore, a detailed assessment has been provided for this impact pathway. Exposure to loud sounds can lead to a reduction in hearing sensitivity (a shift in hearing threshold), which is generally restricted to particular frequencies. This threshold shift results from physical injury to the auditory system and may be temporary (i.e., temporary threshold shifts (TTS), recoverable) or permanent (i.e., permanent threshold shifts (PTS), unrecoverable).

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 6dB of TTS is a somewhat arbitrary definition of onset, it has been adopted largely because 6dB 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 40dB. 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 40dB of TTS, i.e., 40dB of TTS is assumed to equate to 6dB of PTS.

The PTS-onset thresholds used in this assessment are those presented in Southall et al. (2019) (Table 14.6) and are weighted based upon the functional hearing groups and estimated functional hearing ranges of different marine mammal taxa (i.e, the varying frequencies they hear and communicate at) (Southall et al. 2007, Southall et al. 2019). The method used to calculate PTS-onset impact ranges for both 'instantaneous' PTS (the peak sound pressure level (SPL_{peak})[2], and 'cumulative' PTS (the cumulative sound exposure level; SEL_{cum}), over 24 hours)[3] are detailed in the Underwater Noise Technical Report. For SPL_{peak}, the PTS-onset range is the distance at which the received level drops to below the PTS-onset threshold. For SEL_{cum}, fleeing receptors starting anywhere within the PTS-onset contour will receive a noise level greater than the PTS-onset threshold. Current TTS onset thresholds are inappropriate to determine a biologically significant level of TTS and thus, PTS only is used in the quantitative impact assessment for auditory injury from piling. The predicted ranges for the onset of TTS from piling are presented (see Table 14.26), but no assessment of magnitude, sensitivity or significance of effect is given.

[2] **SPL**: The sound pressure level is an expression of sound pressure using the decibel (dB) scale. **SPL_{peak}**: The highest (zero-peak) positive or negative sound pressure, in decibels.

[3] **SEL**: The constant sound level acting for one second, which has the same amount of acoustic energy, as indicated by the square of the sound pressure, as the original sound. It is the time-integrated, sound-pressure-squared level. SEL is typically used to compare transient sound events having different time durations, pressure levels, and temporal characteristics. **SEL_{cum}**: Single value for the collected, combined total of sound exposure over a specified time or multiple instances of a noise source.

Table 14.6 PTS-onset thresholds for impulsive noise (Southall et al., 2019).

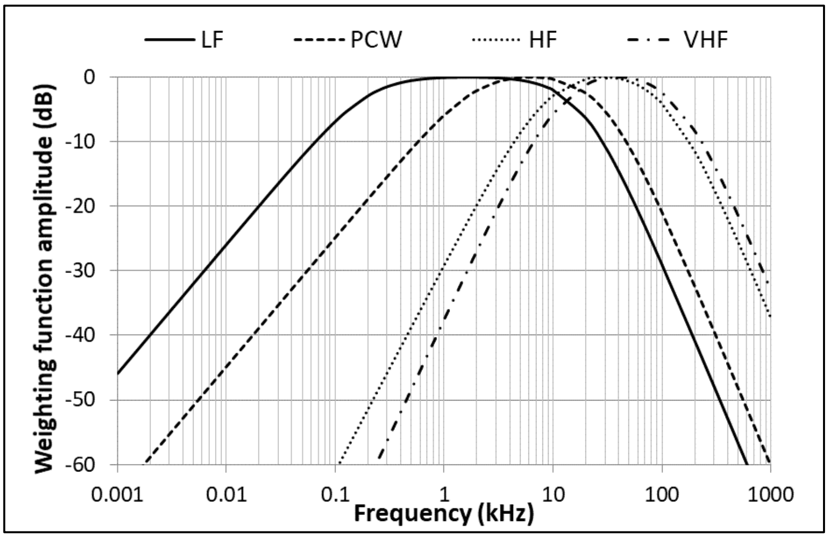
Hearing group	Species	Cumulative PTS (SELcum dB re 1 µPa2s weighted)	Instantaneous PTS (SPLpeak dB re 1 µPa unweighted)
Very High Frequency (VHF) Cetacean	Harbour porpoise	155	202
High Frequency (HF) Cetacean	Dolphin species	185	230
Low Frequency (LF) Cetacean	Minke whale	183	219
Phocid (in water)	Grey and harbour seal	185	218

The calculated PTS onset impact ranges represent the minimum starting distances from the piling location for animals to escape and prevent them from receiving a dose higher than the threshold.

In calculating the received noise level that animals are likely to receive during the whole piling sequence, all animals were assumed to start fleeing at a swim speed of 1.5m/s once the piling has started (based on reported sustained swimming speeds for harbour porpoises) (Otani et al. 2000), except for minke whales which are assumed to flee at a speed of 3.25m/s (Blix and Folkow 1995).

Other marine mammal fleeing swimming speeds have previously been recommended by Nature Scot (previously Scottish Natural Heritage (2016). They recommend that 1.4m/s is used for harbour porpoise, however this is based on an average descent and ascent speed from tagged porpoise (Westgate et al. 1995), not a fleeing speed. Kastelein et al. (2018) found that swimming speeds of ~7km/h (1.94m/s) are sustainable for harbour porpoise (throughout a 30 min test period), thus, the modelling is conservative as it used fleeing speeds lower than this. Scottish Natural Heritage (2016) also recommend a fleeing speed of 2.1m/s for minke whales based on Williams (2009), however this reference states that the routine speeds for mysticete whales is 2.1 to 2.6m/s and is thus not representative of fleeing speeds. Scottish Natural Heritage (2016) recommend a swimming speed of 1.8m/s for grey seals, based on Thompson (2015) which estimated that typical swimming speeds were in the range of 1.8-2.0m/s. This typical swimming speed is faster than the 1.5m/s used in the modelling and thus the modelled fleeing speed for grey seals is conservative.

Southall et al. (2019) propose the SPL_{peak} metric is 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). 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) (Graph 14.1).



Graph 14.1 Auditory weighting functions for low frequency (LF), high frequency (HF) and very high frequency (VHF) cetaceans as well as phocid (PCW) pinnipeds in water taken from to Southall et al. (2019)

14.2.9.1 PTS – pile driving

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) has been determined using the thresholds presented by Southall et al. (2019). 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.

The SEL_{cum} threshold for PTS-onset considers the sound exposure level (SEL) 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.

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 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. Several 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.

There is the potential for WTG foundations to be installed using drilling depending on seabed type or if a pile refuses during impact piling operations. However, impact piling is considered the greatest magnitude of impact and as such an assessment of drilled WTG foundations is not included in this assessment.

14.2.9.2 PTS – UXO clearance

Current practice is that the PTS-onset thresholds in Southall et al. (2019) should be used for assessing the impacts from UXO detonation on marine mammals. The Southall et al. (2019) PTS-onset threshold metrics which are currently used for assessing impacts from UXO are believed to be potentially over-conservative, namely due to the fact there is a lack of empirical evidence from the action of UXO detonation to confirm that current propagation models for UXO detonation accurately predict the range at which PTS-onset thresholds are exceeded.

Full details of the underwater noise modelling and the resulting PTS-onset impact areas and ranges are detailed in the Underwater Noise Modelling Report. A selection of explosive sizes have been considered based on what has been found at other sites in Irish waters and, in each case, it has been assumed that the maximum explosive charge in each device is present and detonates with the clearance (a “high order” event). The range of equivalent charge weights for the potential UXO devices have been estimated as 25, 55, 120, 240, and 525kg. Estimation of the source noise level for each charge weight has been carried out in accordance with the methodology of Soloway and Dahl (2014), which follows Arons (1954) and the Marine Technical Directorate (Barett 1996). Therefore, these results are considered to be an indication of the potential maximum noise output from each charge size and, as such, likely an overestimate of PTS-onset impact ranges, especially for larger charge sizes.

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.

14.2.9.3 PTS – Other construction activities

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

An assessment of the noise impacts from non-piling noise is presented in the Underwater Noise Modelling Report. This includes an assessment of the potential PTS and TTS-onset impact ranges for:

- 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
- Trenching: Plough trenching may be required during offshore cable installation
- Cable laying: Noise from the cable laying vessel and any other associated noise during the offshore cable installation
- Rock placement: Potentially required on site for installation of offshore cables (cable crossings and cable protection) and scour protection around foundation structures
- Vessel noise: Vessel noise from large- and medium-sized vessels
- Sheet vibro-piling: Sheet vibro-piling may be required for the landfall pit exit
- Horizontal Directional Drilling (HDD): The cable landfall will be constructed by HDD; and
- Drilling of foundations: Some WTG foundations may require drilling for installation either in addition to or as an alternative to piling due to the seabed conditions across the array area.

Prior to an evaluation in relation to each item of equipment, the overlap between typical construction equipment operating characteristics and marine mammal functional hearing capability is considered. Where there is no overlap between hearing capability and operating characteristics, 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.

14.2.10 Assessment of Disturbance (behavioural response)

In an EIA context, the impact of anthropogenic noise on the behaviour of marine mammals has been generally synonymous with displacement. The Commission's guidance (European Union, 2021) states that *"Any activity that deliberately disturbs a species to the extent that it may affect its chances of survival, reproductive ability or breeding success, or that leads to a reduction in the area occupied by the species or to its relocation or displacement, should be regarded as a 'disturbance' under the terms of Article 12".* Behavioural response (disturbance) from underwater noise can mean a change in the spatial/temporal distribution of animals and/or disruption to an animal's typical behavioural patterns (e.g. migration, breathing, nursing, feeding, sheltering).

14.2.10.1 Disturbance from piling

The assessment of disturbance (behavioural response) 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.

Compared with the effective deterrence range (EDR)[4] and fixed noise threshold approaches, the application of a dose-response function allows for more realistic assumptions about animal response varying with dose (i.e., different levels of response at different sound exposure levels), which is supported by a growing number of studies. A dose-response function is used to quantify the probability of a response from an animal to a dose of a certain stimulus or stressor (Dunlop et al. 2017) and is based on the assumption that not all animals in an impact zone will respond.

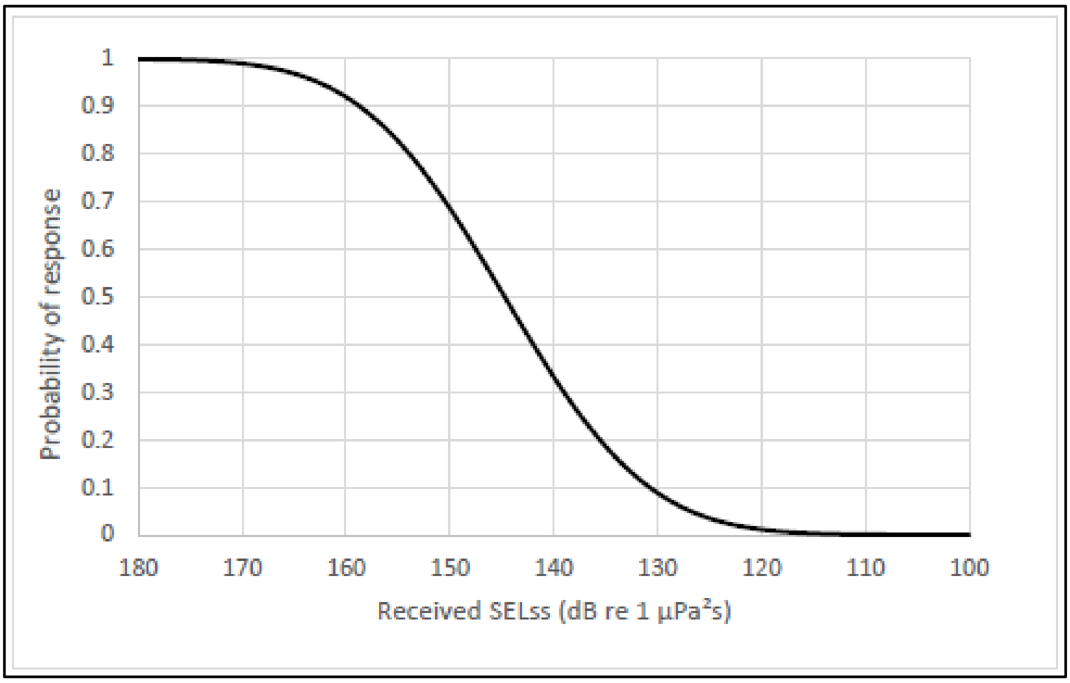
[4] A fixed distance from a noise source by which disturbance shall occur.

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".*

Noise contours at 5 decibel (dB) intervals were generated by noise modelling and were overlain on species density surfaces (see Section 14.3 and the Marine Mammal Baseline Characterisation Report) to predict the number of animals present within the impacted area. This allowed for the quantification of the number of animals that will potentially respond using the dose-response function.

Harbour porpoise dose-response function

To estimate the number of porpoise predicted to experience a behavioural response (disturbance) as a result of pile driving, this impact assessment uses the porpoise dose-response curve presented in Graham et al. (2017a) (Graph 14.2).



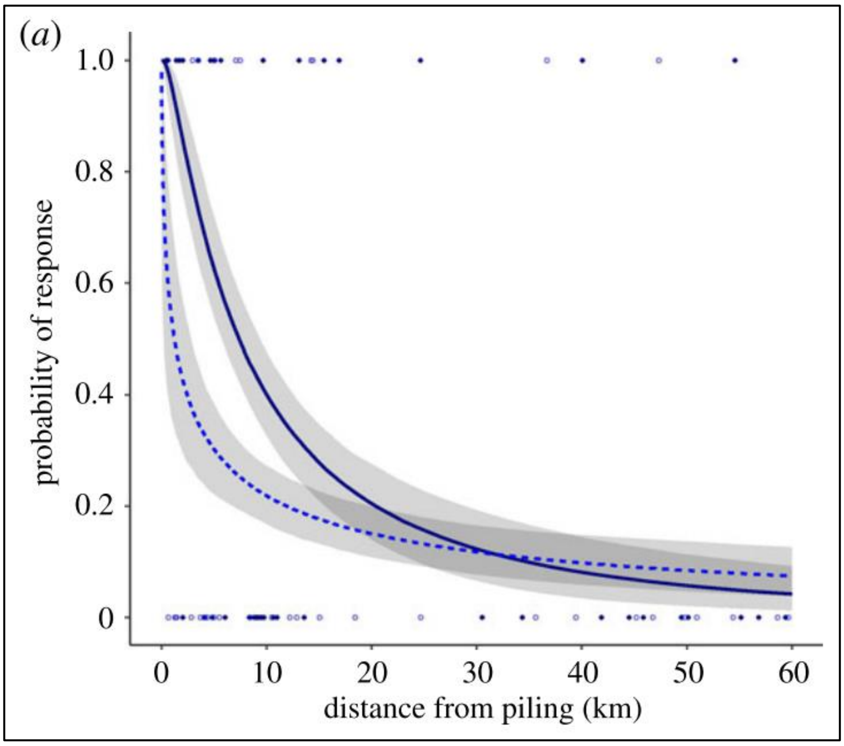
Graph 14.2 Relationship between the proportion of porpoise responding and the received single strike SEL (SEL_{ss}) (Graham et al. 2017a)

The Graham et al. (2017a) dose-response function was developed using data on harbour porpoise collected during the first six weeks of piling during phase one of the Beatrice Offshore Wind Farm monitoring program. Changes in porpoise occurrence (detection positive hours per day) were estimated using 47 CPODs[5] placed around the wind farm site during piling and compared with baseline data from 12 sites outside of the wind farm area prior to the commencement of operations, to characterise this variation in occurrence.

Porpoise were considered to have exhibited a behavioural response to piling when the proportional decrease in occurrence was greater than 0.5 (with respect to the probability of response, see Graph 14.3). The probability of response to piling was modelled along with the received single strike SEL at the CPOD location (Graham et al. 2017a).

[5] 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

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). A PAM study showed a 50% probability of porpoise response (a significant reduction in occurrence (detection) relative to baseline) within 7.4km at the first foundation location piled, with decreasing response levels over the construction period to a 50% probability of response within 1.3km by the final foundation piling location (Graph 14.3) (Graham et al. 2019). Therefore, using the dose-response function derived from the initial piling events for all piling events in the impact assessment is precautionary, as evidence shows that porpoise response is likely to diminish over the construction period.



Graph 14.3 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)

There is no disturbance threshold (effective disturbance range or dose-response function) for any other cetacean species included in this assessment. Therefore, in the absence of species-specific data on dolphin species or minke whales, the porpoise dose-response function has been adopted for all cetaceans, however it is considered that the application of the porpoise dose-response function to other cetacean species is highly precautionary. 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. 2021).

Various studies have shown that other cetacean species show comparatively less of a behavioural response to disturbance 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 harbour porpoise (Stone et al. 2017). In the Moray Firth, bottlenose dolphins have been shown to remain in the impacted area during both seismic activities and pile installation activities (Fernandez-Betelu et al. 2021) which highlights that animals are not excluded from the impacted area.

Harbour porpoise are considered to be particularly responsive to anthropogenic disturbance compared to other odontocetes (e.g., Ketten 2000, Lucke et al. 2009, Brandt et al. 2013, Thompson et al. 2013, Tougaard et al. 2013, Brandt et al. 2018, Sarnocinska et al. 2019, Thompson et al. 2020, Benhemma-Le Gall et al. 2021). Lucke et al. (2009) aimed to provide the first reliable information for the harbour porpoise for impulsive sound exposure as the threshold shift for the harbour porpoise differs from other odontocetes. The study concluded that harbour porpoise exhibit a relatively high temporary threshold shift (TTS) growth factor and have a slow recovery rate which, in combination, make them more vulnerable than mid-frequency cetaceans. Further recent TTS experiments and field studies also support that harbour porpoise are more sensitive to sound than initially anticipated from extrapolation of bottlenose dolphin results. Their behavioural reactions to noise also suggest that the noise response thresholds and TTS both critically depend on stimulus frequency (Tougaard et al. 2015).

A study conducted by Moray Offshore Renewables Limited (2012) reviewing responses of both harbour porpoise and bottlenose dolphins to received sound level showed that the best-fit relationships were indicative of a higher level responses by harbour porpoises than bottlenose dolphins at similar noise levels, with moderate changes in behaviour predicted to occur at approximately 50-60dB re 1μPa lower in harbour porpoises compared to bottlenose dolphins (Moray Offshore Renewables Limited 2012).

Likewise, other high-frequency cetacean species, such as striped (*Stenella coeruleoalba*) and common dolphins, have been shown to display less of a behavioural response to underwater noise signals and construction-related activities compared with harbour porpoise (e.g., Kastelein et al. 2006, Culloch et al. 2016).

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.

Level B harassment threshold

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, 2022) uses the Level B harassment threshold to predict marine mammal behavioural harassment. This threshold predicts that Level B harassment[6] will occur when an animal is exposed to received levels above 160dB re 1μPa (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 160dB re 1μPa rms (Malme et al. 1984).

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.

Seal dose-response function

For seals, the dose-response function adopted was based on the data presented in Whyte et al. (2020) (Graph 14.4). The Whyte et al. (2020) study updates the initial dose-response information presented in Russell et al. (2016) 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 estimate levels of seal usage in the area in order to assess how seal usage changed in relation to the pile driving activities at the Lincs Offshore Wind farm in 2011-2012.

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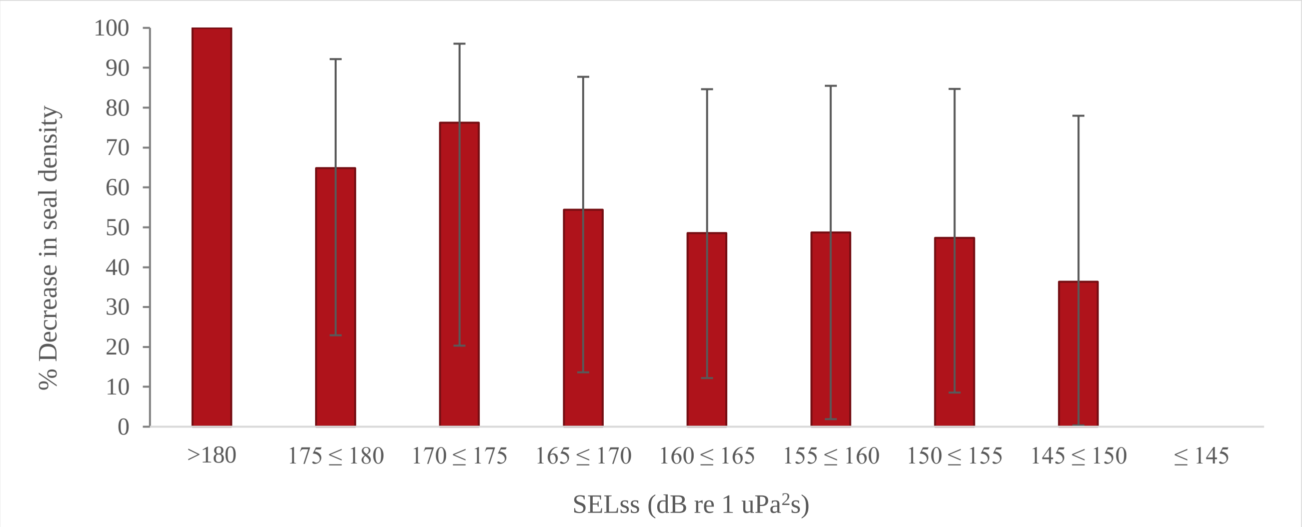
[6] Level B harassment refers to acts that have the potential to disturb (but not injure) a marine mammal or marine mammal stock in the wild by disrupting behavioural patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

In the Whyte et al. (2020) dose-response function, it has been assumed that all seals are displaced at sound exposure levels above 180dB re 1µPa²s. 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⩽180dB re 1µPa²s is slightly anomalous (higher response at a lower sound exposure level) due to the small number of spatial grid cells included in the analysis for these categories). 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.

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 an appropriate proxy for grey seals, since both species are categorised within the same functional hearing group. However, it is likely that this overestimates the grey seal response, since grey seals are less sensitive to behavioural disturbance than harbour seals and could tolerate more days of disturbance (where disturbance correlates to periods of non-foraging time) 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 is behavioural 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 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 precautionary as it will likely over-estimate the potential for impact on grey seals.



Graph 14.4 Predicted decrease in seal density as a function of estimated sound exposure level, error bars show 95% CI (Whyte et al. 2020)

14.2.10.2 Disturbance (behavioural response) from UXO clearance

While there are empirically derived dose-response relationships for pile driving, these are not directly applicable to the assessment of UXO detonation due to the very different nature of the sound emission.

While both sound sources (piling and explosives) are categorised as "impulsive" sound sources, they differ drastically in the number of pulses and the overall duration of the noise emission, both of which will ultimately drive the behavioural response.

While one UXO -detonation is anticipated to result in a one-off startle-response, 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. However, for UXO detonation 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.

Since there is no dose-response function available that appropriately reflects the behavioural response from UXO detonation, other behavioural response thresholds have been considered instead. These alternatives are summarised in the sections below.

EDR – 26km for high order UXO clearance

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 EDR of 26km 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.

The recommendation for the 26km 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 500kJ hammer energy to install piles of 2.4m to 2.6m diameter up to 30m penetration depth. The JNCC (2020) guidance itself acknowledges that this EDR is based on the EDR recommended for pile driving of monopiles, since there is no equivalent data for explosives. The guidance states that:

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

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).

The number of animals expected within the 26km EDR range has been calculated and presented as a proportion of the relevant (estimated) population size.

While the 26km EDR has been presented here, it is important to acknowledge that there is no direct 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 500kJ 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 26km EDR approach. The other approaches are outlined below.

EDR - 5km for low order UXO clearance

There are no empirical data upon which to set a threshold for disturbance from low-order UXO clearance. Data have shown that low-order deflagration detonations produce underwater noise that is over 20 dB lower than high-order detonation of charges of 5-10 kg (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 MNR disturbance tool (JNCC 2023) provides default EDRs with the greatest magnitude of impact for various noise sources, and lists the default low-order UXO clearance EDR as 5km. In the absence of any further data, this 5km EDR for low-order UXO clearance has been assumed here.

The number of animals expected within the 5km EDR range has been calculated and presented as a proportion of the relevant (estimated) population size.

Fixed noise threshold – TTS-onset

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. 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).

"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).

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).

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

The number of animals expected within the TTS-onset range has been calculated and presented as a proportion of the relevant (estimated) population size.

14.2.10.3 Disturbance from other construction activities

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

14.2.10.4 Population modelling

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

The iPCoD model has been parameterised for the following species: harbour porpoise, bottlenose dolphins, minke whale, harbour seal and grey seal. It cannot be used for other dolphin species at present.

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.

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 of a group of experts regarding the effect of disturbance on the probability of survival and fertility in harbour porpoise, harbour seal and grey seals (Booth et al. 2019). Note: the iPCoD model for bottlenose dolphin and minke whale disturbance was last updated following the expert elicitation in 2013 (Harwood et al. 2014).

When this expert elicitation was conducted, the experts provided responses on the assumption that a disturbed individual would not forage for 24 hours which is highly unrealistic and will over-estimate the true disturbance levels expected from the proposed development (see Appendix 1, section C: Population modelling).

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.

The demographic parameters used in the iPCoD modelling were derived from Sinclair et al. (2020) and adjusted slightly in order to align with the demographic parameter recommendations made by National Resources Wales (NRW) for other offshore wind farm projects in the Irish Sea. The demographic parameters used in the iPCoD modelling are summarised in Table 14.7. The piling parameters used in the iPCoD modelling are summarised in Section 14.4.1.

Table 14.7 Demographic parameters used in the iPCoD modelling[7]

Demographic parameter	Harbour porpoise (stable)	Harbour porpoise (declining)	Bottlenose dolphin	Harbour seal	Grey seal
MU	62,517	62,517	293; 469; 1,069; or 8,326	1,635	5,881
Calf/pup survival	0.8455	0.6	0.87	0.4	0.222
Juvenile survival	0.85	0.85	0.94	0.78	0.94
Adult survival	0.925	0.9	0.94	0.92	0.94
Fertility	0.34	0.5	0.245	0.85	0.84
Age at independence	1	1	2	1	1
Age at first birth	5	5	9	4	6

14.2.10.5 Assessment of other impact pathways

Vessel collision and disturbance

The assessment is qualitative, and relates the likelihood of impact given the expected level of vessel activity specific to the proposed development to the 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.

Indirect impacts to prey

A qualitative assessment is provided, based on the predicted impacts to marine mammal prey species, as assessed in Volume 3, Chapter 13: Fish and Shellfish Ecology.

Increased concentrations of suspended sediments

A qualitative assessment is provided, based on evidence in the published literature on marine mammal presence and behaviour in turbid environments.

Decommissioning

The effects of decommissioning activities on marine mammals are considered to be similar to, or less than those occurring during construction although this is likely to be a highly precautionary assessment due to the lack of high noise producing activities (piling or UXO clearance).

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[7] Note: minke whales were not modelled in this assessment since the disturbance impacts are predicted to such a low proportion of the MU (0.45% - 1.1% MU). This will not result in a population level effect and thus has not been modelled.

14.2.11 Uncertainties and limitations

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 Appendix 14.1 and Appendix 14.3. Notwithstanding, the assessment is considered to be robust and uses the good industry practice currently available.

14.3 Baseline Environment

14.3.1 Introduction

The baseline environment for marine mammals is detailed in the Marine Mammal Baseline Characterisation, with a summary provided here. This chapter should therefore be read alongside the detailed Marine Mammal Baseline Characterisation which identifies the range of species and the abundance and density of marine mammals that could potentially be impacted by the proposed development, informed by data collected across previous surveys in the MU and site specific surveys.

14.3.2 Receiving Environment

14.3.2.1 Harbour porpoise

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) (estimated using data from SCANS III and ObSERVE) (IAMMWG 2023). Data from the sources analysed indicates the potential for harbour porpoise presence all year round, although several studies found density and abundance to be highest during the summer months (e.g., Berrow et al. 2008, Rogan et al. 2018). Harbour porpoise densities in the Irish Sea are much lower than in the southern North Sea and in the Celtic Sea (Lacey and Hammond 2020).

In the 29 months of site-specific DAS for the proposed development, a total of 575 harbour porpoise (56.4% of all marine mammal sightings) and 209 dolphin/porpoise (20.5% of all marine mammal sightings) were sighted. The sightings of un-identified marine mammals were apportioned using speciated records across the DAS dataset (Natural Power 2022). The average density estimate (apportioned and corrected) across the 29 surveys was 0.38 porpoise/km^2, however density varied seasonally, with highest density estimates in the autumn and winter months (0.49 and 0.54 porpoise/km^2 respectively) compared to spring and summer months (0.33 and 0.22 porpoise/km^2 respectively). It is important to note that the site-specific density estimates are not representative of animals densities across the wider scale for large scale impacts such as disturbance from UXO clearance or piling as the survey area did not extend far enough to cover the ranges of these potential impacts, therefore other density estimates are also considered in the quantitative assessment.

Given the range of density estimates available and the different areas covered by the density estimates, a range of relevant density estimates have been taken forward to the quantitative impact assessment. These include: the site-specific survey estimate (not suitable for wide scale disturbance impacts), the SCANS IV uniform density estimate, the SCANS III density surface estimate and the Evans and Waggitt (2023) density surface.

14.3.2.2 Bottlenose dolphin

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 in 2016 and ObSERVE in 2015/2016) (IAMMWG 2023). The predicted density of bottlenose dolphins within the Irish Sea and other UK coastal waters is generally low, with highest predicted densities in the Celtic Sea and the Bay of Biscay (Lacey and Hammond 2020).

In the 29 months of site-specific DAS for the proposed development, bottlenose dolphin density estimates were on average 0.002 dolphins/km^2 across the 29 surveys, ranging from 0.000 dolphins/km^2 in the winter to 0.004 in the spring dolphins/km^2. The proposed development 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. SCANS III in 2016 estimates there to be 288 bottlenose dolphins in the Irish Sea, while SCANS IV in 2022 estimates there to be 8,326 bottlenose dolphins in the Irish Sea. The current recommended population estimate for the Irish Sea MU is based on the SCANS III abundance, and is therefore completely incompatible with the SCANS IV block CS-D density estimate. Therefore, where the SCANS IV density estimate is used in the quantitative impact assessment the Irish Sea MU abundance estimate is assumed to be 8,326 instead of 293.

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. As noted for the SCANS IV surveys, the Evans and Waggitt (2023) maximum density surface is not compatible with the Irish Sea MU population size estimate of 293 bottlenose dolphins which was based on the 2016 SCANS III survey data (IAMMWG 2023). If the Evans and Waggitt (2023) 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). Therefore, where the Evans and Waggitt (2023) maximum density surface is used in the quantitative impact assessment the Irish Sea MU population has to be assumed to be 496 bottlenose dolphins instead of 293 individuals.

Despite coming from the same data source (SCANS III), the modelled density surface presented in (Lacey and Hammond 2020) results in a much higher abundance of bottlenose dolphins within the Irish Sea than is assumed by (IAMMWG 2023). If the (Lacey and Hammond 2020) 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 and Hammond 2020) density surface is 1,069 bottlenose dolphins. Therefore, where the (Lacey and Hammond 2020) density surface is used in the quantitative impact assessment the Irish Sea MU population has to be assumed to be 1,069 bottlenose dolphins instead of 293 individuals.

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 will be taken forward to the quantitative impact assessment which reflect the most robust, up-to-date density estimates available. These include the SCANS IV uniform density estimate, the SCANS III density surface, and the Evans and Waggitt (2023) density surface.

14.3.2.3 Common dolphin

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). A single MU is implemented for common dolphin: Celtic and Greater North Seas. It is estimated that the MU comprises 102,656 common dolphin (95% CI: 58,932 – 178,822, CV: 0.29) (estimated using data from SCANS III and ObSERVE) (IAMMWG 2023).

Common dolphins 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). Common dolphin predicted densities around most of the UK and the Irish Sea MU is low, with highest densities predicted to occur in shelf waters and along the shelf edge in the northern Bay of Biscay and Celtic Sea and around the coasts of Spain and Portugal (Lacey and Hammond 2020).

In the 29 months of site-specific DAS for the proposed development, common dolphin sightings were highly variable, with between 0 and 30 individual common dolphins sighted per survey day. The average density estimate (apportioned and corrected) across the 29 surveys was 0.04 dolphins/km^2. 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 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.

14.3.2.4 Minke whale

Minke whales are observed throughout Ireland's 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). Minke whale abundance is also analysed within the Celtic and Greater North Seas MU and is estimated at 20,118 (95% CI: 14,061 – 28,786, CV: 0.18) (estimated using data from SCANS III and ObSERVE) (IAMMWG 2023).

The SCANS III density surface shows generally low minke whale densities around the UK and Ireland, with highest densities predicted across the central and northeastern North Sea, and in shelf waters west of Scotland (Lacey and Hammond 2020).

In the 29 months of site-specific DAS for the proposed development, a total of 2 minke whale sightings were recorded. These were in July 2020 and October 2021. There were insufficient data to obtain a density estimate for minke whales. Data shows minke whales have patchy distribution within the Irish Sea (Baines and Evans 2012). ObSERVE surveys of the wider area confirmed higher minke whale presence during summer as well as spring (Rogan et al. 2018). It should be noted that the species is expected to be absent in the autumn and winter months due to 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. 2014) and, therefore, the density estimate used for minke whale in this impact assessment is not applicable in these months.

A range of density estimates have been taken forward to the quantitative impact assessment. These include the SCANS IV uniform density estimate, the SCANS III density surface, the ObSERVE density estimate and the Evans and Waggitt (2023) density surface.

14.3.2.5 Harbour seals

Harbour seals occur throughout Irish waters in estuarine, coastal, and fully marine areas. For this impact assessment, harbour seals have been assessed within the East region of Ireland and the Northern Ireland MU. MU size has been estimated as a proportion of the haul out count for the region and the total August counts for the East region (131), South-east region (34) and the Northern Ireland MU (1,012) 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 harbour seal count totals 1,177 harbour seals with a resulting population estimate of 1,635 harbour seals in the reference population (95% CI: 1,338–2,180). In the 29 months of site-specific DAS for the proposed development, no harbour seals were sighted. Although the site-specific DAS does not indicate harbour seal sightings at the array area, the Lambay Island SAC is within 20km of the offshore development area, which is within the typical foraging range of harbour seals (40-50km from their haul-out sites; SCOS 2019). Given the proximity of the proposed development to the Lambay Island SAC, densities in the vicinity of the proposed development are higher compared to the Irish Sea in general, with density estimates for the cells adjacent to the Lambay Island SAC reaching up to 0.25 harbour seals/km^2 (extracted from Carter et al. 2020, 2022). The average harbour seal density across grid cells within the array area and offshore Export Cable Corridor (ECC) is 0.115 harbour seals/km^2 (extracted from Carter et al. 2020, 2022).

Given that there is no alternative, it is recommended that the at-sea density estimates obtained from the habitat preference maps (Carter et al. 2020, 2022) are used in the impact assessment for the proposed development.

14.3.2.6 Grey seals

Grey seals are known to be present off all Irish coasts year-round. The East and South east regions of Ireland MUs and the Northern Ireland MU have been combined to provide the most appropriate MU for grey seals. The total August counts for the East region (418), South-east region (556) and the Northern Ireland MU (549) can be scaled by the estimated proportion of animals hauled-out at the time of the survey (25.15%, 95% CI 21.45% - 29.07%) (SCOS 2022) to provide an estimate of the total population (hauled-out and at-sea at the time of the count). The combined count totals 1,523 grey seals with a resulting population estimate of 6,056 grey seals in the reference population (95% CI: 5,239 – 7,100). In the 29 months of site-specific DAS surveys for the proposed development, 23 grey seals were sighted (2.3% of all marine mammal sightings). Additionally, there were 41 sightings of unidentified seals (4.0% of all marine mammal sightings) which were all assumed to be grey seals. Grey seals were sighted year-round during site-specific DAS, with an average density of 0.02 seals/km^2. Whilst there have been several studies on grey seal abundance and distribution at haul-outs around Ireland, there is a lack of at-sea density estimates due to a lack of telemetry data in Irish waters. However, telemetry data for grey seals tagged in UK waters have shown connectivity between the east coast of the Ireland, Northern Ireland, Wales, Southwest England and the southwest coast of Scotland (Carter et al. 2020). The average grey seal density across grid cells within the array area and ECC is 0.421 grey seals/km^2 (extracted from Carter et al. 2020).

Although grey seals were sighted year-round during site-specific DAS, with an average density of 0.02 seals/km^2, it is recommended that the at-sea density estimates obtained from the habitat preference maps are used in the impact assessment for the proposed development rather than a site-specific density estimate. This is precautionary since the site-specific density estimates were lower than those obtained from habitat preference maps. Additionally, given the proximity of the offshore development area to the Lambay Island SAC, grey seal densities in the vicinity of the proposed development are higher compared to the Irish Sea in general, with density estimates for the cells adjacent to the Lambay Island SAC and the ECC reaching up to 1.25 grey seals/km^2 (extracted from Carter et al. 2020).

14.3.3 Designated Sites

Designated sites, including Natura 2000 sites, that have the potential for likely significant effects due to the proposed development are presented in Table 14.8 below.

Table 14.8 Designated sites within the relevant marine mammal MUs

Site	Site Code	Species	Country	Distance to array area	Distance to ECC
Rockabill to Dalkey Island SAC	IE003000	Harbour porpoise	Ireland	2.4km	2.9km
Lambay Island SAC	IE0000204	Harbour seal Grey seal Harbour porpoise	Ireland	14.8km	15.7km
Slaney River Valley SAC	IE0000781	Harbour seal	Ireland	79.1km	71.7km
Saltee Islands SAC	IE0000707	Grey seal	Ireland	169.3km	165.9km
Roaringwater Bay and Islands SAC	E000101	Harbour porpoise	Ireland	320.0km	317.6km
Blasket Islands SAC	E002172	Harbour porpoise	Ireland	346.6km	331.8km
West Connacht Coast SAC	IE002998	Bottlenose dolphin Harbour porpoise	Ireland	477km	486km
Codling Fault Zone SAC	IE003015	Harbour porpoise	Ireland	28km	38km
Blackwater Bank SAC	IE002953	Harbour porpoise	Ireland	121km	128km
Carnsore Point SAC	IE002269	Harbour porpoise	Ireland	154km	160km
Hook Head SAC	IE000764	Bottlenose dolphin Harbour porpoise	Ireland	199km	205km
Kenmare River SAC	IE002158	Harbour porpoise	Ireland	453km	459km

Site	Site Code	Species	Country	Distance to array area	Distance to ECC
Belgica Mound Province SAC	IE002327	Bottlenose dolphin Harbour porpoise	Ireland	545km	552km
Kilkieran Bay and Islands SAC	IE002111	Harbour porpoise	Ireland	615km	623km
Inishmore Island SAC	IE000213	Harbour porpoise	Ireland	636km	644km
Bunduff Lough and Machair/Trawalua/Mullaghmore SAC	IE000625	Harbour porpoise	Ireland	436km	444km
Murlough SAC	UK0016612	Harbour seal	Northern Ireland	41.3km	47.1km
Strangford Lough SAC	UK0016618	Harbour seal	Northern Ireland	64.7km	71.9km
North Channel SAC	UK0030399	Harbour porpoise	Northern Ireland	48.4km	63.2km
North Anglesey Marine SAC	UK0030398	Harbour porpoise	Wales	34.7km	42.9km
Lleyn Peninsula and the Sarnau SAC	UK0013117	Bottlenose dolphin	Wales	106.7km	116.8km
West Wales SAC	UK0030397	Harbour porpoise	Wales	100.7km	110.6km
Cardigan Bay SAC	UK0012712	Bottlenose dolphin	Wales	161.9km	171.6km
Bristol Channel Approaches SAC	UK0030396	Harbour porpoise	Wales & England	223.0km	232.2km
French ZSCs	various	Harbour porpoise	France	18 sites in the French waters of the Celtic and Irish Seas MU	

14.3.4 Summary

The data available have confirmed the likely presence of harbour porpoise, bottlenose dolphin, common dolphin, minke whale, harbour seal and grey seal in the offshore development area and the wider study area and, therefore, these species should be considered within the quantitative impact assessment. The most robust and relevant density estimates within each MU were determined for each receptor (Table 14.9). Where possible, density estimates derived from site- DAS have been used, however it is important to note that the site-specific density estimates are not representative of animals densities across the wider scale for large scale impacts such as disturbance from UXO clearance or piling.

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 are 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 14.9).

Table 14.9 Marine mammal MU and density estimates (# animals/km^2) utilised for quantitative impact assessment

Species	MU	MU size	MU source	Density (animals/km2)	Density source
Harbour porpoise	Celtic and Irish Sea	62,517	IAMMWG (2023)	0.38	Site-specific DAS
				0.2803	SCANS IV Gilles et al. (2023)
				Grid cell specific	SCANS III density surface (Lacey et al. 2022)
					Irish Sea density surface (Evans and Waggitt 2023)

Species	MU	MU size	MU source	Density (animals/km2)	Density source
Bottlenose dolphin	Irish Sea	293 (8,326[8] 1,069[9] 496[10])	IAMMWG (2023)	0.002	Site-specific DAS
				0.2352	SCANS IV Gilles et al. (2023)
				Grid cell specific	SCANS III density surface (Lacey et al. 2022)
					Irish Sea density surface (Evans and Waggitt 2023)
Common dolphin	Celtic and Greater North Sea	102,656	IAMMWG (2023)	0.04	Site-specific DAS
				0.0272	SCANS IV Gilles et al. (2023)
				Grid cell specific	SCANS III density surface (Lacey et al. 2022)
					Irish Sea density surface (Evans and Waggitt 2023)
Minke whale	Celtic and Greater North Sea	20,118	IAMMWG (2023)	0.0137	SCANS IV Gilles et al. (2023)
				Grid cell specific	SCANS III density surface (Lacey et al. 2022)
					Irish Sea density surface (Evans and Waggitt 2023)
Harbour seal	East regions of Ireland & Northern Ireland MU	1,365	Scaled count from Morris and Duck (2019) and SCOS (2023)	Grid cell specific (0.115: average across array and ECC area)	Carter et al. (2020)
Grey seal	East regions of Ireland & Northern Ireland MU	6,056	Scaled count from Morris and Duck (2019) and SCOS (2023)	Grid cell specific (0.421: average across array and ECC area)	Carter et al. (2020)

14.4 Characteristics of the Proposed Development

This section outlines the characteristics of the proposed development that are relevant to the identification and assessment of effects on marine mammal ecology during each phase of the proposed development. In this chapter this is limited to activities and infrastructure occurring in the offshore environment and it considers both Project Option 1 and Project Option 2 (the key characteristics of which are provided in Table 14.10, and are detailed in full in the Offshore Description Chapter).

Table 14.10 Key characteristics of Project Option 1 and Project Option 2

Key Offshore Characteristics	Project Option 1	Project Option 2
Array area	88.5km2	88.5km2
ECC	36.45km2	36.45km2

[8] 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.

[9] 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.

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

Key Offshore Characteristics	Project Option 1	Project Option 2
Landfall	One landfall site, immediately south of Bremore Point, which includes two subtidal exit pits within the ECC	One landfall site, immediately south of Bremore Point, which includes two subtidal exit pits within the ECC
Wind Turbine Generator (WTG)	49 WTGs with 250m rotor diameter	35 WTGs with 276m rotor diameter
WTG Foundations	49 monopiles of 12.5m diameter requiring seabed preparation	35 monopiles of 12.5m diameter or jacket foundations (three or four leg configurations, with 6m diameter pin piles) requiring seabed preparation
Offshore Substation Platform (OSP) Foundations (array area)	One OSP, with either a four-legged jacket foundation with pin piles, or one monopile; or two monopiles	One OSP, with either a four-legged jacket foundation with pin piles, or one monopile; or two monopiles
Cables	Installation of 111km of inter-array cables within the array area and installation of two 18km subsea export cables within the ECC	Installation of 91km of inter-array cables within the array area and installation of two 18km subsea export cables within the ECC

A presentation of the potential impacts in relation to Project Option 1 and Project Option 2 is provided, and the magnitude of those impacts in relation to the size and scale of the proposed development parameters. This enables the identification of the Project Option that will result in the greatest magnitude of impact on receptors and will therefore present the greatest potential for a likely significant effect (Table 14.10).

To determine the magnitude of the impact level, modelling, calculations and mapping have been undertaken for the Project Option with the greatest magnitude of impact, for all impacts for the relevant receptor/s.

The significance of effect assessment is then undertaken for both project options, which considers both receptor sensitivity and the magnitude of the impact and is detailed in Section 14.5.

14.4.1 Parameters for Assessment

The below activities, infrastructure and key design parameters have been considered within this chapter when determining the potential impacts. Further detail on the offshore elements of the proposed development is provided in the Offshore Description Chapter and Offshore Construction Chapter. These parameters apply to both project options and any differences in values that may require consideration have been identified in Table 14.10.

14.4.2 Construction

During construction the following activities and infrastructure have the potential to impact on marine mammal ecology:

- Pre-construction surveys (noise impacts)
- UXO clearance (noise impacts)
- Piling activities (noise impacts)
- Other construction activities, including dredging, cable laying, rock placement, drilling of foundations11, HDD and trenching (noise impacts); and
- Vessel movements (collision and noise impacts).

[11] Note: There is the potential for WTG foundations to be installed using drilling depending on seabed type or if a pile refuses during impact piling operations. However, impact piling is considered the scenario for the greatest magnitude of impact for underwater noise and as such an assessment of underwater noise from drilled WTG foundations is not included. It is noted that drilled WTG foundations will have greater impacts on water quality than pile driven WTG foundations.

14.4.2.1 Piling parameters

Four modelling locations were selected, each of which represent the corners of the array area furthest offshore within the proposed development and where depth ranges differed (Table 14.11), as shown in the Underwater Noise Report.

Project Option 1 (49 monopile WTGs): For the calculation of cumulative PTS-onset from monopiles, the assumption has been made that 1 monopile is installed in a 24-hour period. For the assessment of disturbance, the number of piling days for monopiles is 49 piling days for WTGs (and 2 days for the OSP), assuming piling will occur between April and October 2028 inclusive (see Table 14.12).

Project Option 2 (35 jacket WTGs): For the calculation of cumulative PTS-onset from multi-leg pin-piled jackets, the assumption has been made that 2 pin-piles can be installed at one location in a 24-hour period. For the assessment of disturbance, the number of piling days for pin-piles is 70 days, assuming piling will occur between April and September 2028 inclusive (see Table 14.13).

A full breakdown of the piling parameters utilised for the assessment of PTS are detailed in Table 14.12 and Table 14.13.

A simultaneous (concurrent) piling scenario has not been modelled, as no simultaneous pile driving is anticipated during the construction of the proposed development (see Section 14.4, Table 14.10).

Table 14.11 Noise modelling (piling) locations and piling depth

Location ID	Latitude	Longitude	Depth (m)
NE	53.73610	-5.85351	51.4
NW	53.73423	-5.98617	34.8
SE	53.63831	-5.85010	58.6
SW	53.63242	-5.92449	43.8

Table 14.12 Piling parameters for noise modelling – monopile WTGs

	Monopile foundation: 12.5m diameter, 1 installed per day, 6 hours 5 minutes piling per day						
Energy (kJ)	825	825	1,100	2,200	3,300	4,400	5,500
No. of strikes	3	300	600	300	300	300	8,745
Duration	30 mins	30 mins	20 mins	6 mins 40 sec	6 mins 40 sec	6 mins 40 sec	4 hours 25 mins
Strike rate (bl/min)	0.1	10	30	45	45	45	33

Table 14.13 Piling parameters for noise modelling – jacket WTGs

	Jacket foundation: 6m diameter, 2 pins installed per day, 6 hours 40 minutes piling per day						
Energy (kJ)	450	450	600	1,200	1,800	2,400	3,000
No. of strikes	3	300	600	300	300	300	3,300
Duration	30 mins	30 mins	20 mins	6 mins 40 sec	6 mins 40 sec	6 mins 40 sec	4 hours 25 mins
Strike rate (bl/min)	0.1	10	30	45	45	45	33

14.4.3 Operational Phase

During operation, the following activities and infrastructure have the potential to impact on marine mammal ecology:

- Vessel activity associated with all offshore maintenance, repair and replacement works; and

- Reburial or replacement of array cables.

14.4.4 Decommissioning

The impacts of decommissioning activities on marine mammals are considered to be similar to, or less than those occurring during construction due to the lack of high noise producing activities (piling or UXO clearance).

14.4.5 Embedded Mitigation Measures

The following embedded mitigation measures in Table 14.14 have been identified through the design and consultation process and are assumed to be incorporated as part of the proposed development. The embedded mitigation measures will not be considered again at the residual impact stage.

A MMMP (Volume 9, Appendix 14.4; hereafter the MMMP) and Offshore Environmental Management Plan (EMP) (Volume 9, Appendix 6.1; hereafter the Offshore EMP) have been prepared and will be implemented for all phases of the proposed development.

Table 14.14 Embedded mitigation measures relating to marine mammal ecology

Measure	Mitigation detail
Construction	
Marine Pollution Contingency Procedure (MPCP)	An offshore Environment Management Plan (EMP) is provided in Appendix 6.1 and will be implemented to cover the construction, operational and decommissioning phase of the proposed development. The Offshore EMP includes a MPCP to cover accidental spills, potential contaminant release and include key emergency contact details. Key measures in the MPCP include: • Compliance with MARPOL; • Spill kits on board all vessels; • Fuel and chemical storage according to relevant storage regulations; • Handling of waste in accordance with relevant waste regulations; and • Vessel refuelling to take place in port. The measures included in the MPCP would reduce the likelihood of potentially harmful pollutants to be released into the marine environment which may then impact on marine mammal receptors. Further information is provided in Appendix 6.1.
Collision avoidance	The 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). Alongside this Marine Notice, the Irish Whale and Dolphin Group provided a Code of Conduct for all watercraft encountering whales and dolphins (IWDG 2005). These guidelines were drafted specifically for the interactions between small vessels and marine mammals (e.g. whale watching passenger vessels), however the key principals will be followed by all project vessels where practicable to minimise the risk of vessel collisions with marine mammals and disturbance to marine mammals from vessels. These measures are captured within Appendix 14.5 Environmental Vessel Management Plan (EVMP). Other key measures to mitigate collision risk, as described in the EVMP include: • When an animal(s) is first sighted, vessels should maintain a steady course (speed and direction) to allow marine mammals to predict the vessel's path; • Where practicable, when an animal(s) is in close proximity (for example 100 – 200 m), vessel speed should be gradually reduced and maintained below 7 knots (in accordance with DCMNR, 2005). The exception to this is when behaviour such as bow riding is experienced, where speed should be maintained on a steady course; • If animals are moving in a consistent direction, maintain a parallel course; • Do not cut off individuals by moving across their path; • Avoid deliberately approaching marine mammals when sighted; • Avoid abrupt changes to course or speed should marine mammals approach the vessel, be on course to cross the path of a vessel or bow-ride; • Transit vessels should maintain a minimum distance of 150m or more from the coast, , particularly when near to known seal haul-out sites during sensitive periods (i.e. moulting and breeding seasons). Vessels should remain in the vicinity of seals for no more than 15 minutes; and • Further information is provided in Appendix 6.1.

Measure	Mitigation detail
Pile driving parameters and soft start procedures	In order to reduce the risk of PTS and disturbance to marine mammals during piling activities the maximum hammer energy to be used during pile driving (5,500kJ for monopile, 3,000kJ for multi leg pin-piles). Inclusion of soft-start and ramp up procedures for pile driving have also been incorporated into the design and no simultaneous piling events will occur. This requirement is captured within the MMMP.
Operation	
Marine Pollution Contingency Procedure (MPCP)	The Offshore EMP includes a MPCP to cover accidental spills, potential contaminant release and include key emergency contact details. Key measures in the MPCP include: • Compliance with MARPOL; • Spill kits on board all vessels; • Fuel and chemical storage according to relevant storage regulations; • Handling of waste in accordance with relevant waste regulations; and • Vessel refuelling to take place in port. The MPCP would reduce the likelihood of potentially harmful pollutants to be released into the marine environment which may then impact on marine mammal receptors.
Collision avoidance	The 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). Alongside this Marine Notice, the Irish Whale and Dolphin Group provided a Code of Conduct for all watercraft encountering whales and dolphins (IWDG 2005). These guidelines were drafted specifically for the interactions between small vessels and marine mammals (e.g. whale watching passenger vessels), however the key principals will be followed by all proposed development vessels where practicable to minimise the risk of vessel collisions with marine mammals and disturbance to marine mammals from vessels. These measures are captured within Appendix 14.5 EVMP. Other key measures from the EVMP are the same as those listed in the construction collision avoidance mitigations section of this table.
Decommissioning	
Collision avoidance	The 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). Alongside this Marine Notice, the Irish Whale and Dolphin Group provided a Code of Conduct for all watercraft encountering whales and dolphins (IWDG 2005). These guidelines were drafted specifically for the interactions between small vessels and marine mammals (e.g. whale watching passenger vessels), however the key principals will be followed by all Project vessels where practicable to minimise the risk of vessel collisions with marine mammals and disturbance to marine mammals from vessels. These measures are captured within the EVMP. Other key measures from the EVMP are the same as those listed in the construction collision avoidance mitigations section of this table.
Assessment of impacts and best practice environmental management	Prior to decommissioning a study of the potential environmental impacts to marine mammal receptors from the proposed decommissioning activities will be undertaken, considering the baseline environment at the pre-decommissioning stage. All mitigation measures to be delivered will be captured within the Rehabilitation Schedule and Offshore EMP. Any licences or authorisations that might be required will be identified and obtained prior to decommissioning, including any validation, updating or new submission of an EIAR, as required.

14.4.6 Potential Impacts

The identification of potential impacts has been undertaken by considering the relevant characteristics from both project options (refer to Section 14.4.1) and the potential for a pathway for direct and indirect effects on known receptors (as identified in Section 14.3). Each identified impact relevant to marine mammal ecology is presented in Table 14.15.

For each impact, the relevant characteristics of Project Option 1 and Project Option 2 are presented to determine the magnitude (size or extent) of the potential impact, defined by the proposed development parameters in the Offshore Description Chapter and in consideration of the WTG Limits of Deviation (LoD[12]), in line with the approach detailed in the EIAR Methodology chapter. A comparison of the project options has then been undertaken to determine which project option has the greatest magnitude of impact.

[12] Both Project Option 1 and Project Option 2 layouts have a 500m Limit of Deviation (LoD)

Table 14.15 Potential impacts and magnitude of impact per project option. The project option that has the greatest magnitude of impact is identified in blue

Impact	Project Option 1 (49 WTG)	Project Option 2 (35 WTG)	Rationale for the project option with the greatest magnitude of impact
Construction Phase			
1. Auditory injury (PTS) from pre-construction surveys	A series of pre-construction surveys will be undertaken in the array area and along the ECC. Geophysical surveys will utilize towed equipment such as side scan sonar, sub bottom profiler, multibeam echosounder and magnetometer.	A series of pre-construction surveys will be undertaken in the array area and along the ECC. Geophysical surveys will utilize towed equipment such as side scan sonar, sub bottom profiler, multibeam echosounder and magnetometer.	The magnitude of impact is considered to be the same for both Project Option 1 and Project Option 2.
2. Disturbance from pre-construction surveys	A series of pre-construction surveys will be undertaken in the array area and along the ECC. Geophysical surveys will utilize towed equipment such as side scan sonar, sub bottom profiler, multibeam echosounder and magnetometer.	A series of pre-construction surveys will be undertaken in the array area and along the ECC. Geophysical surveys will utilize towed equipment such as side scan sonar, sub bottom profiler, multibeam echosounder and magnetometer.	The magnitude of impact is considered to be the same for both Project Option 1 and Project Option 2.
3. Auditory injury (PTS) from UXO clearance	A detailed UXO survey will be completed prior to construction. The type, size (net explosive quantities (NEQ) and number of possible detonations and duration of UXO clearance operations is not known at this stage. Therefore, an illustrative assessment is presented here, using a range of UXO charge sizes from 25kg to 525kg.	A detailed UXO survey will be completed prior to construction. The type, size (NEQ) and number of possible detonations and duration of UXO clearance operations is not known at this stage. Therefore, an illustrative assessment is presented here, using a range of UXO charge sizes from 25kg to 525kg.	The magnitude of impact is considered to be the same for both Project Option 1 and Project Option 2.
4. Disturbance from UXO clearance	A detailed UXO survey will be completed prior to construction. The type, size (net explosive quantities (NEQ) and number of possible detonations and duration of UXO clearance operations is not known at this stage. Therefore, an illustrative assessment is presented here, using a range of UXO charge sizes from 25kg to 525kg.	A detailed UXO survey will be completed prior to construction. The type, size (net explosive quantities (NEQ) and number of possible detonations and duration of UXO clearance operations is not known at this stage. Therefore, an illustrative assessment is presented here, using a range of UXO charge sizes from 25kg to 525kg.	The magnitude of impact is considered to be the same for both Project Option 1 and Project Option 2.
5. Auditory Injury (PTS) from pile driving	**WTGs:** 49 monopile WTG foundations; 12.5m diameter piles; Maximum hammer energy: 5,500kJ; Maximum 6 hours and 5 minutes hours per pile; and One monopile foundation installed in a 24- hour period = 49 piling days. **OSP:** 1 OSP installed on 2 monopiles; 12.5m diameter piles; Maximum hammer energy: 5,500kJ;	**WTGs:** 35 jacket WTGs, 4 pin-piles per jacket = total 140 pin piles; 6m diameter pin-piles; Maximum hammer energy: 3,000kJ; Maximum 3 hours 20 minutes hours per pile; and 2 pin-piles installed per 24-hour period = 70 piling days. Project Option 2 also includes the possibility of 35 WTGs on monopile foundations, however as this is less than the 49 WTG on monopile foundation model	Project Option 1 represents the greatest magnitude of impact in relation to PTS from piling. The magnitude of the impact is defined by the extent of noise propagation resulting from the installation of WTG and OSP foundations during the construction phase. Note: impact pile driving is considered to be more impactful than drilling for marine mammals. Therefore, the assessment is based on impact pile driving of foundations only.

Impact	Project Option 1 (49 WTG)	Project Option 2 (35 WTG)	Rationale for the project option with the greatest magnitude of impact
	One monopile foundation installed in a 24-hour period; Maximum 6 hours 5 minutes per pile; and 1 monopile installed per day = 2 piling days.	undertaken for Project Option 1 it has not been modelled separately. WTG jacket foundations have been modelled for Project Option 2 as these are not included in Project Option 1. **OSP:** 1 OSP installed on 2 monopiles; Maximum hammer energy: 5,500kJ; Maximum 6 hours 5 minutes per pile; and 1 monopile installed per day = 2 piling days.	
6. Auditory Injury (TTS) from pile driving	As above for PTS from piling	As above for PTS from piling	As above for PTS from piling
7. Disturbance from piling	**WTGs:** 49 monopile WTG foundations; 12.5m diameter piles; Maximum hammer energy: 5,500kJ; Maximum 6 hours 5 minutes per pile; and One monopile foundation installed in a 24- hour period = 49 piling days. **OSP:** 1 OSP installed on 2 monopiles; 12.5m diameter piles; Maximum hammer energy: 5,500kJ; One monopile foundation installed in a 24-hour period; Maximum 6 hours 5 minutes per pile; and 1 monopile installed per day = 2 piling days.	**WTGs:** 35 jacket WTGs, 4 pin-piles per jacket = total 140 pin piles; 6m diameter pin-piles; Maximum hammer energy: 3,000kJ; Maximum 3 hours 20 minutes per pile; and 2 pin-piles installed per 24-hour period = 70 piling days. Project Option 2 also includes the possibility of 35 WTGs on monopile foundations, however as this is less than the 49 WTG on monopile foundation model undertaken for Project Option 1 it has not been modelled separately. WTG jacket foundations have been modelled for Project Option 2 as these are not included in Project Option 1. **OSP:** 1 OSP installed on 2 monopiles; Maximum hammer energy: 5,500kJ; Maximum 6 hours 5 minutes per pile; and 1 monopile installed per day = 2 piling days.	Project Option 1 represents the greatest magnitude of impact in relation to disturbance from piling. The magnitude of the impact is defined by the extent of noise propagation resulting from the installation of WTG and OSP foundations during the construction phase. Note: impact pile driving is considered to be more impactful than drilling for marine mammals. Therefore, the assessment is based on impact pile driving of foundations only.

Impact	Project Option 1 (49 WTG)	Project Option 2 (35 WTG)	Rationale for the project option with the greatest magnitude of impact
8. Auditory injury (PTS) from other construction activities	**Inter-array cables:** Installation of 111km of array cables; Installation method: jetting, ploughing, trenching; Protection: burial, mattressing and/or loose rock; and Duration: 240 days. **Export cables:** Installation of 18km of export cables; Installation: jetting, ploughing, trenching; Protection: mattressing and/or loose rock; and Duration: 180 days. **Landfall:** HDD.	**Inter-array cables:** Installation of 91km of array cables; Installation method: jetting, ploughing, trenching; Protection: burial, mattressing and/or loose rock; and Duration: 240 days. **Export cables:** Installation of 18km of export cables; Installation: jetting, ploughing, trenching; Protection: mattressing and/or loose rock; and Duration: 180 days. **Landfall:** HDD.	Project Option 1 represents the greatest magnitude of impact in relation to PTS from other construction noise. The magnitude of the impact is defined by the extent of construction activity which will generate noise.
9. Disturbance from other construction noise	**Inter-array cables:** Installation of 111km of array cables; Installation method: jetting, ploughing, trenching; Protection: burial, mattressing and/or loose rock; and Duration: 240 days. **Export cables:** Installation of 18km of export cables; Installation: jetting, ploughing, trenching; Protection: mattressing and/or loose rock; and Duration: 180 days. **Landfall:** HDD.	**Inter-array cables:** Installation of 91km of array cables; Installation method: jetting, ploughing, trenching; Protection: burial, mattressing and/or loose rock; and Duration: 240 days. **Export cables:** Installation of 18km of export cables; Installation: jetting, ploughing, trenching; Protection: mattressing and/or loose rock; and Duration: 180 days. **Landfall:** HDD.	Project Option 1 represents the greatest magnitude of impact in relation to PTS from other construction noise. The magnitude of the impact is defined by the extent of construction activity which will generate noise.
10. Collision with vessels	**Total construction vessel numbers:** Total vessels: 67; Total number of return trips: 3,008 and Maximum vessels simultaneously onsite: 49. **Guard vessels:** 4 guard vessels; 5 marinelife observation vessels; and 2 CTVs.	**Total construction vessels numbers:** Total vessels: 69; Total number of return trips: 2,530; and Maximum vessels simultaneously onsite: 47. **Guard vessels:** 4 guard vessels; 5 marinelife observation vessels; and 2 CTVs.	Project Option 1 represents the greatest magnitude of impact in relation to collision with vessels. The magnitude of the impact is defined by the number of vessels associated with construction activities.

Impact	Project Option 1 (49 WTG)	Project Option 2 (35 WTG)	Rationale for the project option with the greatest magnitude of impact
	Foundation installation vessels: 2 installation vessels; 3 personal support vessels; 3 component transport vessels; and 2 scour protection vessels. **WTG installation vessels:** 2 installation vessels; 6 support vessels; 2 transport vessels; and 1 support helicopter. **WTG commissioning works:** 2 SOVs; and 6 CTVs. **ECC installation vessels:** 1 cable laying vessel; 1 burial vessel; 1 support vessel; 12 work boats/Rigid Inflatable Boat (RIBs); 1 work boat for landfall HDD installation; 1 small JUV for landfall HDD installation; and 1 guard vessel for HDD and cable installation. **Array cable installation vessels:** 1 main laying vessel; 1 burial vessel; 1 main support vessel; and 1 main SOV/CTV. **OSP installation:** 1 installation vessel; 2 component transport vessels 2 personnel transport vessels; and 1 transport vessel.	**Foundation installation vessels:** 2 installation vessels; 3 personal support vessels; 3 component transport vessels; 2 scour protection vessels; 1 dredging vessel; and Placing of 1 template for pre-piling of 50% of locations (18 No.). **WTG installation vessels:** 2 installation vessels; 6 support vessels; 2 transport vessels; and 1 support helicopter. **WTG commissioning works:** 2 SOVs; and 6 CTVs. **ECC installation vessels:** 1 cable laying vessel; 1 burial vessel; 1 support vessel; 12 work boats/RIBs; 1 work boat for landfall HDD installation; 1 small JUV for landfall HDD installation; and 1 guard vessel for HDD and cable installation. **Array cable installation vessels:** 1 main laying vessel; 1 burial vessel; 1 main support vessel; and 1 main SOV/CTV. **OSP installation:** 1 installation vessel; 2 component transport vessels 2 personnel transport vessels; and	

Impact	Project Option 1 (49 WTG)	Project Option 2 (35 WTG)	Rationale for the project option with the greatest magnitude of impact
		1 transport vessel.	
11. Disturbance from vessels	**Total construction vessel numbers:** Total vessels: 67; Total number of return trips: 3,008; and Maximum vessels simultaneously onsite: 49. **Guard vessels:** 4 guard vessels; 5 marinelife observation vessels; and 2 CTVs. **Foundation installation vessels:** 2 installation vessels; 3 personal support vessels; 3 component transport vessels; and 2 scour protection vessels. **WTG installation vessels:** 2 installation vessels; 6 support vessels; 2 transport vessels; and 1 support helicopter. **WTG commissioning works:** 2 SOVs; and 6 CTVs. **ECC installation vessels:** 1 cable laying vessel; 1 burial vessel; 1 support vessel; 12 work boats/Rigid Inflatable Boat (RIBs); 1 work boat for landfall HDD installation; 1 small JUV for landfall HDD installation; and 1 guard vessel for HDD and cable installation. **Array cable installation vessels:** 1 main laying vessel; 1 burial vessel;	**Total construction vessel numbers:** Total vessels: 69; Total number of return trips: 2,530; and Maximum vessels simultaneously onsite: 47. **Guard vessels:** 4 guard vessels; 5 marinelife observation vessels; and 2 CTVs. **Foundation installation vessels:** 2 installation vessels; 3 personal support vessels; 3 component transport vessels; 2 scour protection vessels; 1 dredging vessel; and Placing of 1 template for pre-piling of 50% of locations (18 No.). **WTG installation vessels:** 2 installation vessels; 6 support vessels; 2 transport vessels; and 1 support helicopter. **WTG commissioning works:** 2 SOVs; and 6 CTVs. **ECC installation vessels:** 1 cable laying vessel; 1 burial vessel; 1 support vessel; 12 work boats/Rigid Inflatable Boat (RIBs); 1 work boat for landfall HDD installation; 1 small JUV for landfall HDD installation; and 1 guard vessel for HDD and cable installation.	Project Option 1 represents the greatest magnitude of impact in relation to disturbance from vessels. The magnitude of the impact is defined by the number of vessels associated with construction activities.

Impact	Project Option 1 (49 WTG)	Project Option 2 (35 WTG)	Rationale for the project option with the greatest magnitude of impact
	1 main support vessel; and 1 main SOV/CTV. **OSP installation:** 1 installation vessel; 2 component transport vessels 2 personnel transport vessels; and 1 transport vessel.	**Array cable installation vessels:** 1 main laying vessel; 1 burial vessel; 1 main support vessel; and 1 main SOV/CTV. **OSP installation:** 1 installation vessel; 2 component transport vessels 2 personnel transport vessels; and 1 transport vessel.	
12. Prey availability and distribution	See the Potential Impacts table in Section 13.4 of the Fish and Shellfish Ecology Chapter	See the Potential Impacts table in Section 13.4 of the Fish and Shellfish Ecology Chapter	Project Option with the greatest magnitude varies across different impact types on fish and shellfish
13. Increased concentration of suspended sediments	Total volume of suspended sediment and sediment deposition 805,292m3. **WTG drill cutting:** 49 turbine foundations with 75% requiring drilling resulting in 338,243m3 of sediment. **OSP Foundations (array):** One OSP foundation requiring seabed preparation and drill cutting resulting in the suspension of 22,089m3 of sediment. **Cable trenching:** Installation of 111km max of array cables resulting in the suspension of 333,000m3 of sediment. Installation of two export cables resulting in the suspension of 108,000m3 of sediment (excluding the part of the export cable within the array); and **HDD exit pits:** Exit pits total volume = 3,960m3.	Total volume of suspended sediment and sediment deposition 897,061m3. **WTG drill cutting:** 35 turbine foundations with 75% requiring drilling resulting in 356,257m3 of sediment. **OSP Foundations (array):** One OSP foundation requiring seabed preparation and drill cutting resulting in the suspension of 22,089m3 of sediment. **Cable Trenching:** Installation of 91km max of array cables resulting in the suspension of 273,000m3 of sediment. Installation of two export cables resulting in the suspension of 108,000m3 of sediment (excluding the part of the export cable within the array); and **HDD exit pits:** Exit pits total volume = 3,960m3.	Project Option 1 represents the greatest magnitude of impact in relation to increased concentration of suspended sediments. The greatest likely significant effect for foundation installation results from the largest volume suspended from seabed preparation. For cable installation, the greatest likely significant effect results from the greatest volume installation using energetic means (CFE). This also assumes the largest number of cables and the greatest burial depth. A total of one OSP will be constructed Project Option 1 has a higher total volume than Project Option 2 (2,417,667m3 more volume of materials) and presents the greatest likely significant effect.
Operational Phase			
14. Collisions with vessels	Total operation vessel numbers: Total vessels: 12 Total number of return trips: 1,261; and	Total operation vessel numbers: Total vessels: 12 Total number of return trips: 1,055; and	Project Option 1 represents the greatest magnitude of impact in relation to collision with vessels.

Impact	Project Option 1 (49 WTG)	Project Option 2 (35 WTG)	Rationale for the project option with the greatest magnitude of impact
	Maximum number of vessels simultaneously onsite: 12. **Vessel activity:** 1 JUV;; 1 SOV; 1 CTV; 1 lift vessels; 1 cable vessels; and 7 aux vessels.	Maximum number of vessels simultaneously onsite: 12. **Vessel activity:** 1 JUV; 1 SOV; 1 CTV; 1 lift vessels; 1 cable vessels; and 7 aux vessels.	The magnitude of the impact is defined by the number of vessels associated with operation activities.
15. Disturbance from vessels	Total operation vessel numbers: Total vessels: 12 Total number of return trips: 1,261; and Maximum number of vessels simultaneously onsite: 12. **Vessel activity:** 1 JUV; 1 SOV; 1 CTV; 1 lift vessels; 1 cable vessels; and 7 aux vessels.	Total operation vessel numbers: Total vessels: 12 Total number of return trips: 1,055; and Maximum number of vessels simultaneously onsite: 12. **Vessel activity:** 1 JUV; 1 SOV; 1 CTV; 1 lift vessels; 1 cable vessels; and 7 aux vessels.	Project Option 1 represents the greatest magnitude of impact in relation to disturbance from vessels. The magnitude of the impact is defined by the number of vessels associated with operation activities.
16. Prey availability and distribution	See the Potential Impacts table in Section 13.4 of the Fish and Shellfish Ecology Chapter	See the Potential Impacts table in Section 13.4 of the Fish and Shellfish Ecology Chapter	Project Option with the greatest magnitude varies across different impact types on fish and shellfish.
17. Increased concentration of suspended sediments	See the Potential Impacts table in Section 10.4 of the Marine Physical Processes chapter	See the Potential Impacts table in Section 10.4 of the Marine Physical Processes chapter	Impact dependent on the result of the Marine Physical Processes assessment.
Decommissioning			
18. PTS and disturbance from decommissionin g	The final method chosen shall be dependent on the technologies available at the time of decommissioning. The numbers of vessels and/or plant required for each activity is therefore not available at this stage. The indicative methodology, however, would be:	The final method chosen shall be dependent on the technologies available at the time of decommissioning. The numbers of vessels and/or plant required for each activity is therefore not available at this stage. The indicative methodology, however, would be:	Project Option 1 represents the greatest magnitude of impact in relation to PTS and disturbance from decommissioning More infrastructure will require decommissioning for Project Option 1, with a similar indicative methodology for both project

Impact	Project Option 1 (49 WTG)	Project Option 2 (35 WTG)	Rationale for the project option with the greatest magnitude of impact
	Deployment of ROV's 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 1-2m 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.	Deployment of ROV's 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 1-2m 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.	options. As such, Project Option 1 has the greatest magnitude of impact for PTS and disturbance from decommissioning.
19. Collisions with vessels	The greatest potential for a likely significant effect is identical to (or less than) that of the construction phase	The greatest potential for a likely significant effect is identical to (or less than) that of the construction phase	Project Option 1 represents the greatest magnitude of impact in relation to collisions with vessels. The number of vessels required during decommissioning is dependent upon the technologies available at the time of decommissioning, and the methodology likely to be used. More infrastructure will require decommissioning for Project Option 1. As such, Project Option 1 has the greatest magnitude of impact for collisions with vessels.
20. Disturbance from vessels	The greatest potential for a likely significant effect is identical to (or less than) that of the construction phase	The greatest potential for a likely significant effect is identical to (or less than) that of the construction phase	Project Option 1 represents the greatest magnitude of impact in relation to disturbance from vessels. The number of vessels required during decommissioning is dependent upon the technologies available at the time of decommissioning, and the methodology likely to be used.

Impact	Project Option 1 (49 WTG)	Project Option 2 (35 WTG)	Rationale for the project option with the greatest magnitude of impact
			More infrastructure will require decommissioning for Project Option 1. As such, Project Option 1 has the greatest magnitude of impact for collisions with vessels.
21. Prey availability and distribution	See the Potential Impacts table in Section 13.4 of the Fish and Shellfish Ecology Chapter	See the Potential Impacts table in Section 13.4 of the Fish and Shellfish Ecology Chapter	Project Option with the greatest magnitude varies across different impact types on fish and shellfish.
22. Increased concentration of suspended sediments	See the Potential Impacts table in Section 10.4 of the Marine Physical Processes chapter	See the Potential Impacts table in Section 10.4 of the Marine Physical Processes chapter	Impact dependent on the result of the Marine Physical Processes assessment.

14.4.6.1 Impacts scoped out

Impacts from onshore activities during construction

No impact pathways from the onshore development above the HWM have been identified with the potential to effect marine mammal receptors, therefore the impact assessment in this chapter is limited to activities and infrastructure in the offshore development area.

Electromagnetic fields (EMF)

EMFs are emitted along the lengths of subsea cables. 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. Potential EMF impacts on prey species may impact foraging success for marine mammals. The scale of the indirect impact to marine mammals will be informed by the assessment of prey availability and distribution.

Auditory injury and disturbance from drilling of WTGs

Impact pile driving is considered to be more impactful than drilling for marine mammals. Therefore, the assessment is based on impact pile driving of foundations only.

Auditory injury and disturbance from operational activities

Operational activity such as offshore maintenance, repair and replacement works, reburial or replacement of array cables will result in minimal underwater noise. The underwater noise produced during these activities will be largely dominated by the associated vessel noise, which has been assessed separately.

Pollution

Activities relating to the construction and decommissioning of the proposed development may influence water quality as a result of the accidental release of fuels, oils and/or hydraulic fluids. These impacts however are expected to be localised and short-lived.

With regards to the accidental release of fuels, oils and/or hydraulic fluids, the impact of pollution is associated with the construction of infrastructure and use of supply/service vessels may lead to direct mortality of marine mammals or a reduction in prey availability either of which may affect species' survival rates. However, with implementation of an appropriate offshore EMP (including Marine Pollution Contingency measures), a major incident that may impact any species at a population level is considered very unlikely. It is predicted that any impact would be of local spatial extent, short term duration, intermittent and reversible within the context of the regional populations and be not significant in EIA terms.

Operationally, the risk of accidental release of pollutants is limited to oils and fluids contained within the WTGs and vessels. The potential for full inventory release from a WTG is considered extremely remote and would occur as a slow release, which would be almost undetectable and immediately dispersed, limiting the potential interactions between pollutants and marine mammals. For these reasons, localised, temporary changes to water quality will not have a significant impact on marine mammals.

Operational Noise

Existing evidence suggests that operational noise associated with fixed-bottom offshore wind farms is likely to be considerably less than that of construction noise. 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 10dB compared to the same size geared turbine) (Stöber and Thomsen 2021). While underwater sound is expected to increase with increasing turbine size, new direct drive technology means that new WTG will produce considerably less underwater noise compared to the older geared WTG. Additionally, as WTG 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 WTG; however, given the presence of marine mammals (both porpoise and seals) within operational windfarms (e.g. Russell et al. 2016a, Brandt et al. 2018, Benhemma-Le Gall et al. 2020), it is unlikely that operational noise is expected to be of a level that would result in any disturbance effects. In addition, reviews have concluded that operational, fixed-bottom wind farm noise will have negligible effects on marine mammals (Madsen et al. 2006, Teilmann et al. 2006a, Teilmann et al. 2006b, CEFAS 2010, Brasseur et al. 2012).

Barrier Effects

A number of recent 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).

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 any stage of the proposed development will result in a permanent barrier to the movement of marine mammals in the area.

14.5 Potential Effects

The likely significant effects, both positive and negative, on marine mammal ecology for each stage of the proposed development are considered. Specifically, the potential impact of the proposed development during its construction, operational, and decommissioning phases associated with the offshore development area. The environment in the vicinity of the proposed development is naturally dynamic, and as such will exhibit some level of natural variation and change over time whether the proposed development proceeds or not. Consequently, the identification and assessment of likely significant effects must be done in the context of natural change, both spatial and temporal.

The assessment of likely significant effects on the designated sites listed in Table 14.8 is an intrinsic part of the assessment of the regional population of marine mammals assessed in this section, of which the citation population forms part of. An assessment of the in-direct impacts on the marine mammals designated within these sites including impacts to supporting habitats and water quality is also included in this assessment.

A Natura Impact Statement (NIS; North Irish Sea Array Windfarm Ltd, 2024) has been prepared which is a standalone document independent of the findings of this EIAR, in compliance with the Habitats and Birds Directives (92/42/EEC Conservation of the Wild Birds Directive 2009/147/EC). The NIS assesses how the proposed development might affect the Natura 2000 conservation objectives, and the mitigation measures that will be implemented to ensure that adverse effects on site integrity do not arise, are considered. The conclusion of the NIS assessment was that the proposed development will not adversely affect the integrity of any European site, either alone or in combination with other plans or projects.

14.5.1 Do-Nothing Scenario

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) (including loss of available habitat, changes in prey abundance and distribution, altered primary and secondary plankton production, and marine mammal range shifts), but they concluded that this topic remains poorly understood.

Since then, numerous studies have, and are being undertaken to understand the potential impacts of climate change on marine mammals. Building upon the work by Evans and Bjørge (2013), Martin et al. (2023) provided a further review on climate change impacts on marine mammals around the UK and Ireland, highlighting 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, food-web alterations (Nøttestad et al. 2015, Ramp et al. 2015); and increased potential for prevalence of disease amongst marine mammal populations through the introduction of novel diseases (Blanchet et al. 2021, SCOS 2022). Whilst Martin et al. (2023) provides an overview of what is, and what could happen to marine mammal populations around the UK and Ireland, the review does not 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.

14.5.2 Construction Phase

This section presents the assessment of impacts arising from the construction phase of the proposed development.

The potential environmental impacts arising from the construction of the proposed development are listed in Table 14.15 along with the Project Option with the greatest magnitude of impact against which each construction phase impact has been assessed. A description of the likely significant effects on marine mammal ecology receptors caused by each identified impact is given below.

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

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

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

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

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

- **Sub Bottom Profiler (SBP):** The SBP is a type of geophysical survey tool that uses low-frequency or high frequency sounds (pings) to identify acoustic impedance of the sub-surface geology and to identify transitions from one stratigraphic sequence to another[13]. 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[14].

- **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, it is therefore scoped out of assessment.

An essential step in assessing the potential for effects on relevant species is a consideration of their auditory sensitivities. Marine mammal hearing groups and auditory injury criteria from Southall et al. (2019), and corresponding species of relevance to this assessment, are summarised in Table 14.16. 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 14.16 Marine mammal hearing groups, estimated hearing range and sensitivity and injury criteria and corresponding species relevant to this assessment (Southall et al., 2019)

Hearing Group	Species	Estimated hearing range	Estimated region of greatest sensitivity†	Estimated peak sensitivity†
Low-frequency (LF) cetaceans	Minke whale	7Hz –35kHz	200Hz–19kHz	-
High-frequency (HF) cetaceans	Bottlenose dolphin Common dolphin	150Hz–160kHz	8.8–110kHz	58kHz
Very high-frequency (VHF) cetacean	Harbour porpoise	275Hz–160kHz	12–140kHz	105kHz
Phocid carnivores in water (PCW)	Harbour seal Grey seal	50Hz–86kHz	1.9–30kHz	13kHz

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

Prior to an evaluation in relation to each item of equipment, the overlap between typical survey equipment operating characteristics and marine mammal functional hearing capability is considered in Table 14.17. Table 14.17 presents typical values for geophysical surveys for large offshore wind farms, but equipment specific values will vary between different survey contractors. Where there is no overlap between hearing capability and functional hearing, there is no potential for disturbance effects to occur. High magnitude pressure waves may result in physiological damage to organs regardless of hearing range overlap, i.e. blast trauma from underwater explosions; however, the acoustic signals from high frequency geophysical sources (e.g. MBES, SSS) which are above the hearing range of marine mammals are not impulsive enough to have the potential to result in hearing injury or other harm through such a mechanism.

Table 14.17 Comparison of typical noise emitting survey equipment operating characteristics and overlap with the estimated hearing range of different marine mammal functional hearing groups

Equipment	Estimated source pressure level (dB re 1μPa)	Expected Sound Frequency	LF	HF	VHF	PCW
MBES	210–240dB re 1μPa (SPLpeak) for multiple beams* (Lurton and Deruiter 2011) 197dB re 1μPa (SPLpeak) for a single beam at an operational frequency of 200 kHz (Risch et al. 2017)	200–400kHz (Hartley Anderson Ltd 2020)	Above all hearing ranges			

[13] https://www.aspectsurveys.com/survey-services/geophysical/sub-bottom-profiling/

[14] https://www.ixblue.com/maritime/subsea-imagery/sub-bottom-profilers/

Equipment	Estimated source pressure level (dB re 1µPa)	Expected Sound Frequency	LF	HF	VHF	PCW
SSS	210dB re 1µPa (SPLpeak) (Crocker and Fratantonio 2016, Crocker et al. 2019)	300 & 900kHz (Crocker and Fratantonio 2016, Crocker et al. 2019)	Above all hearing ranges			
SBP	210–220dB re 1µPa (SPLpeak) (Hartley Anderson Ltd 2020)	Frequency selectable. Typically 2–15kHz with a peak frequency of 3.5kHz (Hartley Anderson Ltd 2020)	Yes	Yes	Yes	Yes

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

Sensitivity of the receptor

MBES and SSS: While the indicative source levels for MBES and SSS exceed the unweighted injury threshold for harbour porpoise and seals, the operational frequency of each sound source (MBES: 200 – 400kHz; SSS: 300 & 900kHz) is far above that of greatest hearing sensitivity for both porpoise (275Hz–160kHz (peak sensitivity: 105kHz)) and seals (50Hz–86kHz (peak sensitivity: 13kHz)). As there is no overlap between the hearing ranges of these species and the expected sound frequency of equipment, there is expected to be no reduction in the hearing abilities of either species.

For dolphin species and minke whales, the indicative source levels for SSS (210dB re 1µPa (SPL_{peak})) are unlikely to exceed the unweighted injury thresholds for PTS (dolphins: 230dB re 1µPa (SPL_{peak}); minke whale: 219dB re 1µPa (SPL_{peak})). As such, there is no risk of auditory injury to these species from the use of SSS. For MBES the indicative source levels (210–240dB re 1µPa (SPL_{peak})) could exceed unweighted injury thresholds for PTS for both dolphin species and minke whale depending on the source level used during surveys. In the event that the PTS thresholds are exceeded for both species during use of MBES equipment, the operational frequency (200 – 400kHz) is far above that of the hearing range for dolphins (150Hz–160kHz) and minke whales (7Hz –35kHz). As such, the expected sound frequency does not overlap with the functional hearing range of these species and hence there is no potential to affect the hearing abilities of dolphins and minke whale.

The sensitivity of all marine mammals to PTS-onset from use of MBES and SSS equipment is assessed as negligible.

SBP: The indicative source levels for SBP exceed the unweighted injury threshold for harbour porpoise and seals. While harbour porpoise and seal hearing ranges are between 275Hz–160kHz (porpoise peak sensitivity: 105kHz) and 50Hz–86kHz (seal peak sensitivity: 13kHz) respectively, the operational frequencies of SBP (2–15kHz (peak: 3.5kHz)) shall typically operate below that at which harbour porpoise and seals are most sensitive to auditory impact. Therefore, whilst there is a risk of auditory injury to both species, this risk is expected to be minimal. The sensitivity of porpoise and seals to PTS-onset from use of SBP is therefore assessed as low.

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

The source levels of SBP (210 – 220dB re 1 µPa (SPL_{peak})) exceed the PTS-onset thresholds for minke whale (219dB re 1µPa (SPL_{peak})) within the upper range. In addition, the expected operable sound frequencies of SBP (2-15kHz) overlap with minke whale hearing ranges (7z-35kHz) and thus, there is a risk of injury if an individual minke whale is close enough to the sound source. Although the operable sound frequencies of SBP overlap with the hearing range of minke whale, when the equipment is emitting higher frequency sounds, the source level tends to be lower (Lurton and Deruiter 2011), and thus is less likely to exceed the PTS-onset threshold. At the PTS-onset threshold, a 6dB elevation of the hearing threshold somewhere within the SPB frequency range (2-15kHz) is likely to affect only a small region of minke whale hearing, which is unlikely to result in changes to vital rates. Therefore, they have been assumed to have low sensitivity to PTS-onset from SBP.

Magnitude of impact

MBES and SSS: JNCC (2017) do not advise that mitigation to avoid injury from use of MBES is necessary in shallow (<200 m) waters where the MBES used are of high frequencies (as they are planned to be here). EPS Guidance (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 to all marine mammals is concluded to be of negligible magnitude.

SBP: For dolphins, the source levels of SBP equipment are below the PTS-onset thresholds (see Table 14.6). 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.

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

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 proposed development 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 SBPs have shown slightly greater propagation from sources generating low frequencies (<10kHz), whilst some of the highest frequency sources (>50kHz) were only weakly detectable or undetected by recording equipment located a few hundred metres from the source (Halvorsen and Heaney 2018). However, noise modelling for pipeline surveys have previously indicated PTS-onset in minke whales within 5m of the source when SBP pingers operate with a sound source of 220dB re 1µPa (SPL_{peak}) (Shell 2017), and ~10m for seals (Department for Business Energy & Industrial Strategy 2019). While the likelihood of an animal experiencing PTS-onset from SBP is very low, PTS is a permanent effect on the hearing sensitivity of the animal, and thus the magnitude is considered medium.

Significance of the effect

As the sensitivity of all marine mammals to PTS onset from MBES and SSS equipment has been assessed as negligible, and the magnitude of impact has been assessed as negligible, the significance of the effect for Project Option 1 and Project Option 2 is assessed as imperceptible, which is not significant in EIA terms.

As the sensitivity of dolphin species have been assessed as negligible, and the magnitude of impact from the use of SBPs has been assessed as negligible**.** As such, the significance of the effect for Project Option 1 and Project Option 2 is assessed as imperceptible, which is not significant in EIA terms.

For harbour porpoise, seals and minke whale, the sensitivity has been assessed as low, and the magnitude of impact from the use of SBP has been assessed as medium. As such, the significance of the effect for Project Option 1 and Project Option 2 is assessed as slight, which is not significant in EIA terms, for these species.

14.5.2.2 Impact 2 - Disturbance from pre-construction surveys

Sensitivity of the receptor

MBES or SSS: As indicated in Table 14.17 there is no potential for disturbance effects to occur through use of MBES or SSS, as the sound levels emitted are above 200kHz and therefore above the hearing frequency range of the marine mammals likely to be present in the region. The sensitivity of all marine mammals to disturbance from MBES and / or SSS is therefore assessed as negligible.

SBP: As indicated in Table 14.17, the expected sound frequency for SBPs falls within the functional hearing range for all relevant marine mammal species and, therefore, has the potential to result in disturbance effects. While harbour porpoise, dolphin, minke whale seal hearing ranges are between 275Hz–160kHz (porpoise peak sensitivity: 105kHz), 150Hz–160kHz (dolphin peak sensitivity: 8.8–110kHz), 7Hz –35kHz (minke whale peak sensitivity: 200Hz–19kHz) and 50Hz–86kHz (seal peak sensitivity: 13kHz) respectively, the operational frequencies of SBP (2–15kHz (peak: 3.5kHz)) shall typically operate below that at which harbour porpoise dolphins and seals are most sensitive to disturbance effects. Although the operable sound frequencies of SBP overlap with the hearing range of minke whale, when the equipment is emitting higher frequency sounds, the source level tends to be lower (Lurton and Deruiter 2011) and thus, the probability of a disturbance response is anticipated to be reduced at lower source levels (Tougaard 2021). As such, the sensitivity of all marine mammals to disturbance from SBP is therefore assessed as low.

Magnitude of impact

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

SBP: There are currently no empirical data available on the behavioural responses of marine mammals to SBP. 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 SBPs are highly directional, with noise levels outside of the main beam considerably lower and therefore with limited horizontal propagation of noise levels. Any response will likely be temporary; for example, evidence from Thompson et al. (2013) suggests that short-term disturbance caused by a commercial two-dimensional seismic survey (a much louder noise source (peak-to-peak source levels estimated to be 242–253dB re 1µPa at 1m than SBP) does not lead to long-term displacement of harbour porpoises. 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.

Significance of the effect

As the sensitivity of all marine mammals to disturbance from **MBES and SSS** equipment has been assessed as negligible, and the magnitude of impact has been assessed as negligible, the significance of the effect for Project Option 1 and Project Option 2 is assessed as imperceptible, which is not significant in EIA terms.

As the sensitivity of all marine mammals to disturbance from **SBP** equipment has been assessed as low, and the magnitude of impact has been assessed as low, the significance of the effect for Project Option 1 and Project Option 2 is assessed as slight, which is not significant in EIA terms.

14.5.2.3 Impact 3 - Auditory injury (PTS) from UXO clearance

Studies to date indicate the array area to be low risk and one area within the ECC near the coast in the southwest is considered medium risk of encountering UXOs (Ref. 6 Alpha Associates, 2021). If found, a risk assessment will be undertaken and items of UXO will either be avoided, removed, or detonated in situ. Recent advancements in the available methods for UXO clearance mean that high-order detonation may be avoided. The methods of UXO clearance considered for the proposed development may include the primary methods of removal/ relocation or low-order deflagration. If this is not possible, then high-order detonation will be a last resort method.

As the detailed pre-construction surveys have not yet been completed, it is not possible at this time to determine how many items of UXO will require clearance.

The preferred clearance method is to remove or deflagrate the UXO. Low order deflagration has been modelled assuming a donor of 0.25kg. The maximum equivalent charge weight for the potential UXO devices that could be present within the offshore development area has been estimated as 525kg (TNT equivalent). This has been modelled for high-order detonation alongside a range of smaller devices, at charge weights of 25, 55, 120, and 240kg. In each case, an additional donor weight of 0.5kg has been included to initiate detonation. The unweighted UXO clearance source levels are presented in Table 14.18, whilst Table 14.19 presents the impact ranges for UXO detonation, considering various charge weights and impact criteria. Full details of the underwater noise modelling and the resulting auditory injury (PTS-onset) impact areas and ranges are detailed in the Underwater Noise Modelling Report.

Table 14.18 Summary of the unweighted SPL_{peak} and weighted SEL_{ss} source levels used for UXO clearance modelling

Charge weight (TNT equivalent)	Unweighted SPL_{peak} source level	Weighted SEL_{ss} source level
Low order (0.25kg)	269.8dB re 1µPa @ 1m	215.2dB re 1µPa^{2}s @ 1m
25kg + 0.5kg donor	284.9dB re 1µPa @ 1m	228.0dB re 1µPa^{2}s @ 1m
55kg + 0.5kg donor	287.5dB re 1µPa @ 1m	230.1dB re 1µPa^{2}s @ 1m
120kg + 0.5kg donor	290.0dB re 1µPa @ 1m	232.3dB re 1µPa^{2}s @ 1m
240kg + 0.5kg donor	292.3dB re 1µPa @ 1m	234.2dB re 1µPa^{2}s @ 1m
525kg + 0.5kg donor	294.8dB re 1µPa @ 1m	236.4dB re 1µPa^{2}s @ 1m

Sensitivity of the receptor

Most of the acoustic energy produced by a high-order detonation is below a few hundred Hz, decreasing on average by about SEL 10dB per decade above 100Hz, and there is a pronounced drop-off in energy levels above ~5-10kHz (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 porpoise, dolphins and seals (Southall et al. 2019). If PTS were to occur within this low frequency range, it would be unlikely to result in any significant impact to vital rates of porpoise, dolphins, and seals. Therefore, porpoise, dolphins, and seals have been assessed as having a low sensitivity to auditory injury (PTS-onset) from UXO clearance.

Recent acoustic characterisation of UXO clearance noise has shown that there is more energy at lower frequencies (<100Hz) 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 as having a medium sensitivity to auditory injury (PTS-onset) from UXO clearance.

Magnitude of impact

As UXO detonation is defined as a single pulse and thus both the weighted SEL_{ss} criteria and the unweighted SPL_{peak} criteria from Southall et al. (2019) have been given in Table 14.19.

Low-order deflagration

The auditory injury (PTS-onset) range for low-order deflagration is small across all species, with a greatest impact range of <1km. For all species, this equates to 1 or <1 individual impacted. Therefore, for low-order deflagration the magnitude is assessed as negligible.

High-order detonation

For high-order detonation HF cetaceans (dolphins) have the smallest predicted impact range of up to 730m (SPL_{peak}). Seal species are predicted to have larger PTS-onset impact ranges, with a greatest PTS-onset impact range of 2.5km (SPL_{peak}) for the high order clearance of the largest charge size. Both harbour porpoise and minke whales have much larger PTS-onset impact ranges predicted for the greatest high-order charge size. The greatest PTS-onset impact range is 12km (SPL_{peak}) for VHF cetaceans (harbour porpoise) and 9.5km for LF cetaceans (minke whales) (SEL_{ss}).

Bottlenose dolphins and common dolphins are predicted to have ≤1 individual to experience auditory injury (PTS-onset) from UXO clearance activities (Table 14.20). If <1 individual is predicted to be impacted, then the magnitude is assessed as negligible.

For harbour porpoise, up to 172 individuals are predicted to experience auditory injury (PTS-onset) from high order UXO clearance at the greatest charge weight, which is 0.27% of the MU. For minke whale, up to 4 individuals are predicted to experience auditory injury (PTS-onset) from high order UXO clearance at the largest charge weight, which is <1% of the MU. For harbour seals, up to 1 individual is predicted to experience auditory injury (PTS-onset) from high order UXO clearance at the greatest charge weight, which is 0.10% of the MU. For grey seals, up to 8 individuals are predicted to experience auditory injury (PTS-onset) from high order UXO clearance at the greatest charge weight, which is 0.14% of the MU.

For porpoise, minke whales and seals, where the number of animals predicted to be impacted is >1, the unmitigated impact magnitude has been assessed as medium. This is due to the fact that while only a very small number of animals are predicted to be impacted, auditory injury (PTS) is a permanent impact. Therefore, auditory injury from UXO clearance is expected to have a permanent effect on individuals that may influence individual survival but not at a level that would alter population trajectory over a generational scale.

Table 14.19 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 183dB	HF 185dB	VHF 155dB	PCW 185dB	LF 219dB	HF 230dB	VHF 202dB	PCW 218dB
Low order (0.25kg)	230m	<50m	80m	40m	170m	60m	990m	190m
25kg + donor	2.2km	<50m	570m	390m	820m	260m	4.6km	910m
55kg + donor	3.2km	<50m	740m	570m	1.0km	340m	6.0km	1.1km
120kg + donor	4.7km	<50m	950m	830m	1.3km	450m	7.8km	1.5km
240kg + donor	6.5km	<50m	1.1km	1.1km	1.7km	560m	9.8km	1.9km
525kg + donor	9.5km	50m	1.4km	1.6km	2.2km	730m	12km	2.5km

Significance of the effect

Low-order deflagration

The sensitivity of harbour porpoise, dolphins and seals has been assessed as low, and the magnitude of auditory injury (PTS-onset) impacts from low-order deflagration UXO clearance have been assessed as negligible, this effect has been assessed as imperceptible, which is not significant in EIA terms, for Project Option 1 and Project Option 2.

The sensitivity of minke whales has been assessed as medium, and the magnitude of auditory injury (PTS-onset) impacts from low-order deflagration UXO clearance have been assessed as negligible, the significance of effect has been assessed as slight, which is not significant in EIA terms, for Project Option 1 and Project Option 2.

High-order detonation

The sensitivity of dolphins has been assessed as low, and the magnitude of auditory injury (PTS-onset) impacts from high-order detonation UXO clearance have been assessed as negligible, this impact has been assessed as imperceptible, which is not significant in EIA terms, for Project Option 1 and Project Option 2.

The sensitivity of porpoise and seals has been assessed as low, and the magnitude of auditory injury (PTS-onset) impacts from high-order detonation UXO clearance have been assessed as medium, this impact has been assessed as slight, which is not significant in EIA terms, for Project Option 1 and Project Option 2.

The sensitivity of minke whales has been assessed as medium, and the magnitude of auditory injury (PTS-onset) impacts from high-order detonation UXO clearance have been assessed as medium, this impact has been assessed as moderate, which is significant in EIA terms, for Project Option 1 and Project Option 2.

Table 14.20 Estimated number of marine mammals potentially at risk of PTS during UXO clearance

			PTS weighted SEL_{ss}						PTS unweighted SPL_{peak}					
Species	**Density (#/km²)**	**Impact**	**Low order (0.25 kg)**	**25kg + donor**	**55kg + donor**	**120kg + donor**	**240kg + donor**	**525kg + donor**	**Low order (0.25 kg)**	**25kg + donor**	**55kg + donor**	**120kg + donor**	**240kg + donor**	**525kg + donor**
Harbour porpoise (site-specific DAS)	0.38	# animals	<1	<1	<1	1	1	2	1	25	43	73	115	172
		% of MU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.07	0.12	0.18	0.27
Harbour porpoise (SCANS III)	0.239	# animals	<1	<1	<1	1	1	1	1	16	27	46	72	108
		% of MU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.07	0.12	0.17
Harbour porpoise (SCANS IV)	0.2803	# animals	<1	<1	<1	1	1	1	1	19	32	54	85	127
		% of MU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.05	0.09	0.14	0.20
Common dolphin (site-specific DAS)	0.04	# animals	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
		% of MU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Common dolphin (SCANS IV)	0.0272	# animals	<1	1	1	1	1	1	<1	<1	<1	<1	<1	<1
		% of MU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minke whale (SCANS IV)	0.0137	# animals	<1	<1	<1	1	2	4	<1	<1	<1	<1	<1	<1
		% of MU	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Bottlenose dolphin (SCANS III)	0.008	# animals	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
		% of MU (293)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bottlenose dolphin (site-specific DAS)	0.002	# animals	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
		% of MU (293)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.2352	# animals	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

			PTS weighted SEL_{ss}						PTS unweighted SPL_{peak}					
Species	**Density (#/km^2)**	**Impact**	**Low order (0.25 kg)**	**25kg + donor**	**55kg + donor**	**120kg + donor**	**240kg + donor**	**525kg + donor**	**Low order (0.25 kg)**	**25kg + donor**	**55kg + donor**	**120kg + donor**	**240kg + donor**	**525kg + donor**
Bottlenose dolphin (SCANS IV)		% of MU (8,326)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Harbour seal (average across array area and ECC)	0.115	# animals	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	1	1
		% of MU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.10
Grey seal (average across array area and ECC)	0.421	# animals	<1	<1	<1	1	2	3	<1	1	2	3	5	8
		% of MU	0.00	0.00	0.00	0.02	0.03	0.06	0.00	0.02	0.03	0.06	0.08	0.14

14.5.2.4 Impact 4 - Disturbance from UXO clearance

Studies to date indicate the array area to be low risk and one area within the ECC near the coast in the southwest is considered medium risk of encountering UXOs. (Ref. 6 Alpha Associates, 2021). Therefore UXO clearance activities are expected to occur very infrequently (likely over a few days at most, given the low risk of UXO presence in the area).

This assessment presents results for each of the following behavioural disturbance thresholds:

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

Sensitivity of the receptor

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 UXO detonation would result in any significant impacts, and that disturbance 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.

26km EDR

There is no guidance available from NPWS or IWDG on the methodology that should be used to assess disturbance from UXO clearance. It is advised by UK statutory nature conservation bodies (SNCBs) that an EDR of 26km 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). Within this 26 EDR, all animals are assumed to be disturbed. While the advice acknowledges that there is no empirical evidence of harbour porpoise avoidance from UXO clearance, this is the only guidance available and so it is used in this assessment. In the absence of agreed metrics for the use of other marine mammal species for disturbance and given a lack of empirical data on the likelihood of response to explosives, this 26km radius (area of 2,124km^2) has been applied for all species for high order detonations. The resulting number of animals, proportion of the reference population and impact magnitude is detailed in Table 14.21. This is quantified as the numbers of animals likely to be within the EDR (by multiplying the area of the impact footprint by the appropriate density estimate).

Magnitude of impact

The greatest estimated disturbance occurs for grey seals, harbour seals and bottlenose dolphins, where up to 894 grey seals (14.76% MU), 244 harbour seals (17.88% MU) and 499 bottlenose dolphins are predicted to be disturbed per detonation (5.99% MU assuming a population size of 8,326 dolphins) (Table 14.21). While the number of animals and the proportion of the MU this represents is non-negligible, the duration of disturbance is expected to negligible (disturbance lasting less than a day per detonation event) and the frequency of the impact is expected to be negligible (likely over a few days at most, given the low risk of UXO presence in the area). The consequence of the impact is therefore short-term and intermittent with temporary behavioural effects that are very unlikely to alter survival and reproductive rates to the extent that the population trajectory would be altered. Therefore, disturbance impacts associated with high-order UXO clearance on all marine mammals are assessed as low in magnitude.

Table 14.21 Estimated number of marine mammals potentially at risk of disturbance during UXO clearance (assuming a 26km EDR, resulting in a 2,123.72km^2 impact area)

Species	Density (animals km2)	MU	Number Impacted	% MU
Harbour porpoise	0.38 (site-specific DAS)	62,517	807	1.29%
	0.2803 (SCANS IV)		595	0.95%
Bottlenose dolphin	0.002 (site-specific DAS)	293	4	1.37%
	0.2352 (SCANS IV)	8,326	499	5.99%
Common dolphin	0.04 (site-specific DAS)	102,656	85	0.08%
	0.0272 (SCANS IV)		58	0.06%
Minke whale	0.0137 (SCANS IV)	20,118	29	0.14%
Grey seal	0.421 (average across array and ECC)	6,056	894	14.76%
Harbour seal	0.115 (average across array and ECC)	1,365	244	17.88%

Significance of the effect

The sensitivity of all marine mammals to disturbance from high-order UXO clearance has been assessed as low, whilst the magnitude of the impact (assuming a 26km EDR) has been assessed as low. Therefore, for all marine mammals for Project Option 1 and Project Option 2 the significance of effect is assessed as a slight, which is not significant in EIA terms.

It is important to note that while high-order detonation represents the scenario with the greatest magnitude of impact for UXO clearance, it is regarded as the "last resort method", with a preference for removal/relocation or low-order deflagration methods to be used.

5km EDR

Low-order deflagration clearance is expected to be the primary method used to clear any UXOs present. This will result in substantially lower impact than high-order detonation clearance.

Magnitude of impact

The greatest estimated disturbance occurs for grey seals, harbour seals and bottlenose dolphins, where 33 grey seals (0.54% MU), 9 harbour seals (0.66% MU) and 18 bottlenose dolphins are predicted to be disturbed (0.22% MU when assuming a population size of 8,326 individuals) (Table 14.22). The consequence of the impact is short-term and intermittent with temporary behavioural effects that are very unlikely to alter survival and reproductive rates to the extent that the population trajectory would be altered. Therefore, disturbance impacts associated with low-order deflagration on all marine mammals are assessed as low in magnitude.

Table 14.22 Estimated number of marine mammals potentially at risk of disturbance during UXO clearance (assuming an EDR of 5km, resulting in a 78.54km^2 impact area)

Species	Density (animals/km^2)	MU	Number Impacted	% MU
Harbour porpoise	0.38 (site-specific DAS)	62,517	30	0.05%
	0.2803 (SCANS IV)		22	0.04%
Bottlenose dolphin	0.002 (site-specific DAS)	293	<1	<0.34%
	0.2352 (SCANS IV)	8,326	18	0.22%
Common dolphin	0.04 (site-specific DAS)	102,656	3	<0.01%
	0.0272 (SCANS IV)		2	<0.01%
Minke whale	0.0137 (SCANS IV)	20,118	1	<0.01%
Grey seal	0.421 (average across array and ECC)	6,056	33	0.54%
Harbour seal	0.115 (average across array and ECC)	1,365	9	0.66%

Significance of the effect

Given that the sensitivity of all marine mammals to disturbance from low-order UXO clearance has been assessed as low and the magnitude of the impact (assuming a 5km EDR) to all marine mammals has also been assessed as low, the significance of effect of disturbance from low-order UXO clearance to all marine mammals for Project Option 1 and Project Option 2 is assessed as being slight, which is not significant in EIA terms.

TTS-onset as a proxy for disturbance

Table 14.23 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 the Underwater Noise Modelling Report.

Magnitude of impact

HF cetaceans (dolphins) have the smallest predicted impact range of up to a maximum of 1.3km for high-order detonation of a 525kg UXO. Impact ranges for VHF cetaceans (harbour porpoise) were up to a maximum of 23km for high-order detonation of a 525kg UXO, whilst for PCW (seals) impact ranges were up to a maximum of 19km for high-order detonation of a 525kg UXO. LF cetaceans (minke whale) show the greatest impact range, where the maximum impact range was up to 100km for high-order detonation of a 525kg UXO.

For common dolphins and bottlenose dolphins, <1% of the MU is predicted to experience TTS as a proxy for disturbance for high-order detonation of a 525kg UXO. For harbour porpoise, a maximum of 1.01% of the MU is predicted to experience TTS as a proxy for disturbance for high-order detonation of a 525kg UXO. For minke whales, despite the large and unrealistic impact range of 100km, only 2.14% of the MU is predicted to experience TTS as a proxy for disturbance for high-order detonation of a 525kg UXO. In the case of minke whales, the number of individuals predicted to be impacted is highly unlikely to ever reach anywhere near the numbers outlined in Table 14.24 for 240kg and 525kg charge sizes. This is due to the fact the that the distances between some land masses across the Irish Sea are less than 100km apart. Thus, sound is unlikely to propagate as far as the theoretical predicted ranges for the highest charge sizes (Table 14.23). Predicted impacts are highest to the two seal species, where up to 9.55% of the harbour seal MU and 7.88% of the grey seal MU is predicted to experience TTS as a proxy for disturbance for high-order detonation of a 525kg UXO.

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. In addition, 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 short-term and intermittent with temporary behavioural effects that are very unlikely to alter survival and reproductive rates to the extent that the population trajectory would be altered, TTS impacts associated with UXO clearance on all marine mammals are assessed as low in magnitude.

Table 14.23 Summary of the TTS 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)	TTS (weighted SELss)				TTS (unweighted SPLpeak)			
	LF 168dB	HF 170dB	VHF 140dB	PCW 170dB	LF 213dB	HF 224dB	VHF 196dB	PCW 212dB
Low order (0.25kg)	3.2km	<50m	750m	570m	320m	100m	1.8km	360m
25kg + donor	29km	150m	2.4km	5.2m	1.5km	490m	8.5km	1.6km

Southall et al., (2019)	TTS (weighted SELss)				TTS (unweighted SPLpeak)			
	LF 168dB	HF 170dB	VHF 140dB	PCW 170dB	LF 213dB	HF 224dB	VHF 196dB	PCW 212dB
55kg + donor	41km	210m	2.8km	7.5km	1.9km	640m	11km	2.1km
120kg + donor	57km	300m	3.2km	10km	2.5km	830m	14km	2.8km
240kg + donor	76km	390m	3.5km	14km	3.2km	1.0km	18km	3.5km
525kg + donor	100km	530m	4.0km	19km	4.1km	1.3km	23km	4.6km

Significance of the effect

Given that the sensitivity of all marine mammals to disturbance from UXO clearance has been assessed as low and the magnitude of the impact (assuming TTS as a proxy for disturbance) to all marine mammals has also been assessed as low, the impact of TTS as a proxy for disturbance from UXO clearance to all marine mammals for Project Option 1 and Project Option 2 is assessed as being a slight effect, which is not significant in EIA terms.

Table 14.24 Estimated number of marine mammals potentially at risk of disturbance (using TTS as a proxy) during UXO clearance

Species	Density (#/km2)	Impact	TTS as a proxy for disturbance (weighted SELss)						TTS as a proxy for disturbance (unweighted SPLpeak)					
			Low order (0.25kg)	**25kg + donor**	**55kg + donor**	**120kg + donor**	**240kg + donor**	**525kg + donor**	**Low order (0.25kg)**	**25kg + donor**	**55kg + donor**	**120kg + donor**	**240kg + donor**	**525kg + donor**
Harbour porpoise (site-specific DAS)	0.38	#	<1	7	9	12	15	19	4	86	144	234	387	632
		% MU	<0.01	0.01	0.01	0.02	0.02	0.03	0.01	0.14	0.23	0.37	0.62	1.01
Harbour porpoise (SCANS IV)	0.2803	#	<1	5	7	9	11	14	3	64	107	173	285	466
		% MU	<0.01	0.01	0.01	0.01	0.02	0.02	<0.01	0.10	0.17	0.28	0.46	0.75
Common dolphin (site-specific DAS)	0.04	#	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
		% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Common dolphin (SCANS IV)	0.0272	#	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
		% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Minke whale (SCANS IV)	0.0137	#	<1	36	72	140	249	430	<1	<1	<1	<1	<1	1
		% MU	<0.01	0.18	0.36	0.70	1.24	2.14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Bottlenose dolphin (site-specific DAS)	0.002	#	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
		% MU (293)	<0.34	<0.34	<0.34	<0.34	<0.34	<0.34	<0.34	<0.34	<0.34	<0.34	<0.34	<0.34
Bottlenose dolphin (SCANS IV)	0.2352	#	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	1	1
		% MU (8,326)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01	0.01
Harbour seal (average density)	0.115	#	<1	10	20	36	71	130	<1	1	2	3	4	8
		% MU	<0.01	0.72	1.49	2.65	5.19	9.55	<0.01	0.07	0.12	0.21	0.32	0.56
Grey seal (average density)	0.421	#	<1	36	74	132	259	477	<1	3	6	10	16	28
		% MU	<0.01	0.59	1.23	2.18	4.28	7.88	<0.01	0.06	0.10	0.17	0.27	0.46

14.5.2.5 Impact 5 - Auditory Injury (PTS) from pile driving

Magnitude of impact

The predicted areas and maximum impact ranges for auditory injury (PTS-onset) from pile driving of a monopile and pin-piles for each marine mammal receptor are outlined in Table 14.25 and

Table 14.26. This includes the prediction of impact for each of the four modelling locations.

Monopiles: For seals and dolphins the maximum auditory injury (PTS-onset) impact range was <100 m, and as such no seals or dolphins are expected to be impacted (Figure 14.2).

For minke whales the maximum auditory injury (PTS-onset) impact range was 26km for the installation of a monopile at the SE modelling location, assuming a hammer energy of 5,500kJ. This equates to a maximum of 16 minke whales experiencing auditory injury (0.08% MU) for piling at the SE monopile location (Figure 14.7).

For harbour porpoise the maximum auditory injury (PTS-onset) impact range was 15km for the installation of a monopile at the SE modelling location (Figure 14.4). This equates to a maximum of 136 porpoise experiencing auditory injury (0.22% MU). However, for harbour porpoise in particular, 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. 2021, 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 5km of the pile by up to 33% at Beatrice and 13% at Moray East prior to piling (Benhemma-Le Gall et al. 2023). 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).

Multi-leg foundation: For seals and dolphins the maximum auditory injury (PTS-onset) impact range was <100m, and as such no seals or dolphins are expected to be impacted.

For minke whales the maximum auditory injury (PTS-onset) impact range was 17km for the installation of two sequential pin piles at the SE modelling location. This equates to a maximum of 7 minke whales experiencing auditory injury (0.03% MU). For harbour porpoise the maximum auditory injury (PTS-onset) impact range was 9.5km for the installation of two sequential pin piles at the SE modelling location. This equates to a maximum of 57 porpoise experiencing auditory injury (0.09% MU).

For all marine mammal species (except dolphins), the unmitigated impact magnitude has been assessed as medium. This is due to the fact that while only very small number of animals are predicted to be impacted, auditory injury (PTS) is a permanent impact. Therefore, auditory injury from piling is expected to have a permanent effect on individuals that may influence individual survival but not at a level that would alter population trajectory over a generational scale.

For all dolphin species, no individuals are predicted to experience auditory injury (PTS). As such, the impact magnitude for dolphins is determined as negligible.

Table 14.25 Monopile foundation: Auditory injury (PTS-onset) from pile driving

Species	Density (#/km2)	NE				SE				NW				SW			
		Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU
Instantaneous PTS (SPLpeak)																	
Harbour porpoise	0.38 (site-specific DAS)	2	800	1	0.00	2	810	1	0.00	1.7	740	<1	0.00	1.9	790	1	0.00
	0.2803 (SCANS IV)			1	0.00			1	0.00			<1	0.00			<1	0.00
	SCANS III surface			1	0.00			1	0.00			<1	0.00			1	0.00
	Irish Sea surface			1	0.00			1	0.00			1	0.00			1	0.00
Bottlenose dolphin	0.002 (site-specific DAS)	<0.01	< 50	<1	0.00	<0.01	< 50	<1	0.00	<0.01	< 50	<1	0.00	<0.01	< 50	<1	0.00
	0.2352 (SCANS IV)			<1	0.00			<1	0.00			<1	0.00			<1	0.00
	SCANS III surface			<1	0.00			<1	0.00			<1	0.00			<1	0.00
	Irish Sea surface			<1	0.00			<1	0.00			<1	0.00			<1	0.00
Common dolphin	0.0272 (SCANS IV)			<1	0.00			<1	0.00			<1	0.00			<1	0.00
	SCANS III surface			<1	0.00			<1	0.00			<1	0.00			<1	0.00
	Irish Sea surface			<1	0.00			<1	0.00			<1	0.00			<1	0.00
Minke whale	0.0137 (SCANS IV)	0.01	50	<1	0.00	0.01	50	<1	0.00	0.01	50	<1	0.00	0.01	50	<1	0.00
	SCANS III surface			<1	0.00			<1	0.00			<1	0.00			<1	0.00
	Irish Sea surface			<1	0.00			<1	0.00			<1	0.00			<1	0.00
Harbour seal	Habitat preference surface	0.01	60	<1	0.00	0.01	60	<1	0.00	0.01	60	<1	0.00	0.01	60	<1	0.00
Grey seal				<1	0.00			<1	0.00			<1	0.00			<1	0.00
Cumulative PTS (SELcum) 1 monopile per day																	
Harbour porpoise	0.38 (site-specific DAS)	340	14,000	130	0.21	360	15,000	136	0.22	140	10,000	52	0.08	240	13,000	90	0.14
	0.2803 (SCANS IV)			96	0.15			100	0.16			38	0.06			66	0.11
	SCANS III surface			88	0.14			91	0.16			36	0.06			60	0.10
	Irish Sea surface			114	0.18			119	0.19			45	0.07			81	0.13

Species	Density (#/km2)	NE				SE				NW				SW			
		Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU
Bottlenose dolphin	0.002 (site-specific DAS)	< 0.1	< 100	<1	0.00	< 0.1	< 100	<1	0.00	<0.01	< 50	<1	0.00	< 0.1	< 100	<1	0.00
	0.2352 (SCANS IV)			<1	0.00			<1	0.00			<1	0.00			<1	0.00
	SCANS III surface			<1	0.00			<1	0.00			<1	0.00			<1	0.00
	Irish Sea surface			<1	0.00			<1	0.00			<1	0.00			<1	0.00
Common dolphin	0.0272 (SCANS IV)			<1	0.00			<1	0.00			<1	0.00			<1	0.00
	SCANS III surface			<1	0.00			<1	0.00			<1	0.00			<1	0.00
	Irish Sea surface			<1	0.00			<1	0.00			<1	0.00			<1	0.00
	0.002 (site-specific DAS)			<1	0.00			<1	0.00			<1	0.00			<1	0.00
Minke whale	0.0137 (SCANS IV)	740	26,000	10	0.05	790	26,000	11	0.05	310	18,000	4	0.02	560	22,000	8	0.04
	SCANS III surface			16	0.08			16	0.08			6	0.03			11	0.05
	Irish Sea surface			8	0.04			9	0.04			3	0.01			6	0.03
Harbour seal	Habitat preference surface	< 0.1	< 100	<1	0.00	< 0.1	< 100	<1	0.00	< 0.1	< 100	<1	0.00	< 0.1	< 100	<1	0.00
Grey seal				<1	0.00			<1	0.00			<1	0.00			<1	0.00

Table 14.26 Multi-leg foundation: Auditory injury (PTS-onset) from pile driving

Hearing Group	Threshold	Density (#/km^2)	NE				SE				NW				SW			
			Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU
Instantaneous PTS-onset (unweighted SPL_{peak}), installation of 1 pile																		
Minke whale	219	0.0137 (SCANS IV)	0.01	<50	0	0.00	0.01	<50	0	0.00	0.01	<50	0	0.00	0.01	<50	0	0.00
		SCANS III surface			0	0.00			0	0.00			0	0.00			0	0.00
		Irish Sea surface			0	0.00			0	0.00			0	0.00			0	0.00
Common dolphin	230	0.04	<0.01	<50	0	0.00	<0.01	<50	0	0.00	<0.01	<50	0	0.00	<0.01	<50	0	0.00
		0.0272			0	0.00			0	0.00			0	0.00			0	0.00
		SCANS III surface			0	0.00			0	0.00			0	0.00			0	0.00
		Irish Sea surface			0	0.00			0	0.00			0	0.00			0	0.00
Bottlenose dolphin	230	0.002	<0.01	<50	0	0.00	<0.01	<50	0	0.00	<0.01	<50	0	0.00	<0.01	<50	0	0.00
		0.2352			0	0.00			0	0.00			0	0.00			0	0.00
		SCANS III surface			0	0.00			0	0.00			0	0.00			0	0.00
		Irish Sea surface			0	0.00			0	0.00			0	0.00			0	0.00
Harbour porpoise	202	0.38	1.4	680	1	0.00	1.5	690	1	0.00	1.2	620	0	0.00	1.4	660	1	0.00
		0.2803			0	0.00			0	0.00			0	0.00			0	0.00
		SCANS III surface			0	0.00			0	0.00			0	0.00			0	0.00
		Irish Sea surface			1	0.00			1	0.00			0	0.00			0	0.00
Harbour seal	218	0.115	0.01	50	0	0.00	0.01	50	0	0.00	0.01	<50	0	0.00	0.01	50	0	0.00
Grey seal	218	0.421	0.01	50	0	0.00	0.01	50	0	0.00	0.01	<50	0	0.00	0.01	50	0	0.00
Cumulative PTS-Onset (weighted SEL_{cum}), installation of 1 pile																		
Minke whale	219	0.0137 (SCANS IV)	280	15,000	4	0.02	300	15,000	4	0.02	75	9,500	1	0.00	180	13,000	3	0.02
		SCANS III surface			6	0.03			6	0.03			1	0.00			4	0.02
		Irish Sea surface			3	0.02			3	0.02			1	0.00			2	0.01
	230	0.04	<0.1	<100	0	0.00	<0.1	<100	0	0.00	<0.1	<100	0	0.00	<0.1	<100	0	0.00

Hearing Group	Threshold	Density (#/km^2)	NE				SE				NW				SW			
			Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU
Common dolphin		0.0272			0	0.00			0	0.00			0	0.00			0	0.00
		SCANS III surface			0	0.00			0	0.00			0	0.00			0	0.00
		Irish Sea surface			0	0.00			0	0.00			0	0.00			0	0.00
Bottlenose dolphin	230	0.002	<0.1	<100	0	0.00	<0.1	<100	0	0.00	<0.1	<100	0	0.00	<0.1	<100	0	0.00
		0.2352			0	0.00			0	0.00			0	0.00			0	0.00
		SCANS III surface			0	0.00			0	0.00			0	0.00			0	0.00
		Irish Sea surface			0	0.00			0	0.00			0	0.00			0	0.00
Harbour porpoise	202	0.38	99	7,300	38	0.06	110	7,600	41	0.0	31	4,700	12	0.0	62	6,500	24	0.04
		0.2803			28	0.04			30	0.05			9	0.01			18	0.03
		SCANS III surface			26	0.04			27	0.04			8	0.01			16	0.03
		Irish Sea surface			35	0.06			37	0.06			10	0.02			22	0.04
Harbour seal	218	0.115	<0.1	<100	0	0.00	<0.1	<100	0	0.00	<0.1	<100	0	0.00	<0.1	<100	0	0.00
Grey seal	218	0.421	<0.1	<100	0	0.00	<0.1	<100	0	0.00	<0.1	<100	0	0.00	<0.1	<100	0	0.00
Cumulative PTS-Onset (weighted SEL_{cum}), installation of 2 sequential piles																		
Minke whale	183	0.0137	340	17,000	5	0.02	370	17,000	5	0.02	100	11,000	1	0.00	230	15,000	3	0.01
		SCANS III surface			7	0.03			7	0.03			2	0.01			5	0.02
		Irish Sea surface			4	0.02			4	0.02			1	0.00			2	0.01
Common dolphin	185	0.04	<0.1	<100	0	0.00	<0.1	<100	0	0.00	<0.1	<100	0	0.00	<0.1	<100	0	0.00
		0.0272			0	0.00			0	0.00			0	0.00			0	0.00
		SCANS III surface			0	0.00			0	0.00			0	0.00			0	0.00
		Irish Sea surface			0	0.00			0	0.00			0	0.00			0	0.00
Bottlenose dolphin	185	0.002	<0.1	<100	0	0.00	<0.1	<100	0	0.00	<0.1	<100	0	0.00	<0.1	<100	0	0.00
		0.2352			0	0.00			0	0.00			0	0.00			0	0.00
		SCANS III surface			0	0.00			0	0.00			0	0.00			0	0.00

Hearing Group	Threshold	Density (#/km^2)	NE				SE				NW				SW			
			Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU
		Irish Sea surface			0	0.00			0	0.00			0	0.00			0	0.00
Harbour porpoise	155	0.38	140	9,100	53	0.08	150	9,500	57	0.09	45	6,000	17	0.03	90	8,200	35	0.06
		0.2803			39	0.06			42	0.07			13	0.02			25	0.04
		SCANS III surface			36	0.06			38	0.06			12	0.02			23	0.04
		Irish Sea surface			49	0.09			52	0.08			14	0.02			32	0.05
Harbour seal	185	0.115	<0.1	<100	0	0.00	<0.1	<100	0	0.00	<0.1	<100	0	0.00	<0.1	<100	0	0.00
Grey seal	185	0.421	<0.1	<100	0	0.00	<0.1	<100	0	0.00	<0.1	<100	0	0.00	<0.1	<100	0	0.00

Harbour porpoise

Sensitivity of the receptor

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 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. Several 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.

For piling noise, most energy is between ~30–500Hz, with a peak usually between 100–300Hz and energy extending above 2kHz (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 8kHz (Kastelein et al. 2016) and centred at 4kHz (Kastelein et al. 2012a, Kastelein et al. 2012b, Kastelein et al. 2013b, Kastelein et al. 2017). Therefore, during the expert elicitation workshop (Booth and Heinis 2018), the experts agreed that any threshold shifts as a result of pile driving would manifest themselves in the 2–10kHz range (Kastelein et al. 2017) and that a PTS 'notch' of 6–18dB in a narrow frequency band in the 2–10kHz region is unlikely to significantly affect the fitness of individuals (ability to survive and reproduce). The expert elicitation concluded that:

"… the effects of a 6dB 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."

For harbour porpoise, the predicted decline in 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 14.27.

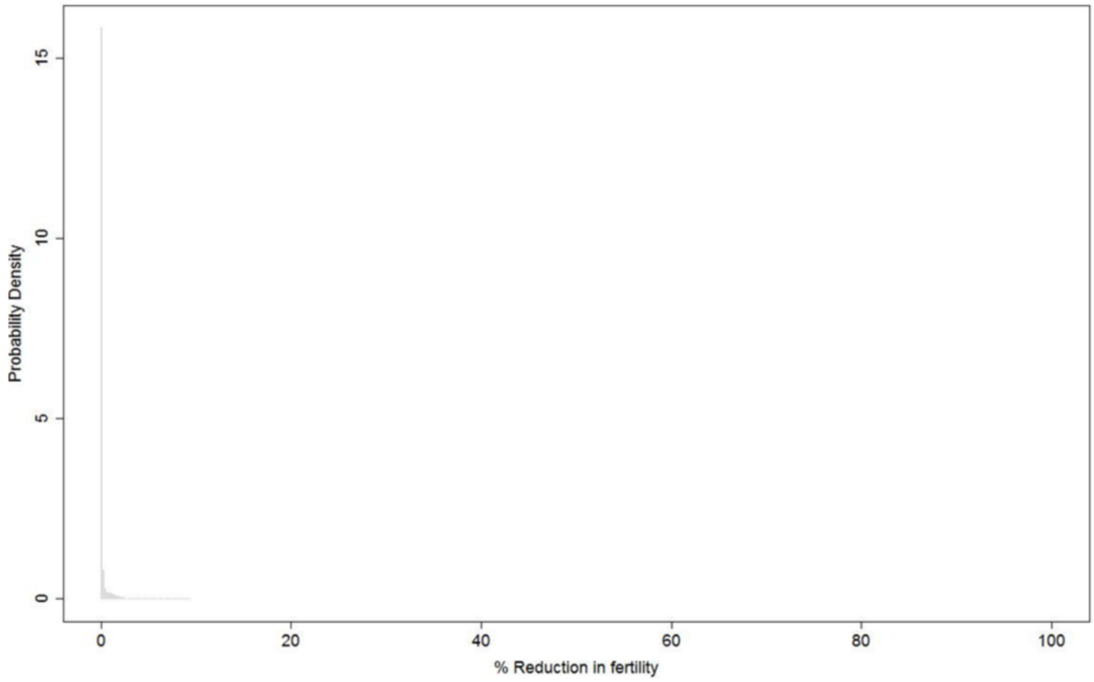
Table 14.27 Predicted decline in harbour porpoise vital rates for different percentiles of the elicited probability distribution

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

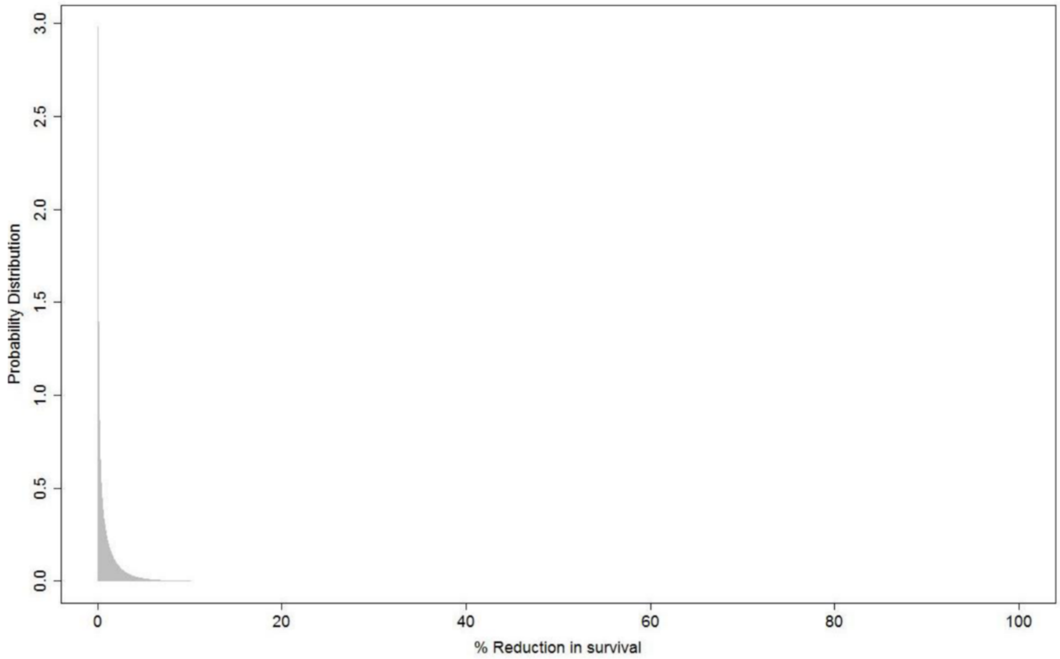
The data provided in Table 14.27 should be interpreted as:

- Experts estimated that the median decline in an individual mature female harbour porpoise's survival was 0.01% (due to a 6dB PTS (a notch a few kHz wide and 6dB high) occurring somewhere in the hearing between 2-10kHz) (Graph 14.5).
- Experts estimated that the median decline in an individual mature female harbour porpoise's fertility was 0.09% (due to a 6dB PTS (a notch a few kHz wide and 6dB high) occurring somewhere in the hearing between 2-10kHz) (Graph 14.6).

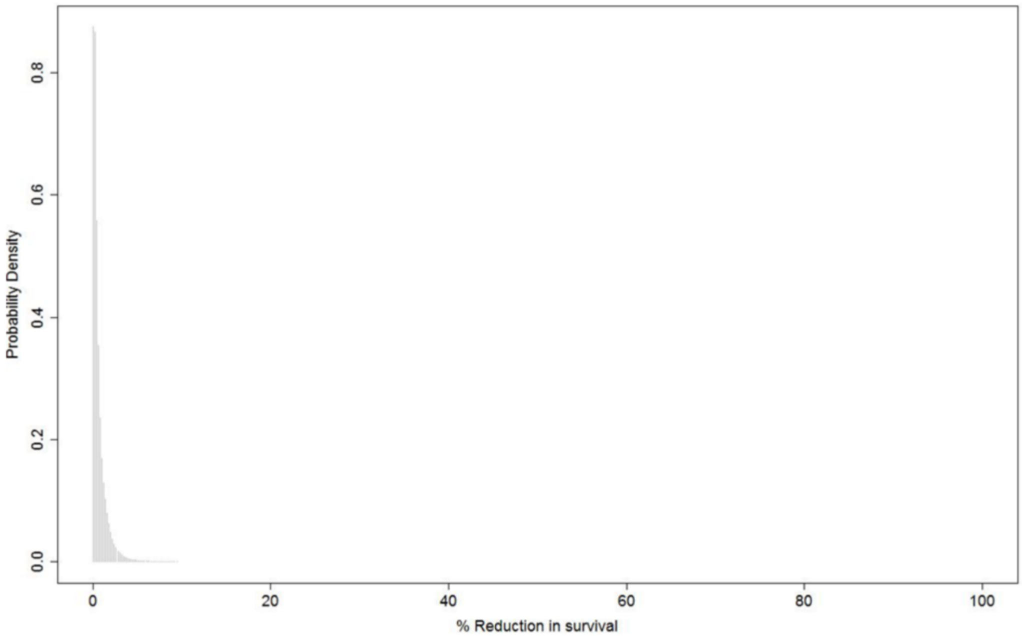
- Experts estimated that the median decline in an individual harbour porpoise juvenile or dependent calf survival was 0.18% (due to a 6dB PTS (a notch a few kHz wide and 6dB high) occurring somewhere in the hearing between 2-10kHz) (Graph 14.7).



Graph 14.5 Probability distribution showing the consensus distribution for the effects on fertility of a mature female harbour porpoise as a consequence of a maximum 6dB of PTS within a 2-10kHz band (Booth and Heinis 2018)



Graph 14.6 Probability distribution showing the consensus distribution for the effects on survival of a mature female harbour porpoise as a consequence of a maximum 6dB of PTS within a 2-10kHz band (Booth and Heinis 2018)



Graph 14.7 Probability distribution showing the consensus distribution for the effects on survival of juvenile or dependent calf harbour porpoise as a consequence of a maximum 6dB of PTS within a 2-10kHz band (Booth and Heinis 2018)

Data collected during wind farm 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. 2021). 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.

Whilst PTS is a permanent effect which cannot be recovered from, the evidence does not suggest that the level of PTS (6dB) at the PTS-onset 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-onset from pile driving.

Significance of the effect

Project Option 1

Given that the sensitivity of harbour porpoise receptors has been assessed as low, and the magnitude of auditory injury (PTS-onset) impacts from unmitigated pile driving have been assessed as medium, this impact has been assessed as slight, which is not significant in EIA terms, for Project Option 1.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of harbour porpoise receptors is low, and the magnitude of auditory injury (PTS-onset) impacts from unmitigated pile driving shall be medium. This significance of effect for Project Option 2 has therefore been assessed as slight, which is not significant in EIA terms.

Bottlenose dolphin

Sensitivity of the receptor

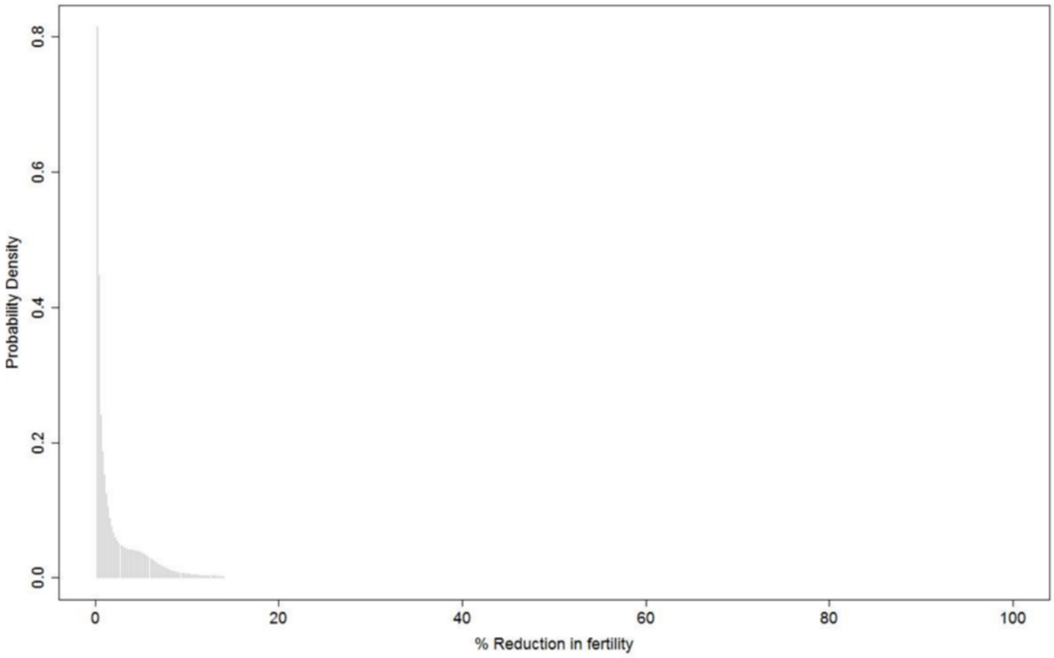
As for harbour porpoise, the ecological consequences of PTS for bottlenose dolphins are uncertain. At the same expert elicitation workshop detailed above in the porpoise section, experts in marine mammal hearing discussed the nature, extent and potential consequence of PTS to bottlenose dolphins arising from exposure to repeated low-frequency impulsive noise such as pile driving (Booth and Heinis 2018, Fernandez-Betelu et al. 2022). The predicted decline in bottlenose dolphin vital rates from the impact of a 6dB PTS in the 2-10kHz band for different percentiles of the elicited probability distribution are provided in Table 14.28.

Table 14.28 Predicted decline in bottlenose dolphin vital rates for different percentiles of the elicited probability distribution

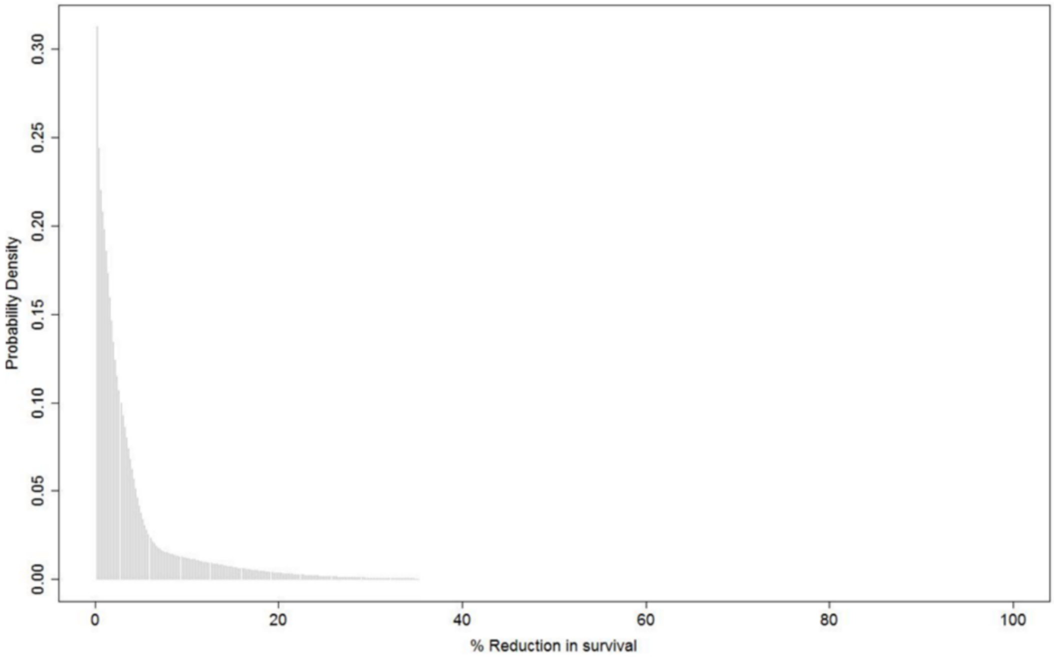
	Percentiles of the elicited probability distribution								
	10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**
Adult survival	0	0.18	0.57	1.04	1.6	2.34	3.39	5.18	10.99
Fertility	0	0.04	0.13	0.26	0.43	0.85	1.66	3.49	6.22
Juvenile survival	0.01	0.11	0.35	0.75	1.32	2.14	3.3	5.19	11.24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

The data provided in Table 14.28 should be interpreted as:

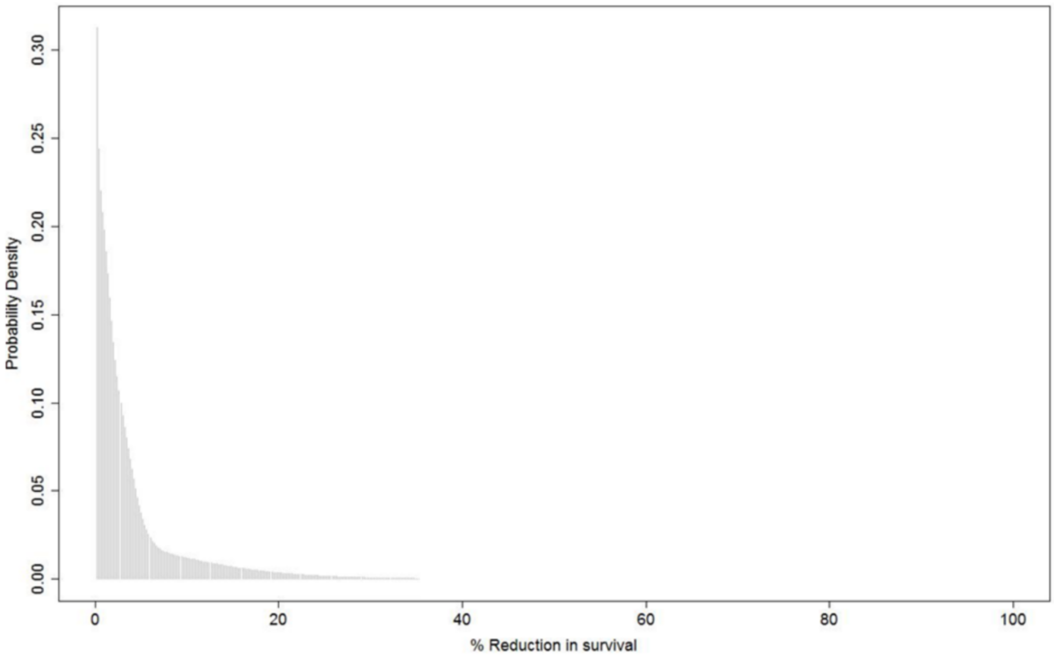
- Experts estimated that the median decline in an individual mature female bottlenose dolphin's fertility was 0.43% (due to a 6dB PTS (a notch a few kHz wide and 6dB high) occurring somewhere in the hearing between 2-10kHz) (Graph 14.8).
- Experts estimated that the median decline in an individual mature female bottlenose dolphin's survival was 1.6% (due to a 6Db PTS (a notch a few kHz wide and 6Db high) occurring somewhere in the hearing between 2-10kHz) (Graph 14.9).
- Experts estimated that the median decline in an individual bottlenose dolphin juvenile survival was 1.32% (due to a 6Db PTS (a notch a few kHz wide and 6Db high) occurring somewhere in the hearing between 2-10kHz) (Graph 14.10).
- Experts estimated that the median decline in an individual bottlenose dolphin dependent calf survival was 2.96% (due to a 6dB PTS (a notch a few kHz wide and 6dB high) occurring somewhere in the hearing between 2-10kHz) (Graph 14.10).



Graph 14.8 Probability distribution showing the consensus distribution for the effects on fertility of mature female bottlenose dolphin as a consequence of a maximum 6dB of PTS within a 2-10kHz band (Booth and Heinis 2018)



Graph 14.9 Probability distribution showing the consensus distribution for the effects on survival of mature female bottlenose dolphin as a consequence of a maximum 6dB of PTS within a 2-10kHz band (Booth and Heinis 2018)



Graph 14.10 Probability distribution showing the consensus distribution for the effects on survival of juvenile or dependent calf bottlenose dolphin as a consequence of a maximum 6dB of PTS within a 2-10kHz band (Booth and Heinis 2018)

Whilst PTS is a permanent effect which cannot be recovered from, the evidence does not suggest that the level of PTS (6 dB) at the PTS-onset from piling will cause a significant impact on either survival or reproductive rates, bottlenose dolphin have been assessed as having a low sensitivity to PTS.

Significance of the effect

Project Option 1

Given that the sensitivity of bottlenose dolphin receptors has been assessed as low, and the magnitude of disturbance impacts from pile driving have been assessed as negligible, this impact has been assessed as imperceptible for Project Option 1, which is not significant in EIA terms.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of bottlenose dolphin receptors has been assessed as low, and the magnitude of disturbance impacts from pile driving have been assessed as negligible. Therefore, the significance of effect for Project Option 2 has been assessed as imperceptible, which is not significant in EIA terms.

Common dolphin

Sensitivity of the receptor

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

Significance of the effect

Project Option 1

Given that the sensitivity of common dolphin receptors has been assessed as low, and the magnitude of disturbance impacts from pile driving have been assessed as negligible, this impact has been assessed as imperceptible for Project Option 1, which is not significant in EIA terms.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of common dolphin receptors has been assessed as low, and the magnitude of disturbance impacts from pile driving have been assessed as negligible. Therefore, the significance of effect for Project Option 2 has been assessed as imperceptible, which is not significant in EIA terms.

Minke whale

Sensitivity of the receptor

The PTS expert elicitation report (Booth & Heinis, 2018) provides a summary of the likely significant 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).

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

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

Data on minke whale hearing and likely significant 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 (sensu Booth & Heinis, 2018) – it is considered that it is unlikely that vital rates would be altered in a biologically meaningful way as a result of PTS from piling. Therefore, the sensitivity of minke whales to PTS from piling is low.

Significance of the effect

Project Option 1

Given that the sensitivity of minke whale receptors has been assessed as low, and the magnitude of auditory injury (PTS) impacts from unmitigated pile driving have been assessed as medium, therefore the significance of effect for Project Option 1 has been assessed as slight, which is not significant in EIA terms.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of minke whale receptors has been assessed as low, and the magnitude of auditory injury (PTS) impacts from unmitigated pile driving have been assessed as medium. Therefore, the significance of effect for Project Option 2 has been assessed as slight, which is not significant in EIA terms.

Harbour and grey seals

Sensitivity of the receptor

The predicted decline in harbour and grey seals 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 14.29.

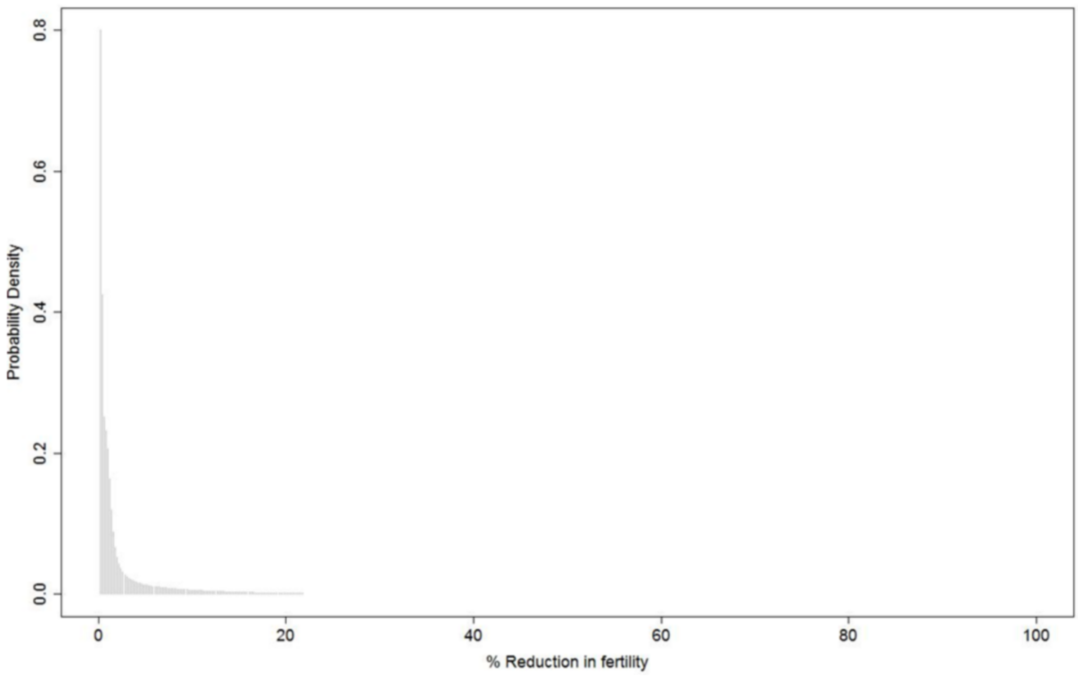
Table 14.29 Predicted decline in harbour and grey seal vital rates for different percentiles of the elicited probability distribution

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

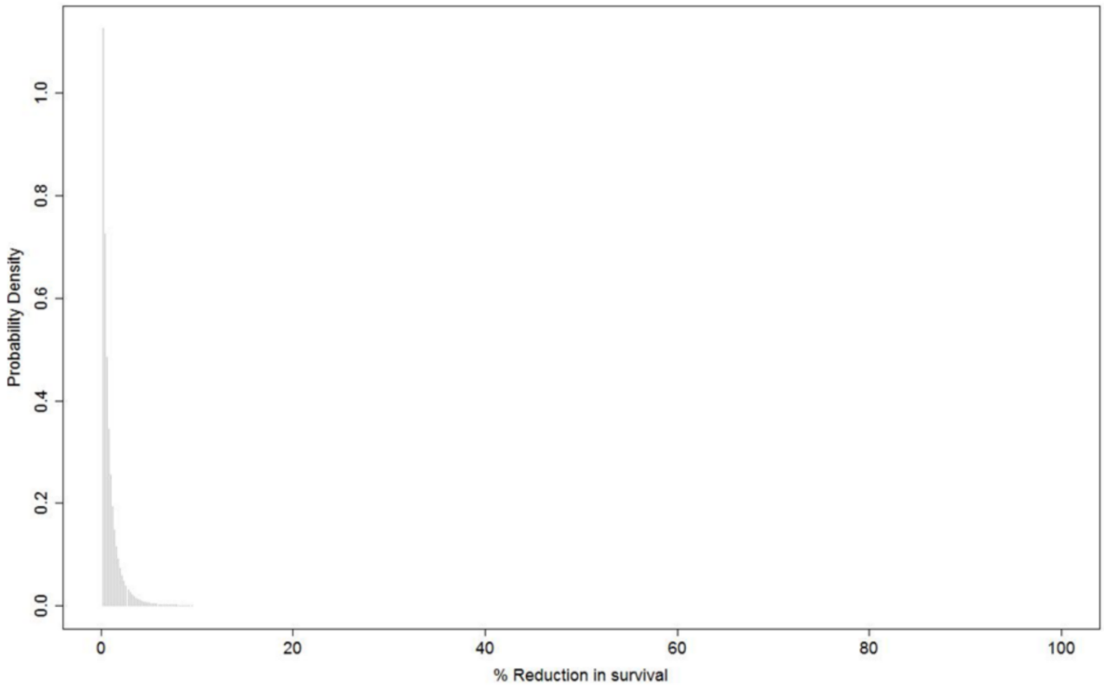
The data provided in Table 14.29 should be interpreted as:

- Experts estimated that the median decline in an individual mature female seal's survival was 0.39% (due to a 6dB PTS (a notch a few kHz wide and 6dB high) occurring somewhere in the hearing between 2-10kHz) (Graph 14.11).
- Experts estimated that the median decline in an individual mature female seal's fertility was 0.27% (due to a 6dB PTS (a notch a few kHz wide and 6dB high) occurring somewhere in the hearing between 2-10kHz) (Graph 14.12).
- Experts estimated that the median decline in an individual seal pup/juvenile survival was 0.52% (due to a 6dB PTS (a notch a few kHz wide and 6dB high) occurring somewhere in the hearing between 2-10kHz) (Graph 14.13).

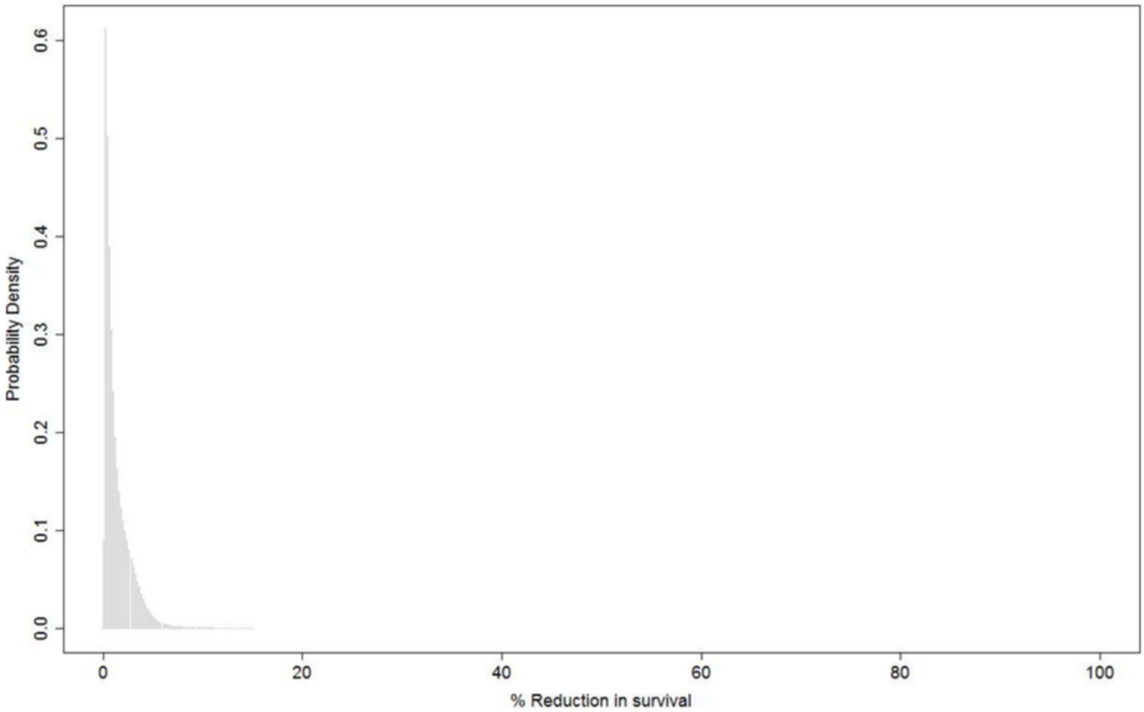
Whilst PTS is a permanent effect which cannot be recovered from, the evidence does not suggest that the level of PTS (6dB) at the PTS-onset from piling will cause a significant impact on either survival or reproductive rates; therefore, both seal species have been assessed as having a low sensitivity to PTS.



Graph 14.11 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 6dB of PTS within a 2 10kHz band (Booth and Heinis 2018)



Graph 14.12 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 6dB of PTS within a 2-10kHz band (Booth and Heinis 2018)



Graph 14.13 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 6dB of PTS within a 2-10kHz band (Booth and Heinis 2018)

Significance of the effect

Project Option 1

Given that the sensitivity of both harbour and grey seal receptors have been assessed as low, and the magnitude of disturbance impacts from pile driving have been assessed as medium, therefore, the significance of effect for Project Option 1 has been assessed as slight, which is not significant in EIA terms.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of both harbour and grey seal receptors have been assessed as low, and the magnitude of disturbance impacts from pile driving have been assessed as medium. Therefore, the significance of effect for Project Option 2 has been assessed as slight, which is not significant in EIA terms.

14.5.2.6 Impact 6 - Auditory Injury (TTS) from pile driving

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-onset threshold (6dB shift in threshold) would lead to a substantial overestimate of the potential impact of TTS as a 6dB shift in threshold, while measurable, is not considered to result in a biologically significant effect. Essentially, there are no thresholds to determine a *biologically significant* effect from TTS-onset. These concepts are explained in detail in Appendix 14.3: Marine Mammal Uncertainties and Limitations. Predicted TTS impact ranges and the number of animals within those ranges are presented in this impact assessment. However, no assessment of the sensitivity of marine mammals to TTS is provided, nor is the magnitude of TTS assessed[15].

[15] This approach follows that which has been agreed with Natural England and the Marine Management Organisation for EIAs in English waters. In Scottish waters TTS is typically not assessed at all.

Monopiles: For minke whale the maximum instantaneous TTS-onset (SPL_{peak}) impact range was 0.14km for the installation of a monopile at the NE and SE modelling locations. For harbour porpoise, the maximum instantaneous TTS-onset impact range was 2.1km for the installation of a monopile at the NE and SE modelling locations. For seals, the maximum instantaneous TTS-onset impact range was between 0.16km at the NE, SE, and SW modelling locations. For all other marine mammal receptors (HF hearing group), the maximum instantaneous TTS-onset impact range was 0km for all scenarios modelled. When considering the maximum cumulative TTS-onset ranges (SEL_{cum}), the maximum was for minke whales at the NE modelling location (105km). By comparison, the smallest range was for dolphin species (0km).

Monopiles: Using instantaneous TTS onset thresholds the maximum pile driving of a monopile impact range for harbour porpoise was calculated at 2.1km at the SE monopile location. This resulted in an impact to 5 harbour porpoise using the site-specific aerial survey density estimate, and 0.0% of the MU. Using the cumulative TTS-onset thresholds the maximum impact range for harbour porpoise during a single monopile piling event was calculated at 83km for the SE monopile location. This equated to a maximum of 2,866 harbour porpoise using the site-specific aerial survey density estimate, and 4.58% of the MU. Although minke whales are anticipated to be subject to the largest cumulative TTS-onset impact range (SE modelling location), the number of individuals likely to be impacted is less than that of harbour porpoise (222 individuals, 1.10% of MU). For seals, the maximum level of impact is at the NE modelling location for harbour seals (55 individuals, 4.03% MU) and the SE modelling location for grey seals (477 individuals, 7.88% MU).

Multi-leg foundation: For minke whales the maximum instantaneous TTS-onset (SPL_{peak}) impact range was 0.12km for the installation of pin piles at the SE modelling location. For harbour porpoise, the maximum instantaneous TTS-onset impact range was 1.8km for the installation of pin piles at the SE modelling location. For seals, the maximum instantaneous TTS-onset impact range was 0.13km at the SE modelling location. For all other marine mammal receptors (HF hearing group), the maximum instantaneous TTS-onset impact range was 0km for all scenarios modelled. When considering the maximum cumulative TTS-onset ranges (SEL_{cum}), the maximum was for LF cetaceans at the SE modelling location (104km). By comparison, the smallest range was for HF cetaceans (0km).

Multi-leg foundation: Using instantaneous TTS onset thresholds the maximum pile driving of pin piles impact range for harbour porpoise was calculated at 1.8km at the NE and SE monopile locations. This resulted in an impact to 4 harbour porpoise using the site-specific aerial survey density estimate, and 0% of the MU. Using the cumulative TTS-onset thresholds a maximum of 2,268 harbour porpoise are expected to experience TTS using the site-specific aerial survey density estimate (3.63% of the MU) for the piling two sequential pin piles at the SE modelling location. Although minke whales are anticipated to be subject to the largest cumulative TTS-onset impact range of all marine mammals (95km, SE modelling location), the number of individuals likely to be impacted is less than that of harbour porpoise (190 individuals, 0.94% of MU). For seals, the maximum level of impact is at the NE modelling location for harbour seals (42 individuals, 3.08% MU) and the SE modelling location for grey seals (397 individuals, 6.56% MU), both for the installation of 2 sequential pin piles.

Table 14.30 Monopile foundation: TTS-onset

Hearing Group	Threshold	Density (#/km2)	NE				SE				NW			SW				
			Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU
Instantaneous TTS-onset (unweighted SPLpeak), installation of 1 pile																		
Minke whale	213	0.0137 SCANS IV	0.06	140	0	0.0	0.06	140	0	0.0	0.05	130	0	0.0	0.06	130	0	0.0
		SCANS III surface			0	0.0			0	0.0			0	0.0			0	0.0
		Irish Sea surface			0	0.0			0	0.0			0	0.0			0	0.0
Common dolphin	224	0.04 site-specific DAS	< 0.01	< 50	0	0.0	< 0.01	< 50	0	0.0	< 0.01	< 50	0	0.0	< 0.01	< 50	0	0.0
		0.0272 SCANS IV			0	0.0			0	0.0			0	0.0			0	0.0
		SCANS III surface			0	0.0			0	0.0			0	0.0			0	0.0
		Irish Sea surface			0	0.0			0	0.0			0	0.0			0	0.0
Bottlenose dolphin	224	0.002 site-specific DAS	< 0.01	< 50	0	0.0	< 0.01	< 50	0	0.0	< 0.01	< 50	0	0.0	< 0.01	< 50	0	0.0
		0.2352 SCANS IV			0	0.0			0	0.0			0	0.0			0	0.0
		SCANS III surface			0	0.0			0	0.0			0	0.0			0	0.0
		Irish Sea surface			0	0.0			0	0.0			0	0.0			0	0.0
Harbour porpoise	196	0.38 site-specific DAS	13	2,100	5	0.0	14	2,100	5	0.0	11	1,900	4	0.0	13	2,000	5	0.0
		0.2803 SCANS IV			4	0.0			4	0.0			3	0.0			4	0.0
		SCANS III surface			3	0.0			4	0.0			3	0.0			3	0.0
		Irish Sea surface			5	0.0			5	0.0			3	0.0			4	0.0
Harbour seal	212	0.115	0.08	160	0	0.0	0.08	160	0	0.0	0.07	150	0	0.0	0.08	160	0	0.0

Hearing Group	Threshold	Density (#/km2)	NE				SE				NW			SW				
			Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU
Grey seal	212	0.421	0.08	160	0	0.0	0.08	160	0	0.0	0.07	150	0	0.0	0.08	160	0	0.0
Cumulative TTS-Onset (weighted SELcum), installation of 1 pile																		
Minke whale	168	0.0137 SCANS IV	9,600	105,000	131	0.65	9,900	102,000	136	0.68	7,400	92,000	101	0.50	8,900	99,000	122	0.61
		SCANS III surface			221	1.10			222	1.10			170	0.85			199	0.99
		Irish Sea surface			150	0.75			158	0.79			109	0.54			138	0.69
Common dolphin	170	0.04 site-specific DAS	< 0.1	< 100	0.0	0.0	< 0.1	< 100	0.0	0.0	< 0.1	< 100	0.0	0.0	< 0.1	< 100	0	0.0
		0.0272 SCANS IV			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0
		SCANS III surface			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0
		Irish Sea surface			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0
Bottlenose dolphin	170	0.002 site-specific DAS	< 0.1	< 100	0.0	0.0	< 0.1	< 100	0.0	0.0	< 0.1	< 100	0.0	0.0	< 0.1	< 100	0	0.0
		0.2352 SCANS IV			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0
		SCANS III surface			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0
		Irish Sea surface			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0
Harbour porpoise	145	0.38 site-specific DAS	7,200	81,000	2,758	4.41	7,500	83,000	2,866	4.58	5,200	70,000	1,968	3.15	6,500	78,000	2,468	3.95
		0.2803 SCANS IV			2,034	3.25			2,114	3.38			1,452	2.32			1,821	2.91
		SCANS III surface			1,862	2.98			1,919	3.07			1,324	2.12			1,649	2.64
		Irish Sea surface			2,294	3.67			2,420	3.87			1,611	2.58			2,062	2.30

Hearing Group	Threshold	Density (#/km2)	NE				SE				NW			SW				
			Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU
Harbour seal	170	0.115	3,300	51,000	55	4.03	3,400	50,000	41	3.00	1,900	40,000	45	3.30	2,700	46,000	39	2.86
Grey seal	170	0.421	3,300	51,000	449	7.40	3,400	50,000	477	7.86	1,900	40,000	367	6.05	2,700	46,000	449	7.40

Table 14.31 Multi-leg foundation: TTS-onset

Hearing Group	Threshold	Density (#/km2)	NE				SE				NW			SW				
			Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU
Instantaneous TTS-onset (unweighted SPLpeak), installation of 1 pile																		
Minke whale	213	0.0137 SCANS IV	0.04	110	0	0.0	0.04	120	0	0.0	0.04	110	0	0.0	0.04	110	0	0.0
		SCANS III surface			0	0.0			0	0.0			0	0.0			0	0.0
		Irish Sea surface			0	0.0			0	0.0			0	0.0			0	0.0
Common dolphin	224	0.04 site-specific DAS	< 0.01	< 50	0	0.0	< 0.01	< 50	0	0.0	< 0.01	< 50	0	0.0	< 0.01	< 50	0	0.0
		0.0272 SCANS IV			0	0.0			0	0.0			0	0.0			0	0.0
		SCANS III surface			0	0.0			0	0.0			0	0.0			0	0.0
		Irish Sea surface			0	0.0			0	0.0			0	0.0			0	0.0

Hearing Group	Threshold	Density (#/km2)	NE				SE				NW			SW				
			Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Rang e (m)	#	% MU	Area (km2)	Range (m)	#	% MU
Bottlenose dolphin	224	0.002 site-specific DAS	< 0.01	< 50	0	0.0	< 0.01	< 50	0	0.0	< 0.01	< 50	0	0.0	< 0.01	< 50	0	0.0
		0.2352 SCANS IV			0	0.0			0	0.0			0	0.0			0	0.0
		SCANS III surface			0	0.0			0	0.0			0	0.0			0	0.0
		Irish Sea surface			0	0.0			0	0.0			0	0.0			0	0.0
Harbour porpoise	196	0.38 site-specific DAS	9.6	1,800	4	0.0	9.9	1,800	4	0.0	7.8	1,600	3	0.0	9	1,700	3	0.0
		0.2803			3	0.0			3	0.0			2	0.0			3	0.0
		SCANS III surface			3	0.0			3	0.0			2	0.0			2	0.0
		Irish Sea surface			4	0.0			4	0.0			3	0.0			3	0.0
Harbour seal	212	0.115	0.06	140	0	0.0	0.06	140	0	0.0	0.05	130	0	0.0	0.05	130	0	0.0
Grey seal	212	0.421	0.06	140	0	0.0	0.06	140	0	0.0	0.05	130	0	0.0	0.05	130	0	0.0
Cumulative TTS-Onset (weighted SELcum), installation of 1 pile																		
Minke whale	168	0.0137 SCANS IV	7,900	91,000	108	0.54	8,200	95,000	113	0.56	5,800	79,00 0	80	0.40	7,300	90,000	100	0.50
		SCANS III surface			183	0.91			185	0.92			134	0.67			162	0.81

Hearing Group	Threshold	Density (#/km2)	NE				SE				NW				SW			
			Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU
		Irish Sea surface			121	0.60			128	0.64			82	0.41			110	0.55
Common dolphin	170	0.04 site-specific DAS	< 0.1	< 100	0.0	0.0	< 0.1	< 100	0.0	0.0	< 0.1	< 100	0.0	0.0	< 0.1	< 100	0	0.0
		0.0272 SCANS IV			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0
		SCANS III surface			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0
		Irish Sea surface			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0
Bottlenose dolphin	170	0.002 site-specific DAS	< 0.1	< 100	0.0	0.0	< 0.1	< 100	0.0	0.0	< 0.1	< 100	0.0	0.0	< 0.1	< 100	0	0.0
		0.2352 SCANS IV			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0
		SCANS III surface			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0
		Irish Sea surface			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0
Harbour porpoise	145	0.38 site-specific DAS	4,900	62,000	1,875	2.99	5,100	61,000	1,955	3.13	3,200	51,000	1,226	1.96	4,200	58,000	1,617	2.59
		0.2803 SCANS IV			1,383	2.21			1,442	2.31			905	1.45			1,193	1.91
		SCANS III surface			1,262	2.02			1,303	2.08			825	1.32			1,078	1.72

Hearing Group	Threshold	Density (#/km2)	NE				SE				NW			SW				
			Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Rang e (m)	#	% MU	Area (km2)	Range (m)	#	% MU
		Irish Sea surface			1,54 5	2.47			1,63 2	2.61			972	1.55			1,338	2.14
Harbour seal	170	0.115	2,000	36,000	37	2.71	2,100	36,000	28	2.05	1,100	28,00 0	30	2.19	1,500	33,000	26	1.90
Grey seal	170	0.421	2,000	36,000	310	5.11	2,100	36,000	352	5.80	1,100	28,00 0	260	4.28	1,500	33,000	333	5.49
Cumulative TTS-Onset (weighted SEL_{cum}), installation of 2 sequential piles																		
Minke whale	168	0.0137 SCANS IV	8,100	94,000	111	0.55	8,500	95,000	116	0.58	6,000	81,00 0	83	0.41	7,500	91,000	102	0.51
		SCANS III surface			188	0.93			190	0.94			139	0.69			167	0.83
		Irish Sea surface			125	0.62			133	0.66			86	0.43			114	0.57
Common dolphin	170	0.04 site-specific DAS	< 0.1	< 100	0.0	0.0	< 0.1	< 100	0.0	0.0	< 0.1	< 100	0.0	0.0	< 0.1	< 100	0	0.0
		0.0272 SCANS IV			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0
		SCANS III surface			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0
		Irish Sea surface			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0

Hearing Group	Threshold	Density (#/km2)	NE				SE				NW			SW				
			Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU	Area (km2)	Range (m)	#	% MU
Bottlenose dolphin	170	0.002 site-specific DAS	< 0.1	< 100	0.0	0.0	< 0.1	< 100	0.0	0.0	< 0.1	< 100	0.0	0.0	< 0.1	< 100	0	0.0
		0.2352 SCANS IV			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0
		SCANS III surface			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0
		Irish Sea surface			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0
Harbour porpoise	145	0.38 site-specific DAS	5,700	70,000	2,182	3.49	5,900	71,000	2,268	3.63	3,900	59,000	1,487	2.38	5,000	66,000	1,916	3.06
		0.2803 SCANS IV			1,609	2.57			1,673	2.68			1,097	1.75			1,413	2.26
		SCANS III surface			1,468	2.35			1,513	2.42			999	1.60			1,275	2.04
		Irish Sea surface			1,801	2.88			1,897	3.03			1,201	1.92			1,590	2.54
Harbour seal	170	0.115	2,600	44,000	42	3.08	2,700	44,000	31	2.27	1,400	34,000	35	2.56	1,800	36,000	28	2.05
Grey seal	170	0.421	2,600	44,000	359	5.92	2,700	44,000	397	6.55	1,400	34,000	301	4.96	1,800	36,000	355	5.85

14.5.2.7 Impact 7 - Disturbance from pile driving

Table 14.32 and Table 14.33 outline the number of each marine mammal receptor predicted to experience behavioural disturbance as a result of unmitigated piling, and unmitigated piling activity using the harbour porpoise and seal dose-response functions. Additionally, the Level B harassment threshold is used for dolphins and minke whales given the conservatism in using a porpoise dose-response function for these species.

The number of marine mammal individuals predicted to experience behavioural disturbance is assessed as a proportion of their respective MU. Predictions are made for the NE, NW, SE, and SW modelling locations separately for both monopiles and pin piles.

Table 14.32 Predicted impact for disturbance from monopile (MP) and pin pile (PP) foundation piling activity (bold = maximum values)

Species	Density (#/km2)	Impact	NE		NW		SE		SW	
			MP	PP	MP	PP	MP	PP	MP	PP
Harbour porpoise (site specific DAS)	0.38	Number animals	3,801	3,464	2,954	2,661	3,896	3,553	3,468	3,147
		% of MU	6.08	5.54	4.73	4.27	6.23	5.68	5.55	5.03
Harbour porpoise (SCANS IV)	0.2803	Number animals	2,877	2,614	2,221	1,995	2,942	2,675	2,611	2,363
		% of MU	4.60	4.18	3.55	3.19	4.71	4.28	4.18	3.78
Harbour porpoise (SCANS III surface)	Grid cell specific	Number animals	2,692	2,445	2,082	1,870	2,731	2,483	2,429	2,197
		% of MU	4.31	3.91	3.33	2.99	4.37	3.97	3.89	3.51
Harbour porpoise (Irish Sea surface)	Grid cell specific	Number animals	3,168	2,885	2,448	2,200	3,274	2,985	2,908	2,637
		% of MU	5.08	4.61	3.92	3.52	5.24	4.77	4.65	4.22
Common dolphin (site-specific DAS)	0.04	Number animals	400	365	311	280	410	374	365	331
		% of MU	0.39	0.36	0.30	0.27	0.40	0.36	0.36	0.32
Common dolphin (SCANS IV)	0.0272	Number animals	264	241	207	187	271	248	242	220
		% of MU	0.26	0.23	0.20	0.18	0.26	0.24	0.24	0.21
Common dolphin (SCANS III surface)	Grid cell specific	Number animals	175	160	136	123	188	172	167	152
		% of MU	0.17	0.16	0.13	0.12	0.18	0.17	0.16	0.15
Common dolphin (Irish Sea surface)	Grid cell specific	Number animals	238	221	189	173	251	233	224	207
		% of MU	0.23	0.22	0.18	0.17	0.24	0.23	0.22	0.20
Minke whale (SCANS IV)	0.0137	Number animals	136	124	106	95	139	127	124	133
		% of MU	0.68	0.62	0.53	0.47	0.69	0.63	0.62	0.56
Minke whale (SCANS III surface)	Grid cell specific	Number animals	222	202	173	156	222	203	199	180
		% of MU	1.10	1.00	0.86	0.78	1.10	1.01	0.99	0.89
Minke whale (Irish Sea surface)	Grid cell specific	Number animals	132	120	100	90	138	126	122	110
		% of MU	0.67	0.59	0.49	0.45	0.69	0.63	0.61	0.55
	0.002	Number animals	20	18	16	14	21	19	18	17

Species	Density (#/km2)	Impact	NE		NW		SE		SW	
			MP	PP	MP	PP	MP	PP	MP	PP
Bottlenose dolphins (site-specific DAS)		% of MU (293)	6.83	6.14	5.46	4.78	7.16	6.48	6.14	5.80
Bottlenose dolphin (SCANS IV)	0.2352	Number animals	2,282	2,088	1,788	1,616	2,346	2,148	2,096	1,908
		% of MU (8,326)	27.41	25.08	21.47	19.41	28.18	25.80	25.17	22.92
Bottlenose dolphin (SCANS III surface)	Grid cell specific	Number animals	251	230	199	180	256	235	230	210
		% of MU (1,069)	23.47	21.51	18.62	16.84	23.95	21.98	21.51	19.64
Bottlenose dolphin (Irish Sea surface)	Grid cell specific	Number animals	31	27	22	19	32	28	28	24
		% of MU (496)	6.25	5.44	4.34	3.83	6.45	5.65	5.65	4.84
Harbour seal	Grid cell specific	Number animals	200 (21 – 377)	177 (18 – 337)	158 (17 – 296)	139 (14 – 265)	161 (15 – 311)	139 (12 – 270)	138 (13 – 267)	136 (10 – 266)
		% of MU	14.65 (1.54 – 27.62)	12.97 (1.32 – 24.69)	11.58 (1.25 – 21.68)	10.18 (1.03 – 19.41)	11.79 (1.10 – 22.78)	10.18 (0.88 – 19.78)	10.11 (0.95 – 19.56)	8.49 (0.73 – 16.56)
Grey seal	Grid cell specific	Number animals	788 (87 – 1,465)	694 (78 – 1,280)	585 (76 – 1,063)	528 (66 – 963)	790 (100 – 1,454)	703 (85 – 1,302)	699 (91 – 1,279)	627 (76 – 1,157)
		% of MU	13.01 (1.44 – 24.19)	11.46 (1.29 – 21.30)	9.66 (1.25 – 17.55)	8.72 (1.09 – 15.90)	13.04 (1.65 – 24.01)	11.61 (1.40 – 21.50)	11.54 (1.50 – 21.12)	10.35 (1.25 – 19.11)

Table 14.33 Predicted impact for disturbance from monopile and pin pile foundation piling activity, using Level B (160 dB) harassment threshold (dolphins and minke whales only)

Species	Density (#/km2)	Impact	NE		NW		SE		SW	
			MP	PP	MP	PP	MP	PP	MP	PP
Common dolphin (site-specific DAS)	0.04	Number animals	165	137	107	86	165	136	133	108
		% of MU	0.16	0.13	0.10	0.08	0.16	0.13	0.13	0.11
Common dolphin (SCANS IV)	0.0272	Number animals	112	93	72	59	112	92	90	74
		% of MU	0.11	0.09	0.07	0.06	0.11	0.09	0.09	0.07
Common dolphin (SCANS III surface)	Grid cell specific	Number animals	80	67	55	46	84	70	70	58
		% of MU	0.08	0.07	0.05	0.04	0.08	0.07	0.07	0.06
Common dolphin (Irish Sea surface)	Grid cell specific	Number animals	169	152	112	82	168	150	144	124
		% of MU	0.16	0.15	0.11	0.08	0.16	0.15	0.14	0.12
Minke whale (SCANS IV)	0.0137	Number animals	56	47	37	30	57	47	46	37
		% of MU	0.28	0.23	0.18	0.15	0.28	0.23	0.23	0.18
Minke whale (SCANS III surface)	Grid cell specific	Number animals	91	74	55	44	88	71	69	56
		% of MU	0.45	0.37	0.27	0.22	0.43	0.35	0.34	0.28
Minke whale (Irish Sea surface)	Grid cell specific	Number animals	45	35	23	17	50	40	37	28
		% of MU	0.22	0.17	0.11	0.08	0.25	0.20	0.18	0.14
Bottlenose dolphins (site-specific DAS)	0.002	Number animals	8	7	5	4	8	7	7	5
		% of MU (293)	2.73	2.39	1.71	1.37	2.73	2.39	2.39	1.71
Bottlenose dolphin (SCANS IV)	0.2352	Number animals	969	804	627	508	972	800	782	636
		% of MU (8,326)	11.64	9.66	7.53	6.10	11.67	9.61	9.39	7.64
Bottlenose dolphin (SCANS III surface)	Grid cell specific	Number animals	115	96	79	65	114	94	94	77
		% of MU (1,069)	10.76	8.98	7.39	6.08	10.66	8.79	8.79	7.20
Bottlenose dolphin (Irish Sea surface)	Grid cell specific	Number animals	8	7	6	5	7	7	7	6
		% of MU (496)	1.61	1.41	1.21	1.01	1.41	1.41	1.41	1.21

Harbour porpoise

Sensitivity of the receptor

Previous studies have shown that harbour porpoises are displaced from the vicinity of piling events. For example, studies at wind farms in the German North Sea have recorded large declines in porpoise detections close to the piling (>90% decline at noise levels above 170dB re 1µPa^{2}s) with decreasing effect with increasing distance from the pile (25% decline at noise levels between 145 and 150dB) (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.

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 et al. (2016) paper that bring these conclusions into question. These concerns are summarized in a rebuttal to the original paper by Hoekendijk et al. (2018) which call for "a cautious, critical, and rational assessment of the results and interpretations". One of the key issues highlighted is that the porpoise were trapped in a pound net for 24+ hours before tagging and were not allowed to recover from stress and starvation once released. The high levels of foraging observed do not necessarily represent the typical foraging – i.e. they are not necessarily indicative of vulnerability to disturbance. Foraging behaviour after release may in part be a response to being captured and held. It is typical for the initial data recorded from tags to be excluded from analysis as it is not expected to be representative of typical behaviour (e.g. Wright et al 2017). Given that the tags on the porpoise in Wisniewska et al. (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.

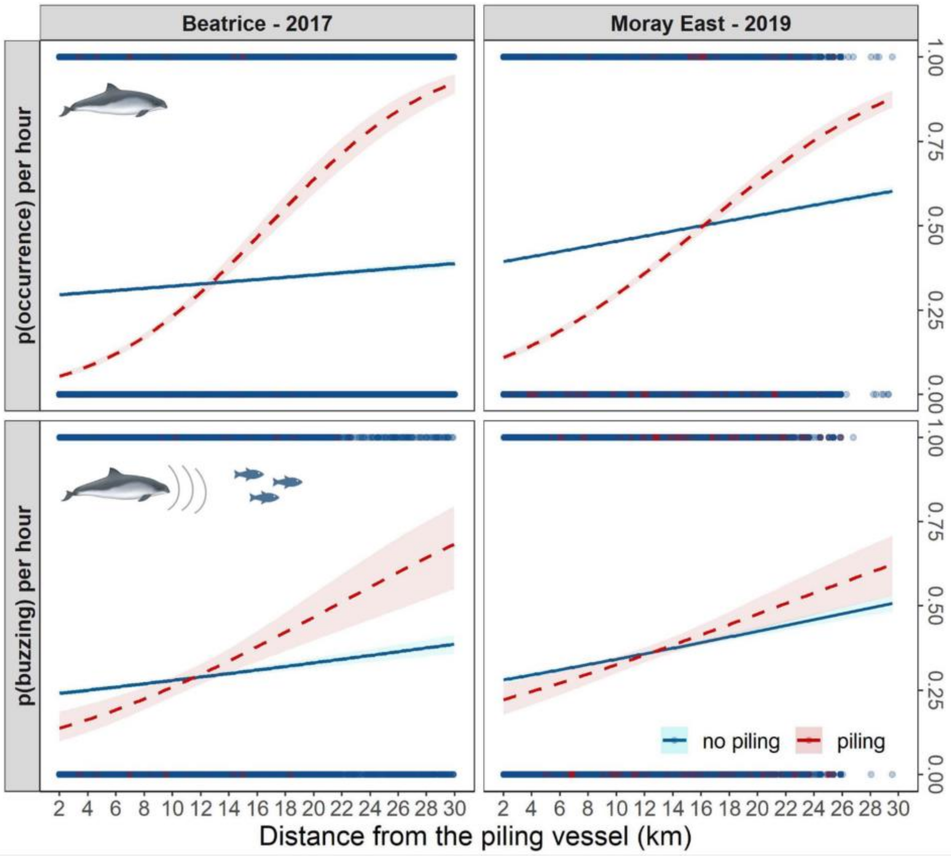
Further to this, a subsequent paper by Booth (2020) used the Wisniewska et al. (2016) data combined with additional information on porpoise diet and the energy derived from different prey to highlight that the tagged animals likely were able to consume significant amounts of energy (well in excess of energetic requirements – based on the data available). Booth (2020) disputes the conclusion that porpoise exist on an "energetic knife-edge" as Wisniewska et al. (2016) claim but do not justify in their paper.

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

Monitoring of harbour porpoise activity at the Beatrice Offshore Wind Farm during pile driving activity has indicated that porpoises were displaced from the immediate vicinity of the pile driving activity – with a 50% probability of response occurring at approximately 7km (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 1.3km. In addition, the study indicated that porpoise activity recovered between pile driving events.

A recent study by Benhemma-Le Gall et al. (2021) provided two key findings in relation to harbour porpoise response to pile driving. Porpoise were not completely displaced from the piling site: detection of clicks (echolocation) and buzzing (associated with prey capture) in the short-range (2km) did not cease in response to pile driving.

Furthermore, detections of both clicks (echolocation) and buzzing (associated with prey capture) increased above baseline levels with increasing distance from the pile, which could be a result of increased local density of animals through augmentation by animals displaced closer to piling and/or that displaced porpoises compensate by increasing foraging activities beyond the impact range (Graph 14.14). Therefore, porpoise that experience displacement are expected to be able to compensate for the lost foraging opportunities and increased energy expenditure of fleeing.



Graph 14.14 The probability of harbour porpoise occurrence and buzzing activity per hour during (dashed red line) and out with (blue line) pile-driving hours, in relation to distance from the pile-driving vessel at Beatrice (left) and Moray East (right). Obtained from Benhemma-Le Gall et al. (2021)

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 420–690m (SEL 135–147dB 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 variability in responses from individual harbour porpoises exposed to low frequency broadband pulsed noise (including both airguns and pile-driving).

At an expert elicitation workshop in 2018, experts in marine mammal physiology, behaviour and energetics discussed the nature, extent and potential consequences of disturbance to harbour porpoise from exposure to low frequency broadband pulsed noise (e.g. pile-driving, airgun pulses) (Booth et al. 2019).

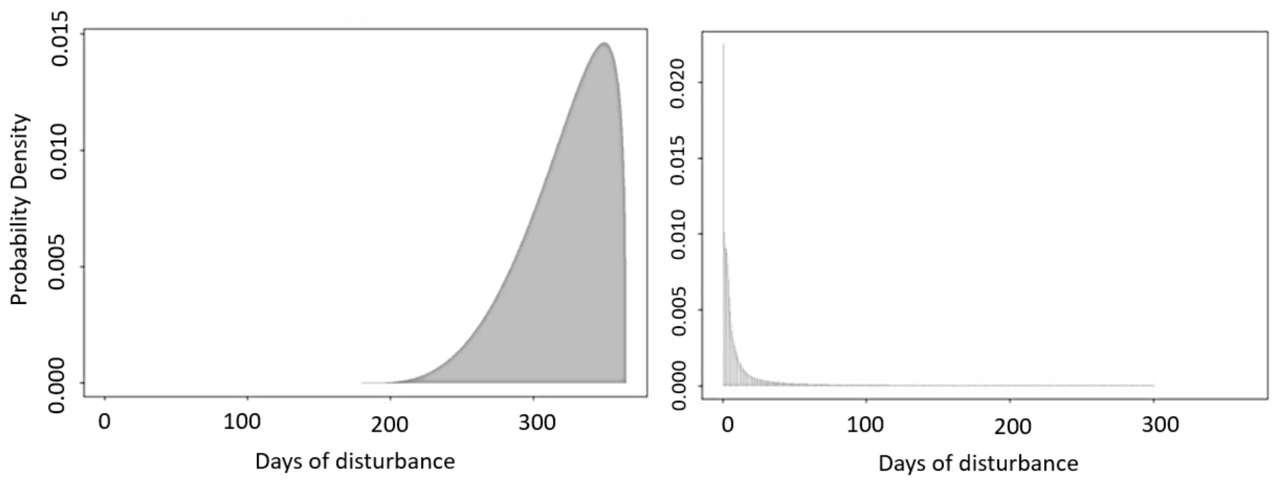
Experts were asked to estimate the potential consequences of a six-hour period of zero energy intake, assuming that disturbance from a pile driving event resulted in missed foraging opportunities for this duration. A Dynamic Energy Budget model for harbour porpoise (based on the Dynamic Energy Budget (DEB) model in Hin et al. 2019) was used to aid discussions regarding the likely significant 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.

The experts agreed that first year calf survival (post-weaning) and fertility were the most likely vital rates (survival and reproduction) to be affected by disturbance, but that juvenile and adult survival were unlikely to be significantly affected as these life-stages were 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 (Graph 14.15 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 (Graph 14.15 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.

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



Graph 14.15 Probability distributions showing the consensus of the expert elicitation for harbour porpoise disturbance from piling (Booth et al. 2019)

Magnitude of impact

For harbour porpoise, the scenario with the maximum level of disturbance per day is the SE monopile installation. Figure 14.4 shows the behavioural disturbance dose-response contours for the installation of a monopile at the SE location.

Using the **site-specific DAS density estimate** of 0.38 porpoise/km^2, it was estimated that 3,896 individuals (6.23% of the MU) will experience behavioural disturbance as a result of piling of a monopile at the SE location. For pin-piles, up to 3,553 individuals (5.68% MU) will experience behavioural disturbance as a result of piling at the SE location.

The wider **SCANS IV block CS-D uniform density estimat**e of 0.2803 porpoise/km^2 is considered to be more representative of porpoise density across the wider disturbance area compared to the site-specific DAS estimated density. This approach estimated that 2,942 individuals (4.71% of the MU) will experience behavioural disturbance as a result of piling of a monopile at the SE location. For pin-piles, up to 2,675 individuals (4.28% MU) will experience behavioural disturbance as a result of piling at the SE location. The disadvantage of this approach is that it is unrealistic to assume a uniform density of porpoise across the Irish Sea.

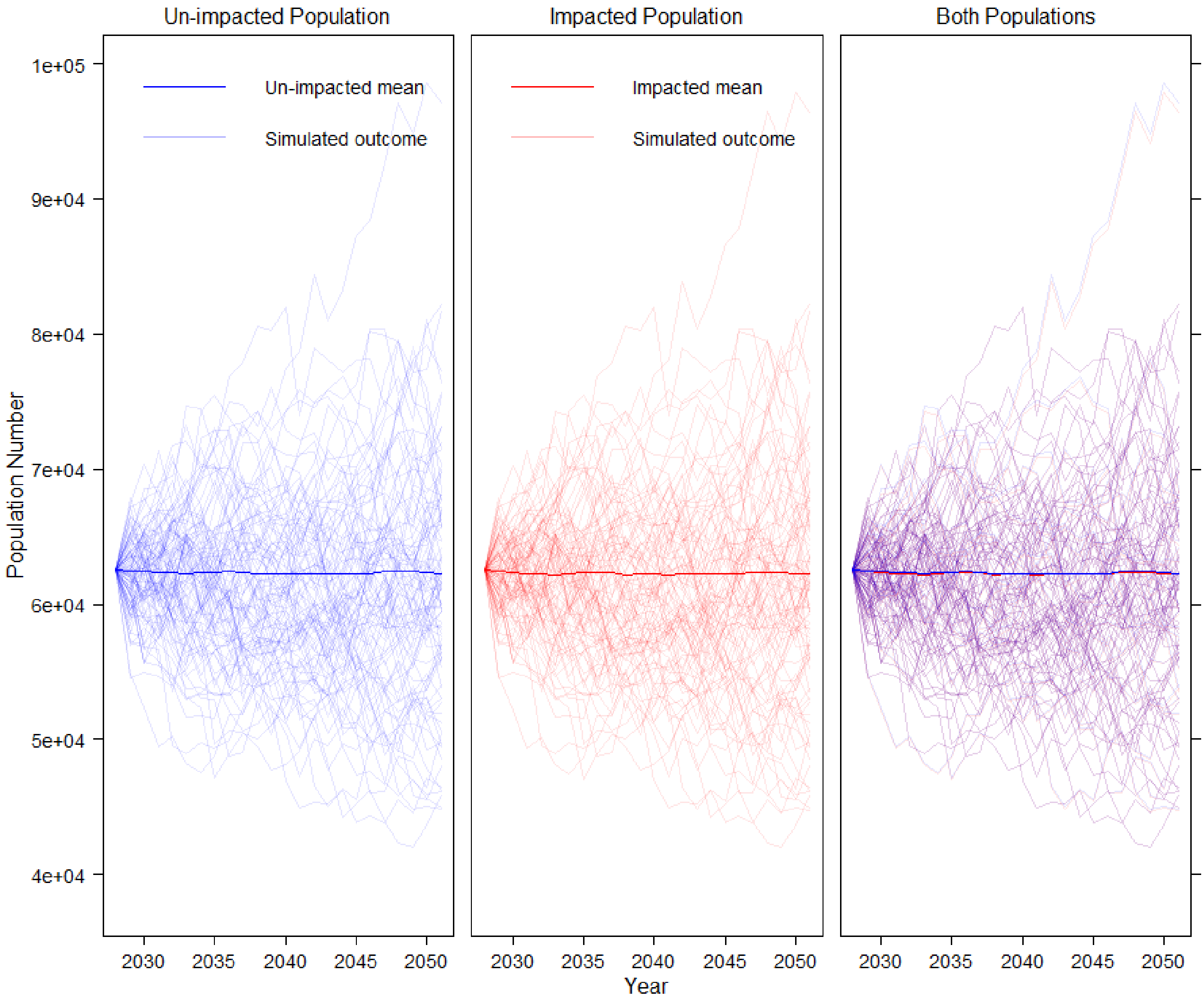
The wider **SCANS III modelled density surface** was also presented to take into consideration the fact that porpoise density is not expected to be uniform across the Irish Sea. This estimated that 2,731 individuals (4.37% of the MU) will experience behavioural disturbance as a result of piling of a monopile at the SE location. For pin-piles, up to 2,483 individuals (3.97% MU) will experience behavioural disturbance as a result of piling at the SE location.

An alternative **Irish Sea grid cell specific density surface** from various Irish Sea surveys was also presented. This estimated that 3,274 individuals (5.24% of the MU) will experience behavioural disturbance as a result of piling of a monopile at the SE location. For pin-piles, up to 2,985 individuals (4.77% MU) will experience behavioural disturbance as a result of piling at the SE location.

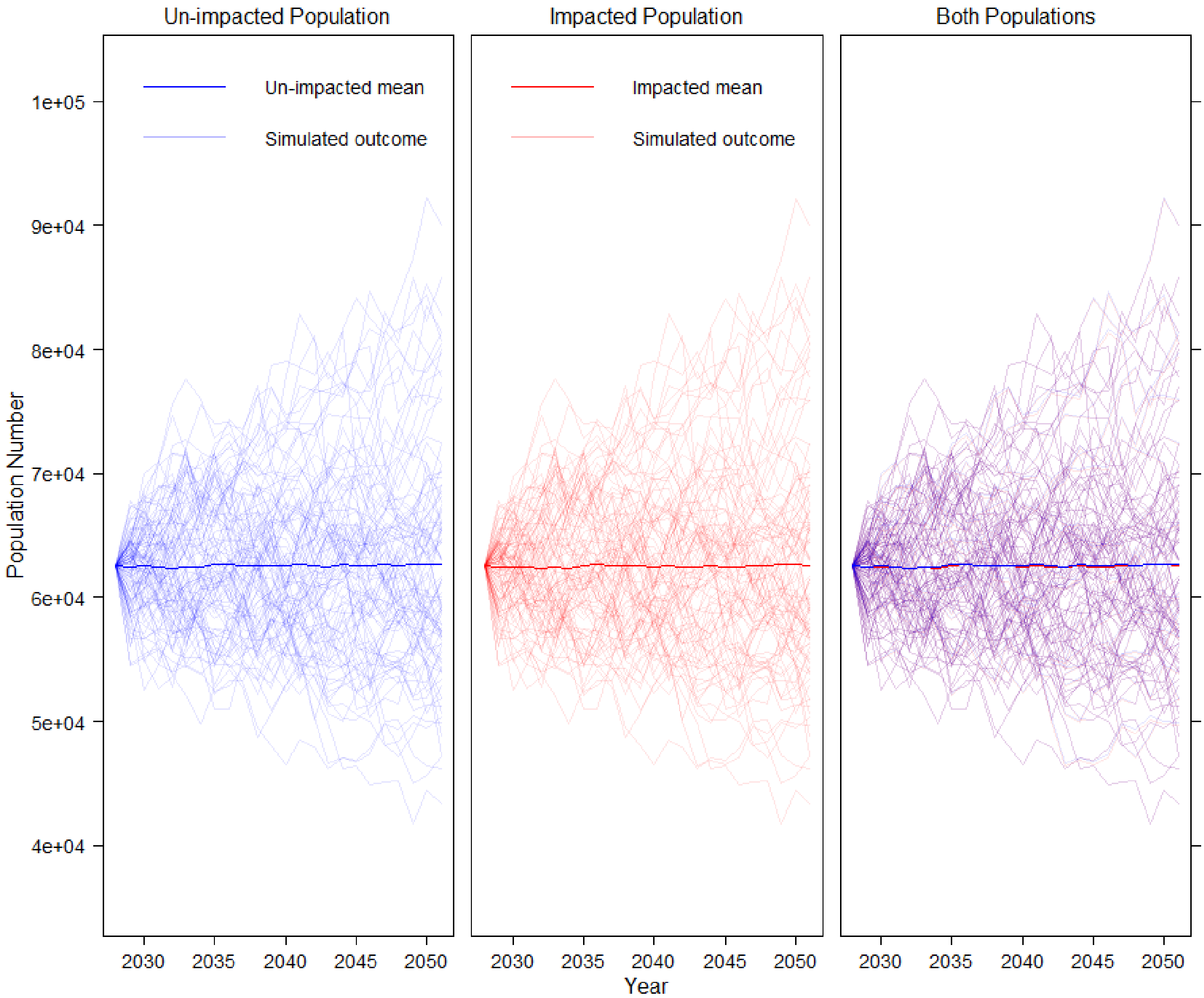
Population Modelling

To determine whether this level of disturbance is expected to result in population level impacts, iPCoD modelling was conducted. Modelling assumed the installation of monopiles over a single construction (piling) year, resulting in 51 piling days throughout this period. Modelling also assumed the installation of pin piles over a single piling year, resulting in 72 piling days. The disturbance value used in the modelling was 3,896 harbour porpoise per day since this was the highest number of animals predicted to be impacted by a single monopile location, and 3,553 harbour porpoise per day by a single pin pile location.

For both piling schedules, the results of the iPCoD modelling show that there is no effect of disturbance resulting from the proposed development on the size and trajectory of the harbour porpoise population (Graph 14.16, Graph 14.17, Table 14.34 and Table 14.35). The magnitude of disturbance from pile driving has been assessed as low, since it is expected to result in short-term/ intermittent and temporary behavioural effects (behavioural changes that last days at the most) in a small proportion of the population that occurs over less than a year. Survival and reproductive rates are very unlikely to be impacted to the extent that the population trajectory would be altered.



Graph 14.16 Predicted population trajectories for the un-impacted (baseline) and impacted harbour porpoise iPCoD simulations (51 days piling (of monopiles) impacting 3,896 harbour porpoise per day)



Graph 14.17 Predicted population trajectories for the un-impacted (baseline) and impacted harbour porpoise iPCoD simulations (72 days piling (of pin piles) impacting 3,553 harbour porpoise per day)

Table 14.34 Results of iPCoD modelling for harbour porpoise

Simulation year	Un-impacted mean population size	Impacted mean population size	Impacted as % of un-impacted population size	Median ratio impacted: un-impacted growth rate
Monopiles				
End 2027 (before piling commences)	62,516	62,516	100	1.00
End 2028 (after piling stops)	62,569	62,546	99.9	0.99
End 2034 (6 years after piling stops)	62,777	62,725	99.9	0.99
End 2040 (12 years after piling stops)	62,885	62,832	99.9	0.99
Pin Piles				
End 2027 (before piling commences)	62,516	62,516	100	1.00
End 2028 (after piling stops)	62,554	62,523	99.9	0.99
End 2034 (6 years after piling stops)	62,590	62,525	99.8	0.99

Simulation year	Un-impacted mean population size	Impacted mean population size	Impacted as % of un-impacted population size	Median ratio impacted: un-impacted growth rate
End 2040 (12 years after piling stops)	62,780	62,714	99.8	0.99

Table 14.35 Predicted impact of disturbance from pile driving activities on harbour porpoise using the DAS uniform density estimate

Location	Number Impacted	% MU Impacted	Magnitude informed by iPCoD
Monopile – 5,500kJ			
NE	3,801	6.08	Low
NW	2,954	4.73	Low
SE	3,896	6.23	Low
SW	3,468	5.55	Low
Pin Pile – 3,000kJ			
NE	3,464	5.54	Low
NW	2661	4.27	Low
SE	3,553	5.68	Low
SW	3,147	5.03	Low

Significance of the effect

Project Option 1

Given that the sensitivity of harbour porpoise receptors has been assessed as low, and the magnitude of disturbance impacts from pile driving have been assessed as low, this significance of effect for Project Option 1 has been assessed as slight, which is not significant in EIA terms.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of harbour porpoise receptors has been assessed as low, and the magnitude of disturbance impacts from pile driving have been assessed as low. Therefore, the significance of effect for Project Option 2 has been assessed as slight, which is not significant in EIA terms.

Bottlenose dolphin

Sensitivity of the receptor

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 240dB re 1µPa (range ± 8dB) with a single pulse source level of 198dB re $\mu Pa^2 s$. The pile driving resulted in a slight reduction of the presence, detection positive hours and the encounter duration for dolphins within the Cromarty Firth; however, this response was only significant for the encounter durations.

Encounter durations decreased within the Cromarty Firth (though only by a few minutes) and increased outside of the Cromarty Firth on days of piling activity. These data highlight a small spatial and temporal scale disturbance to bottlenose dolphins as a result of impact piling activities.

In addition, 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 behavioural response among harbour porpoise at a wide range of received SPLs (100 and 180dB 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 140dB re 1µPa (Moray Offshore Renewables Limited 2012), indicating that moderate level responses by bottlenose dolphins will be exhibited at a higher received SPL and, therefore, they are likely to show a lesser response to disturbance.

According to the opinions of the experts involved in the first expert elicitation for iPCoD in 2013, , 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). Note: bottlenose dolphins were not included in the second (most recent) expert elicitation in 2018.

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.

Furthermore, the relatively dynamic social structure of bottlenose dolphins (Connor et al. 2001) and the fact that they have no significant predation threats and do not appear to face excessive competition for food with other marine mammal species, have potentially resulted in a higher tolerance to perceived threats or disturbances in their environment, which may make them less sensitive to disturbance.

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.

Magnitude of impact

For bottlenose dolphins, the scenario with the maximum level of disturbance per day is the SE monopile installation. Given the uncertainty in the bottlenose dolphin density estimates and thus, MU population sizes, four different approaches have been used in the disturbance assessment:

1. Using the site-specific DAS density estimate of 0.002 dolphins/km^2 across the entire impact contour
2. Using the SCANS IV density estimate of 0.2352 dolphins/km^2 across the entire impact contour;
3. Using the SCANS III grid cell specific density surface estimate across the entire impact contour
4. Using the Irish Sea modelled density surface across the entire impact contour.

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

Additionally, given the lack of data on bottlenose dolphin behavioural responses to pile driving, an assessment is presented using both the porpoise dose-response function and the Level B harassment threshold.

Dose-response

Using the **site-specific DAS density** only results in 21 dolphins predicted to be disturbed (7.16% MU, assuming the MU is 293) when a monopile is installed at the SE location. For pin-piles, up to 19 individuals (6.48% MU) will experience behavioural disturbance as a result of piling at the SE location. There is however no evidence that this density is applicable out with the boundary of the survey area and thus this result is not considered to be robust.

Using the **SCANS III grid cell specific density surface estimate** approach, a total of 256 individuals are predicted to be disturbed (23.95% MU, assuming the MU population size is 1,069) when a monopile is installed at the SE location. For pin-piles, up to 235 individuals (21.98% MU) will experience behavioural disturbance as a result of piling at the SE location.

Using the **SCANS IV uniform density** approach, a total of 2,346 individuals (28.18% MU, assuming the MU population size is 8,326) are predicted to be disturbed when a monopile is installed at the SE location. For pin-piles, up to 2,148 individuals (25.80% MU) will experience behavioural disturbance as a result of piling at the SE location.

Using the combined **Irish Sea density surface** approach, a total of 32 individuals are predicted to be disturbed (6.45% MU, assuming the MU population size is 496) when a monopile is installed at the SE location. For pin-piles, up to 28 individuals (5.65% MU) will experience behavioural disturbance as a result of piling at the SE location.

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 assumes 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.

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

Level B harassment threshold

Using the **site-specific DAS density** only results in 8 dolphins predicted to be disturbed (2.73% MU, assuming the MU is 293) when a monopile is installed at the SE location. For pin-piles, up to 7 individuals (2.39% MU) will experience behavioural disturbance as a result of piling at the SE location. There is however no evidence that this density is applicable out with the boundary of the survey area and thus this result is not considered to be robust.

Using the **SCANS III grid cell specific density surface estimate** approach, a total of 115 individuals are predicted to be disturbed (10.76% MU, assuming the MU population size is 1,069) when a monopile is installed at the NE location. For pin-piles, up to 96 individuals (8.98% MU) will experience behavioural disturbance as a result of piling at the NE location.

Using the **SCANS IV uniform density** approach, a total of 972 individuals (11.67% MU, assuming the MU population size is 8,326) are predicted to be disturbed when a monopile is installed at the SE location. For pin-piles, up to 800 individuals (9.61% MU) will experience behavioural disturbance as a result of piling at the SE location.

Using the combined **Irish Sea density surface** approach, a total of 8 individuals are predicted to be disturbed (1.61% MU, assuming the MU population size is 496) when a monopile is installed at the NE location. For pin-piles, up to 7 individuals (1.41% MU) will experience behavioural disturbance as a result of piling at the NE location.

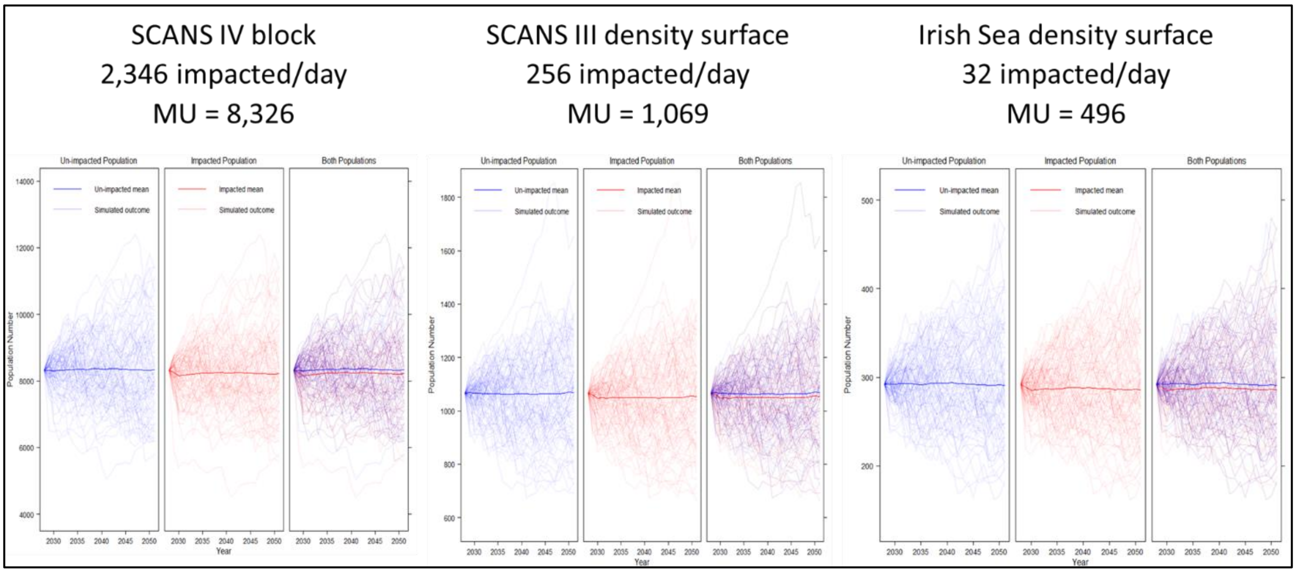
Population Modelling

To determine whether this level of disturbance is expected to result in population level impacts, iPCoD modelling was conducted. Modelling assumed the installation of monopiles over a single construction (piling) year, resulting in 51 piling days throughout this period. Modelling also assumed the installation of pin piles over a single piling year, resulting in 72 piling days. The iPCoD model used the disturbance values obtained using the precautionary porpoise dose-response function.

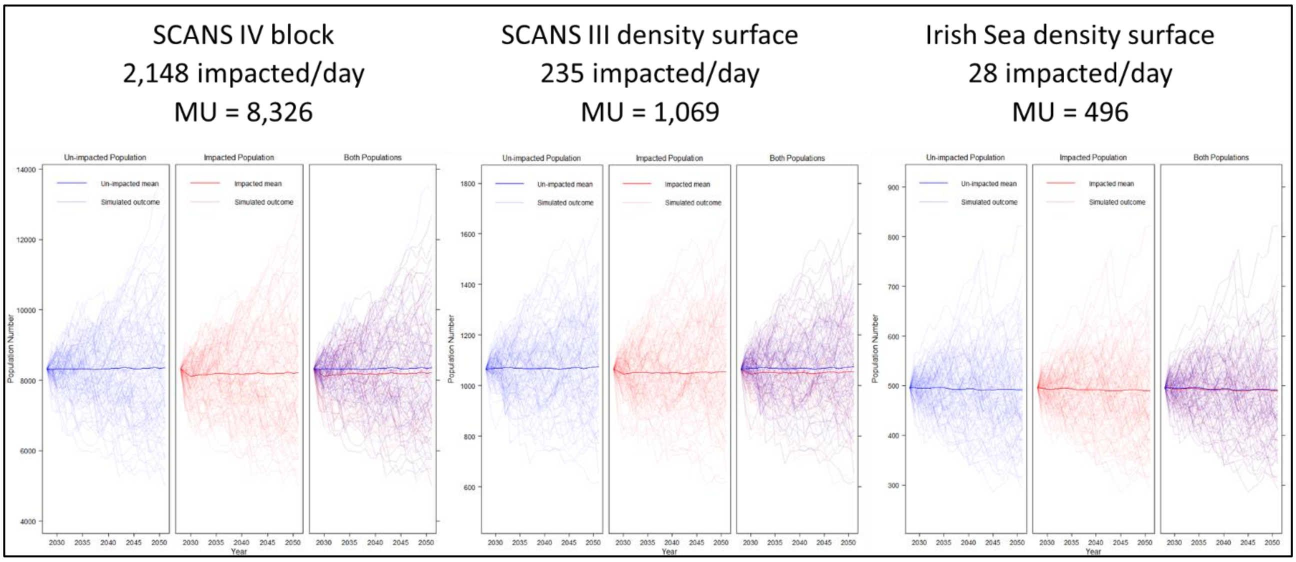
The results of the iPCoD modelling shows a clear deviation from the baseline resulting from the pile driving disturbance at the proposed development. This is highly conservative since the porpoise dose-response function will likely over-estimate dolphin response. Under all density and MU size scenarios, 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.

As piling will only occur within a single piling year, the effects will occur for less than a year. While temporary changes in behaviour and/or distribution of individuals are anticipated, these will not be 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. As such, the magnitude of disturbance as a result of piling has therefore been assessed as medium**.**



Graph 14.18 Predicted population trajectories for the un-impacted (baseline) and impacted bottlenose dolphins iPCoD simulations (51 days piling of monopiles)



Graph 14.19 Predicted population trajectories for the un-impacted (baseline) and impacted bottlenose dolphins iPCoD simulations (72 days piling of pin piles)

Table 14.36 Results of iPCoD modelling for bottlenose dolphins

		End 2027 (before piling commences)	End 2028 (after piling stops)	End 2034 (6 years after piling stops)	End 2040 (12 years after piling stops)
Monopiles					
SCANS III surface 256 disturbed/day MU = 1,069	Unimpacted population mean size	1,066	1,066	1,067	1,064
	Impacted population mean size	1,066	1,060	1,055	1,051
	Impacted as proportion of unimpacted	100	99.4	98.9	98.7
SCANS IV block 2,346 disturbed/day MU = 8,326	Unimpacted population mean size	8,326	8,339	8,327	8,312
	Impacted population mean size	8,326	8,275	8,211	8,188
	Impacted as proportion of unimpacted	100	99.2	98.6	98.5
Irish Sea surface 32 disturbed/day MU = 496	Unimpacted population mean size	496	496	495	492
	Impacted population mean size	496	496	494	491
	Impacted as proportion of unimpacted	100	100	99.8	99.8
Pin Piles					
SCANS III surface 235 disturbed/day MU = 1,069	Unimpacted population mean size	1,066	1,065	1,064	1,064
	Impacted population mean size	1,066	1,057	1,050	1,050
	Impacted as proportion of unimpacted	100	99.3	98.7	98.7
SCANS IV block 2,148 disturbed/day MU = 8,326	Unimpacted population mean size	8,326	8,315	8,338	8,373
	Impacted population mean size	8,326	8,226	8,202	8,228
	Impacted as proportion of unimpacted	100	98.9	98.3	98.3
Irish Sea surface 28 disturbed/day MU = 496	Unimpacted population mean size	496	496	498	498
	Impacted population mean size	496	496	497	496
	Impacted as proportion of unimpacted	100	100	99.8	99.6

Table 14.37 Predicted impact of disturbance from pile driving activities on bottlenose dolphin using the SCANS IV uniform density estimate

Location	Number Impacted	% MU Impacted	Magnitude informed by iPCoD
Monopile – 5,500kJ			
NE	2,282	27.41	Medium
NW	1,788	21.47	Medium
SE	2,346	28.18	Medium

Location	Number Impacted	% MU Impacted	Magnitude informed by iPCoD
SW	2,096	25.17	Medium
Pin Pile – 3,000kJ			
NE	2,088	25.08	Medium
NW	1,616	19.41	Medium
SE	2,148	25.80	Medium
SW	1,908	22.92	Medium

Significance of the effect

Project Option 1

Given that the sensitivity of bottlenose dolphin has been assessed as low, and the magnitude of disturbance impacts from pile driving have been assessed as medium, this significance of effect for Project Option 1 has been assessed as slight, which is not significant in EIA terms.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of bottlenose dolphin has been assessed as low, and the magnitude of disturbance impacts from pile driving have been assessed as medium. Therefore, the significance of effect for Project Option 2 has been assessed as slight, which is not significant in EIA terms.

Common dolphin

Sensitivity of the receptor

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

Relatively few studies document the impacts of marine construction or investigation on common dolphins, but there is some evidence of the impacts of vessel traffic and boat noise on common dolphins. While the direct impacts of vessel noise on common dolphins are rather under-researched, the presence of vessel activity has been found to alter their behavioural states and has been linked to disturbance.

In New Zealand, Markov chain models were used to assess the impacts of tourism on the behaviour of common dolphins. Foraging and resting bouts were significantly disrupted by boat interactions, with less time spent in these states. In addition, post-disturbance activity indicated a shift from foraging states to milling and socialising and returns to foraging took significantly longer (Stockin et al. 2008, Meissner et al. 2015). While the aforementioned studies relate to short term impacts, a long-term study of common dolphins in the waters around Ischia Island found declines that could have resulted from a combination of habitat degradation and disturbance from increasing traffic.

The surrounding area has been listed as one of the noisiest in the Mediterranean due to a range of marine traffic, commercial and seismic surveys, and drilling activity (Mussi et al. 2019). Conversely, some research suggests that common dolphins may be altering their communication to compensate for high levels of anthropogenic noise. It has been suggested that a difference in the frequency of whistles between two populations of common dolphins, one in the Celtic sea, and one in the English Channel, may reflect a shift in acoustic characteristics to counter masking caused by high levels of vessel traffic in the latter location (Ansmann et al. 2007). Recently, for both Atlantic spotted dolphins and short-beaked common dolphins, the presence of high noise levels was associated with an increase in the maximum whistle frequency, indicating vocal compensation for potential masking in a noisy environment (Papale et al. 2015).

There is sparse information available for the impacts of construction, seismic activity and vessel noise on common dolphins. While there is some evidence of disturbance of animals by seismic activity, and reduced presence in increasingly noisy habitat, this species may adjust its whistle characteristics to account for masking, suggesting some flexibility or tolerance.

It is assumed that common dolphins have a low sensitivity to disturbance from piling noise, the same as assumed for bottlenose dolphins, given that they are in the same functional hearing group.

Magnitude of impact

For common dolphins, the scenario with the maximum level of disturbance per day is the SE monopile installation. For common dolphins, it is predicted that a maximum of 410 individuals (0.40% of the MU) (see Table 14.32) will be disturbed, based on the site-specific density estimate. This is considered to be highly conservative since there is no evidence that the density within the site-specific survey area is the same across the wider Irish Sea which the disturbance contours extend across. Therefore, alternative density estimates were also presented.

Additionally, given the lack of data on common dolphin behavioural responses to pile driving, an assessment is presented using both the porpoise dose-response function and the Level B harassment threshold.

Dose-response

Using the **site-specific DAS density estimate** of 0.04 dolphins/km^2, it was estimated that 410 individuals (0.4% of the MU) will experience behavioural disturbance as a result of piling of a monopile at the SE location. For pin-piles, up to 374 individuals (0.36% MU) will experience behavioural disturbance as a result of piling at the SE location. This is considered to be **highly conservative** since there is no evidence that the density within the site-specific survey area is the same across the wider Irish Sea which the disturbance contours extend across.

The wider **SCANS III grid cell specific density estimate** is considered to be more realistic of dolphin density across the wider disturbance area compared to the site-specific DAS estimated density. This approach estimated that 188 individuals (0.18% of the MU) will experience behavioural disturbance as a result of piling of a monopile at the SE location. For pin-piles, up to 172 individuals (0.17% MU) will experience behavioural disturbance as a result of piling at the SE location.

The **SCANS IV density estimate** estimated that 271 individuals (0.26% of the MU) will experience behavioural disturbance as a result of piling of a monopile at the SE location. For pin-piles, up to 248 individuals (0.24% MU) will experience behavioural disturbance as a result of piling at the SE location.

In addition, the **Irish Sea grid cell specific** modelled density surface was also presented. This estimated that 251 individuals (0.24% of the MU) will experience behavioural disturbance as a result of piling of a monopile at the SE location. For pin-piles, up to 233 individuals (0.23% MU) will experience behavioural disturbance as a result of piling at the SE location.

Little information is available regarding common dolphin response to behavioural disturbance from piling. As previously discussed for bottlenose dolphins, the number and proportion of common dolphin disturbed during piling were calculated based on the Graham et al. (2017a) dose-response curve for harbour porpoise, and is, therefore, likely to be an overestimate. Therefore, Level B harassment thresholds are also presented.

Level B harassment threshold
Using the **site-specific DAS density estimate** of 0.04 dolphins/km^2, it was estimated that 165 individuals (0.16% of the MU) will experience behavioural disturbance as a result of piling of a monopile at the SE location. For pin-piles, up to 136 individuals (0.13% MU) will experience behavioural disturbance as a result of piling at the SE location. This is considered to be **highly conservative** since there is no evidence that the density within the site-specific survey area is the same across the wider Irish Sea which the disturbance contours extend across.

The wider **SCANS III grid cell specific density estimate** is considered to be more realistic of dolphin density across the wider disturbance area compared to the site-specific DAS estimated density. This approach estimated that 84 individuals (0.08% of the MU) will experience behavioural disturbance as a result of piling of a monopile at the SE location. For pin-piles, up to 70 individuals (0.07% MU) will experience behavioural disturbance as a result of piling at the SE location.

The **SCANS IV density estimate** estimated that 112 individuals (0.11% of the MU) will experience behavioural disturbance as a result of piling of a monopile at the SE location. For pin-piles, up to 92 individuals (0.09% MU) will experience behavioural disturbance as a result of piling at the SE location.

In addition, the **Irish Sea grid cell specific** modelled density surface was also presented. This estimated that 168 individuals (0.16% of the MU) will experience behavioural disturbance as a result of piling of a monopile at the SE location. For pin-piles, up to 150 individuals (0.15% MU) will experience behavioural disturbance as a result of piling at the SE location.

Summary
The impact is predicted to be of local spatial extent, relatively short term duration (51 days of piling for monopiles or 72 days piling for jackets), intermittent and reversible. In addition, given the number of common dolphins predicted to be impacted and the proportion of the population this represents, this impact is considered to be of low magnitude.

Note: iPCoD modelling is not available for common dolphins.

Significance of the effect

Project Option 1
Given that the sensitivity of common dolphin receptors has been assessed as low, and the magnitude of disturbance impacts from pile driving have been assessed as low, this significance of effect for Project Option 1 has been assessed as slight, which is not significant in EIA terms.

Project Option 2
Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of common dolphin receptors have been assessed as low, and the magnitude of disturbance impacts from pile driving have been assessed as low. Therefore, the significance of effect for Project Option 2 has been assessed as slight, which is not significant in EIA terms.

Minke whale

Sensitivity of the receptor
There is little information available on the behavioural responses of minke whales to underwater noise. Minke whales have been shown to change their diving patterns and behavioural state in response to disturbance from whale watching vessels and it was suggested that a reduction in foraging activity at feeding grounds could result in reduced reproductive success (Christiansen et al. 2013b). There is only one study showing minke whale reactions to sonar signals (Sivle et al. 2015). This showed prolonged avoidance and cessation of feeding (7 hours) for a received SPL of 146dB re 1μPa and a behavioural score of 8 (long-term (6 hour) avoidance of area) for a received SPL of 158dB re 1μPa.

There is a study detailing minke whale responses to the Lofitech 'seal scarer' acoustic deterrent device, which has a source level of 204dB re 1µPa @1m, which showed minke whales within 500m and 1,000m of the source exhibiting a behavioural response of increased swim speed and movement away from the source. Estimated received level at 1,000m was 136.1dB re 1µPa (McGarry et al. 2017).

Since minke whales are known to forage in Irish (and UK) waters primarily in the spring/summer months, there is the potential for temporary displacement from foraging grounds. 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 without impacts to vital rates. Therefore, they are considered to have a low sensitivity.

Magnitude of impact

For minke whale, the scenario with the maximum level of disturbance per day is the SE monopile installation when using the Lacey et al. (2020) SCANS III density surface estimate, for both the dose-response and Level B harrasment threshold approaches.

Dose-response

The wider **SCANS III grid cell specific density estimate** approach estimated that 222 individuals (1.10% of the MU) will experience behavioural disturbance as a result of piling of a monopile at the SE location.

The **SCANS IV density estimate** estimated that 139 individuals (0.69% of the MU) will experience behavioural disturbance as a result of piling of a monopile at the SE location.

In addition, the **Irish Sea grid cell specific** modelled density surface was also presented. This estimated that 138 individuals (0.69% of the MU) will experience behavioural disturbance as a result of piling of a monopile at the SE location.

Level B harassment threshold

The wider **SCANS III grid cell specific density estimate** approach estimated that 88 individuals (0.43% of the MU) will experience behavioural disturbance as a result of piling of a monopile at the SE location.

The **SCANS IV density estimate** estimated that 57 individuals (0.28% of the MU) will experience behavioural disturbance as a result of piling of a monopile at the SE location.

In addition, the **Irish Sea grid cell specific** modelled density surface was also presented. This estimated that 50 individuals (0.25% of the MU) will experience behavioural disturbance as a result of piling of a monopile at the SE location.

Summary

The impact is predicted to be of local spatial extent, relatively short term duration (51 days of piling), intermittent and temporary. It is also important to note here that minke whales are expected to only be present in the summer months, and therefore any pile driving activities that occur outside the summer months is expected to have no impact on minke whales as none are expected to be present. Given the seasonal presence, the number of whales predicted to be impacted and the proportion of the population this represents, this impact is considered to be of low magnitude.

Significance of the effect

Project Option 1

Given that the sensitivity of minke whale receptors have been assessed as low, and the magnitude of disturbance impacts from pile driving have been assessed as low, this significance of effect for Project Option 1 has been assessed as slight, which is not significant in EIA terms.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of minke whale receptors have been assessed as low, and the magnitude of disturbance impacts from pile driving have been assessed as low. Therefore, the significance of effect for Project Option 2 has been assessed as slight, which is not significant in EIA terms.

Harbour seals

Sensitivity of the receptor

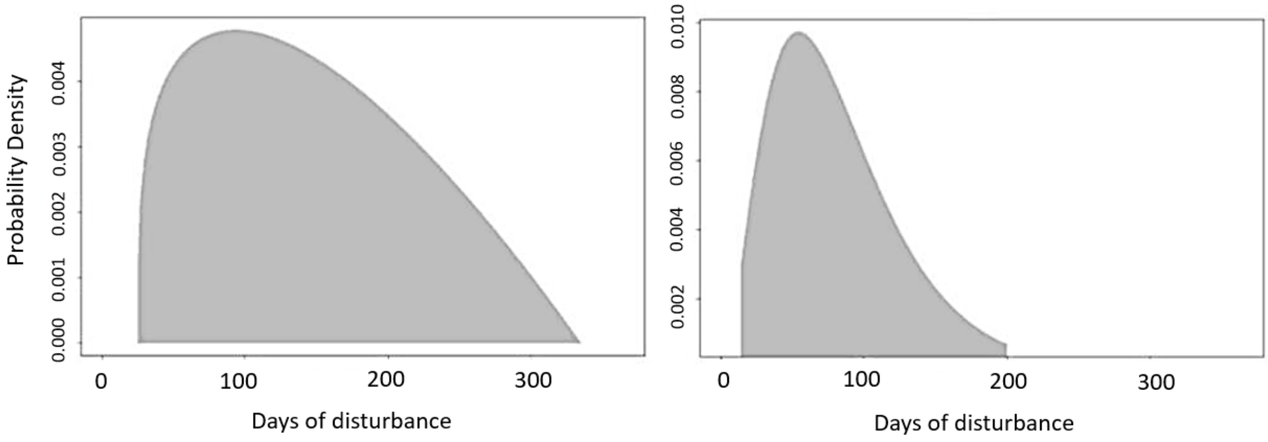
A study of tagged harbour seals in The Wash has shown that they are displaced from the vicinity of piles during pile-driving activities. Russell et al. (2016) showed that seal abundance was significantly reduced within an area of radius of 25km from a pile, during piling activities, with a 19 to 83% decline in abundance during pile-driving compared to during breaks in piling.

The duration of the displacement was only short-term as seals returned to non-piling distributions within two hours after the end of a pile-driving event. Unlike harbour porpoise, both harbour and grey seals store energy in a thick layer of blubber, which means that they are more tolerant of periods of fasting when hauled out and resting between foraging trips, and when hauled out during the breeding and moulting periods. Therefore, they are unlikely to be particularly sensitive to short-term displacement from foraging grounds during periods of active piling.

At an expert elicitation workshop in 2018 (Booth et al. 2019), experts agreed upon the most likely potential consequences of a six-hour period of zero energy intake. This was under the assumption that disturbance (from exposure to low frequency broadband pulsed noise e.g. pile-driving, airgun pulses) resulted in 6 hours of no foraging activity. 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 (animals which have been successfully weaned, i.e., no longer rely on their mother for survival), 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. 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 (Graph 14.20 left), however there was a large amount of uncertainty in this estimate, with opinions ranging between <50 days and >300 days.

The ‘weaned of the year’ were considered to be most vulnerable following the post-weaning fast, and that during this time, experts felt it might take ~ 60 days of repeated disturbance before there was expected to be any effect on the probability of survival (Graph 14.20 right), however again, there was a lot of uncertainty surrounding this estimate with estimates ranging between <50 days and >200 days. Similarly to the above, it is considered unlikely that individual harbour seals would repeatedly return to a site where they’d been previously displaced from in order to experience this number of days of repeated disturbance.

Due to observed responsiveness to piling, harbour seals have been assessed as having low sensitivity to disturbance and resulting displacement from foraging grounds during pile-driving events.



Graph 14.20 Probability distributions showing the consensus of the expert elicitation for harbour seal disturbance from piling (Booth et al. 2019)

Magnitude of impact

For harbour seals, the scenario with the maximum level of disturbance per day is the NE monopile installation. The maximum level of disturbance to harbour seals is likely to occur at the NE monopile location due to this piling location's proximity to the Strangford Lough and Murlough SACs designated for harbour seals in Northern Ireland. Within the SACs and their surrounds, increased at-sea densities of harbour seal were observed and thus have the greatest overlap with the noise contours overlain on species density surfaces at the NE monopile location (Figure 14.8).

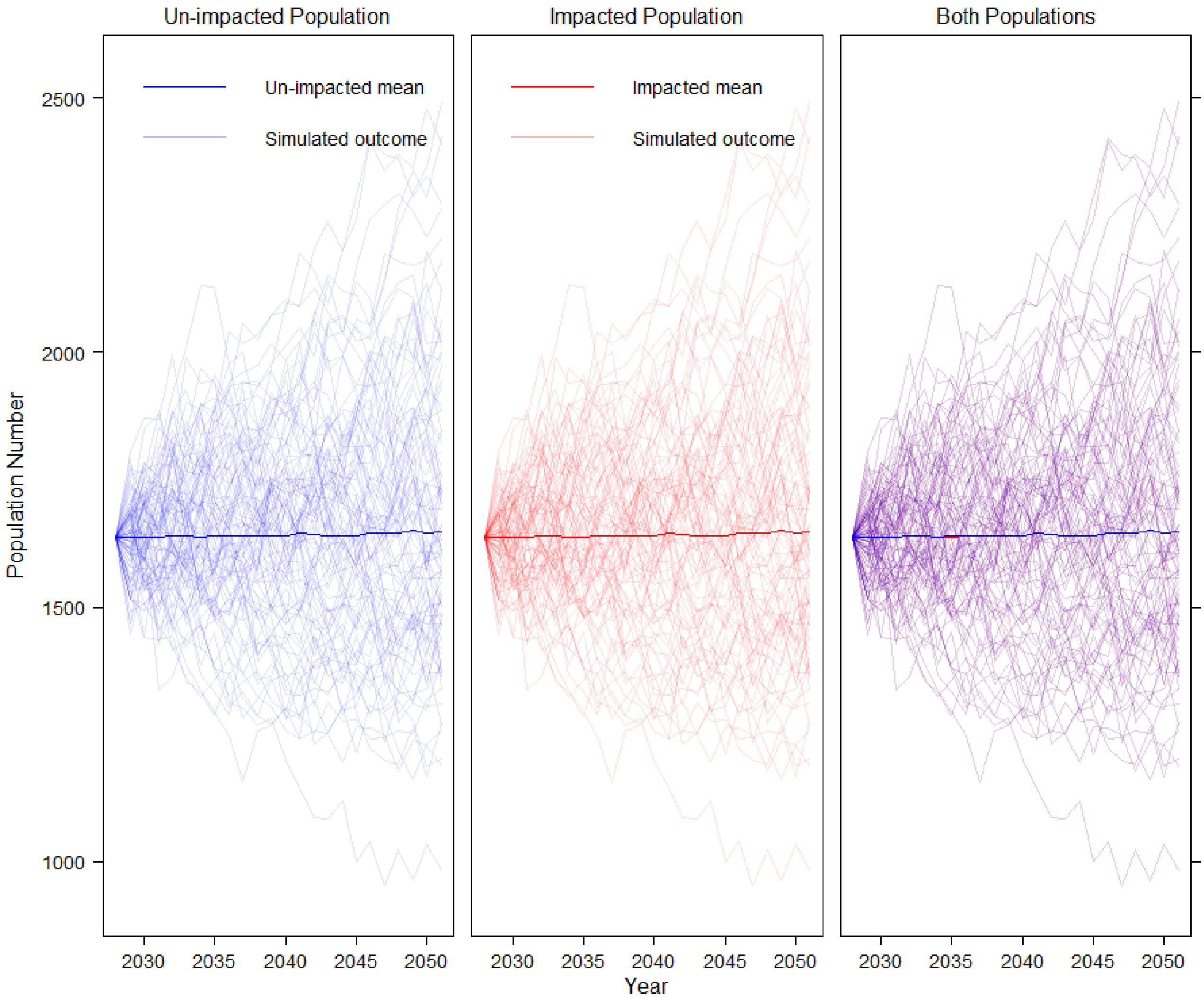
The results for harbour seals are presented with 95% confidence intervals as there was a large amount of uncertainty in dose-response function. A total of 200 harbour seals (95% CI: 21 – 377) are predicted to be impacted within the East and South Ireland, and Northern Ireland MUs due to piling of a monopile at the NE location. This represents 14.65% (95% CI: 1.54% - 27.62%) of the reference population.

For pin piling, a total of 177 harbour seals (95% CI: 18 – 337) are predicted to be impacted within the East and South Ireland, and Northern Ireland MUs at the NE location. This represents 12.97% (95% CI: 1.32% - 24.69%) of the reference population.

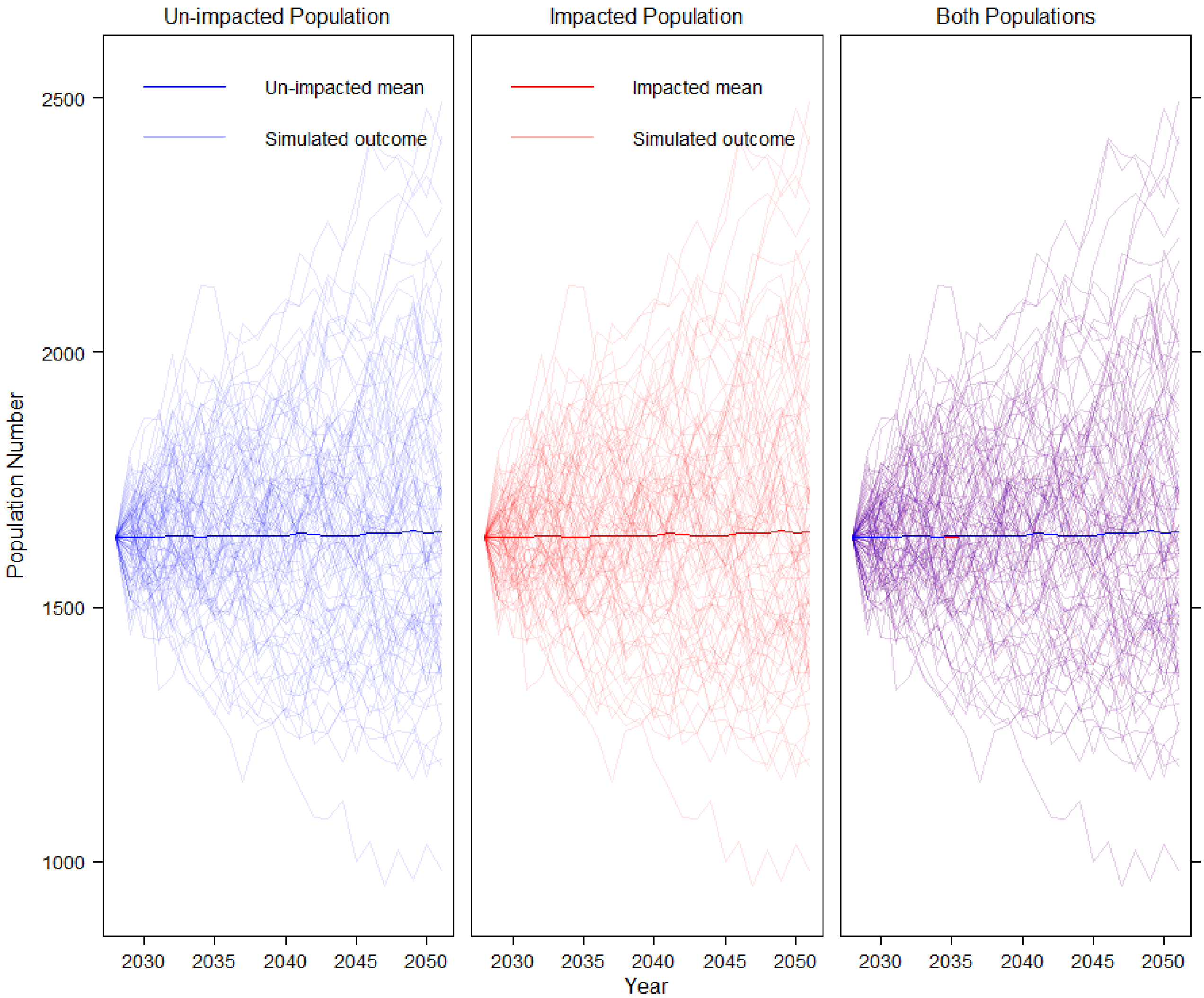
Population modelling

To determine whether this level of disturbance is expected to result in population level impacts, iPCoD modelling was conducted. Modelling assumed the installation of monopiles over a single construction (piling) year, resulting in 51 piling days throughout this period. Modelling also assumed the installation of pin piles over a single piling year, resulting in 72 piling days. The disturbance value used in the modelling was 200 individuals per day for the installation of monopiles, and 177 for the installation of pin piles.

The results of the iPCoD modelling show that there is no effect of disturbance resulting from the proposed development on the size and trajectory of the harbour seal population (Graph 14.21, Graph 14.22, Table 14.38 and Table 14.39). The magnitude of disturbance from pile driving has been assessed as low, since it is expected to result in short-term/ intermittent and temporary behavioural effects (behavioural changes that last days at the most) in a small proportion of the population that occurs over less than a year. Survival and reproductive rates are very unlikely to be impacted to the extent that the population trajectory would be altered.



Graph 14.21 Predicted population trajectories for the un-impacted (baseline) and impacted harbour seals iPCoD simulations (51 days piling (of monopiles) impacting 200 harbour seals per day)



Graph 14.22 Predicted population trajectories for the un-impacted (baseline) and impacted harbour seals iPCoD simulations (72 days piling (of pin piles) impacting 177 harbour seals per day).

Table 14.38 Results of iPCoD modelling for harbour seals

Simulation year	Un-impacted mean population size	Impacted mean population size	Impacted as % of un-impacted population size	Median ratio impacted: un-impacted growth rate
Monopiles				
End 2027 (before piling commences)	1,636	1,636	100	1.00
End 2028 (after piling stops)	1,634	1,634	100	1.00
End 2034 (6 years after piling stops)	1,636	1,636	99.9	1.00
End 2010 (12 years after piling stops)	1,640	1,640	99.9	1.00
Pin Piles				
End 2027 (before piling commences)	1,636	1,636	100	1.00
End 2028 (after piling stops)	1,638	1,638	100	1.00
End 2034 (6 years after piling stops)	1,641	1,641	100	1.00

Simulation year	Un-impacted mean population size	Impacted mean population size	Impacted as % of un-impacted population size	Median ratio impacted: un-impacted growth rate
End 2010 (12 years after piling stops)	1,647	1,647	99.9	1.00

Table 14.39 Predicted impact of disturbance from pile driving activities on harbour seals, with 95% confidence intervals presented in brackets

Location	Number Impacted	% Full MU Impacted	Magnitude informed by iPCoD
Monopile – 5,500 kJ			
NE	200 (21–377)	14.65 (1.54–27.62)	Low
NW	158 (17–296)	11.58 (1.25–21.68)	Low
SE	161 (15–311)	11.79 (1.10–22.78)	Low
SW	138 (13–267)	10.11 (0.95–19.56)	Low
Pin Pile – 3,000 kJ			
NE	177 (18 – 337)	12.97 (1.32–24.69)	Low
NW	139 (14–265)	10.18 (1.03–19.41)	Low
SE	139 (12–270)	10.18 (0.88–19.78)	Low
SW	136 (10–266)	8.49 (0.73–16.56)	Low

Significance of the effect

Project Option 1

Given that the sensitivity of harbour seal receptors has been assessed as low, and the magnitude of disturbance impacts from pile driving has been assessed as low, this significance of effect for Project Option 1 has been assessed as slight, which is not significant in EIA terms.

Project Option 2

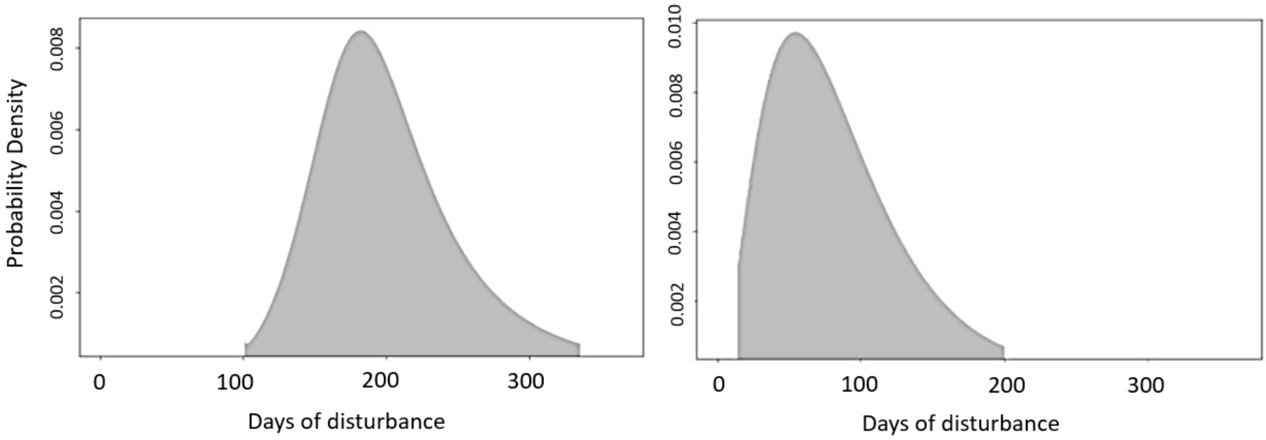
Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of harbour seal receptors has been assessed as low, and the magnitude of disturbance impacts from pile driving has been assessed as low. Therefore, the significance of effect for Project Option 2 has been assessed as slight, which is not significant in EIA terms.

Grey seals

Sensitivity of the receptor

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

The disturbance 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 (animals which have been successfully weaned, i.e., no longer rely on their mother's for survival) and fertility were determined to be most sensitive parameters to disturbance (i.e. reduced energy intake). However, in general, experts agreed that grey seals would be much more robust than harbour seals to the effects of disturbance due to their larger energy stores and more generalist and adaptable foraging strategies. It was agreed that grey seals would require moderate-high levels of repeated disturbance before there was any effect on fertility rates to reduce fertility (Graph 14.23, 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 (Graph 14.23, right). However, there was a lot of uncertainty surrounding this estimate.



Graph 14.23 Probability distributions showing the consensus of the expert elicitation for grey seal disturbance from piling (Booth et al. 2019)

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 can adjust 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 can move 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.

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.

Magnitude of impact

For grey seals, the scenario with the maximum level of disturbance per day is the SE monopile location when using the seal dose-response function.

The results for grey seals are presented with 95% confidence intervals as there was a large amount of uncertainty in dose-response function. A total of 790 grey seals (95% CI: 100 – 1,454) are predicted to be impacted within the East and South Ireland, and Northern Ireland MUs due to piling of a monopile at the SE location. This represents 13.04% (95% CI: 1.65% - 24.01%) of the reference population.

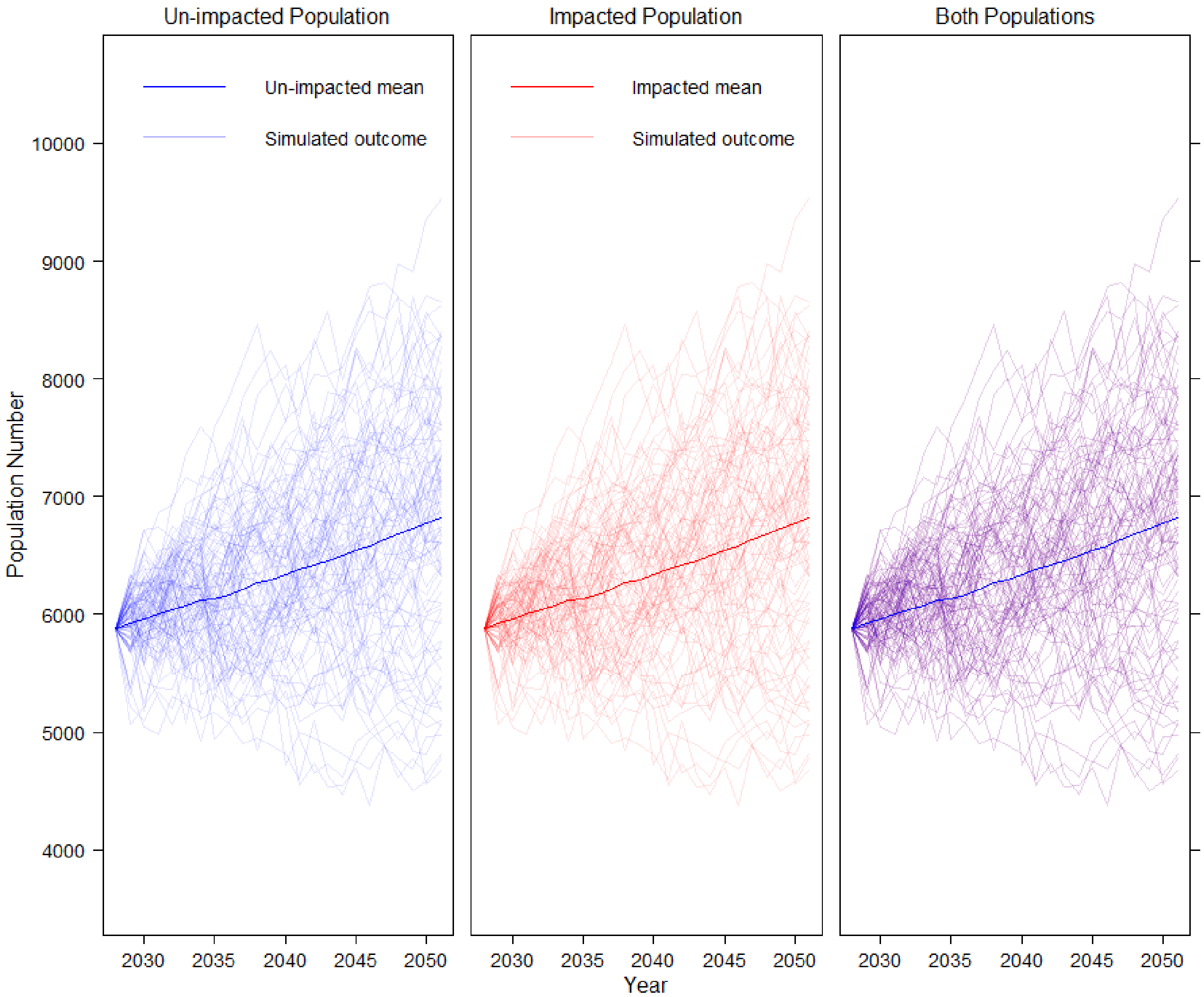
For pin piling, a total of 703 grey seals (95% CI: 85 – 1,302) are predicted to be impacted within the East and South Ireland, and Northern Ireland MUs at the SE location. This represents 11.61% (95% CI: 1.40% - 21.50%) of the reference population.

Population Modelling

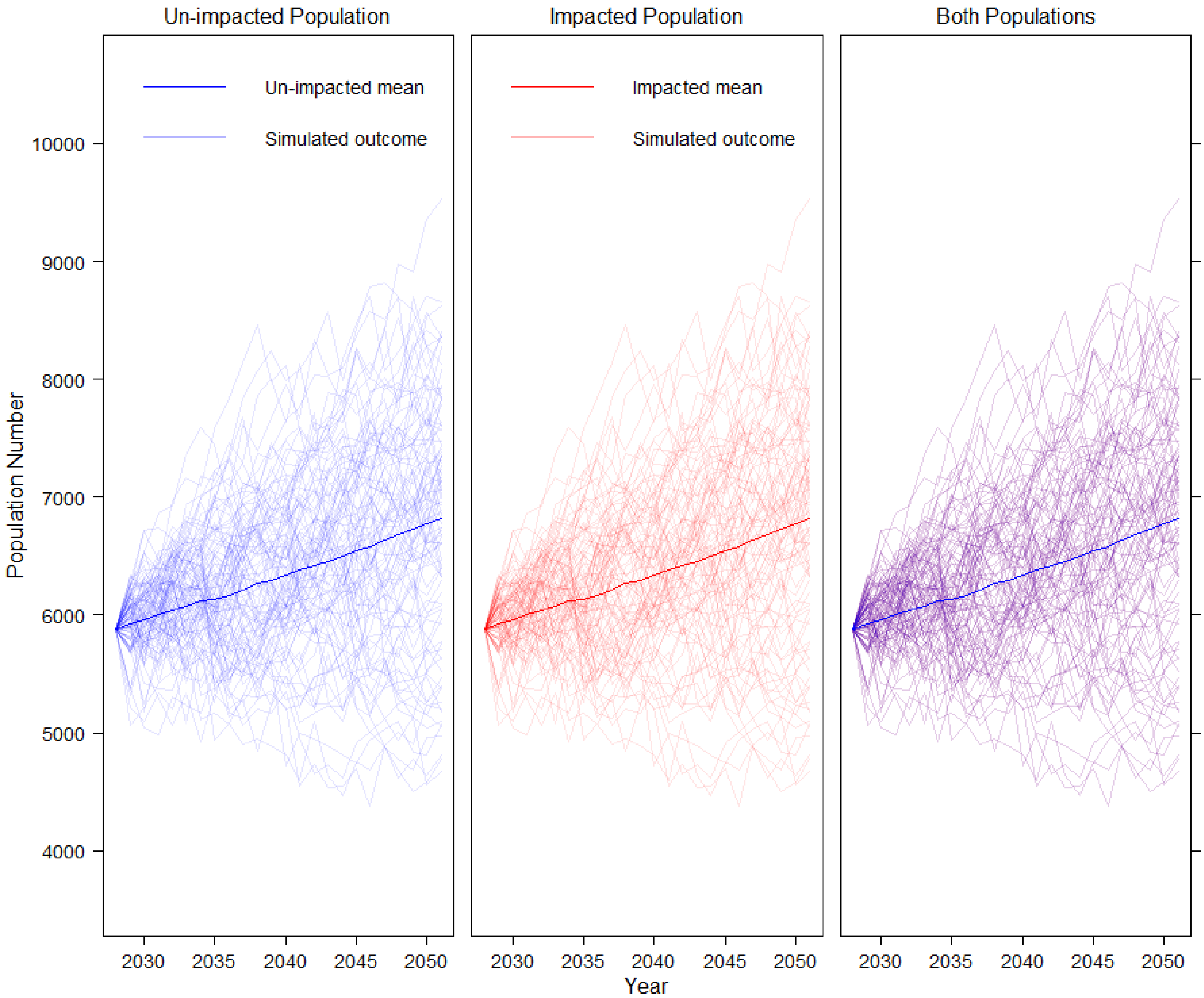
To determine whether this level of disturbance is expected to result in population level impacts, iPCoD modelling was conducted. Modelling assumed the installation of monopiles over a single construction (piling) year, resulting in 51 piling days for the installation of a monopiles, and 72 days for the installation of pin piles. The disturbance value used in the modelling was 790 individuals per day since this was the highest number of animals predicted to be impacted by a monopile location, and 703 for pin piles.

The results of the iPCoD modelling show that there is no effect of disturbance resulting from the proposed development on the size and trajectory of the grey seal population for the installation of monopiles or pin piles (Graph 14.24, Graph 14.25,

Table 14.40 and Table 14.41). The magnitude of disturbance form pile driving has been assessed as low, since it is expected to result in short-term, intermittent and temporary behavioural effects (behavioural changes that last days at the most) in a small proportion of the population that occurs over less than a year. Survival and reproductive rates are very unlikely to be impacted to the extent that the population trajectory would be altered.



Graph 14.24 Predicted population trajectories for the un-impacted (baseline) and impacted harbour seals iPCoD simulations (51 days piling (of monopiles) impacting 790 grey seals per day)



Graph 14.25 Predicted population trajectories for the un-impacted (baseline) and impacted harbour seals iPCoD simulations (72 days piling (of pin piles) impacting 703 grey seals per day)

Table 14.40 Results of iPCoD modelling for grey seals

Simulation year	Un-impacted mean population size	Impacted mean population size	Impacted as % of un-impacted population size	Median ratio impacted: un-impacted growth rate
Monopiles				
End 2027 (before piling commences)	5,880	5,880	100%	1.00
End 2028 (after piling stops)	5,920	5,920	100%	1.00
End 2034 (6 years after piling stops)	6,150	6,150	100%	1.00
End 2040 (12 years after piling stops)	6,409	6,409	100%	1.00
Pin Piles				
End 2027 (before piling commences)	5,880	5,880	100%	1.00
End 2028 (after piling stops)	5,925	5,925	100%	1.00
End 2034 (6 years after piling stops)	6,141	6,141	100%	1.00

Simulation year	Un-impacted mean population size	Impacted mean population size	Impacted as % of un-impacted population size	Median ratio impacted: un-impacted growth rate
End 2040 (12 years after piling stops)	6,358	6,358	100%	1.00

Table 14.41 Predicted impact of disturbance from pile driving activities on grey seals, with 95% confidence intervals presented in brackets

Location	Number Impacted	% Full MU Impacted	Magnitude informed by iPCoD
Monopile – 5,500kJ			
NE	788 (87–1,465)	12.99 (1.43–24.15)	Low
NW	585 (76–1,063)	9.65 (1.25–17.53)	Low
SE	790 (100 – 1,454)	13.03 (1.65 – 23.97)	Low
SW	699 (91 – 1,279)	11.53 (1.50 – 21.09)	Low
Pin Pile – 3,000kJ			
NE	694 (78–1,280)	11.44 (1.28–21.27)	Low
NW	528 (66–963)	8.71 (1.09–15.88)	Low
SE	703 (85 – 1,302)	11.59 (1.40 – 21.47)	Low
SW	627 (76 – 1,157)	10.34 (1.25 – 19.08)	Low

Significance of the effect

Project Option 1

Given that the sensitivity of grey seal receptors has been assessed as negligible, and the magnitude of disturbance impacts from pile driving have been assessed as low, this significance of effect for Project Option 1 has been assessed as imperceptible, which is not significant in EIA terms.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of grey seal receptors have been assessed as negligible, and the magnitude of disturbance impacts from pile driving have been assessed as low. Therefore, the significance of effect for Project Option 2 has been assessed as imperceptible, which is not significant in EIA terms.

14.5.2.8 Impact 8 - Auditory injury (PTS) from other construction activities

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:

- Cable laying (if not trenched): Noise from the cable laying vessel and any other associated noise during the offshore cable laying activities;
- 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 the most impactful approach;
- Trenching: Plough trenching and/or jet trenching may be required during offshore cable installation;
- Drilling: the cable landfall will be constructed by HDD. Note: there is the potential for WTG foundations to be installed using drilling depending on seabed type or if a pile refuses during impact piling operations. WTG installation using impact pile driving is considered the most impactful approach and thus the assessment of foundation installation above is solely for impact piling; and

- Rock placement: Potentially required on site for installation of offshore cables (cable crossings and cable protection) and scour protection around foundation structures.

Each of these activities is an additional underwater noise generating activity occurring in the marine environment. Where these activities occur at the same time as piling, the piling activities will dominate the underwater noise levels. As such, the PTS-onset impact ranges for cable laying, dredging, drilling, trenching and rock placement activities are assessed below.

Sensitivity of the receptor

Cable laying (if not trenched) 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 cable installation is taking place (Genesis 2011). Therefore, the sensitivity of marine mammals from cable laying activities will be the same as for vessel noise (see below). **Vessel noise** is continuous, and is dominated by sounds from propellers, thrusters, and various rotating machinery (e.g., power generation, pumps). In general, support and supply vessels (50-100m in length) are expected to have broadband source levels in the range 165-180dB re 1µPa, with the majority of energy below 1kHz (OSPAR 2009). Large commercial vessels (>100m in length) produce relatively loud and predominately low frequency sounds, with the strongest energy concentrated below several hundred Hz. For porpoise, dolphins and seals, the hearing sensitivity below 1kHz 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 porpoise, dolphins, and seals to PTS from cable laying is assessed as low. The low frequency noise produced during cable laying may be more likely to overlap with the hearing range of low frequency cetacean species such as minke whales. Therefore, the sensitivity of minke whales to PTS from cable laying is assessed as medium.

Dredging is described as a continuous broadband sound source, with the main energy below 1kHz; however, the frequency and sound pressure level can vary considerably depending on the equipment, activity, and environmental characteristics (Todd et al. 2015). At the proposed development, dredging will potentially be required for seabed preparation work for foundations as well as for export cable and inter-array cable installations. The source level of dredging has been described to vary between SPL 172-190dB re 1µPa @ 1m with a frequency range of 45Hz to 7kHz (Evans 1990, Thompson et al. 2009, Verboom 2014). It is expected that the underwater noise generated by dredging will be below the PTS-onset threshold (Todd et al. 2015) and thus the risk of injury is unlikely, though disturbance may occur. For porpoise, dolphins and seals, the hearing sensitivity below 1kHz 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 porpoise, dolphins, and seals to PTS from dredging is assessed as low. 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 2kHz (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 40dB of best sensitivity) to extend from 30 to 100Hz up to 7.5 to 25kHz, depending on the specific model used. Therefore, the sensitivity of minke whale to PTS from dredging is precautionarily assessed as medium.

Trenching during cable installation is highly variable underwater noise generation 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 100Hz–1kHz and in general the sound levels were generally only 10–15dB above background levels (Nedwell et al. 2003). For porpoise, dolphins and seals, the hearing sensitivity below 1kHz 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 porpoise, dolphins, and seals to PTS from trenching is assessed as low. The low frequency noise produced during trenching may be more likely to overlap with the hearing range of low frequency cetacean species such as minke whales. Therefore, the sensitivity of minke whale to PTS from trenching is precautionarily assessed as medium.

Drilling noise 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 is concentrated at 125Hz (Nedwell et al. 2003). For harbour porpoise, dolphins and seals, the hearing sensitivity below 1kHz is relatively poor and thus it is expected that a PTS at these low frequency ranges would result in little impact to vital rates.

Therefore, the sensitivity of harbour porpoise, dolphins and seals to PTS from drilling noise is assessed as low. The low frequency noise produced during drilling 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.

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

MMO (2015) provide information on the acoustic properties of anthropogenic continuous noise sources; this includes noise sources such as dredging, drilling and shipping. For all three activities, the main energy is listed as being <1kHz. For porpoise, dolphins and seals species considered here, the hearing sensitivity below 1kHz is relatively poor and thus it is expected that a PTS at these low frequency ranges would result in little impact to vital rates and, therefore, their sensitivity is assessed as low. As minke whales have a greater hearing sensitivity below 1kHz, meaning their hearing range is more likely to overlap with other construction, activities their sensitivity has precautionarily been assessed as medium.

Magnitude of impact

Using the non-impulsive weighted SEL_{cum} PTS-onset thresholds resulted in estimated PTS impact ranges of <100m for all marine mammal species for all non-piling construction noise (Table 14.42). Given the *de minimis* extent of the impact range, <1 individual of each species is predicted to be impacted by each of these activities. Therefore, the impact of these sources will have a negligible magnitude.

Table 14.42 Summary of the source level (SPL_{rms} dB re 1μPa @ 1m) and PTS-onset impact ranges for the different construction noise sources using the non-impulsive SEL_{cum} criteria from Southall et al., (2019)

Source	Estimated unweighted source level dB re 1μPa @ 1m (RMS)	VHF (Harbour porpoise)	HF (Common dolphin, bottlenose dolphin)	LF (Minke whale)	PCW (Grey & harbour seal)
Cable laying	171	<100m	<100m	<100m	<100m
Suction dredging	186	<100m	<100m	<100m	<100m
Backhoe dredging	165	<100m	<100m	<100m	<100m
Trenching	172	<100m	<100m	<100m	<100m
Drilling	169	<100m	<100m	<100m	<100m
Rock placement	172	<100m	<100m	<100m	<100m

Significance of the effect

Project Option 1

The sensitivity of porpoise, dolphins and seals to auditory injury (PTS) from other construction activities has been assessed as low. The sensitivity of minke whales to auditory injury (PTS) from other construction activities has been assessed as medium. The magnitude of auditory injury (PTS) from other construction activities has been assessed as negligible for all species. Therefore, the significance of effect for Project Option 1 is imperceptible, which is not significant in EIA terms, for porpoise, dolphins and seals, and slight, which is not significant in EIA terms, for minke whales.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of porpoise, dolphins and seals to auditory injury (PTS) from other construction activities is assessed as low, and the sensitivity of minke whales to auditory injury (PTS) from other construction activities is assessed as medium. Therefore, the significance of effect for Project Option 2 is imperceptible, which is not significant in EIA terms, for porpoise, dolphins and seals, and slight, which is not significant in EIA terms, for minke whales.

14.5.2.9 Impact 9 - Disturbance from other construction activities

Although impact piling is expected to be the greatest overall noise source during construction, several other anthropogenic noise sources may be present. However, in general there is little evidence on the impact of disturbance of marine mammals from all other construction activities, and available studies focus primarily on disturbance from dredging where confirmed behavioural responses have been observed in cetaceans. The likely sensitivities of each species based on the evidence presented from the available studies, and the likely impact magnitudes are discussed in turn below.

Sensitivity

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).

Harbour porpoise

Harbour porpoise occurrence decreased at the Beatrice and Moray East offshore wind farms during non-piling construction periods. The probability of detecting porpoise in the absence of piling decreased by 17% as the sound pressure levels from vessels during the construction period increased by 57dB (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 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 porpoise to disturbance from other construction activities is considered low.

Dolphin species (Bottlenose and common dolphins)

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).

In a study conducted in northwest Ireland, construction related activity (including dredging) did not result in any evidence of a negative impact to common dolphins (Culloch et al. 2016).

In addition, 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. 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).

Therefore, their sensitivity to disturbance from other construction activities is assessed as low.

Minke whale

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. 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, their sensitivity to disturbance from other construction activities is assessed as low.

Harbour and grey seal

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 2 hours of the piling activity (Russell et al. 2016). 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 area is located in a low-density area for both species of seal, and thus it is not expected that any short term-local displacement caused by construction related activities would result in any changes to individual vital rates. Therefore, the sensitivity of both seal species to disturbance from other construction activities is considered low.

Magnitude

Dredging

Harbour porpoise: Dredging at a source level of 184dB re 1μPa at 1m resulted in avoidance up to 5km 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 600m 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 192dB re 1μPa) predicted a disturbance range of 400m, while a more conservative approach predicted avoidance of harbour porpoise up to 5km (McQueen et al. 2020). As disturbance from dredging activities has been observed as short-term and/or intermittent behavioural effects on a small proportion of harbour porpoise individuals, the magnitude of this impact is considered low.

Bottlenose dolphin: 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 1km 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).

Again, as disturbance from dredging activities has been observed as short-term and/or intermittent behavioural effects on a small proportion of dolphin individuals, the magnitude of this impact is considered low.

Common dolphin: There is currently no information available on the impacts of dredging for common dolphins. Localised, temporary avoidance of dredging activities is assumed as with bottlenose dolphins and thus, a low magnitude of impact is predicted.

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). However, disturbance from dredging activities on minke whale is predicted to be short-term and thus, the magnitude of this impact is considered low.

Grey and harbour seal: Based on the generic threshold of behavioural avoidance of pinnipeds (140dB re 1µPa SPL) (Southall et al. 2007), acoustic modelling of dredging demonstrated that disturbance could be caused to individuals between 400m to 5km from site (McQueen et al. 2020). However, disturbance from dredging activities on seal species, irrespective of disturbance distance, is predicted to be short-term and thus, the magnitude of this impact is considered low.

Drilling (cable HDD)

Drilling noise and its impacts to marine mammals is largely unknown. 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 115dB 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 122dB 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 baleen whales may occur at distances of between 10-20km, and will vary depending on the species (Greene Jr 1986, LGL and Greeneridge 1986, Richardson and Wursig 1990). Whilst information is not available for the species of concern for the proposed development, it is still considered useful as it suggests that at least some species of cetacean may experience disturbance as a result of drilling.

Drilling activity associated with the cable HDD 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 proposed development. Therefore, it is considered that drilling associated with the cable HDD could potentially cause disturbance over distances of up to 5km from the noise source based on results for dredging, rather than up to 20km based on results from the drilling literature, as this literature is considered slightly outdated. However, disturbance from drilling activities is predicted to be short-term and thus, the magnitude of this impact is considered low.

Drilling activity associated with WTG foundation installation is considered to be less than that of impact piling and thus is not assessed further here.

Other

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).

It is expected that any disturbance impact will be primarily driven by the underwater noise generated by vessels during non-piling construction related activities, and, as such, it is expected that any impact of disturbance is highly localised (within 5km). The indicative offshore construction period is expected to start in 2027 with:

- Offshore export cable installation lasting up to 4.5 months
- Foundation installation lasting up to nine months
- Array cable installation lasting up to six months; and
- Wind turbine installation lasting up to 7.5 months.

Given that there will be overlap in these activities, it is expected that offshore construction related work will occur within a 3 year period. Therefore, the duration of disturbance will be limited to two breeding cycles. This aligns with the definition of low magnitude.

Significance of the effect

Project Option 1

The sensitivity of all species to disturbance from other construction activities has been assessed as low. The magnitude of disturbance from other construction activities has been assessed as low for all species. Therefore, the significance of effect for Project Option 1 is slight for all species, which is not significant in EIA terms.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of all marine mammals to disturbance from other construction activities is assessed as low, and the magnitude of disturbance from other construction activities is assessed as low. Therefore, the significance of effect for Project Option 2 is slight for all species, which is not significant in EIA terms.

14.5.2.10 Impact 10 - Collision with vessels

The area surrounding the proposed development already experiences a high amount of vessel traffic see Volume 3, Chapter 17: Shipping and Navigation (hereafter the Shipping and Navigation Chapter) for full details). The dedicated marine traffic survey (detailed within Chapter 17 Shipping and Navigation) study recorded 28 days of vessel traffic data, with surveys in summer 2022 (14 days in July) and winter 2023 (14 days in December).

For the 14 days analysed in summer 2022, there was an average of 39 unique vessels per day recorded within the shipping and navigation study area, ten unique vessels per day intersecting the array area, and six unique vessels per day intersecting the ECC. The busiest day recorded 60 unique vessels within the shipping and navigation study area. The main vessel types within the shipping and navigation study area in the summer were fishing vessels (38%), recreational vessels (32%), and cargo vessels (11%).

For the 14 days analysed in winter 2023, there was an average of 17 unique vessels per day recorded within the shipping and navigation study area, three unique vessels per day intersecting the array area, and three unique vessels per day intersecting the ECC. The busiest day recorded 28 unique vessels within the shipping and navigation study area. The main vessel types within the shipping and navigation study area in the winter were cargo vessels (46%), fishing vessels (27%), and other vessels (11%) which were mainly pilot vessels associated with Drogheda Port and RNLI lifeboats and a buoy-laying vessel.

During the construction phase of the proposed development, a total of 47 construction vessels may be on site at one time with a maximum total of 2,386 return vessel trips throughout the construction phase. A potential source of impact from increased vessel activity is physical trauma from collision with a boat or ship. These injuries include blunt trauma to the body or injuries consistent with propeller strikes.

The risk of collision of marine mammals with vessels would be directly influenced by the type of vessel and the speed with which it is travelling (Laist et al. 2001) and indirectly by ambient noise levels underwater and the behaviour the marine mammal is engaged in.

Generally, vessels travelling at higher speeds pose a higher collision risk, and smaller vessels that are more manoeuvrable are expected to pose a lower collision risk (Schoeman et al. 2020).

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 Ireland 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[16], 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.

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).

Sensitivity of the receptor

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. 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. However, should a collision event occur, this has the potential to kill the animal. As a result of the low vulnerability to a strike but the serious consequences of a strike, marine mammal receptors are considered to have a high sensitivity to vessel collisions.

Magnitude of impact

The embedded mitigation of vessel codes of conduct (see Section 14.4.5) will ensure that vessel traffic moves (where possible) along predictable routes and will define how vessels should behave in the presence of marine mammals. It is highly likely that a proportion of vessels will be stationary or slow moving throughout construction activities for significant periods of time. Therefore, the actual increase in vessel traffic moving around the site and to/from port to the site will occur over short periods of the offshore construction activity. Furthermore, due to the already high volume of vessel traffic already in the vicinity of the proposed development, the introduction of additional vessels during construction of the proposed development is not a novel impact for marine mammals present in the area. It is not expected that the level of vessel activity during construction would cause an increase in the risk of mortality from collisions. The adoption of a vessel code of conduct during construction will minimise the potential for any impact. Therefore, the magnitude of the risk of vessel collisions occurring is negligible.

Significance of the effect

Project Option 1

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 for Project Option 1 is concluded to be slight, which is not significant in EIA terms.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of all marine mammals is assessed as high, and the magnitude of impact is assessed as negligible.

[16] (CSIP 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)

Therefore, the significance of the effect of collisions from vessels Project Option 2 is concluded to be slight, which is not significant in EIA terms.

14.5.2.11 Impact 11 - Disturbance from vessels

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.

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

As stated in the Shipping and Navigation chapter, the area surrounding the proposed development already experiences high levels of vessel traffic. Therefore, the introduction of additional vessels during construction 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.

The results of the quantitative assessment are presented in Table 14.43 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 4km no significant effects of construction vessels could be detected (Benzema-Le Gall et al. 2021). As such, a 4km disturbance range has been used to determine the magnitude of impact.
- *Bottlenose dolphins*: vessels within 400m 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 400m disturbance range has been used to determine the magnitude of impact.
- *Common dolphin*: vessels within 300m of a dolphin group have been found to result in short-term changes to common dolphin behaviour (Meissner et al. 2015). As such, a 300m disturbance range has been used to determine the magnitude of impact.
- *Minke whale*: in baleen whales, observed changes in foraging behaviour were apparent when whale-watching vessels were within ~250m of an animal (Sullivan and Torres 2018). As such, a 250m 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 1km (Young et al. 2014). As such, a 1km disturbance range has been used to determine the magnitude of impact.

Table 14.43 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/km2)	Disturbance Radius	Area (km2)	Number Impacted	% MU
Harbour porpoise	0.2803 (SCANS IV)	4km	50.27	14	<0.1%
	0.38 (site-specific DAS)			19	<0.1%
Bottlenose dolphin	0.2352 (SCANS IV)	400m	0.50	< 1	<0.1%
	0.002 (DAS)			< 1	<0.1%
Common dolphin	0.04 (site-specific DAS)	300m	0.28	< 1	<0.1%
	0.0272 (SCANS IV)			< 1	<0.1%
Minke whale	0.0137 (SCANS IV)	250m	0.20	< 1	<0.1%
Grey seal	0.421 (average across array area and ECC)	1km	3.14	1	<0.1%
Harbour seal	0.115 (average across array area and ECC)			< 1	<0.1%

Harbour porpoise

Sensitivity of the receptor

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).

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. 2021). For example, the probability of harbour porpoise occurrence at a mean vessel distance of 2km 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 3km, the probability decreased by up to 57% to 0.16 for the highest vessel intensity, and no apparent response was observed at 4km.

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. 2021). 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 2km 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).

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, a stereotypical disturbance behaviour, was observed in 27.5% of cases (Dyndo et al. 2015).

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 1km 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 200m 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.

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 96dB re 1 µPa (16kHz 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).

Behaviour based modelling has indicated the potential for vessel disturbance to have population level effects under certain circumstances. Nabe-Nielsen et al. (2014) simulated harbour porpoise response 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 and, therefore, Nabe-Nielsen et al. (2014) suggest that conservation efforts should instead focus more closely on this issue.

In conclusion, there is some 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. 2021). This displacement can also be exemplified by surveying for harbour porpoise in an area with variable levels of vessel traffic, where reductions in local density suggest disturbance from the surrounding area. Furthermore, the type of vessel impacts the frequency distribution of the produced sound; this is likely of importance for harbour porpoise as high frequency components have been linked to negative behavioural responses, even at low levels. The sensitivity of harbour porpoise to disturbance from vessel activity is therefore classified as medium.

Magnitude of impact

Benhemma-Le Gall et al. (2021) found no apparent response of harbour porpoise to construction vessels in the Moray Firth at 4km. Therefore, a 4km disturbance range for harbour porpoise disturbance from construction vessels has been used to determine the magnitude of impact (Table 14.43). Using the 4km disturbance radii, up to 19 harbour porpoise individuals are anticipated to be disturbed by construction vessels, which equates to <0.1% of the MU. When considering the impact 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 shall only impact a very small proportion of the population. As such, the magnitude of disturbance from construction vessel activity from the proposed development can be assessed as negligible.

Significance of the effect

Project Option 1

The sensitivity of porpoise has been assessed as medium and the magnitude of disturbance from construction vessels has been assessed as negligible. Therefore, the significance of effect for Project Option 1 is assessed as slight, which is not significant in EIA terms.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of porpoise is assessed as medium and the magnitude of disturbance from construction vessels has been assessed as negligible. Therefore, the significance of effect Project Option 2 is assessed as slight (not significant).

Bottlenose dolphin

Sensitivity of the receptor

Although no studies on the interactions of bottlenose dolphins with vessels exist for Ireland specifically, other studies have demonstrated vessel disturbance has been shown to negatively affect foraging activity. Pirotta et al. (2015b) used PAM to quantify how vessel disturbance affected foraging activity. The results indicated that a short term 49% reduction in foraging activity, with animals resuming foraging after the vessel had travelled through the area was associated with vessel presence.

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 plays a larger role in disturbance as vessel noise was not taken into consideration (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).

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 1m and 13m respectively). Dolphins have been demonstrated to avoid shallow waters as a predator avoidance response, and similar responses have resulted from vessel disturbance (Lusseau 2006).

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.

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).

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 wind farm development. The parameters for the model are similar to those of the proposed development, where existing vessel traffic is high. 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).

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 and can cause 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

Vessels within 400m 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 400m disturbance range has been used to determine the magnitude of impact (Table 14.43). Using the 400m disturbance radii, <1 bottlenose dolphin individual is predicted to be disturbed by vessel presence, which equates to <0.1% of the MU.

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 shall 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

Project Option 1

The sensitivity of bottlenose dolphins has been assessed as low and the magnitude of disturbance from construction vessels has been assessed as negligible. Therefore, the significance of effect for Project Option 1 is assessed as imperceptible, which is not significant in EIA terms.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of bottlenose dolphins to disturbance from construction vessels is assessed as low and the magnitude of disturbance is assessed as negligible. Therefore, the significance of effect Project Option 2 is assessed as imperceptible, which is not significant in EIA terms.

Common dolphin

Sensitivity of the receptor

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.

Meissner et al. (2015) reported that the presence of interacting vessels affected the behavioural budget (the proportion or percent of time that an animal spends in a particular activity based on the observations made) 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 > 300m away from dolphin group). In addition, Meissner et al. (2015) reported that the probability of starting to forage while engaged in travelling in the presence of a cetacean-watching vessel decreased by two thirds. Given foraging tactics used by common dolphins include cooperative herding of prey (Neumann and Orams 2003), it is possible that the behavioural changes of some individuals, as a result of approaching vessels, could compromise the success of the overall foraging event (Meissner et al., 2015).

When considering the impacts of cetacean-watching vessels reported by Meissner et al. (2015) to those likely to occur from construction vessel activities, they cannot be directly transposed, as the likely interactions between common dolphins and vessels during the construction of the proposed development 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

As vessels within 300m of a common dolphin group have been found to result in short-term changes to common dolphin behaviour, a 300m disturbance range has been used to determine the magnitude of impact (Table 14.43). Using the 300m disturbance radii, <1 common dolphin individual is predicted to be disturbed by vessel presence, which equates to <0.1% of the MU.

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 shall 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

Project Option 1

The sensitivity of common dolphins has been assessed as low and the magnitude of disturbance from construction vessels has been assessed as negligible. Therefore, the significance of effect for Project Option 1 is assessed as imperceptible, which is not significant in EIA terms.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of common dolphins to disturbance from construction vessels is assessed as low, and the magnitude of impact is assessed as negligible. Therefore, the significance of effect Project Option 2 is assessed as imperceptible, which is not significant in EIA terms.

Minke whale

Sensitivity of the receptor

There is little information available on the behavioural responses of minke whales as a result of vessel presence and/or disturbance.

Minke whales have been shown to change their diving patterns and behavioural state in response to disturbance from whale watching vessels; and it was suggested that a reduction in foraging activity at feeding grounds could result in reduced reproductive success in this capital breeding species (Christiansen et al. 2013a). By analysing the respiration rate of minke whales, energy expenditure was estimated to be 28% higher during boat interactions, regardless of swim speed. In the same study, Christiansen et al. (2013) also analysed the respiration rate and reported that 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).

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 imperceptible impact.

When considering the impacts of whale watching vessels reported by Christiansen et al. (2013 & 2015) and Christiansen and Lusseau (2015) to those likely to occur from construction vessel activities, they cannot be directly transposed, as disturbance effects from whale watching are from vessels targeting the animals, whilst those from construction activities are vessels which do not target animals. However, as there are little empirical data on the behavioural variability of minke whale as a result of vessel disturbance, the information presented by Christiansen et al. (2013) and Christiansen and Lusseau (2015) is used as a proxy to inform this assessment.

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

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 vessel were within ~150m of the individuals. In grey whales, observed changes in foraging behaviour were apparent when whale-watching vessels were within ~250m 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 (Table 14.43). Using the 250m disturbance radii, <1 minke whale individual is predicted to be disturbed by vessel presence, which equates to <0.1% of the MU.

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 shall 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

Project Option 1

The sensitivity of minke whales has been assessed as low and the magnitude of disturbance from construction vessels has been assessed as negligible. Therefore, the significant of effect for project Option 1 is assessed as imperceptible, which is not significant in EIA terms.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of minke whales to disturbance from construction vessels is assessed as low and the magnitude of impact is assessed as negligible. Therefore, the significance of effect Project Option 2 is assessed as imperceptible, which is not significant in EIA terms.

Harbour and grey seals

Sensitivity

A recent 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 of the 28 tagged individuals may have experienced a TTS due to cumulative sound exposure levels exceeding the TTS-threshold for pinnipeds exposed to continuous underwater noise (183dB re 1μPa^2) proposed by Southall et al. (2007). The overlap between seals and vessel activity most frequently occurred within 50km 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.

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 to decrease 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

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 1km (Young et al. 2014), whilst alertness in seals at the haul-out site can increase when small vessels (i.e., kayaks and small motorboats) are within 300m 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 (Table 14.43). Using the 1km disturbance radii, 1 grey seal individual and < 1 harbour seal individual are predicted to be disturbed by vessel presence, which equates to <0.1% of the MU for both species.

When considering the impact of disturbance from vessel noise, this is predicted to be of local spatial extent, short-term and reversible. In addition, seals are able to shift to an energetically conservative state in response to the disturbance event whilst in water, and vessels will be required to follow specific navigation routes to and from the proposed development, with limited to no interactions with seal haul-out sites. The magnitude of disturbance from vessel activity is therefore assessed as negligible.

Significance of the effect

Project Option 1

The sensitivity of both seal species has been assessed as low and the magnitude of disturbance from construction vessels has been assessed as negligible. Therefore, the significance of effect for Project Option 1 is assessed as imperceptible, which is not significant in EIA terms.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of both harbour and grey seals to disturbance from construction vessels is low, and the magnitude of impact is negligible. Therefore, the significance of effect for Project Option 2 is assessed as imperceptible, which is not significant in EIA terms.

14.5.2.12 Impact 12 - Prey availability and distribution

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 these fish species, including:

- Temporary increase in suspended sediment concentration (SSC) and sediment deposition
- Temporary damage and disturbance of the seabed
- Reduction in water and sediment quality through the release of contaminated sediments and/or accidental contamination
- Introduction of underwater noise and vibration leading to mortality, injury, behavioural changes, or auditory masking.

The key prey species for each marine mammal receptor are listed in Table 14.44.

Table 14.44 Key prey species of the marine mammal receptors (bold = species present at the proposed development)

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 sp.	Hernandez-Milian et al. (2015)
Common dolphin	British Isles	Seabass, goby, cod, cephalopods, mackerel, lanternfish, blue whiting	Brophy et al. (2009)
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, sandeel, dragonet, red bandfish, plaice, flounder, sole, squid and octopus species	Kavanagh et al. (2010)

Sensitivity

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

Magnitude

The assessment provided in Volume 3, Chapter 13: Fish and Shellfish Ecology indicates that the overall adverse impacts to fish species from the construction of the proposed development will be not significant to slight (not significant):

- Temporary increase in SSC and sediment deposition = Slight
- Temporary damage and disturbance of the seabed = Slight
- Reduction in water and sediment quality through the release of contaminated sediments and/or accidental contamination = Not significant
- Introduction of underwater noise and vibration leading to mortality, injury, behavioural changes, or auditory masking = Slight.

Given that there is expected to be no significant impacts to any of their prey species, the predicted impact on marine mammals is of negligible magnitude.

Significance of the effect

Project Option 1

The sensitivity of receptors as low and the magnitude of the impact has been assessed as negligible. Therefore, the significance of the effect of changes in fish abundance/distribution, in relation to impacts on marine mammals during construction for Project Option 1, is concluded to be imperceptible, which is not significant in EIA terms.

Project Option 2
Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of to changes in prey availability shall remain low, and the magnitude of impact shall be negligible. Therefore, the significance of effect to changes in fish abundance/distribution for Project Option 2 is determined to be imperceptible, which is not significant in EIA terms.

14.5.2.13 Impact 13 - Increased concentrations of suspended sediments
Disturbance to water quality as a result of construction activities can have both direct and indirect impacts on marine mammals. Indirect impacts include effects on prey species. Direct impacts include the impairment of visibility and therefore foraging ability which might be expected to reduce foraging success. During construction of the proposed development, sediment will be disturbed and released into the water column. This will give rise to suspended sediment plumes and localised changes in bed levels as material settles out of suspension.

Sensitivity
Marine mammals are well known to forage in tidal areas where water conditions are turbid and visibility conditions poor. For example, harbour porpoise and harbour seals in the UK have been documented foraging in areas with high tidal flows (Pierpoint 2008, Marubini et al. 2009, Hastie et al. 2016); therefore, low light levels, turbid waters and suspended sediments are unlikely to negatively impact marine mammal foraging success. As such, the sensitivity of marine mammals is assessed as negligible.

Magnitude
It is important to note that it is hearing, not vision that is the primary sensory modality for most marine mammals. When the visual sensory systems of marine mammals are compromised, they are able to sense the environment in other ways, for example, seals can detect water movements and hydrodynamic trails with their mystacial vibrissae[17]; while odontocetes primarily use echolocation to navigate and find food in darkness (Hanke et al. 2010, Hanke and Dehnhardt 2013, Hanke et al. 2013). Any disturbance to the seabed will be localised and any resultant increase in SSC will be temporary so will be of negligible magnitude.

Significance of the effect

Project Option 1
Short-term increased turbidity is not anticipated to impact marine mammals which rely primarily on hearing, resulting in negligible sensitivity of marine mammals to changes in water quality and the magnitude of the impact has been assessed as negligible. Therefore, the significance of the effect of changes in water quality for Project Option 1 is concluded to be imperceptible, which is not significant in EIA terms.

Project Option 2
Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of changes to suspended sediments shall remain negligible, and the magnitude of impact shall be negligible. Therefore, the significance of effect to changes in suspended sediments for Project Option 2 shall be imperceptible (not significant).

14.5.3 Operational Phase
The potential environmental impacts arising from the operational phase of the proposed development are listed in Table 14.15. A description of the likely significant effects on marine mammal ecology receptors caused by each identified impact is given below.

[17] Vibrissae are the facial whiskers (or mystacial vibrissae).

14.5.3.1 Impact 14 - Collision with vessels

As stated in Section 14.5.2.10, the area surrounding the proposed development already experiences a high amount of vessel traffic (see the Shipping and Navigation Chapter for full details). Therefore, the introduction of additional vessels during the operational phase of the proposed development is not a novel impact for marine mammals present in the area.

Sensitivity of the receptor

The sensitivity of marine mammals to vessel collisions is the same irrespective of the proposed development phase. As detailed in Section 14.5.2.10, marine mammal receptors are considered to have a high sensitivity to vessel collisions.

Magnitude of impact

The operational phase may last for up to 35 years with up to 21 operational vessels located on-site simultaneously, in turn making a maximum of 1,018 return trips to port for Project Option 1 and 856 for Project Option 2 throughout the 35-year operational period. A proportion of these vessels will be stationary or slow moving throughout the operational phase activities for significant periods of time.

The embedded mitigation of vessel codes of conduct (see Section 14.4.5) will ensure that vessel traffic moves (where practicable along predictable routes and will define how vessels should behave in the presence of marine mammals. It is highly likely that a proportion of vessels will be stationary or slow moving throughout operational phase activities for significant periods of time. Furthermore, due to the already high volume of vessel traffic already in the vicinity of the proposed development, the introduction of additional vessels during the operational phase of the proposed development is not a novel impact for marine mammals present in the area. It is not expected that the level of vessel activity during the operational phase would cause an increase in the risk of mortality from collisions. The adoption of a vessel code of conduct will reduce the potential for any impact. Therefore, the magnitude of the risk of vessel collisions occurring is negligible.

Significance of the effect

Project Option 1

The sensitivity of receptors has been assessed as high magnitude and the impact has been assessed as negligible. Therefore, the significance of the effect of collisions from vessels for Project Option 1 is concluded to be of slight, which is not significant in EIA terms.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of all marine mammals is assessed as high, and the magnitude of impact is assessed as negligible. Therefore, the significance of the effect of collisions from vessels Project Option 2 is concluded to be slight, which is not significant in EIA terms.

14.5.3.2 Impact 15 - Disturbance from vessels

As stated in Section 14.5.2.11, 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.

Sensitivity of the receptor

The sensitivity of marine mammals to vessel disturbance is the same irrespective of the proposed development phase. As detailed in Section 14.5.2.11, the sensitivity of marine mammals is as follows:

- Harbour porpoise: Medium
- Bottlenose dolphin: Low

- Common dolphin: Low
- Minke whale: Low
- Seals: Low.

Magnitude of impact
As stated in Section 14.5.2.11, the area surrounding the proposed development already experiences a high amount of vessel traffic (see the Shipping and Navigation Chapter for full details). Therefore, the introduction of additional vessels during the operational phase of the proposed development is not a novel impact for marine mammals present in the area. Results from the dedicated marine traffic survey (detailed within Chapter 17 Shipping and Navigation) identified an average of 39 vessels within the study area per day during the summer survey in 2022 and 17 per day during winter of 2023 as a baseline level of vessel activity.

The operational phase will last for 35 years with up to 21 operational vessels located on-site simultaneously, in turn making a maximum of 1,018 return trips to port for Project Option 1 and 856 for Project Option 2 throughout the 35-year operational period. A proportion of these vessels will be stationary or slow moving throughout the operational phase activities for significant periods of time.

Vessel traffic in the proposed development boundary, even considering the addition of the proposed development operational traffic is less than that during the construction period (when up to 47 vessels may be on site at the same time). When considering the impact of disturbance from vessel noise, this is predicted to be of local spatial extent, short-term and reversible. However, the duration of the overall impact (35 years) is much longer than during the construction phase, therefore the magnitude of impact during the operational phase should be considered higher than in the construction phase. The magnitude of disturbance from vessel activity is therefore assessed as low.

Significance of the effect

Project Option 1
The sensitivity of marine mammals has been assessed as low to medium and the magnitude of impact has been assessed as low. Therefore, the significance of effect of disturbance from operational vessels for Project Option 1 is assessed as being slight, which is not significant in EIA terms.

Project Option 2
Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of all marine mammals to operational vessel disturbance is assessed as low to medium, and the magnitude of impact is assessed as low. Therefore, the significance of the effect of vessel disturbance from vessels Project Option 2 is concluded to be slight, which is not significant in EIA terms.

14.5.3.3 Impact 16 - Prey availability and distribution
Any change in fish abundance and/or distribution as a result of operations is important to assess as, given marine mammals are dependent on fish as prey species, there is the potential for indirect effect on marine mammals. The key prey species for each marine mammal receptor are listed in Table 14.44.

During operational and maintenance activities, there is the potential for impacts upon fish species, including:

- Temporary increase in SSC and sediment deposition
- Temporary damage and disturbance of the seabed
- Long-term loss of benthic habitat due to the placement of subsea infrastructure
- Reduction in water and sediment quality through the release of contaminated sediments and/or accidental contamination
- Increase in hard substrate and structural complexity due to the placement of subsea infrastructure

- Potential barriers to movement through the presence of WTG and EMF from export cables and inter-array cables.

Sensitivity of the receptor

As detailed in Section 14.5.2.12, while there may be certain species that comprise the main part of their diet, all marine mammals in this assessment are considered to be generalist feeders and are thus not reliant on a single prey species. Therefore, they are assessed as having a low sensitivity to changes in prey abundance and distribution.

Magnitude of impact

The assessment provided in Volume 3, Chapter 13: Fish and Shellfish Ecology indicates that the overall adverse impacts to fish species from the operational phase of the proposed development will be slight (not significant):

- Temporary increase in SSC and sediment deposition = Slight
- Temporary damage and disturbance of the seabed = Slight
- Long-term loss of benthic habitat due to the placement of subsea infrastructure = Slight
- Reduction in water and sediment quality through the release of contaminated sediments and/or accidental contamination = Slight
- Increase in hard substrate and structural complexity due to the placement of subsea infrastructure = Slight
- Potential barriers to movement through the presence of WTG and EMF from export cables and inter-array cables = Slight.

Given that there is expected to be no significant impacts to any of their prey species, the predicted impact on marine mammals is of negligible magnitude.

Significance of the effect

Project Option 1

The sensitivity of marine mammals has been assessed as low and the magnitude of impact has been assessed as negligible. Therefore, the significance of the effect of changes in fish abundance/distribution during the operational phase for Project Option 1 is concluded to be imperceptible, which is not significant in EIA terms.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of to changes in prey availability shall remain low, and the magnitude of impact shall be negligible. Therefore, the significance of effect to changes in fish abundance/distribution for Project Option 2 shall be imperceptible, which is not significant in EIA terms.

14.5.3.4 Impact 17 - Increased concentrations of suspended sediments

During the operational phase, SSC could potentially be increased and an associated deposition of material within the array area and ECC due to reburial or replacement of array cables.

Sensitivity of the receptor

The sensitivity of marine mammals to increased concentrations of suspended sediment remain the same, irrespective of the proposed development phase. Therefore, as detailed in Section 14.5.2.13, the sensitivity of marine mammals is assessed as negligible.

Magnitude of impact

Any disturbance to the seabed however will be localised and any resultant increase in SSC will be temporary. The changes in SSC and resultant water quality during the operational phase are anticipated to be lesser than those associated with construction, which were considered to be of negligible magnitude to marine mammals (Section 14.5.2.13) and, therefore the magnitude during the operational phase is also rated as negligible in magnitude.

Significance of the effect

Project Option 1

The sensitivity of marine mammals has been assessed as negligible and the magnitude of impact has been assessed as negligible. Therefore, the significance of the effect of changes in water quality and increased suspended sediments for Project Option 1 is concluded to be imperceptible, which is not significant in EIA terms.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity to changes in water quality and suspended sediments shall remain negligible, and the magnitude of impact shall be negligible. Therefore, the significance of effect to changes in suspended sediments for Project Option 2 shall be imperceptible, which is not significant in EIA terms.

14.5.4 Decommissioning

The impacts of the offshore decommissioning of the proposed development have been assessed on marine mammals. The potential environmental impacts arising from the decommissioning of the proposed development are listed in Table 14.15 along with the project option with the greatest magnitude of impact against which each decommissioning phase impact has been assessed. A description of the likely significant effect on marine mammal ecology receptors caused by each identified impact is given below. As detailed in the Offshore Construction Chapter, it is anticipated that any offshore decommissioning process will involve similar activities to the construction process but that these will be undertaken in reverse, with removal of above surface structures initially followed by removal of foundations and associated subsurface infrastructure. It may be determined that the removal of foundations, pilings, scour protection and inter-array/offshore export cabling may cause greater environmental impacts than leaving in-situ and that if safe to do so, then certain infrastructure may be cut at or just below the seabed at an assumed depth of 1m–2m below seabed level with cabling left buried. The effects of these activities on marine mammals are considered to be similar to or less (as a result of there being no piling) than those occurring as a result of construction. Therefore, the effects of decommissioning are considered to be no greater than those described for the construction phase.

14.5.4.1 Impact 18 - PTS and disturbance from decommissioning

The final method chosen shall be dependent on the technologies available at the time of decommissioning.

Sensitivity of the receptor

As the effects of underwater noise on marine mammals during decommissioning are considered to be no greater than those described for the construction phase (Section 14.5.2), 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 (Sections 14.5.2.5 and 14.5.2.8). As such, the sensitivity of all marine mammals is assessed as low.

Magnitude of impact

It is envisaged that piled foundations would be cut below seabed level, and the protruding section removed. Typical current methods for cutting piles are abrasive water jet cutters or diamond wire cutting. The final method chosen shall be dependent on the technologies available at the time of decommissioning. The indicative methodology 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; and
- Inspect seabed and remove debris.

As the exact methods to be used for decommissioning are to be decided, the impact from PTS and disturbance levels of decommissioning activities cannot be accurately determined at this time. However, it is anticipated that with the implementation of mitigation in the form of the Offshore EMP and Rehabilitation Strategy (Section 14.4.5) the significance of these impacts will be reduced.

The impacts of decommissioning activities will likely be similar or of a lesser extent than during piling in the construction phase and the magnitude of impact will be negligible.

Significance of the effect

Project Option 1

The impacts of decommissioning activities for Project Option 1 will likely be similar or of a lesser extent than during piling in the construction phase. The sensitivity of marine mammals to PTS and disturbance is assessed as low, and the magnitude is assessed as negligible, therefore the significance of effect will be imperceptible, which is not significant in EIA terms.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of marine mammals to PTS and disturbance from decommissioning activities is assessed as low, and the impact magnitude is assessed as negligible. Therefore, the significance of effect for Project Option 2 is assessed as imperceptible, which is not significant in EIA terms.

14.5.4.2 Impact 19 - Collision with vessels

As stated in Section 14.5.2.10, the area surrounding the proposed development already experiences a high amount of vessel traffic (see the Shipping and Navigation Chapter for full details). Therefore, the introduction of additional vessels during the decommissioning of the proposed development is not a novel impact for marine mammals present in the area.

Sensitivity of the receptor

The sensitivity of marine mammals to vessel collisions is the same irrespective of the proposed development phase. As detailed in Section 14.5.2.10, marine mammal receptors are considered to have a high sensitivity to vessel collisions.

Magnitude of impact
The embedded mitigation of vessel codes of conduct (see Section 14.4.5) will ensure that vessel traffic moves (where practicable) along predictable routes and will define how vessels should behave in the presence of marine mammals. It is highly likely that a proportion of vessels will be stationary or slow moving throughout decommissioning phase activities for significant periods of time.

Furthermore, due to the already high volume of vessel traffic already in the vicinity of the proposed development, the introduction of additional vessels during the decommissioning phase of the proposed development is not a novel impact for marine mammals present in the area. It is not expected that the level of vessel activity during the decommissioning phase would cause an increase in the risk of mortality from collisions. The adoption of a vessel code of conduct will reduce the potential for any impact. Therefore, the magnitude of the risk of vessel collisions occurring is negligible.

Significance of the effect

Project Option 1
The sensitivity of receptors has been assessed as high and the magnitude of the impact has been assessed as negligible. Therefore, the significance of the effect of collisions from vessels for Project Option 1 is concluded to be slight, which is not significant in EIA terms.

Project Option 2
Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of all marine mammals is assessed as high, and the magnitude of impact is assessed as negligible. Therefore, the significance of the effect of collisions from vessels for Project Option 2 is concluded to be slight, which is not significant in EIA terms.

14.5.4.3 Impact 20 - Disturbance from vessels
As stated in Section 14.5.2.11, 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.

Sensitivity of the receptor
The sensitivity of marine mammals to vessel disturbance is the same irrespective of the proposed development phase. As detailed in Section 14.5.2.11, the sensitivity of marine mammals is as follows:

- Harbour porpoise: Medium
- Bottlenose dolphin: Low
- Common dolphin: Low
- Minke whale: Low
- Seals: Low.

Magnitude of impact
As stated in Section 14.5.2.11, the area surrounding the proposed development already experiences a high amount of vessel traffic (see the Shipping and Navigation Chapter for full details). Therefore, the introduction of additional vessels during the operational phase of the proposed development is not a novel impact for marine mammals present in the area. The number of vessels present and the number of round trips expected during the decommissioning phase of the proposed development has not been defined at this stage. The greatest potential for a likely significant effect is identical to (or less than) that of the construction phase. The magnitude of impact during the Construction phase was assessed as negligible, thus the same is assumed for the decommissioning phase too.

Significance of the effect

Project Option 1

The sensitivity of all marine mammals to disturbance from vessel activity during decommissioning is classified as low to medium and magnitude of impact assessed as negligible. Therefore, the significance of the effect of disturbance from decommissioning vessels for Project Option 1 is assessed as being slight, which is not significant in EIA terms.

Project Option 2

Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of all marine mammals to operational vessel disturbance is assessed as low to medium, and the magnitude of impact is assessed as negligible. Therefore, the significance of the effect of vessel disturbance from vessels Project Option 2 is concluded to be slight, which is not significant in EIA terms.

14.5.4.4 Impact 21 - Prey availability and distribution

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

- Temporary increase in SSC and sediment deposition;
- Temporary damage and disturbance of the seabed; and
- Reduction in water and sediment quality through the release of contaminated sediments and/or accidental contamination.

Sensitivity of the receptor

As detailed in Section 14.5.2.12, 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

The assessment provided in the Fish and Shellfish Chapter indicates that the overall adverse impacts to fish species from the decommissioning phase of the proposed development will be not significant to slight (not significant):

- Temporary increase in SSC and sediment deposition = Not significant
- Temporary damage and disturbance of the seabed = Slight
- Reduction in water and sediment quality through the release of contaminated sediments and/or accidental contamination = Not significant.

Given that there is expected to be no significant impacts to any of their prey species, the predicted impact on marine mammals is of negligible magnitude.

Significance of the effect

Project Option 1

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, the significance of the effect of changes in fish abundance/distribution during the decommissioning phase for Project Option 1 is concluded to be imperceptible, which is not significant in EIA terms.

Project Option 2
Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity of to changes in prey availability shall remain low, and the magnitude of impact shall be negligible. Therefore, the significance of effect to changes in fish abundance/distribution for Project Option 2 shall be imperceptible, which is not significant in EIA terms.

14.5.4.5 Impact 22 - Increased concentrations of suspended sediments

Sensitivity of the receptor
The sensitivity of marine mammals to increased concentrations of suspended sediment remain the same, irrespective of the proposed development phase. Therefore, as detailed in Section 14.5.2.13, the sensitivity of marine mammals is assessed as negligible.

Magnitude of impact
During decommissioning, SSC could potentially be increased and an associated deposition of material within the array area may occur from activities conducted in reverse of the construction process to remove foundation structure, cables and monopile and multi leg foundation legs.

Any disturbance to the seabed will be localised and any resultant increase in SSC will be temporary. The changes in SSC and resultant water quality during decommissioning are anticipated to be similar or lesser than those associated with construction, which were considered to be of negligible magnitude to marine mammals (Section 14.5.2.13) and, therefore the magnitude during decommissioning is also rated as negligible magnitude.

Significance of the effect

Project Option 1
As the sensitivity of marine mammals has been assessed as negligible and the magnitude of impact has been assessed as negligible, the significance of the effect of changes in water quality for Project Option 1 is concluded to be imperceptible, which is not significant in EIA terms.

Project Option 2
Overall, it is predicted that the sensitivity of receptors, and magnitude of impact for Project Option 2, will be equal to or less than those predicted for Project Option 1. As such, it is predicted that the sensitivity to changes in water quality and suspended sediments shall remain negligible, and the magnitude of impact shall be negligible. Therefore, the significance of effect to changes in suspended sediments for Project Option 2 shall be imperceptible, which is not significant in EIA terms.

14.6 Mitigation and Monitoring Measures

Mitigation measures that were identified and adopted as part of the evolution of the proposed development design (embedded into the proposed development design) and that are relevant to marine mammal ecology are listed in Table 14.14 and not considered again here. Table 14.45 below identifies additional mitigation measures that are not embedded into the proposed development design.

Table 14.45 Mitigation relating to marine mammal ecology

Measure	Mitigation detail
Construction	
Geophysical survey monitoring	• Geophysical survey equipment sources 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 (PTS and disturbance) to negligible levels. Only the SBP is predicted to overlap with the estimated hearing range of relevant marine mammal species. Measures proposed are:

Measure	Mitigation detail
	– A mitigation zone (an area within which mitigation must be applied to prevent instantaneous injury) of 500m radial distance from the SBP source; and – A qualified and experienced marine mammal observer (MMO) will be appointed to monitor for marine mammals and to log all relevant events using standardised data forms in accordance with licensing and regulatory requirements; and – Survey equipment with a source SPL above 170 dB re 1µPa shall commence from a lower energy start-up and increase gradually over a period of 40 minutes. – The start of the acoustic equipment will be delayed if marine mammals are detected within the mitigation zone during the pre-watch, allowing the animals time to move away from the acoustic source. The start of the source will be delayed for at least 30 minutes following the last sighting within the mitigation zone; and – For any breaks in operation of the equipment of 10 minutes the MMO/PAM operator will undertake dedicated monitoring to check no marine mammals are present within the mitigation zone prior to the source restarting; and – For line changes taking longer than 40 minutes, the source will be stopped, then a pre-watch of 30 minutes followed by a soft-start will be required to resume operations. These measures and further detail on these measures are included in the MMMP (Appendix 14.4).
Pre-construction further noise modelling	• Post consent during the pre-construction phase, there will be further noise modelling undertaken with finalised piling and design parameters to confirm impacts on marine mammals, this will be documented within the MMMP (Appendix 14.4).
Piling mitigation, including: • Marine Mammal Observers (MMO) • Passive Acoustic Monitoring (PAM) (if required) • Acoustic Deterrent Devices (ADD) (if required) • At-source noise reduction (if required)	The implementation of a MMMP (see Appendix 14.4) includes measures to ensure the risk of PTS to marine mammals is imperceptible and will be in line with the latest relevant available guidance such as the guidance to manage the risk to marine mammals from man-made sound sources in Irish waters (NPWS 2014). Mitigation measures outlined in the MMMP include those that are considered to be 'industry standard' and are supported by the NPWS (2014) guidance including: • A mitigation zone. The mitigation zone will be defined as the maximum potential PTS onset impact range. Noise modelling will be updated, if required, prior to construction once the final design details are known. The DAHG (2014) guidance recommends a mitigation zone of 1,000m for piling which is greater than the current largest impact range for instantaneous PTS onset modelled for the proposed development (i.e. 810 m). Whilst the SELcum PTS onset ranges are currently larger than this, ADDs are effective at displacing marine mammals at larger ranges and as such can provide cover for impact ranges greater than the advised 1,000m mitigation zone. Additionally, were noise abatement systems to be implemented for the proposed development, the impact ranges would be expected to be reduced compared to those considered in this version of the MMMP. • A qualified and experienced marine mammal observer (MMO) will be appointed to monitor for marine mammals and to log all relevant events using standardised data form. • PAM (if required to supplement to visual observations). PAM will be used as a form of mitigation under hours of darkness and/or low visibility when an MMO cannot visually observe. • In addition, additional mitigation measures that will be implemented to reduce the risk of PTS to negligible levels include the use of ADDs to deter marine mammals from the immediate vicinity of the pile. • Pre-piling deployment of ADDs (if required) Use of ADDs within this protocol follows the JNCC (2010) guidance in the absence of information within DAHG (2014) guidance, as well as best practice followed on recent OWFs in Scottish and English waters. • In the event that impact ranges predicted by the underwater noise modelling to be undertaken based on the final design for the proposed development post-consent are larger than distances capable of passive mitigation (MMOs and PAM) and ADDs, Noise Abatement Systems (NAS) may be used to minimise the risk of injury. NAS will be used if required to reduce the effect to negligible levels. The MMMP with selected mitigation measures will be updated post consent once a piling contractor is in place and final detailed installation methods are known.

Measure	Mitigation detail
UXO clearance mitigation measures, including: • MMO • ADD (if required) • At-source noise reduction (if required)	The implementation of a MMMP (Appendix 14.4) with specific measures should UXO clearance be required, to ensure the risk of PTS to marine mammals is imperceptible (not significant levels). The list of measures and procedures, can be modified in accordance with advice received from the regulator and their specialist UXO advisors as appropriate prior to UXO clearance activities commencing. Measures will include: • If detonation is deemed necessary, a mitigation zone of 1,000m from the detonation location will be established, within which it will be ensured, through visual observations (trained and experienced MMOs). • Where a UXO disposal method has a risk of PTS impact range that may exceed the 1,000m mitigation zone there is a residual risk of auditory injury to marine mammals at a greater range than can be mitigated by monitoring of the 1,000m mitigation zone alone. Therefore, an ADD will be operated for a pre-determined length of time, concurrent to the pre-detonation search, to deter marine mammals to a greater distance prior to any detonation. • Where auditory injury impact ranges from the use of high order detonations are greater than what can be mitigated using MMO/PAM watch and ADD (e.g. >7.5km; e.g. 120kg + donor impact ranges), noise abatement will be used. MMO/PAM pre-watch and ADD use will still be required if noise abatement is used. • It is recommended for the MMO to continue monitoring the mitigation zone during the detonation procedure and undertake a post-detonation search for at least 15 minutes after the final detonation.
Operation	
Nil	No mitigation measures are anticipated to be required specifically during the operational phase.
Decommissioning	
Nil	No additional mitigation measures are anticipated to be required specifically during the decommissioning phase. All relevant embedded mitigation measures will still apply.

14.7 Residual Effects

This section presents the residual effects of the proposed development for Project Option 1 and Project Option 2 once the mitigation outlined in Section 14.6 has been applied. The likely significant effect levels for Project Option 1 and Project Option 2 are the same both pre and post mitigation (residual effects), and so have been presented together for ease of review.

Where the mitigation presented in Section 14.6 has changed the effect level, this has been detailed.

The residual effects of the project options once mitigation has been applied are summarised in Table 14.46.

Table 14.46 Residual effects relating to marine mammals

Potential impact	Species	Sensitivity	Magnitude	Likely significant effect (pre-mitigation) for Project Option 1 and Project Option 2	Mitigation	Post-mitigation magnitude	Residual effect (post-mitigation) for Project Option 1 and Project Option 2
CONSTRUCTION PHASE							
1 Auditory injury (PTS) from pre-construction surveys	Harbour porpoise	Low	Medium	Slight (not significant)	MMO and 1km mitigation zone	Negligible	Imperceptible (not significant)
	Bottlenose dolphin	Negligible	Negligible	Imperceptible (not significant)	MMO and 1km mitigation zone	Negligible	Imperceptible (not significant)
	Common dolphin	Negligible	Negligible	Imperceptible (not significant)	MMO and 1km mitigation zone	Negligible	Imperceptible (not significant)
	Minke whale	Low	Medium	Slight (not significant)	MMO and 1km mitigation zone	Negligible	Imperceptible (not significant)
	Harbour seal	Low	Medium	Slight (not significant)	MMO and 1km mitigation zone	Negligible	Imperceptible (not significant)
	Grey seal	Low	Medium	Slight (not significant)	MMO and 1km mitigation zone	Negligible	Imperceptible (not significant)
2 Disturbance from pre-construction surveys	All	Low	Low	Slight (not significant)	MMO and 1km mitigation zone	Negligible	Imperceptible (not significant)
3 Auditory injury (PTS) from UXO clearance	Harbour porpoise	Low	Low order: Negligible High order: Medium	Low order: Imperceptible (not significant) High order: Slight (not significant)	MMMP	Negligible	Imperceptible (not significant)
	Bottlenose dolphin	Low	Negligible	Imperceptible (not significant)	MMMP	Negligible	Imperceptible (not significant)
	Common dolphin	Low	Negligible	Imperceptible (not significant)	MMMP	Negligible	Imperceptible (not significant)
	Minke whale	Medium	Low order: Negligible High order: Medium	Low order: Slight (not significant) High order: Moderate (significant)	MMMP	Negligible	Slight (not significant)
	Harbour seal	Low	Low order: Negligible High order: Medium	Low order: Imperceptible (not significant) High order: Slight (not significant)	MMMP	Negligible	Imperceptible (not significant)

Potential impact	Species	Sensitivity	Magnitude	Likely significant effect (pre-mitigation) for Project Option 1 and Project Option 2	Mitigation	Post-mitigation magnitude	Residual effect (post-mitigation) for Project Option 1 and Project Option 2
	Grey seal	Low	Low order: Negligible High order: Medium	Low order: Imperceptible (not significant) High order: Slight (not significant)	MMMP	Negligible	Imperceptible (not significant)
4 Disturbance from UXO clearance	All	Low	Low	Slight (not significant)	None	Low	Slight (not significant)
5 Auditory Injury (PTS) from pile driving	Harbour porpoise	Low	Medium	Slight (not significant)	MMMP	Negligible	Imperceptible (not significant)
	Bottlenose dolphin	Low	Negligible	Imperceptible (not significant)	MMMP	Negligible	Imperceptible (not significant)
	Common dolphin	Low	Negligible	Imperceptible (not significant)	MMMP	Negligible	Imperceptible (not significant)
	Minke whale	Low	Medium	Slight (not significant)	MMMP	Negligible	Imperceptible (not significant)
	Harbour seal	Low	Medium	Slight (not significant)	MMMP	Negligible	Imperceptible (not significant)
	Grey seal	Low	Medium	Slight (not significant)	MMMP	Negligible	Imperceptible (not significant)
6 Auditory Injury (TTS) from pile driving	All	TTS sensitivity and magnitude is not assessed. See Appendix 14.3: Marine Mammal Uncertainties and Limitations for full details.					
7 Disturbance from piling	Harbour porpoise	Low	Low	Slight (not significant)	None	Low	Slight (not significant)
	Bottlenose dolphin	Low	Medium	Slight (not significant)	None	Medium	Slight (not significant)
	Common dolphin	Low	Low	Slight (not significant)	None	Low	Slight (not significant)
	Minke whale	Low	Low	Slight (not significant)	None	Low	Slight (not significant)
	Harbour seal	Low	Low	Slight (not significant)	None	Low	Slight (not significant)
	Grey seal	Negligible	Low	Imperceptible (not significant)	None	Low	Imperceptible (not significant)
	Harbour porpoise	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)

Potential impact	Species	Sensitivity	Magnitude	Likely significant effect (pre-mitigation) for Project Option 1 and Project Option 2	Mitigation	Post-mitigation magnitude	Residual effect (post-mitigation) for Project Option 1 and Project Option 2
8 Auditory injury (PTS) from other construction activities	Bottlenose dolphin	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
	Common dolphin	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
	Minke whale	Medium	Negligible	Slight (not significant)	None	Negligible	Slight (not significant)
	Harbour seal	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
	Grey seal	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
9 Disturbance from other construction noise	All	Low	Low	Slight (not significant)	None	Low	Slight (not significant)
10 Collision with vessels	All	High	Negligible	Slight (not significant)	None	Low	Slight (not significant)
11 Disturbance from vessels	Harbour porpoise	Medium	Negligible	Slight (not significant)	None	Negligible	Slight (not significant)
	Bottlenose dolphin	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
	Common dolphin	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
	Minke whale	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
	Harbour seal	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
	Grey seal	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
12 Prey availability and distribution	All	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
13 Increased concentration of suspended sediments	All	Negligible	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
OPERATIONAL PHASE							
14 Collisions with vessels	All	High	Negligible	Slight (not significant)	None	Low	Slight (not significant)

Potential impact	Species	Sensitivity	Magnitude	Likely significant effect (pre-mitigation) for Project Option 1 and Project Option 2	Mitigation	Post-mitigation magnitude	Residual effect (post-mitigation) for Project Option 1 and Project Option 2
15 Disturbance from vessels	Harbour porpoise	Medium	Low	Slight (not significant)	None	Low	Slight (not significant)
	Bottlenose dolphin	Low	Low	Slight (not significant)	None	Low	Slight (not significant)
	Common dolphin	Low	Low	Slight (not significant)	None	Low	Slight (not significant)
	Minke whale	Low	Low	Slight (not significant)	None	Low	Slight (not significant)
	Harbour seal	Low	Low	Slight (not significant)	None	Low	Slight (not significant)
	Grey seal	Low	Low	Slight (not significant)	None	Low	Slight (not significant)
16 Prey availability and distribution	All	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
17 Increased concentration of suspended sediments	All	Negligible	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
DECOMMISSIONING PHASE							
18 PTS and disturbance from decommissioning	Harbour porpoise	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
	Bottlenose dolphin	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
	Common dolphin	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
	Minke whale	Medium	Negligible	Slight (not significant)	None	Negligible	Slight (not significant)
	Harbour seal	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
	Grey seal	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
19 Collisions with vessels	All	High	Negligible	Slight (not significant)	None	Low	Slight (not significant)
20 Disturbance from vessels	Harbour porpoise	Medium	Negligible	Slight (not significant)	None	Negligible	Slight (not significant)
	Bottlenose dolphin	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
	Common dolphin	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)

Potential impact	Species	Sensitivity	Magnitude	Likely significant effect (pre-mitigation) for Project Option 1 and Project Option 2	Mitigation	Post-mitigation magnitude	Residual effect (post-mitigation) for Project Option 1 and Project Option 2
	Minke whale	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
	Harbour seal	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
	Grey seal	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
21 Prey availability and distribution	All	Low	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)
22 Increased concentration of suspended sediments	All	Negligible	Negligible	Imperceptible (not significant)	None	Negligible	Imperceptible (not significant)

14.8 Transboundary Effects

Transboundary effects are defined as those effects upon the receiving environment of other European Economic Area (EEA) states, whether occurring from the proposed development 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. Whilst each species has been assessed within the relevant MU for the proposed development, the MUs under which each species have been assessed varies greatly in the area covered. As the study area (see Section 14.2.2) for each of the project-alone and cumulative assessment is based on the relevant marine mammal MU, transboundary effects have been taken into account throughout the assessment in Section 14.7. For example, the Celtic and Greater North Sea MU includes Irish, UK, Scandinavian, and Northwestern European waters, whilst the Celtic and Irish Sea MU includes Irish, Welsh, English and French waters. 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 Ireland (i.e., in the Irish Sea MU) have been found to travel large distances which may demonstrate connectivity to individuals found on the east and west coasts of UK populations (i.e., in the Coastal West Scotland and Hebrides MU, and Coastal East Scotland MU) (O'Brien et al. 2009, Robinson et al. 2012).

This assessment considers the potential for transboundary residual effects of the proposed development (i.e., after mitigation measures have been applied for the proposed development).

For marine mammals, 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, whether from the proposed development alone, or cumulatively with other projects in the wider area. However, there may be behavioural disturbance or displacement of marine mammals from the proposed development as a result of underwater noise which results in transboundary impacts, as behavioural disturbance could occur over large ranges (tens of kilometres) and extend into waters of other states. In addition, disturbance to prey species from loss of fish spawning and nursery habitat and suspended sediments and deposition may also occur and affect migratory species across MUs. An overview of potential transboundary effects from construction, operational and decommissioning activities is provided in Table 14.47 below.

Table 14.47 Potential transboundary effects on marine mammal receptors

Potential effect	Project Phase	Effect description	Effect significance
Auditory injury (PTS) from geophysical surveys, UXO clearance, pile driving, other activities (e.g., drilling) and decommissioning activities	Construction, Decommissioning	Likely significant effects resulting from auditory injury (PTS) to marine mammals sustained from various OWF construction and decommissioning associated activities. Highly localised impacts such as PTS however, are not considered to be transboundary impacts as impact ranges do not extend into other EEA states, whether from the proposed development alone or cumulatively with other projects in the wider area. The magnitude of impact for the proposed development alone was assessed as negligible to medium and the sensitivity of receptors assessed as negligible. Given that the risk of auditory injury to marine mammals as a result of non-piling construction activities and decommissioning has been assessed as negligible for the proposed development alone, these impacts were not considered further cumulatively with other projects.	Not significant in EIA terms for all species assessed.
Disturbance from UXO clearance	Construction	Likely significant effects resulting from disturbance as a result of UXO removal. The proposed development is located in close proximity to other states (e.g., Northern Irish waters, Welsh waters, Manx waters, Scottish waters and English waters) and, depending on the locality of where UXO are removed, could cause disturbance in these areas. The magnitude of impact for the proposed development alone was assessed as low and the sensitivity of receptors assessed as Low. However, it is expected that going forward, most, if not all, UXO clearance will be conducted using low-order deflagration techniques, and therefore disturbance impacts will be minimal, highly localised and over an extremely short duration. Thus, this impact was not considered further cumulatively with other projects.	Not significant in EIA terms for all species assessed.
Disturbance from pile driving and/or pile removal	Construction, Decommissioning	Likely significant effects resulting from disturbance to marine mammals from pile driving and/or pile removal. The proposed development is located in close proximity to other states (e.g., Northern Irish waters, Welsh waters, Manx waters, Scottish waters and English waters) and disturbance contours extend towards these areas for piling driving during construction. Therefore, there is likely significant effects resulting from disturbance and displacement due to piling activities and the presence of offshore infrastructure across the construction phase. During decommissioning, the extent of these contours is likely to be much less than those during construction. The magnitude of impact for the proposed development alone was assessed as Low to medium and the sensitivity of receptors assessed as negligible to low. The impact of pile driving cumulatively with other projects Northern Irish, Welsh, Manx, Scottish, English and EU waters is assessed in Section 14.9 but was not significant in EIA terms for all species.	Not significant in EIA terms for all species assessed.
Disturbance from vessel activity and other construction activities (e.g. geophysical surveys)	Construction, Operations, Decommissioning	Likely significant effects resulting from disturbance and displacement due to vessel activity and the presence of offshore infrastructure across the construction, operational and decommissioning phases. When considering the impact of disturbance from other development activities, this is predicted to be of local spatial extent, short-term and reversible. The magnitude of impact for the proposed development alone was assessed as negligible and the sensitivity of receptors assessed as negligible to medium. The potential for disturbance from vessel activity during construction, operation and decommissioning of offshore energy developments (i.e., geophysical surveys) cumulatively with other projects is assessed in Section 14.9. In addition, the impacts of overall vessel disturbance cumulatively with other projects Northern Irish, Welsh, Manx, Scottish, English and EU waters is assessed in Section 14.9 but was not significant in EIA terms for all species.	Not significant in EIA terms for all species assessed.
Disturbance to prey species	Construction, Operations, Decommissioning	Likely significant effects resulting from disturbance to prey species from loss of fish spawning and nursery habitat and suspended sediments and deposition. The effects of reduction in prey availability are predicted to be limited in extent to a number of kilometres from the proposed development and are therefore not predicted to extend into the waters of other states. The magnitude of impact for the proposed development alone was assessed as negligible and the sensitivity of receptors assessed as low.	Not significant in EIA terms for all species assessed.

Potential effect	Project Phase	Effect description	Effect significance
		As the effects on prey availability is anticipated to be highly localised and therefore the potential for cumulative effects is considered to be negligible. As such, this impact was not considered further cumulatively with other projects (Section 14.9).	
Collision risk	Construction, Operations, Decommissioning	Likely significant effects due to marine mammal species colliding with vessels during the construction, operational and decommissioning phases. The magnitude of impact for the proposed development alone was assessed as negligible and the sensitivity of receptors assessed as high. As it is expected that all offshore energy projects will employ a vessel management plan/ vessel codes of conduct or follow best practice guidance to reduce the already low risk of collisions with marine mammals, this impact was not considered further cumulatively with other projects.	Not significant in EIA terms for all species assessed.
Increased concentrations of suspended sediments	Construction, Operations, Decommissioning	Likely significance effects due to reductions in water quality as a result of construction, operational and decommissioning activities. These can have both direct and indirect impacts on marine mammals. Indirect impacts include effects on prey species. Direct impacts include the impairment of visibility and therefore foraging ability which might be expected to reduce foraging success. During each phase of the proposed development, sediment will be disturbed and released into the water column. This will give rise to suspended sediment plumes and highly localised changes in bed levels as material settles out of suspension. However, marine mammals are well known to forage in tidal areas where water conditions are turbid and visibility conditions poor. The magnitude of impact for the proposed development alone was assessed as negligible and the sensitivity of receptors assessed as negligible. As this impact shall be highly localised, this impact was not considered further cumulatively with other projects.	Not significant in EIA terms for all species assessed.

In summary, for each of the transboundary impacts assessed in Table 14.47, the magnitude of impact for each of the effects after mitigation has been applied has been assessed as negligible too low for each of the proposed development phases (see Section 14.7). Further, the sensitivity of marine mammals to each of the transboundary impacts outlined in Table 14.47, have been assessed as negligible to medium. Therefore, the significance of all potential transboundary impacts is concluded to be of slight significance, which is not significant in terms of the EIA regulations.

14.9 Cumulative Effects

Likely significant cumulative effects of the proposed development in-combination with existing and / or approved projects for marine mammal ecology have been identified, considered and assessed. The methodology for this cumulative assessment is a three-stage approach which is presented in the Cumulative and Inter-Related Effects Chapter.

The Cumulative and Inter-Related Effects Chapter contains the outcome of Stage 1 Establishing the list of 'Other Existing and/or Approved Projects'; and Stage 2 'Screening of 'Other Existing and/or Approved Projects'. This section presents Stage 3, an assessment of whether the proposed development in combination with other projects, grouped in tiers, would be likely to have significant cumulative effects.

The assessment specifically considers whether any of the approved developments in the local or wider area have the potential to alter the significance of effects associated with the proposed development. Developments which are already built and operating, and which are not identified in this chapter, are included in the baseline environment or have been screened out as there is no potential to alter the significance of effects.

The assessment of cumulative effects has considered likely significant effects that may arise during construction, operation and decommissioning of the proposed development. Cumulative effects were assessed to a level of detail commensurate with the information that has either been directly shared with the proposed development or was publicly available at the time of assessment.

Given the location and nature of the proposed development, a tiered approach to establishing the list of other existing and/or approved projects has been undertaken in Stage 1 of the cumulative effects assessment. The tiering of projects is based on project relevance to the proposed development and it is not a hierarchical approach nor based on weighting. Further information on the tiers is provided in Section 14.9.2 and in the Cumulative and Inter-Related Effects Chapter.

14.9.1 Marine mammal ecology cumulative screening exercise

The existing and/or approved projects selected as relevant to the cumulative effects assessment of impacts to marine mammal ecology are based on an initial screening exercise undertaken on a long list (see Cumulative and Inter-Related Effects Chapter) based on spatial distance to the proposed development. Consideration of effect-receptor pathways, data confidence and temporal and spatial scales has then allowed the selection of the relevant projects for the marine mammal ecology cumulative short list.

When assessing likely significant effects for marine mammal ecology, projects were screened into the assessment based on their ability to impact receptors within a Zone of Influence (ZoI).

The ZoI for marine mammals is based on the species-specific MUs:

1. Celtic and Irish Sea MU for harbour porpoise;

- Irish Sea MU for bottlenose dolphin;
- Celtic and Greater North Seas MU for common dolphin and minke whale; and
- The East and Southeast Ireland and Northern Ireland MUs for both harbour and grey seal.

The time period considered in the cumulative effects assessment for marine mammals is 2023 to 2031 inclusive. This allows for the quantification of impacts to the MUs both prior to the construction of the proposed development (since the baseline was collated) and during the period when piling at the proposed development is anticipated in 2028[18]. The cumulative impact window has been extended to include 2031 as this is the timeframe used in the cumulative Phase One population modelling scenario (see Section 14.9.4.4). In the assessment of magnitude, the complete cumulative effects assessment time period of 2023 to 2031 is considered, with particular importance placed on the proportion of the population potentially impacted by piling at the proposed development cumulatively with Tier 1, Tier 2 and Tier 3 projects in 2028.

For the full list of projects considered, including those screened out, please see the Cumulative and Inter-Related Effects Chapter and Appendix 38.2.

The long list of projects, plans and activities was used to generate a list of projects initially screened into the marine mammal cumulative effects assessment. The long-list of projects was screened to remove all projects that have:

- No temporal overlap
- No physical effect-receptor
- No effect-receptor pathway; and
- No/low data confidence.

Further information on the screening criteria is provided in Appendix 38.2. For the potential likely significant cumulative effects for marine mammals, large-scale development such as 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, only those occurring in OSPAR Region III: Celtic Seas were screened into the assessment.

Subsequently, the following offshore project types were screened out of the marine mammal cumulative short list:

- 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 where the timing of construction activities is unknown.

14.9.2 Projects considered within the cumulative effects assessment

The planned, existing and/or approved projects selected through the screening exercise as potentially relevant to the assessment of impacts to marine mammal ecology are presented in Table 14.49.

The tiers for the assessment are:

- Tier 1 is the Operation and Maintenance Facility (OMF) for the proposed development. The OMF option being considered involved the adaption and leasing part of an existing port facility at Greenore. Further detail is provided in the Offshore Description Chapter.
- Tier 2 is the east coast Phase One Offshore Wind Farms.
- Tier 3 is all other projects that have been screened in for this topic.

[18] To note: construction at the proposed development will take place between 2027 to 2029, however, for the purposes of the cumulative effects assessment, only one year when piling is anticipated has been considered.

The tiering structure is intended to provide an understanding of the potential for likely significant effects of the proposed development with the construction of its OMF (tier one); followed by a cumulative assessment of the likely significant effect of that scenario combined with the east coast Phase One Offshore Wind Farms (tier two); and lastly the combination of tier one and tier two with all other existing and/or approved projects that have been screened in (tier three).

14.9.3 Screening impact pathways

Certain impacts assessed for the proposed development alone are not considered in the marine mammal cumulative effects assessment due to:

- The highly localised nature of the impacts;
- Management and mitigation measures in place at the proposed development and on other projects will reduce the risk occurring; and
- Where the potential significance of the impact from the proposed development alone has been assessed as negligible.

The impacts excluded from the marine mammal cumulative effects assessment for these reasons are presented in Table 14.48.

Table 14.48 Impacts scoped out from further consideration in the cumulative impact assessment.

Impact	Justification
Auditory injury (PTS)	• Where PTS may result from activities such as pile driving and UXO clearance, as a requirement of European Protected Species legislation, suitable mitigation must be put in place to reduce injury risk to marine mammals to negligible levels across all projects considered in the cumulative assessment (JNCC 2010a, b). Similarly, any risk of PTS during decommissioning will be determined via appropriate decommissioning plans and if required, mitigated. As such, assuming application of appropriate mitigation measures, any risk of injury it is considered highly unlikely and potential for cumulative effects on marine mammals due to PTS as a result of piling, UXO and decommissioning was not considered further. The risk of auditory injury to marine mammals as a result of non-piling construction activities has been assessed as very localised (less than 100m, see Section 14.5.2.8) and it is anticipated that underwater noise associated with vessel activity will deter animals from the injury zone. As such any risk of injury it is considered highly unlikely and potential for cumulative effects on marine mammals due to PTS as a result of non-piling construction activities was not considered further.
Disturbance from UXOs	• It is expected that, where feasible, across all projects, UXO clearance campaigns will be conducted using low-order deflagration techniques. Moreover, 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 that behavioural disturbance is considered negligible in the context of UXO clearance as the duration of the impact (underwater noise) is extremely short, the potential for cumulative effects is considered unlikely and this impact was not considered further.
Disturbance from other construction activities	• Disturbance from other (non-piling) construction activities is anticipated to be highly localised (see Section 14.5.2.9) and is closely associated with the disturbance from vessel presence required for the activity. As such, cumulative effects have been assessed under “disturbance from vessels” impact and potential for cumulative effects due to other (non-piling) construction activities was not considered further.
Collision with vessels	• It is expected that across all project’s vessel movements will be managed through the implementation of vessel codes of conduct that will mitigate the negative impacts to marine mammals (e.g. limited vessel speeds, adherence to vessel transit routes), following relevant guidance to minimise the risks of injury to marine mammals. As such, the potential for cumulative effects is negligible and this impact was not considered further.
Increased concentration of suspended sediments	• The risk of increased concentrations of suspended sediment is expected to be highly localised. As such, the potential for cumulative effects is considered to be negligible and therefore this impact was not considered further.
Prey availability and distribution	• The effects on prey availability is anticipated to be highly localised and therefore the potential for cumulative effects is considered to be negligible. As such, this impact was not considered further.

Therefore, the impacts that are considered in the marine mammal cumulative effects assessment are as follows:

- The potential for disturbance from underwater noise from piling during construction of offshore wind farms (where data are available) and the construction of coastal and offshore developments; and
- The potential for disturbance from vessel activity during construction, operation and decommissioning of coastal and offshore developments.

14.9.4 Disturbance from underwater noise

14.9.4.1 Methods

Depending on the tier considered, the numbers of animals at risk of disturbance during piling at the proposed development are based on:

- Unmitigated numbers of animals calculated using the dose-response approach as presented in the proposed development alone assessment; and
- EDR approach, to allow for comparison with other projects.

It should be noted that where numbers based on unmitigated disturbance, this approach is highly conservative as secondary mitigation measures may also be applied (the MMMP provides an outline of the potential additional mitigation measures, including MMO/PAM watches of a mitigation zone, ADD use and noise abatement methods).

14.9.4.2 Tier 1

The OMF will be required to service the offshore wind farm throughout the operational phase of the proposed development. Since the OMF will be subject to separate planning/permitting consents, it is considered within the cumulative impact assessment for marine mammals. The OMF will be located onshore as a part of an existing port facility at Greenore. The port will need to be adapted to provide, amongst others, berthing facilities to support the crew transfer vessels as well as pontoon. As such, it is anticipated that piling will take place during the construction of the OMF.

Given that the OMF project is at the pre-application stage, any project-specific assessment of potential impacts on marine mammals is unavailable in the public domain. To allow for the quantitative assessment, an indicative number of animals disturbed per day has been calculated based on fixed EDR for piling of pin piles (15km) and species-specific densities:

- For cetaceans SCANS IV block CS-D density based on Gilles et al. (2023); and
- For seals the average of the mean at-sea density across the 15km buffer based on Carter et al. (2020).

For the proposed development, the number of animals disturbed during piling presented in the proposed development alone assessment is based on the dose-response approach, calculated using site- and project-specific parameters (such as hammer energy, pile diameter, bathymetry, see Section 14.2.10 for more details about the dose-response approach). At the time of writing, the OMF project is at the pre-application phase and therefore the number of animals disturbed based on project-specific details is unavailable. As such, to ensure that the numbers presented in the cumulative assessment are comparable to the OMF project, the numbers of animals disturbed during piling at the proposed development are based on the EDR approach using fixed 26km EDR for cetacean species and 25km EDR for pinnipeds. Although this approach will allow for analogous comparison between the OMF project and the proposed development, it should be noted that it may underestimate the numbers of animals potentially affected compared to the dose-response approach.

14.9.4.3 Tier 2

All Phase One offshore wind projects in Ireland have been awarded a Maritime Area Consent (MAC); however, none of the projects will have formally submitted applications for planning consent and were not awarded consent within the timescales for writing the EIAR for the proposed development. Notwithstanding this, due to the likely similar development timelines of the Phase One projects and the resultant risk associated with cumulative effects, East Coast Phase One projects were assessed under Tier 2.

In line with the tier hierarchy (for more details see the Cumulative and Inter-Related Effects Chapter, the assessment for Tier 2 also includes Tier 1 projects.

All Phase One offshore wind projects in Ireland are at the pre-consent stage and as such, at the time of writing Oriel, Dublin, Codling and Arklow do not have quantitative assessments available in the public domain. In order to allow for quantitative cumulative assessment, an indicative number of animals disturbed per day for Phase One OWF Projects has been calculated based on fixed EDRs and species-specific densities as presented in Table 14.49.

Table 14.49 Parameters used to assess number of animals potentially disturbed for East Coast Phase One Offshore Wind Farm Projects

Parameters	Project	Cetaceans	Pinnipeds
Area of Impact	Oriel Dublin Array Codling Wind Park Arklow	26km EDR (impact area of 2,124km2)1	25km EDR (impact area of 1,964km2)2
Density	Oriel Dublin Array Codling Wind Park Arklow	Species-specific SCANS IV CS-D block density (Gilles et al. 2023)	The average at-sea seal density within 25km buffer from the array area (Carter et al. 2022)

[1] Based on JNCC (2020) guidance.

[2] Based on disturbance ranges from Russell et al. (2016b).

As previously described for Tier 1 projects, for the proposed development, the number of animals disturbed during piling presented in the proposed development alone assessment is based on the dose-response approach, calculated using site- and project-specific parameters. Given the stage of other Phase One projects (pre-consent) at the time of writing, the numbers of animals disturbed using the dose-response approach are unavailable and it is not possible to calculate these for the cumulative assessment purposes. As such, to ensure that the numbers presented in the cumulative assessment are comparable across projects, when assessing the proposed development plus Tier 1 and Tier 2 together, the numbers of animals disturbed during piling at the proposed development are based on the EDR approach in line with parameters for other Phase One projects listed in Table 14.49. Although this approach will allow for analogous comparison between Phase One projects, it should be noted that it may underestimate the numbers of animals potentially affected compared to the dose-response approach. However, this approach is considered appropriate to enable a comparable cumulative assessment of projects without dose-response assessments available in the public domain at the time of writing. Additionally, the full assessment of the proposed development with all tiers uses the precautionary does-response approach for the proposed development.

14.9.4.4 Population modelling

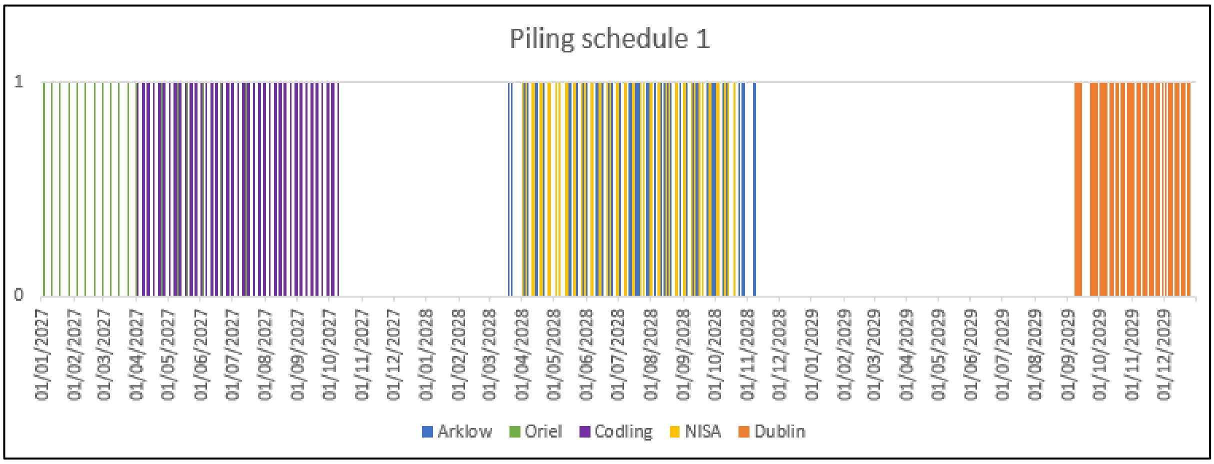
As a result of consultation across all Phase One Projects (see Appendix 1.2: Consultation Report), cumulative iPCoD has been carried out to assess whether cumulative disturbance resulting from pile driving activities across five projects is predicted to result in population level impacts to four marine mammal species (harbour porpoise, bottlenose dolphins, harbour and grey seals). For the purpose of the Phase One Project iPCoD population modelling, the number of animals disturbed per piling day was shared by each Project to SMRU Consulting, under the agreement that the number disturbed per project was kept anonymised in the reporting and that this data was not shared between Projects[19].

Each Phase One Project was required to provide an indicative piling schedule and the number of animals predicted to be disturbed per piling day. Two piling schedules were modelled:

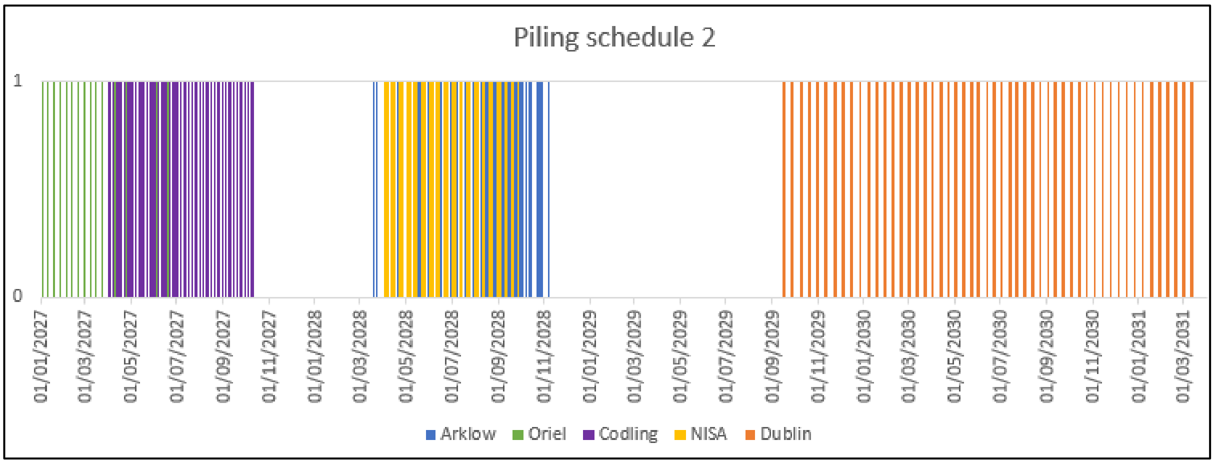
[19] Considering that the proposed development cumulative effects assessment used calculated numbers of animals disturbed across East Coast Phase One Projects based on the EDRs and Phase One iPCoD population modelling used numbers of animals confidentially shared by other developers, the cumulative numbers of animals disturbed presented in the chapter and in Appendix 14.6: East Coast Phase One Irish Offshore Wind Farms: Cumulative iPCoD Modelling are different and should not be compared.

- Piling schedule 1 assumed monopiles at all five projects with piling between January 2027 to December 2029 inclusive (Graph 14.26).
- Piling schedule 2 assumed monopiles at Arklow, Oriel and Codling, pin-pile jackets at the proposed development and Dublin and piling between January 2027 to March 2031 inclusive (Graph 14.27).

The population modelling methods are described in more detail in Appendix 14.6: East Coast Phase One Irish Offshore Wind Farms: Cumulative iPCoD Modelling.



Graph 14.26 Piling schedule 1: assumed monopiles at all five Irish Phase One Projects with indicative piling between January 2027 to December 2029 inclusive



Graph 14.27 Piling schedule 2: assumed monopiles at Arklow, Oriel and Codling, pin-pile jackets at the proposed development and Dublin and indicative piling between January 2027 to March 2031 inclusive.

14.9.4.5 Tier 3

In assessing the potential cumulative impacts for the proposed development, it is also important to consider that some projects have not submitted consent applications yet and therefore the quantitative assessment of impact on marine mammals is not available in the public domain. Given the uncertainty associated with these projects, specifically timeframes for the construction and potential impacts on marine mammal receptors, all Tier 3 projects without quantitative assessment available in the public domain will not be considered further. As such, projects included under Tier 3 are only those with a quantitative assessment within the submission documents available in the public domain. For all offshore projects that had a quantitative impact assessment for pile driving available, the maximum number of animals predicted to be disturbed per day was obtained from the project-specific assessment and used in this cumulative effects assessment for that specific project. This approach provides the most realism as the numbers of animals disturbed are presented using project-specific parameters (where possible, information is provided about the species-specific density source and method used to obtain numbers of animals disturbed). Some projects provided numbers of animals disturbed only for certain marine mammal species, as such, where the proposed development did not include a quantitative assessment of a species in consideration, it has not been considered further in Sections 14.9.5 to 14.9.10.

To align with the approach described above, the numbers of animals disturbed during piling at the proposed development for the Tier 3 assessment were based on the proposed development-specific, dose-response approach.

However, as noted in Section 14.9.4.1 the assessment approach for the proposed development for the Tier 1 and Tier 2 assessments were based on the EDR approach to enable an analogous comparison for the cumulative assessment of the Tier 1 and 2 projects. This approach is considered appropriate as the Tier 1 and Tier 2 projects don't have dose-response assessments publicly available at the time of writing.

14.9.4.6 Projects screened in

The projects screened into the cumulative assessment of underwater noise and the detail the offshore construction period for each is presented in Table 14.50 and include projects with and without quantitative impact assessment as well as the EU and Ireland projects. The timeline information is based on data available in Environmental Statement (ES) and Preliminary Environmental Information Report (PEIR) chapters and/or available development consent, permit or licence information that are available in the public domain.

Table 14.50 Projects and plans considered within the cumulative assessment for marine mammals. Project piling period at the proposed development (2028) is indicated in the red box

= Not yet/no longer operational; = Construction; = Operation and Maintenance, = Decommissioning, = Yes, project within MU, = No, project not in MU

Project	Type	Distance to the proposed development		Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Assessment	CGNS MU	CIS MU	IS MU	EI MU
		Array area (km)	ECC (km)															
OMF	Coastal Assets	33.9	38.8	1										No	Yes	Yes	Yes	Yes
Codling Wind Park	OWF	50.9	56.9	2										No	Yes	Yes	Yes	Yes
Dublin Array	OWF	32.9	37.6	2										No	Yes	Yes	Yes	Yes
Arklow Bank Phase 2	OWF	76.4	80.0	2										No	Yes	Yes	Yes	Yes
Oriel	OWF	16.9	21.6	2										No	Yes	Yes	Yes	Yes
Codling Wind Park Ltd. Site Investigations (FS007045)	Surveys	17.2	13.2	3										EPS	Yes	Yes	Yes	Yes
Codling Wind Park Ltd. Site Investigations (FS007546)	Surveys	68.7	76.3	3										EPS	Yes	Yes	Yes	
Wicklow Sea Wind Ltd., Site Investigations (FS007163)	Surveys	68.8	73.7	3										NIS	Yes	Yes	Yes	Yes
Mona	OWF	117.3	124.8	3										ES	Yes	Yes	Yes	No
Morgan	OWF	111.5	119.9	3										PEIR	Yes	Yes	Yes	No
Awel y Môr	OWF	131.6	139.5	3										ES	Yes	Yes	Yes	No
Morecambe	OWF	138.9	146.5	3										PEIR	Yes	Yes	Yes	No
Erebus Floating Wind Demo	OWF	235.1	239.6	3										ES	Yes	Yes	No	No
White Cross	OWF	274.7	280.6	3										ES	Yes	Yes	No	No
Neart Na Gaoithe	OWF	357.9	366.0	3										ES	Yes	No	No	No
Berwick Bank	OWF	373.3	381.5	3										ES	Yes	No	No	No
Inch Cape	OWF	377.4	385.4	3										ES	Yes	No	No	No
Seagreen Phase 1	OWF	396.6	404.7	3										ES	Yes	No	No	No
Rampion 2	OWF	484.2	494.2	3										ES	Yes	No	No	No
Outer Dowsing	OWF	452.3	459.7	3										PEIR	Yes	No	No	No

Project	Type	Distance to the proposed development		Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Assessment	CGNS MU	CIS MU	IS MU	EI MU
		Array area (km)	ECC (km)															
Sheringham Shoal Extension	OWF	459.2	466.8	3										ES	Yes	No	No	No
Hornsea Project Four	OWF	449.9	457.9	3										ES	Yes	No	No	No
Dudgeon Extension	OWF	465.7	473.1	3										ES	Yes	No	No	No
Dogger Bank South (West)	OWF	470.8	479.2	3										PEIR	Yes	No	No	No
Dogger Bank - Creyke Beck B	OWF	492.6	501.0	3										ES	Yes	No	No	No
Dogger Bank South (East)	OWF	498.8	507.0	3										PEIR	Yes	No	No	No
Dogger Bank - Creyke Beck A	OWF	499.9	508.3	3										ES	Yes	No	No	No
North Falls	OWF	549.0	557.9	3										PEIR	Yes	No	No	No
Hornsea Project Three	OWF	529.4	537.1	3										ES	Yes	No	No	No
Dogger Bank - Teesside B (Sofia)	OWF	526.0	534.5	3										ES	Yes	No	No	No
Moray West	OWF	501.8	508.9	3										ES	Yes	No	No	No
Norfolk Vanguard West	OWF	548.3	556.0	3										ES	Yes	No	No	No
East Anglia Two	OWF	556.0	563.2	3										ES	Yes	No	No	No
Five Estuaries	OWF	564.6	573.4	3										PEIR	Yes	No	No	No
East Anglia One North	OWF	560.5	568.8	3										ES	Yes	No	No	No
Norfolk Vanguard East	OWF	578.6	586.3	3										ES	Yes	No	No	No
East Anglia Three	OWF	582.2	590.1	3										ES	Yes	No	No	No
Dogger Bank C - Teesside A	OWF	564.0	572.4	3										ES	Yes	No	No	No
Green Volt	OWF	554.4	562.3	3										ES	Yes	No	No	No
Pentland Floating	OWF	557.7	564.4	3										ES	Yes	No	No	No
West of Orkney	OWF	566.7	573.0	3										ES	Yes	No	No	No
Perpetuus Tidal Energy Centre (PTEC)	Tidal	459.8	469.8	3										ES	Yes	No	No	No
EMEC Bilia Croo	Tidal	599.6	606.4	3										ES	Yes	No	No	No
Shetland HVDC Link	Subsea Cable	553.3	560.4	3										PEIR	Yes	No	No	No

14.9.4.7 *Conservatism in the cumulative effects assessment*

There are significant levels of precaution/conservatism within this cumulative effects assessment, resulting in the estimated effects being highly precautionary. The main areas of precaution/conservatism in the assessment include:

- The approach of summing across concurrent activities assumes that there is no spatial overlap in the impact footprints between individual activities, which is highly unrealistic considering the proximity of some of the offshore wind farm projects to each other.
- The exact timing of piling driving for each project is unknown, therefore it has been assumed that these activities could occur at any point throughout the piling window at the proposed development (2028). This has resulted in piling activities occurring over multiple consecutive years with associated estimated disturbance levels far greater than would occur in reality. For example, the greatest level of disturbance to minke whale when the proposed development is piling (2028) and Tier 1 + Tier 2 + Tier 3 projects would require that 10 offshore wind developments are piling at the same time. This assumption is precautionary, as it is unlikely that 10 offshore wind developments would pile at the same time.
- The EDRs used in the assessment (see Section 14.9.4.1) are advised for harbour porpoise. No such advice is available for other species and so the same EDRs have been assumed across all species. This is considered conservative since most species show less of a disturbance response compared to harbour porpoise.
- The assumption that all fixed OWF will install pile-driven monopile foundations. The proposed development design parameters for most of these developments includes options for pin-piles or monopiles. As a worst-case assumption monopiles have been assumed; however, it is likely that a portion of these projects will use jacket foundations with pin-piles, which have a much lower recommended effective deterrence range (15km instead of 26km, equating to a 66% smaller area) (JNCC 2020), and will therefore disturb far fewer animals. Additionally, depending on group conditions at the site, some projects allow for drilled, rather than piled structures.

14.9.5 Cumulative Impact 1 - Harbour porpoise – disturbance from underwater noise

Magnitude

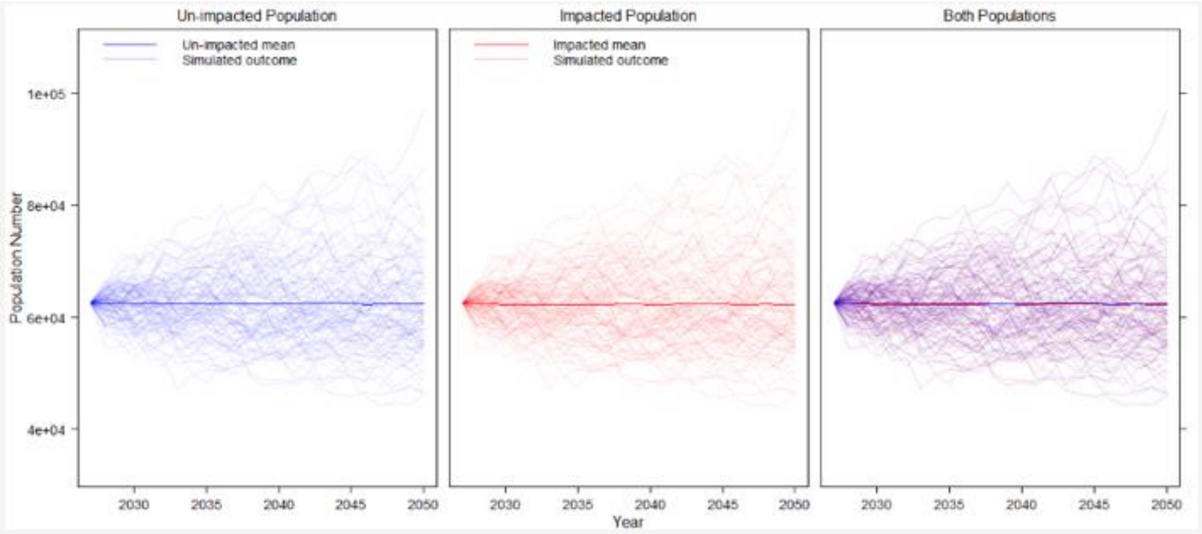
14.9.5.1 *Tier 1*

The construction of the OMF facility will be taking place in 2025 and 2026 (Table 14.51). During piling at the OMF, up to 198 harbour porpoise may experience behavioural disturbance per piling day (0.32% MU assuming a 15km EDR, Table 14.51). An assumption has been made that smaller diameter piles will be required for the OMF (e.g. pin piling) of which a 15km EDR is recommended (Graham et al. 2019). There will be no temporal overlap with piling at the proposed development (in 2028) and therefore there is no potential for cumulative effects.

14.9.5.2 *Tier 1 and 2*

Based on methodology presented in Section 14.9.4.1, across all Tier 1 and 2 projects constructing between 2025 and 2031, the number of harbour porpoise predicted to be disturbed per day ranges between 198 (0.3% MU) in 2025 and 2026 to 1,190 (1.9% MU) in 2027 and 2028 (Table 14.52). Only Arklow is expecting to pile at the same time as the proposed development (Table 14.52).

Based on numbers of animals predicted to be disturbed, population modelling was conducted for the East Coast Phase One Irish OWF Projects to determine if disturbance from piling activities across the five projects is predicted to result in population level changes (see Section 14.9.4.4, and Appendix 14.6: East Coast Phase One Irish Offshore Wind Farms: Cumulative iPCoD Modelling for more details). The iPCoD results show that the level of disturbance predicted under either indicative piling schedule 1 or 2 is not sufficient to result in any changes to the harbour porpoise MU population, since the impacted population is predicted to continue at a stable trajectory at 99.6-99.7% of the size of the un-impacted population.



Graph 14.28 Predicted population trajectories for the un-impacted (baseline) and impacted harbour porpoise iPCoD simulations for piling schedule 1

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 up to 5 years. This is expected to result in intermittent and temporary behavioural effects in a proportion of the population (up to 1.9% MU). 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.

14.9.5.3 Tier 1 and 2 and 3 (All tiers)

Across Tier 1, Tier 2 and Tier 3 projects, between 2023 and 2031, the number of harbour porpoise predicted to be disturbed per day ranges between 70 in 2023 (0.1% MU) to 7,024 (11.2% MU) in 2028 (assuming projects construct on the same day with no overlap of impacted areas, Table 14.53). This assumes piling at five OWFs at the same time within the MU.

Table 14.51 Number of harbour porpoise disturbed by underwater noise for Tier 1 projects. Project piling period at the proposed development (2028) is indicated in the red box

Project	Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Method	Density
The proposed development	1						595				26km EDR	Gilles et al. (2023)
OMF	1			198	198						15km EDR	Gilles et al. (2023)
# animals		**0**	**0**	**198**	**198**	**0**	**595**	**0**	**0**	**0**	-	
% MU		**0.0%**	**0.0%**	**0.3%**	**0.3%**	**0.0%**	**1.0%**	**0.0%**	**0.0%**	**0.0%**		

Table 14.52 Number of harbour porpoise disturbed by underwater noise for Tier 1 and Tier 2 projects. Project piling period at the proposed development (2028) is indicated in the red box

Project	Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Method	Density
The proposed development	1						595				26km EDR	Gilles et al. (2023)
OMF	1			198	198						15km EDR	Gilles et al. (2023)
Codling Wind Park	2					595					26km EDR	Gilles et al. (2023)
Dublin Array	2							595	595	595	26km EDR	Gilles et al. (2023)
Arklow Bank	2						595				26km EDR	Gilles et al. (2023)
Oriel	2					595					26km EDR	Gilles et al. (2023)
# animals		**0**	**0**	**198**	**198**	**1,190**	**1,190**	**595**	**595**	**595**	-	
% MU		**0.0%**	**0.0%**	**0.3%**	**0.3%**	**1.9%**	**1.9%**	**1.0%**	**1.0%**	**1.0%**		

Table 14.53 Number of harbour porpoise disturbed by underwater noise for Tier 1, Tier 2 and Tier 3 projects (with quantitative assessment). Project piling period at the proposed development (2028) is indicated in the red box

Project	Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Method	Density
The proposed development	1						3896				DR	DAS
OMF	1			198	198						15km EDR	Gilles et al. (2023)
Codling Wind Park	2					595					26km EDR	Gilles et al. (2023)
Dublin Array	2							595	595	595	26km EDR	Gilles et al. (2023)
Arklow Bank	2						595				26km EDR	Gilles et al. (2023)
Oriel	2					595					26km EDR	Gilles et al. (2023)
Erebus Floating Wind Demo	3			1967	1967	1967					DR	DAS
Awel y Môr	3				275	275	275	275	275		DR	Paxton et al. (2016)
White Cross	3				649	649					DR	DAS
Mona	3				1142	1142					DR	Evans and Waggitt (2023)
Morgan	3						979	979			DR	DAS
Morecambe	3				1279	1279	1279	1279			DR	DAS
Codling Wind Park Ltd. Site Investigations (FS007045)	3	23									5km[20] EDR	Hammond et al. (2021), Rogan et al. (2018)
Wicklow Sea Wind Ltd., Site Investigations (FS007163)	3	140	140								140 SPLrms	Rogan et al. (2018)
# animals		**70**	**47**	**2,165**	**55,10**	**6,502**	**7,024**	**3,128**	**870**	**595**	-	
% MU		**0.1%**	**0.1%**	**3.5%**	**8.8%**	**10.4%**	**11.2%**	**5.0%**	**1.4%**	**1.0%**		

[20] This assumes an SBP will be used as part of the survey and as a conservative approach, 5km EDR is appropriate (Crocker & Fratantonio 2016, Crocker et al. 2019).

Summary of all tiers

Across all Tiers considered (Table 14.51 to Table 14.53), the number of harbour porpoises potentially disturbed is the highest for Tier 1 + Tier 2 + Tier 3 (Table 14.53). While there is insufficient information on piling schedules across these projects to undertake a specific population-level assessment, it is possible to infer the potential for a population-level effect based on previous theoretical modelling.

Previous population modelling (using iPCoD) of offshore windfarms in eastern English waters has demonstrated low probabilities of population-level impacts, even when 16 piling operations were modelled over a 12-year period (disturbing up to a total of 34,396 porpoise per day) (Booth et al., 2017). The number of porpoise assumed to be disturbed by construction across the Tier 1-3 projects in this cumulative effects assessment is lower than was modelled in Booth et al., (2017). Therefore, with fewer porpoise predicted to be disturbed per day, across fewer years than the previous modelling, the likelihood of population level effects is expected to be very low.

In a recent report to Defra, the iPCoD model was used to investigate the potential population-level effects of disturbance for the Southern North Sea SAC and the Bristol Channel Approaches SAC (Brown et al. 2023). **For the Southern North Sea SAC:** This study provided a wide range of iPCoD simulations including disturbance to harbour porpoise over a 10-year period at the scale of the North Sea MU. One of the most extreme disturbance scenarios assumed a seasonally variable base-level daily disturbance of c. 3,500 - 7,000 porpoise throughout the MU, in addition to disturbance at up to twice the Southern North Sea SAC seasonal disturbance thresholds (up to c. 16,000 porpoise disturbed per day in summer, averaging c. 8,000 disturbed across the season). Even at these persistently high disturbance levels, the predicted declines were low, generally ≤5% after 10 years of disturbance and, in each case, the population remained at a stable size once piling disturbance ended, indicating no long-term effect on the population trajectory (it is important to note here that iPCoD does not allow for density dependence and as such the population cannot increase back to baseline levels after disturbance has ceased). **For the Bristol Channel Approach SAC:** This study provided a wide range of iPCoD simulations including disturbance to harbour porpoise over a 10-year period within the SAC and wider Celtic and Irish Seas MU, with the entire MU considered as the most appropriate reference population. One of the most extreme disturbance scenarios assumed a seasonally-variable level of daily disturbance of c. 1,600 - 2,000 porpoise throughout the MU, in addition to disturbance at up to twice the Bristol Channel Approaches SAC seasonal disturbance thresholds (up to c. 1,000 porpoise disturbed per day in summer, averaging c. 500 disturbed per day across the season). Even at these persistently high disturbance levels (up to c. 3,000 porpoise disturbed per day), the predicted declines were low, generally ≤ 5% after 10 years of disturbance and, in each case, the population remained at a stable size once piling disturbance ended, indicating no long-term effect on the population trajectory (it is important to note here that iPCoD does not allow for density dependence and as such the population cannot increase back to baseline levels after disturbance has ceased).

The DEPONS model has been used to predict the potential population level effects of cumulative OWF construction in the North Sea. Nabe-Nielsen et al. (2018) showed that the North Sea porpoise population was unlikely to be significantly impacted by the construction of 60 wind farms each with 65 WTG resulting in 3,900 disturbance days between 2011-2020, unless impact ranges were assumed to be much larger (exceeding 50km) than that indicated by existing studies. Even at these extreme disturbance scenarios, which far exceed that predicted in this cumulative effects assessment, the modelled North Sea population showed a quick recovery to baseline size (within 6-7 years) despite up to a 20% decline in population size.

The previous large-scale cumulative population modelling studies summarised above consider cases of persistent (i.e. 10+ years), high levels of disturbance, which are higher per day and/or over longer timescales than assumed in this cumulative effects assessment. The results of these studies suggest that such disturbance may result in temporary population declines, however, is unlikely to have long-term effects on population trajectory due to the expected population recovery. While some of these modelling scenarios were conducted for the North Sea, the results are comparable to potential impacts to other stable harbour porpoise populations such as the Celtic and Irish Sea MU.

The level of disturbance predicted to occur within the Celtic and Irish Sea MU between 2023 and 2031 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. The magnitude is therefore assessed as medium.

Sensitivity

As per the proposed development alone assessment, the sensitivity of harbour porpoise to behavioural disturbance as a result of pile driving (and other activities considered here) is low.

Significance of effect

The sensitivity of the receptor is low and the magnitude of the impact is medium, resulting in the overall likely significance effect of the cumulative impact of slight, which is not significant in EIA terms.

14.9.6 Cumulative Impact 2 - Bottlenose Dolphin – disturbance from underwater noise

Magnitude

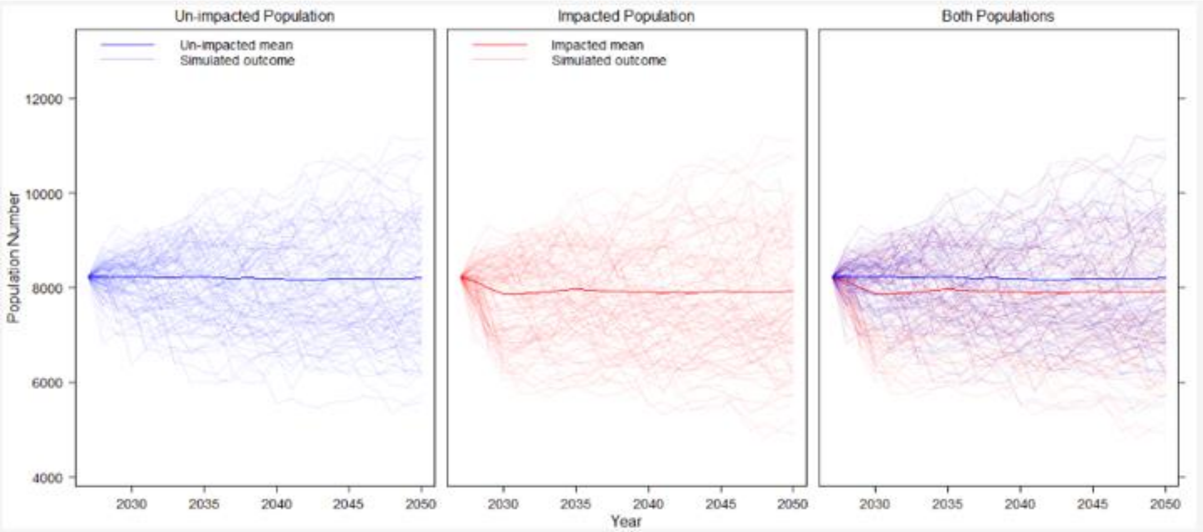
14.9.6.1 Tier 1

The construction of the OMF facility will be taking place in 2025 and 2026 (Table 14.54). During piling at the OMF, up to 166 bottlenose dolphins may experience behavioural disturbance per piling day (2% MU, assuming a 15km EDR, Table 14.54). There will be no temporal overlap with piling at the proposed development (in 2028) and therefore there is no potential for cumulative effects.

14.9.6.2 Tier 1 and 2

Based on methodology presented in Section 14.9.4.1, across all Tier 1 and 2 projects to be constructed between 2025 and 2031, the number of bottlenose dolphins predicted to be disturbed per day ranges between 0 in 2023 and 2024, 166 (2% MU) in 2025 and 2026 to 998 (12% MU) in 2027 and 2028 (Table 14.55). Only Arklow is expecting to pile at the same time as the proposed development (Table 14.55).

Based on numbers of animals predicted to be disturbed the population modelling was conducted for the East Coast Phase One Irish OWF Projects to determine if disturbance from piling activities across the five projects is predicted to result in population level changes (see Section 14.9.4.4, and Appendix 14.6: East Coast Phase One Irish Offshore Wind Farms: Cumulative iPCoD Modelling for more details). Under both piling schedule 1 or 2, when using Project specific disturbance numbers obtained using the dose-response function, the mean impacted population size decreases slightly from the mean unimpacted population size initially in response to piling, after which it continues on the same, stable trajectory at 95-96% of the mean unimpacted population size. Under both piling schedule 1 or 2, when using Project specific disturbance numbers obtained using the level B harassment threshold, 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% 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.



Graph 14.29 Predicted population trajectories for the un-impacted (baseline) and impacted bottlenose dolphin iPCoD simulations for piling schedule 1 using the dose-response function

The effect of disturbance from a single piling event is expected to last less than a day, though the disturbance impact across the five East Coast Phase One OWF projects will occur intermittently across up to 5 years. This is expected to result in intermittent and temporary behavioural effects in a low 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.

14.9.6.3 Tier 1 and 2 and 3 (All tiers)

Across Tier 1, Tier 2 and Tier 3 projects, between 2023 and 2031, the number of bottlenose dolphin predicted to be disturbed per day ranges between seven in 2023 (0.1% MU) to 2,892 (34.7% MU) in 2028 (assuming projects construct on the same day with no overlap of impacted areas, Table 14.56). This assumes piling at five OWFs at the same time within the MU. The iPCoD for the proposed development alone (e.g. for 2,326 animals impacted, 28% MU) showed that although the mean impacted population size decreases very slightly from the mean unimpacted population size, it continues on a stable trajectory in the long-term. 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.

Typically, it is considered that quantitative assessment values from each project is the most realistic approach to the cumulative effects assessment. However, it should be noted that each project included here used various methodologies and different density estimates (Table 14.56) which mean that results are different and not analogous. For example, the proposed development alone assessment used the SCANS IV density estimate (0.2352 dolphins/km^2) which is orders of magnitude higher than the SCANS III density estimate (Hammond et al. 2021) (0.0082 dolphins/km^2). However, it is considered appropriate as the assessment uses the most up to date information available on the projects screened into the cumulative assessment.

Table 14.54 Number of bottlenose dolphin disturbed by underwater noise for Tier 1 projects. Project piling period at the proposed development (2028) is indicated in the red box

Project	Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Method	Density
The proposed development	1						499				26km EDR	Gilles et al. (2023)
OMF	1			166	166						15km EDR	Gilles et al. (2023)
# animals		**0**	**0**	**166**	**166**	**0**	**499**	**0**	**0**	**0**	-	
% MU		**0.0%**	**0.0%**	**2.0%**	**2.0%**	**0.0%**	**6.0%**	**0.0%**	**0.0%**	**0.0%**		

Table 14.55 Number of bottlenose dolphin disturbed by underwater noise for Tier 1 and Tier 2 projects. Project piling period at the proposed development (2028) is indicated in the red box

Project	Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Method	Density
The proposed development	1						499				26km EDR	Gilles et al. (2023)
OMF	1			166	166						15km EDR	Gilles et al. (2023)
Codling Wind Park	2					499					26km EDR	Gilles et al. (2023)
Dublin Array	2							499	499	499	26km EDR	Gilles et al. (2023)
Arklow Bank	2						499				26km EDR	Gilles et al. (2023)
Oriel	2					499					26km EDR	Gilles et al. (2023)
# animals		**0**	**0**	**166**	**166**	**998**	**998**	**499**	**499**	**499**	-	
% MU		**0.0%**	**0.0%**	**2.0%**	**2.0%**	**12.0%**	**12.0%**	**6.0%**	**6.0%**	**6.0%**		

Table 14.56 Number of bottlenose dolphin disturbed by underwater noise for Tier 1, Tier 2 and Tier 3 projects (with quantitative assessment). Project piling period at the proposed development (2028) is indicated in the red box

Project	Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Method	Density
The proposed development	1						2326				DR	Gilles et al. (2023)
OMF	1			166	166						15km EDR	Gilles et al. (2023)
Codling Wind Park	2					499					26km EDR	Gilles et al. (2023)
Dublin Array	2							499	499	499	26km EDR	Gilles et al. (2023)
Arklow Bank	2						499				26km EDR	Gilles et al. (2023)
Oriel	2					499					26km EDR	Gilles et al. (2023)
Awel y Môr	3				23	23	23	23	23		DR	Hammond et al. (2021), Lohrengel et al. (2018)
Mona	3				7	7					DR	Evans and Waggitt (2023)
Morgan	3						22	22			DR	Lohrengel et al. (2018)
Morecambe	3				22	22	22	22			DR	Waggitt et al. (2019)
Codling Wind Park Ltd. Site Investigations (FS007045)	3	3									5km EDR	Hammond et al. (2021), Rogan et al. (2018)
Codling Wind Park Ltd. Site Investigations (FS007546)	3	3	3	3	3	3	3				5km EDR	Hammond et al. (2021), Rogan et al. (2018)
Wicklow Sea Wind Ltd., Site Investigations (FS007163)	3	1	1								1.5km EDR	Rogan et al. (2018)
# animals		**7**	**4**	**166**	**218**	**1,050**	**2,892**	**566**	**522**	**499**	-	
% MU		**0.1%**	**0.0%**	**2.0%**	**2.6%**	**12.6%**	**34.7%**	**6.8%**	**6.3%**	**6.0%**		

Summary of all tiers

Across all Tiers considered (Table 14.54 to Table 14.56), the number of bottlenose dolphins potentially disturbed is the highest for Tier 1 + Tier 2 + Tier 3 (Table 14.56).

The highest levels of disturbance are predicted to occur between 2027 and 2028 (up to 34.7% MU). Project alone iPCoD modelling for the proposed development has shown that impact to 28% of the MU over 1 year will not result in long-term changes to the population trajectory. Likewise, the Phase One iPCoD modelling has shown that impact to 26-53% of the MU over 2 years will not result in long-term changes to 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 at a level where recovery is not expected. The magnitude is therefore medium.

Sensitivity

As per the proposed development alone assessment, the sensitivity of bottlenose dolphins to behavioural disturbance as a result of pile driving is low.

Significance of effect

The sensitivity of the receptor is low and the magnitude of the impact is medium, resulting in the overall likely significance of effect of the cumulative impact of slight, which is not significant in EIA terms.

14.9.7 Cumulative Impact 3 - Common Dolphin – disturbance from underwater noise

Magnitude

14.9.7.1 Tier 1

The construction of the OMF facility will be taking place in 2025 and 2026 (Table 14.57). During piling at the OMF, up to 19 common dolphins may experience behavioural disturbance per piling day (0.02% MU, assuming a 15km EDR, Table 14.57). There will be no temporal overlap with piling at the proposed development (in 2028) and therefore there is no potential for cumulative effects.

14.9.7.2 Tier 1 and 2

Based on methodology presented in Section 14.9.4.1, across all Tier 1 and 2 projects constructing between 2025 and 2031, the number of common dolphins predicted to be disturbed per day ranges between 19 (0.02% MU) in 2025 and 2026 to 116 (0.1% MU) in 2027 and 2028 (Table 14.58). Only Arklow is expecting to pile at the same time as the proposed development (Table 14.58).

Phase One population modelling has not been carried out for common dolphins as the model is not parameterised for this species.

14.9.7.3 Tier 1 and 2 and 3 (All tiers)

Across Tier 1, Tier 2 and Tier 3 projects, between 2023 and 2031, the number of common dolphins predicted to be disturbed per day ranges between zero in 2023 to 2,710 (2.6% MU) in 2027 (assuming projects construct on the same day with no overlap of impacted areas,

Table 14.59). In 2028 when the proposed development is piling, the total number is 1,091 common dolphins (1.1% MU) (Table 14.59). This assumes piling at five OWFs at the same time within the MU.

Typically, it is considered that using quantitative assessment values from each project is the most realistic approach to the cumulative effects assessment. However, it should be noted that each project included here used various methodologies (dose-response vs TTS-onset as a proxy for disturbance, Table 14.59) which mean that results are different and not analogous. However, it is considered appropriate as the assessment uses the most up to date information available on the projects screened into the cumulative assessment.

Table 14.57 Number of common dolphins disturbed by underwater noise for Tier 1 projects. Project piling period at the proposed development (2028) is indicated in the red box

Project	Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Method	Density
The proposed development	1						58				26km EDR	Gilles et al. (2023)
OMF	1			19	19						15km EDR	Gilles et al. (2023)
# animals		**0**	**0**	**19**	**19**	**0**	**58**	**0**	**0**	**0**	-	
% MU		**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.1%**	**0.0%**	**0.0%**	**0.0 %**		

Table 14.58 Number of common dolphins disturbed by underwater noise for Tier 1 and Tier 2 projects. Project piling period at the proposed development (2028) is indicated in the red box

Project	Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Method	Density
The proposed development	1						58				26km EDR	Gilles et al. (2023)
OMF	1			19	19						15km EDR	Gilles et al. (2023)
Codling Wind Park	2					58					26km EDR	Gilles et al. (2023)
Dublin Array	2							58	58	58	26km EDR	Gilles et al. (2023)
Arklow Bank	2						58				26km EDR	Gilles et al. (2023)
Oriel	2					58					26km EDR	Gilles et al. (2023)
# animals		**0**	**0**	**19**	**19**	**116**	**116**	**58**	**58**	**58**	-	
% MU		**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.1%**	**0.1%**	**0.1%**	**0.1%**	**0.1%**		

Table 14.59 Number of common dolphins disturbed by underwater noise for Tier 1, Tier 2 and Tier 3 projects (with quantitative assessment). Project piling period at the proposed development (2028) is indicated in the red box

Project	Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Method	Density
The proposed development	1						410				DR	DAS
OMF	1			19	19						15km EDR	Gilles et al. (2023)
Codling Wind Park	2					58					26km EDR	Gilles et al. (2023)
Dublin Array	2							58	58	58	26km EDR	Gilles et al. (2023)
Arklow Bank	2						58				26km EDR	Gilles et al. (2023)
Oriel	2					58					26km EDR	Gilles et al. (2023)
Awel y Môr	3				17	17	17	17	17		DR	Hammond et al. (2021)
Erebus Floating Wind Demo	3			2067	2067	2067					DR	DAS, Hammond et al. (2021)
White Cross	3				1	1					TTS as a proxy	DAS
Rampion 2	3				597	597	597	597			DR	Laran et al. (2017)
Pentland Floating	3		8	8	8						DR	Waggitt et al. (2019)
West of Orkney	3							90			DR	DAS
Mona	3				3	3					DR	Evans and Waggitt (2023)
Morgan	3						100	100			DR	Hammond et al. (2021)
Morecambe	3				1	1	1	1			TTS as a proxy	Waggitt et al. (2019)
Dogger Bank South (West)	3	1	1								TTS as a proxy	Waggitt et al. (2019)
Dogger Bank South (East)	3			1							TTS as a proxy	Waggitt et al. (2019)
# animals		**0**	**8**	**2,094**	**2,621**	**2,710**	**1,091**	**771**	**75**	**58**	-	
% MU		**0.0%**	**0.0%**	**2.0%**	**2.6%**	**2.6%**	**1.1%**	**0.8%**	**0.1%**	**0.1%**		

Summary of all tiers

Across all Tiers considered (Table 14.57 to Table 14.59), the number of common dolphins potentially disturbed is the highest for Tier 1 + Tier 2 + Tier 3 (Table 14.59). The predicted extent of the cumulative disturbance is still to a low proportion of the MU (0.1 to 2.6% MU over nine years), with short-term behavioural changes expected from each disturbance event an individual is exposed to, with the overall disturbance effect occurring across the projects over several years.

What is important to consider here is the residency of animals within the impacted area, and the likelihood that they will remain in the impacted area long-term to obtain high levels of repeated disturbance over time. Based on tag and genetic data, common dolphins are generally considered to be wide-ranging, capable of travelling large distances (e.g. Evans 1982, Natoli et al., 2006, Genov et al., 2012). Therefore, it is highly unlikely that they would remain in the impacted area over a sufficient number of days for any disturbance effect to result in changes to vital rates. Temporary changes in behaviour and/or distribution of individuals may be at a scale that could result in potential reductions to lifetime reproductive success to some individuals, although likely not enough to affect the population trajectory over a generational scale. The magnitude is therefore medium.

Sensitivity

As per the proposed development alone assessment, the sensitivity of common dolphins to behavioural disturbance as a result of pile driving is low.

Significance of effect

The sensitivity of the receptor is low and the magnitude of the impact is medium, resulting in the overall likely significance of effect of the cumulative impact of slight, which is not significant in EIA terms.

14.9.8 Cumulative Impact 4 - Minke whale – disturbance from underwater noise

Magnitude

14.9.8.1 Tier 1

The construction of the OMF facility will be taking place in 2025 and 2026 (Table 14.60). During piling at the OMF, up to 10 minke whales may experience behavioural disturbance per piling day (0.05% MU, assuming a 15km EDR, Table 14.60). There will be no temporal overlap with piling at the proposed development (in 2028) and therefore potential for cumulative effects is limited.

14.9.8.2 Tier 1 and 2

Based on methodology presented in Section 14.9.4.1, across all Tier 1 and 2 projects constructing between 2025 and 2031, the number of minke whales predicted to be disturbed per day ranges between 10 (0.05% MU) in 2025 and 2026 to 58 (0.3% MU) in 2027 and 2028 (Table 14.61). Only Arklow is expecting to pile at the same time as the proposed development.

Phase One population modelling has not been carried out for minke whale.

14.9.8.3 Tier 1 and 2 and 3 (All tiers)

Across Tier 1, Tier 2 and Tier 3 projects, between 2023 and 2031, the number of minke whales predicted to be disturbed per day ranges between 51 (0.3% MU) in 2031 to 767 (3.8% MU) in 2026 (assuming projects construct on the same day with no overlap of impacted areas, Table 14.62). In 2028 when the proposed development is piling, the total number is 554 minke whales (2.8% MU). This assumes piling at 10 OWFs at the same time within the MU.

Typically, it is considered that using quantitative assessment values from each project is the most realistic approach to the cumulative effects assessment. However, it should be noted that each project included here used various methodologies (dose-response vs TTS-onset as a proxy for disturbance vs level B harassment, Table 14.62) which mean that results are different and not analogous.

However, it is considered appropriate as the assessment uses the most up to date information available on the projects screened into the cumulative assessment.

Table 14.60 Number of minke whales disturbed by underwater noise for Tier 1 projects. Project piling period at the proposed development (2028) is indicated in the red box

Project	Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Method	Density
The proposed development	1						29				26km EDR	Gilles et al. (2023)
OMF	1			10	10						15km EDR	Gilles et al. (2023)
# animals		**0**	**0**	**10**	**10**	**0**	**29**	**0**	**0**	**0**	-	
% MU		**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.1%**	**0.0%**	**0.0%**	**0.0%**		

Table 14.61 Number of minke whales disturbed by underwater noise for Tier 1 and Tier 2 projects. Project piling period at the proposed development (2028) is indicated in the red box

Project	Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Method	Density
The proposed development	1						29				26km EDR	Gilles et al. (2023)
OMF	1			10	10						15km EDR	Gilles et al. (2023)
Codling Wind Park	2					29					26km EDR	Gilles et al. (2023)
Dublin Array	2							29	29	29	26km EDR	Gilles et al. (2023)
Arklow Bank	2						29				26km EDR	Gilles et al. (2023)
Oriel	2					29					26km EDR	Gilles et al. (2023)
# animals		**0**	**0**	**10**	**10**	**58**	**58**	**29**	**29**	**29**	-	
% MU		**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.3%**	**0.3%**	**0.1%**	**0.1%**	**0.1%**		

Table 14.62 Number of minke whales disturbed by underwater noise for Tier 1, Tier 2 and Tier 3 projects (with quantitative assessment). Project piling period at the proposed development (2028) is indicated in the red box

Project	Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Method	Density
The proposed development	1						222				DR	Lacey et al. (2022)
OMF	1			10	10						15km EDR	Gilles et al. (2023)
Codling Wind Park	2					29					26km EDR	Gilles et al. (2023)
Dublin Array	2							29	29	29	26km EDR	Gilles et al. (2023)
Arklow Bank	2						29				26km EDR	Gilles et al. (2023)
Oriel	2					29					26km EDR	Gilles et al. (2023)
Neart Na Gaoithe	3	123	123								DR	Hammond et al. (2017)
Seagreen Phase 1	3	94									DR	Hammond et al. (2017)
Moray West	3	29	29	29							DR	Hammond et al. (2021)
Dogger Bank C - Teesside A	3	8	8	8	8						152dB re 1 µPa2.s	Hammond et al. (2013)
Awel y Môr	3				36	36	36	36	36		DR	Hammond et al. (2021)
Erebus Floating Wind Demo	3			55	55	55					DR	DAS
Inch Cape	3			158	158						DR	Hammond et al. (2017)
Hornsea Project Four	3	46	46	46	46	46					DR	Hammond et al. (2017)
Dogger Bank - Creyke Beck A	3	14	14	14							152dB re 1µPa2.s	Hammond et al. (2013)
Dogger Bank - Creyke Beck B	3	13	13								152dB re 1µPa2.s	Hammond et al. (2013)
Hornsea Project Three	3					51	51	51	51		DR	Hammond et al. (2017)
Dogger Bank - Teesside B (Sofia)	3	36	36	36	36						152dB re 1µPa2.s	Hammond et al. (2013)
White Cross	3				61	61					TTS as a proxy	Hammond et al. (2021), Waggitt et al. (2019)
Berwick Bank	3		132	132	132	132					DR	Hammond et al. (2021)
Rampion 2	3				8	8	8	8			DR	Hammond et al. (2021)
Sheringham Shoal Extension	3	21	21	21	21						TTS as a proxy	Hammond et al. (2017)
Dudgeon Extension	3				21	21	21	21	21		TTS as a proxy	Hammond et al. (2017)

Project	Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Method	Density
Green Volt	3					2					Level B harassment (140 SPLrms)	Hammond et al. (2021)
Pentland Floating	3		40	40	40						DR	Hammond et al. (2021)
West of Orkney	3							90			DR	Hammond et al. (2021)
Mona	3				72	72					DR	Evans and Waggitt (2023)
Morgan	3						96	96			DR	Hammond et al. (2021)
Morecambe	3				2	2	2	2			TTS as a proxy	Waggitt et al. (2019)
Outer Dowsing	3				22	22	22	22	22	22	DR	Hammond et al. (2021)
Dogger Bank South (West)	3	100	100								TTS as a proxy	Hammond et al. (2021)
Dogger Bank South (East)	3			68							TTS as a proxy	Hammond et al. (2021)
North Falls	3			70	70	70	70	70	70		TTS as a proxy	Hammond et al. (2021)
Codling Wind Park Ltd. Site Investigations (FS007045)	3	1									5km EDR	Hammond et al. (2021), Rogan et al. (2018)
Codling Wind Park Ltd. Site Investigations (FS007546)	3	4	4	4	4	4	4				5km EDR	Hammond et al. (2021), Rogan et al. (2018)
Wicklow Sea Wind Ltd., Site Investigations[21] (FS007163)	3	1	1								1.5km EDR	Rogan et al. (2018)
# animals		**464**	**541**	**737**	**767**	**633**	**554**	**422**	**229**	**51**	-	
% MU		**2.3 %**	**2.7 %**	**3.7 %**	**3.8 %**	**3.1 %**	**2.8 %**	**2.1 %**	**1.1 %**	**0.3 %**		

[21] Survey is associated with an OWF that is outside of a DMAP and MARA have confirmed that these surveys will not be approved

Summary of all tiers

Across all Tiers considered (Table 14.60 to Table 14.62), the number of minke whales potentially disturbed is the highest for Tier 1 + Tier 2 + Tier 3 (Table 14.62).

The predicted extent of the cumulative disturbance is still to a low proportion of the MU (0.3 to 3.8% MU over nine years), with short-term behavioural changes expected from each disturbance event an individual is exposed to, with the overall disturbance effect occurring across the projects over several years. It is important to note that minke whale densities are higher in the summer when the SCANS surveys are conducted, and significantly fewer minke whales will be present to be disturbed outside of the key summer months. 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.

Sensitivity

As per the proposed development alone assessment, the sensitivity of minke whales to behavioural disturbance as a result of pile driving is low.

Significance of effect

The sensitivity of the receptor is low and the magnitude of the impact is medium, resulting in the overall likely significance of effect of the cumulative impact of slight, which is not significant in EIA terms.

14.9.9 Cumulative Impact 5 - Harbour seal – disturbance from underwater noise

Magnitude

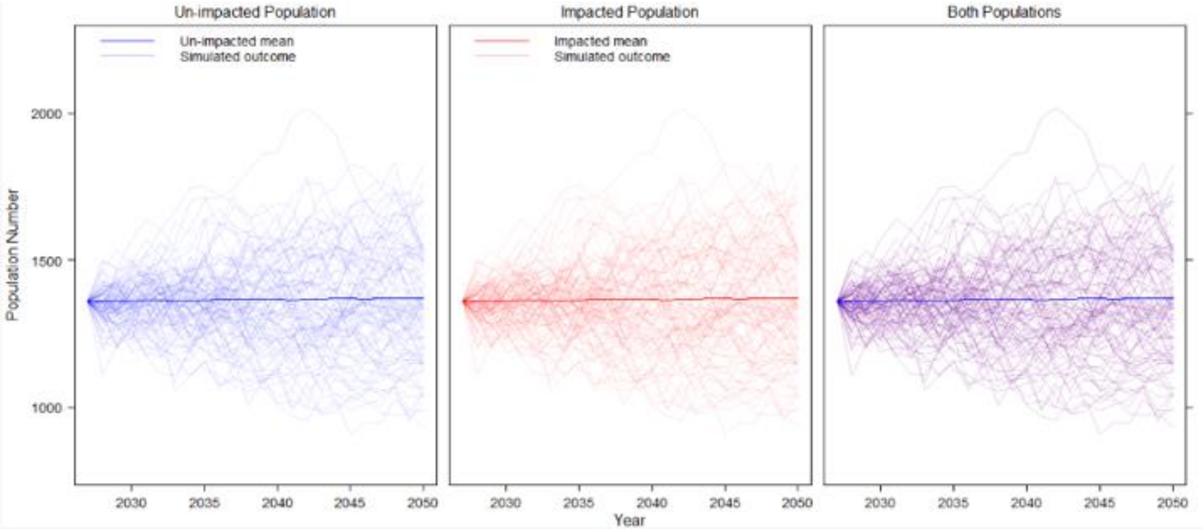
14.9.9.1 Tier 1

The construction of the OMF facility will be taking place in 2025 and 2026 (Table 14.63). The OMF is located near to the high-density areas around the Strangford Lough and Murlough SACs in Northern Ireland and as such, predicted impacts to the MU are relatively high. During piling at the OMF, up to 189 harbour seals may experience behavioural disturbance per piling day (13.5% MU, assuming a 15km EDR, Table 14.63). However, there will be no temporal overlap with piling at the proposed development (in 2028) and therefore there is no potential for cumulative effects.

14.9.9.2 Tier 1 and 2

Based on methodology presented in Section 14.9.4.1, across all Tier 1 and 2 projects constructing between 2025 and 2031, the number of harbour seals predicted to be disturbed per day ranges between 189 (13.8% MU) in 2025 and 2026 to 300 (22.0% MU) in 2027 (Table 14.64). The number of seals disturbed in 2027 is almost entirely driven by Oriel due to the close proximity of Oriel to the high-density areas around the Strangford Lough and Murlough SACs (average 0.14 seals/km^2 in a 25km buffer of Oriel). In 2028 when the proposed development is piling at the same time as Arklow, the total number is 119 harbour seal individuals (8.7% MU, Table 14.64).

Based on numbers of animals predicted to be disturbed (confidentially provided by developers), the population modelling was conducted for the Phase One Irish OWF Projects to determine if disturbance from piling activities across the five projects is predicted to result in population level changes (see Section 14.9.4.4, and Appendix 14.6: East Coast Phase One Irish Offshore Wind Farms: Cumulative iPCoD Modelling for more details). 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 un-impacted population.



Graph 14.30 Predicted population trajectories for the un-impacted (baseline) and impacted harbour seal iPCoD simulations for piling schedule 1

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 up to 5 years. This is expected to result in intermittent and temporary behavioural effects in a proportion of the population (up to 22.0% in 2027). 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.

14.9.9.3 Tier 1 and 2 and 3 (All tiers)

Across Tier 1, Tier 2 and Tier 3 projects, the number of harbour seals predicted to be disturbed per day ranges between one (0.1% MU) in 2023 and 2024 to 300 (22.0% MU) in 2027 (assuming projects construct on the same day with no overlap of impacted areas, Table 14.65). In 2028 when the proposed development is piling, the total number is 202 harbour seal (14.8% MU). This level of disturbance assumes piling at two OWFs at the same time within the MU.

Table 14.63 Number of harbour seals disturbed by underwater noise for Tier 1 project. Project piling period at the proposed development (2028) is indicated in the red box

Project	Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Method	Density
The proposed development	1						117				25km EDR	Carter et al. (2020)
OMF	1			189	189						15km EDR	Carter et al. (2020)
# animals		**0**	**0**	**189**	**189**	**0**	**117**	**0**	**0**	**0**	-	
% MU		**0.0%**	**0.0%**	**13.8%**	**13.8%**	**0.0%**	**8.6%**	**0.0%**	**0.0%**	**0.0%**		

Table 14.64 Number of harbour seals disturbed by underwater noise for Tier 1 and Tier 2 projects. Project piling period at the proposed development (2028) is indicated in the red box

Project	Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Method	Density
The proposed development	1						117				25km EDR	Carter et al. (2020)
OMF	1			189	189						15km EDR	Carter et al. (2020)
Codling Wind Park	2					20					25km EDR	Carter et al. (2020)
Dublin Array	2							33	33	33	25km EDR	Carter et al. (2020)
Arklow Bank	2						2				25km EDR	Carter et al. (2020)
Oriel	2					280					25km EDR	Carter et al. (2020)
# animals		**0**	**0**	**189**	**189**	**300**	**119**	**33**	**33**	**33**	-	
% MU		**0.0%**	**0.0%**	**13.8%**	**13.8%**	**22.0%**	**8.7%**	**2.4%**	**2.4%**	**2.4%**		

Table 14.65 Number of harbour seals disturbed by underwater noise for Tier 1, Tier 2 and Tier 3 projects (with quantitative assessment). Project piling period at the proposed development (2028) is indicated in the red box

Project	Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Method	Density
The proposed development	1						200				DR	Carter et al. (2020)
OMF	1			189	189						15km EDR	Carter et al. (2020)
Codling Wind Park	2					20					25km EDR	Carter et al. (2020)
Dublin Array	2							33	33	33	25km EDR	Carter et al. (2020)
Arklow Bank	2						2				25km EDR	Carter et al. (2020)
Oriel	2					280					25km EDR	Carter et al. (2020)
Wicklow Sea Wind Ltd., Site Investigations (FS007163)	3	1	1								1.5km	Russell et al. (2017)
# animals		**1**	**1**	**189**	**189**	**300**	**202**	**33**	**33**	**33**	**-**	
% MU		**0.1%**	**0.1%**	**13.8 %**	**13.8 %**	**22.0 %**	**14.8 %**	**2.4%**	**2.4%**	**2.4 %**		

Summary of all tiers

Across all Tiers considered (Table 14.63 to Table 14.65), the number of harbour seal potentially disturbed is the highest for Tier 1 + Tier 2 + Tier 3 (Table 14.65).

Across all Tier 1 + Tier 2 + Tier 3 projects, when the proposed development is piling, the number of animals disturbed is lower than the predicted disturbance levels in the preceding year, e.g. 2027 (Table 14.65). 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 piling at the proposed development is not expected to contribute to the extent where the population trajectory is affected over a generational scale. As such, in 2028 when the proposed development is expected to be piling in combination with offshore construction activities off the east coast of Ireland, the magnitude has been assessed as medium.

Sensitivity

As per the proposed development alone assessment, the sensitivity of harbour seals to disturbance as a result of piling is low.

Significance of effect

The sensitivity of the receptor is low and the magnitude of the impact is medium, resulting in the overall likely significance of effect of the cumulative impact to harbour seals of slight, which is not significant in EIA terms.

14.9.10 Cumulative Impact 6 - Grey seal – disturbance from underwater noise

Magnitude

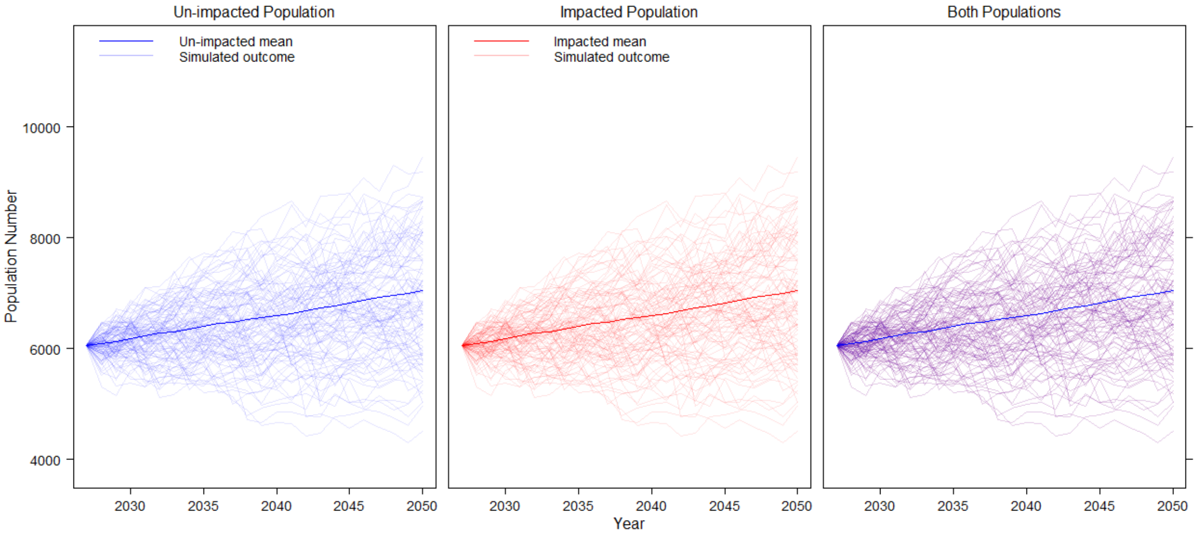
14.9.10.1 Tier 1

The construction of the OMF facility will be taking place in 2025 and 2026 (Table 14.66). During piling at the OMF, up to 87 grey seals may experience behavioural disturbance per piling day (1.4% MU, Table 14.66). However, there will be no temporal overlap with piling at the proposed development (in 2028) and therefore potential for cumulative effects is limited.

14.9.10.2 Tier 1 and 2

Based on methodology presented in Section 14.9.4.1, across Tier 1 and 2 projects constructing between 2025 and 2031, the number of grey seals predicted to be disturbed per day ranges between 87 (1.4% MU) in 2025 and 2026 to 688 (11.4% MU) in 2028 (Table 14.67).

Based on numbers of animals predicted to be disturbed (confidentially provided by developers), the population modelling was conducted for the East Coast Phase One Irish OWF Projects to determine if disturbance from piling activities across the five projects is predicted to result in population level changes (see Section 14.9.4.4, and Appendix 14.6: East Coast Phase One Irish Offshore Wind Farms: Cumulative iPCoD Modelling for more details). 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 a stable trajectory and at exactly the same size of the un-impacted population.



Graph 14.31 Predicted population trajectories for the un-impacted (baseline) and impacted grey seal iPCoD simulations for piling schedule 1

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 up to 5 years. This is expected to result in intermittent and temporary behavioural effects in a proportion of the population (up to 11.4% in 2028). 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.

14.9.10.3 Tier 1 and 2 and 3 (All tiers)

Across Tier 1, Tier 2 and Tier 3 projects, between 2023 and 2031, the number of grey seals predicted to be disturbed per day ranges between one (0.02% MU) in 2023 and 2024 to 990 (16.3% MU) in 2028 (assuming projects construct on the same day with no overlap of impacted areas, Table 14.68). This level of disturbance assumes piling at two OWFs at the same time within the MU.

Table 14.66 Number of grey seal disturbed by underwater noise for Tier 1 project. Project piling period at the proposed development (2028) is indicated in the red box

Project	Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Method	Density
The proposed development	N/A						488				25km EDR	Carter et al. (2020)
OMF	1			87	87						15km EDR	Carter et al. (2020)
# animals		**0**	**0**	**87**	**87**	**0**	**488**	**0**	**0**	**0**	-	
% MU		**0.0%**	**0.0%**	**1.4%**	**1.4%**	**0.0%**	**8.1%**	**0.0%**	**0.0%**	**0.0%**		

Table 14.67 Number of grey seal disturbed by underwater noise for Tier 1 and Tier 2 projects. Project piling period at the proposed development (2028) is indicated in the red box

Project	Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Method	Density
The proposed development	N/A						488				25km EDR	Carter et al. (2020)
OMF	1			87	87						15km EDR	Carter et al. (2020)
Codling Wind Park	2					231					25km EDR	Carter et al. (2020)
Dublin Array	2							325	325	325	25km EDR	Carter et al. (2020)
Arklow Bank	2						200				25km EDR	Carter et al. (2020)
Oriel	2					417					25km EDR	Carter et al. (2020)
# animals		**0**	**0**	**87**	**87**	**648**	**688**	**325**	**325**	**325**	-	
% MU		**0.0%**	**0.0%**	**1.4%**	**1.4%**	**10.7%**	**11.4%**	**5.4%**	**5.4%**	**5.4%**		

Table 14.68 Number of grey seal disturbed by underwater noise for Tier 1, Tier 2 and Tier 3 projects (with quantitative assessment). Project piling period at the proposed development (2028) is indicated in the red box

Project	Tier	2023	2024	2025	2026	2027	2028	2029	2030	2031	Method	Density
The proposed development	N/A						790				DR	Carter et al. (2020)
OMF	1			87	87						15km EDR	Carter et al. (2020)
Codling Wind Park	2					231					25km EDR	Carter et al. (2020)
Dublin Array	2							325	325	325	25km EDR	Carter et al. (2020)
Arklow Bank	2						200				25km EDR	Carter et al. (2020)
Oriel	2					417					25km EDR	Carter et al. (2020)
Wicklow Sea Wind Ltd., Site Investigations (FS007163)	3	1	1								1.5km	Russell et al. (2017)
# animals		**1**	**1**	**87**	**87**	**648**	**990**	**325**	**325**	**325**	**# animals**	**1**
% MU		**0.0%**	**0.0%**	**1.4%**	**1.4%**	**10.7 %**	**16.3%**	**5.4%**	**5.4%**	**5.4%**	**% MU**	**0.0%**

Summary of all tiers

Across all Tiers considered (Table 14.66 to Table 14.68), the number of grey seals potentially disturbed is the highest for Tier 1 + Tier 2 + Tier 3 (Table 14.68).

Across all Tier 1 + Tier 2 + Tier 3 projects, the level of disturbance predicted to occur within the seal MU between 2023 and 2031 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 likely 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.

Sensitivity

As per the proposed development alone assessment, the sensitivity of grey seals to disturbance as a result of piling is negligible**.**

Significance of effect

The sensitivity of the receptor is negligible and the magnitude of the impact is medium, resulting in the overall likely significance of effect of the cumulative impact to grey seals of slight, which is not significant in EIA terms.

14.9.11 Cumulative Impact 7 - Disturbance from vessels

14.9.11.1 Tier 1

As per the proposed development assessment alone, the sensitivity of all marine mammals to disturbance from vessel activity was assessed as low.

The construction of the OMF facility will be taking place in 2025 and 2026 (Table 14.50), with operation occurring thereafter. Given the large degree of temporal and spatial variation in vessel movements between the OMF and the proposed development as well as spatial and temporal variation in marine mammal movements, the magnitude of disturbance is likely to negligible. Further information is provided in Section 14.9.11.3. The cumulative effect of Tier 1 and the proposed development is then determined to be imperceptible, which is not significant in EIA terms.

14.9.11.2 Tier 1 and 2

As per the proposed development assessment alone, the sensitivity of all marine mammals to disturbance from vessel activity was assessed as low.

The construction phases and operational phases of the east coast Phase One Offshore Wind Farms will overlap from 2026 onwards (Table 14.50). Given the large degree of temporal and spatial variation in vessel movements between the Tier 1 and the Tier 2 projects and the proposed development, as well as spatial and temporal variation in marine mammal movements, the magnitude of disturbance is likely to low. Further information is provided in Section 14.9.11.3. The cumulative effect of Tier 1 and Tier 2 and the proposed development is then determined to be slight, which is not significant in EIA terms.

14.9.11.3 Tier 1 and 2 and 3 (All tiers)

Magnitude

Given the large degree of temporal and spatial variation in vessel movements between projects and regions, as well as spatial and temporal variation in marine mammal movements, it is challenging to reliably quantify the level of increased disturbance to marine mammals resulting from increased vessel activity on a cumulative basis.

Although some OWF vessels (such as crew transport and supply vessels) may transit the wind farm at higher speeds, they often travel in repeated/predictable routes within the site.

Many other vessels (e.g. jack-up vessels and pilot or attending vessels) travel more slowly within the wind farm site or spend long periods of time jacked-up, at anchor (minimizing movement and acoustic signature from engines) or using dynamic positioning systems (minimizing movement, although still generating noise). Unfortunately, there are very few species-specific studies covering these vessel types that capture vessel movement patterns as well as their acoustic signatures and the corresponding response of marine mammals.

Vessel routes to and from offshore windfarms and other offshore projects will, for the majority, use existing vessel routes for pre-existing vessel traffic which marine mammals will be accustomed to. They may also have become habituated to the volume of regular vessel movements and therefore the additional risk is predominantly confined to construction sites. The vessel movements for offshore wind farms are likely to be limited and slow, resulting in less risk of disturbance to marine mammal receptors. In addition, most projects are likely to adopt VMPs (or comply with existing Marine Wildlife Watching Codes such as SNH (2017b) and SNH (2017a)) to minimise any likely significant effects on marine mammals.

Seismic surveys do not use existing vessel routes, so may risk adding vessel presence to novel areas; however, these are slow-moving and operate their own mitigation measures to protect marine mammals (while mitigating for PTS the mitigation measures will also reduce disturbance impacts). Therefore, increases in disturbance from vessels from offshore projects are likely to be small in relation to current and ongoing levels of shipping.

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.

Sensitivity

As per the proposed development assessment alone, the sensitivity of all marine mammals to disturbance from vessel activity was assessed as low.

Significance of effect

The sensitivity of the receptor is low and the magnitude of impact is low, resulting in the overall likely cumulative effect for Tier1 and Tier 2 and Tier 3 (all tiers) with the proposed development of slight, which is not significant in EIA terms.

14.10 References

Anderwald, P., A. Brandecker, M. Coleman, C. Collins, H. Denniston, M. D. Haberlin, M. O'Donovan, R. Pinfield, F. Visser, and L. Walshe. 2013. Displacement responses of a mysticete, an odontocete, and a phocid seal to construction-related vessel traffic. Endangered Species Research 21.

BEIS. 2019. Offshore oil and gas licensing 32nd Seaward Round Habitats Regulations Assessment Stage 1 – Block and Site Screenings. The Department for Business Energy and Industrial Strategy.

Benhemma-Le Gall, A., I. M. Graham, N. D. Merchant, and P. M. Thompson. 2021. Broad-scale responses of harbor porpoises to pile-driving and vessel activities during offshore windfarm construction. Frontiers in Marine Science 8:664724.

Benhemma-Le Gall, A., P. Thompson, I. Graham, and N. Merchant. 2020. Lessons learned: harbour porpoises respond to vessel activities during offshore windfarm construction.in Environmental Interactions of Marine Renewables 2020, Online.

Benhemma-Le Gall, A., P. Thompson, N. Merchant, and I. Graham. 2023. Vessel noise prior to pile driving at offshore windfarm sites deters harbour porpoises from potential injury zones. Environmental Impact Assessment Review 103:107271.

Blackwell, S. B., C. S. Nations, A. Thode, M. Kauffman, A. S. Conrad, R. G. Norman, and K. Kim. 2017. Effects of tones associated with drilling activities on bowhead whale calling rate. PLoS ONE 12(11).

Blanchet, M.-A., C. Vincent, J. N. Womble, S. M. Steingass, and G. Desportes. 2021. Harbour Seals: Population Structure, Status, and Threats in a Rapidly Changing Environment. Oceans 2:41-63.

Booth, C. G. 2020. Food for thought: Harbor porpoise foraging behavior and diet inform vulnerability to disturbance. Marine Mammal Science.

Booth, C. G., F. Heinis, and H. J. 2019. Updating the Interim PCoD Model: Workshop Report - New transfer functions for the effects of disturbance on vital rates in marine mammal species. Report Code SMRUC-BEI-2018-011, submitted to the Department for Business, Energy and Industrial Strategy (BEIS), February 2019 (unpublished).

Brandt, M. J., A.-C. Dragon, A. Diederichs, M. A. Bellmann, V. Wahl, W. Piper, J. Nabe-Nielsen, and G. Nehls. 2018. Disturbance of harbour porpoises during construction of the first seven offshore wind farms in Germany. Marine Ecology Progress Series 596:213-232.

Brandt, M. J., C. Hoeschle, A. Diederichs, K. Betke, R. Matuschek, S. Witte, and G. Nehls. 2013. Far-reaching effects of a seal scarer on harbour porpoises, Phocoena phocoena. Aquatic Conservation-Marine and Freshwater Ecosystems 23:222-232.

Brasseur, S., G. Aarts, E. Meesters, T. van Polanen Petel, E. Dijkman, J. Cremer, and P. Reijnders. 2012. Habitat preference of harbour seals in the Dutch coastal area: analysis and estimate of effects of offshore wind farms.

Brown, A. M., M. Ryder, K. Klementisová, U. K. Verfuss, A. K. Darius-O'Hara, A. Stevens, M. Matei, and C. G. Booth. 2023. An exploration of time-area thresholds for noise management in harbour porpoise SACs: literature review and population modelling. Report Number SMRUC-DEF-2022-001. Prepared for Defra. SMRU Consulting. 131pp plus appendices.

Carter, M., L. Boehme, C. Duck, W. Grecian, G. Hastie, B. McConnell, D. Miller, C. Morris, S. Moss, D. Thompson, P. Thompson, and D. Russell. 2020. Habitat-based predictions of at-sea distribution for grey and harbour seals in the British Isles. Sea Mammal Research Unit, University of St Andrews, Report to BEIS, OESEA-16-76/OESEA-17-78.

Carter, M. I. D., L. Boehme, M. A. Cronin, C. D. Duck, W. J. Grecian, G. D. Hastie, M. Jessopp, J. Matthiopoulos, B. J. McConnell, D. L. Miller, C. D. Morris, S. E. W. Moss, D. Thompson, P. M. Thompson, and D. J. F. Russell. 2022. Sympatric Seals, Satellite Tracking and Protected Areas: Habitat-Based Distribution Estimates for Conservation and Management. Frontiers in Marine Science 9.

CEFAS. 2010. Strategic review of offshore wind farm monitoring data associated with FEPA licence conditions – annex 4: underwater noise., Cefas report ME1117.

Copping, A., and L. Hemery. 2020. OES-Environmental 2020 State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World. Report for Ocean Energy Systems (OES).

Crocker, S. E., and F. D. Fratantonio. 2016. Characteristics of sounds emitted during high-resolution marine geophysical surveys. OCS Study, BOEM 2016-44, NUWC-NPT Technical Report 12.

Crocker, S. E., F. D. Fratantonio, P. E. Hart, D. S. Foster, T. F. O’Brien, and S. Labak. 2019. Measurement of Sounds Emitted by Certain High-Resolution Geophysical Survey Systems. Ieee Journal of Oceanic Engineering 44: 796-813.

Czapanskiy, M. F., M. S. Savoca, W. T. Gough, P. S. Segre, D. M. Wisniewska, D. E. Cade, and J. A. Goldbogen. 2021. Modelling short‐term energetic costs of sonar disturbance to cetaceans using high‐resolution foraging data. Journal of Applied Ecology 58:1643-1657.

DAHG. 2014. Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters.

DCMNR. 2005. Marine Notice No 15 of 2005 - GUIDELINES FOR CORRECT PROCEDURES WHEN ENCOUNTERING WHALES AND DOLPHINS IN IRISH COASTAL WATERS.

DECC. 2011. Review and Assessment of Underwater Sound Produced from Oil and Gas Sound Activities and Potential Reporting Requirements under the Marine Strategy Framework Directive. Genesis Oil and Gas Consultants report for the Department of Energy and Climate Change.

DEFRA, Joint Nature Conservation Committee, Natural England, Marine Management Organisation, Department of Agriculture Environment and Rural Affairs (Northern Ireland), Department for Business Energy & Industrial Strategy, and Offshore Petroleum Regulator for Environment and Decommissioning. 2021. Policy paper overview: Marine environment: unexploded ordnance clearance joint interim position statement.

Department for Business Energy & Industrial Strategy. 2019. Spectrum Seismic Survey - Record of the Habitats Regulations Assessment undertaken under Regulation 5 of the Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (As Amended) (DRAFT REPORT). Department for Business Energy & Industrial Strategy.

Diederichs, A., G. Nehls, M. Dähne, S. Adler, S. Koschinski, and U. Verfuß. 2008. Methodologies for measuring and assessing potential changes in marine mammal behaviour, abundance or distribution arising from the construction, operation and decommissioning of offshore windfarms.

Donovan, C., J. Harwood, S. King, C. Booth, B. Caneco, and C. Walker. 2016. Expert elicitation methods in quantifying the consequences of acoustic disturbance from offshore renewable energy developments. Advances in Experimental Medicine and Biology.

European Union, 2021. The strict protection of animal species of Community interest under the Habitats Directive.

Evans, P., and J. Waggitt. 2023. Modelled Distributions and Abundance of Cetaceans and Seabirds in Wales and Surrounding Waters. NRW Evidence Report, Report No: 646, 354 pp. Natural Resources Wales, Bangor.

Evans, P. G., and A. Bjørge. 2013. Impacts of climate change on marine mammals. MCCIP Science Review 2013:134-148.

Gilles, A., M. Authier, N. Ramirez-Martinez, H. Araújo, A. Blanchard, J. Carlström, C. Eira, G. Dorémus, C. FernándezMaldonado, S. Geelhoed, L. Kyhn, S. Laran, D. Nachtsheim, S. Panigada, R. Pigeault, M. Sequeira, S. Sveegaard, N. Taylor, K. Owen, C. Saavedra, J. Vázquez-Bonales, B. Unger, and P. Hammond. 2023. Estimates of cetacean abundance in European Atlantic waters in summer 2022 from the SCANS-IV aerial and shipboard surveys.

Greene, C. 1987. Characteristics of oil industry dredge and drilling sounds in the Beaufort Sea. The Journal of the Acoustical Society of America.

Graham, IM, Merchant, ND, Farcas, A, Candido Barton, TR, Cheney, B, Bono, S & Thompson, PM (2019). Harbour porpoise responses to pile-driving diminish over time, Royal Society Open Science, vol. 6, no. 6, 190335.

Greene Jr, C. R. 1986. Acoustic studies of underwater noise and localization of whale calls. Sect. 2 In: Responses of bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea.

Guan, S., and T. Brookens. 2021. The Use of Psychoacoustics in Marine Mammal Conservation in the United States: From Science to Management and Policy. Journal of Marine Science and Engineering 9:507.

Halvorsen, M., and K. Heaney. 2018. Propagation characteristics of high-resolution geophysical surveys: open water testing. Department of the Interior, Bureau of Ocean Energy Management. Prepared by CSA Ocean Sciences Inc. OCS Study BOEM 2018-052.

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

Hammond, P., C. Lacey, A. Gilles, S. Viquerat, P. Börjesson, H. Herr, K. Macleod, V. Ridoux, M. Santos, M. Scheidat, J. Teilmann, J. Vingada, and N. Øien. 2017. Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys.

Hammond, P. S., K. MacLeod, P. Berggren, D. L. Borchers, L. Burt, A. Cañadas, G. Desportes, G. P. Donovan, A. Gilles, D. Gillespie, J. Gordon, L. Hiby, I. Kuklik, R. Leaper, K. Lehnert, M. Leopold, P. Lovell, N. Øien, C. G. M. Paxton, V. Ridoux, E. Rogan, F. Samarra, M. Scheidat, M. Sequeira, U. Siebert, H. Skov, R. Swift, M. L. Tasker, J. Teilmann, O. Van Canneyt, and J. A. Vázquez. 2013. Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management. Biological Conservation 164:107-122.

Hartley Anderson Ltd. 2020. Underwater acoustic surveys: review of source characteristics, impacts on marine species, current regulatory framework and recommendations for potential management options., NRW Evidence Report No: 448, 119pp, NRW, Bangor, UK.

Harwood, J., S. King, R. Schick, C. Donovan, and C. Booth. 2014. A protocol for Implementing the Interim Population Consequences of Disturbance (PCoD) approach: Quantifying and assessing the effects of UK offshore renewable energy developments on marine mammal populations. Report Number SMRUL-TCE-2013-014. Scottish Marine And Freshwater Science, 5(2).

Hoekendijk, J., J. Spitz, A. J. Read, M. F. Leopold, and M. C. Fontaine. 2018. Resilience of harbor porpoises to anthropogenic disturbance: Must they really feed continuously? Marine Mammal Science 34:258-264.

IAMMWG. 2023. Review of Management Unit boundaries for cetaceans in UK waters (2023). JNCC Report 734, JNCC, Peterborough, ISSN 0963-8091.

IWDG. 2005. CODE OF CONDUCT FOR ALL WATERCRAFT ENCOUNTERING WHALES AND DOLPHINS.

JNCC. 2010a. JNCC guidelines for minimising the risk of injury to marine mammals from using explosives.

JNCC. 2010b. Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise.

JNCC. 2017. JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys.

JNCC. 2020. Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs (England, Wales & Northern Ireland). Report No. 654, JNCC, Peterborough.

JNCC. 2023. MNR Disturbance Tool: Description and Output Generation.

JNCC, NE, and CCW. 2010. The protection of marine European Protected Species from injury and disturbance. Guidance for the marine area in England and Wales and the UK offshore marine area.

Kaschner, K., D. P. Tittensor, J. Ready, T. Gerrodette, and B. Worm. 2011. Current and Future Patterns of Global Marine Mammal Biodiversity. PLoS ONE 6:e19653.

Ketten, D. R. 2000. Cetacean Ears. Pages 43-108 in W. W. L. Au, N. A. Popper, and R. R. Fay, editors. Hearing by whales and dolphins. Springer-Verlag, New York, Berlin, Heidelberg.

Lacey, C., A. Gilles, P. Börjesson, H. Herr, K. Macleod, V. Ridoux, M. Santos, M. Scheidat, J. Teilmann, S. Sveegaard, J. Vingada, S. Viquerat, N. Øien, and P. Hammond. 2022. Modelled density surfaces of cetaceans in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys.

Lacey, C., and P. Hammond. 2020. Appendix 3 - SCANS surveys. In Regional baselines for marine mammal knowledge across the North Sea and Atlantic areas of Scottish waters (Hague et al. 2020). Scottish Marine and Freshwater Science Vol 11 No 12.

Laran, S., M. Authier, A. Blanck, G. Doremus, H. Falchetto, P. Monestiez, E. Pettex, E. Stephan, O. Van Canneyt, and V. Ridoux. 2017. Seasonal distribution and abundance of cetaceans within French waters-Part II: The Bay of Biscay and the English Channel. Deep Sea Research Part II: Topical Studies in Oceanography 141:31-40.

LGL, R., and Greeneridge. 1986. Responses of bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea.

Lindeboom, H. J., H. J. Kouwenhoven, M. J. N. Bergman, S. Bouma, S. Brasseur, R. Daan, R. C. Fijn, D. de Haan, S. Dirksen, R. van Hal, R. Hille Ris Lambers, R. ter Hofstede, K. L. Krijgsveld, M. Leopold, and M. Scheidat. 2011. Short-term ecological effects of an offshore wind farm in the Dutch coastal zone; a compilation. Environmental Research Letters 6:1-13.

Lohrengel, K., P. Evans, C. Lindenbaum, C. Morris, and T. Stringell. 2018. Bottlenose Dolphin Monitoring in Cardigan Bay 2014-2016. Natural Resources Wales, Bangor.

Lucke, K., U. Siebert, P. A. Lepper, and M. Blanchet. 2009. Temporary shift in masked hearing thresholds in a harbor porpoise (Phocoena phocoena) after exposure to seismic airgun stimuli. Journal of the Acoustical Society of America 125:4060-4070.

Lurton, X., and S. Deruiter. 2011. Sound Radiation Of Seafloor-Mapping Echosounders In The Water Column, In Relation To The Risks Posed To Marine Mammals.

Madsen, P. T., M. Wahlberg, J. Tougaard, K. Lucke, and P. Tyack. 2006. Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs. Marine Ecology Progress Series 309:279-295.

Malme, C., P. Miles, C. Clark, P. Tyack, and J. Bird. 1984. Investigations of the Potential Effects of Underwater Noise from Petroleum Industry Activities on Migrating Gray Whale Behavior—Phase II. U-S. Department of the Interior Minerals Management Service.

Martin, E., R. Bagnga, and N. Y. Taylor. 2023. Climate Change Impacts on Marine Mammals around the UK and Ireland. MCCIP Science Review 2023, 22pp.

Mirimin, L., R. Miller, E. Dillane, S. Berrow, S. Ingram, T. Cross, and E. Rogan. 2011. Fine - scale population genetic structuring of bottlenose dolphins in Irish coastal waters. Animal Conservation 14:342-353.

Moray Offshore Renewables Limited. 2012. Telford, Stevenson, MacColl Wind Farms and associated Transmission Infrastructure Environmental Statement: Technical Appendix 7.3 D - A comparison of behavioural responses by harbour porpoises and bottlenose dolphins to noise: Implications for wind farm risk assessments.

Nabe-Nielsen, J., F. van Beest, V. Grimm, R. Sibly, J. Teilmann, and P. M. Thompson. 2018. Predicting the impacts of anthropogenic disturbances on marine populations. Conservation Letters e12563.

Natural Power. 2021. NISA Offshore Wind Farm Baseline Ecology Surveys: 12-Month Interim Technical Report (November 2019 to October 2020).

Natural Power. 2022. NISA Offshore Wind Farm Seabird and Marine Mammal Surveys Baseline Year 2 Technical Report (November 2020 to October 2021).

Nedwell, J., J. Langworthy, and D. Howell. 2003. Assessment of sub-sea acoustic noise and vibration from offshore wind turbines and its impact on marine wildlife; initial measurements of underwater noise during construction of offshore windfarms, and comparison with background noise. Subacoustech Report ref: 544R0423, published by COWRIE.

NMFS. 2022. National Marine Fisheries Service: Summary of Marine Mammal Protection Act Acoustic Thresholds.

Normandeau, Exponent, T. Tricas, and A. Gill. 2011. Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Pacific OCS Region, Camarillo, CA. OCS Study BOEMRE 2011-09.

North Irish Sea Array Windfarm Ltd, 2024. Natura Impact Statement.

Nøttestad, L., B. A. Krafft, V. Anthonypillai, M. Bernasconi, L. Langård, H. L. Mørk, and A. Fernö. 2015. Recent changes in distribution and relative abundance of cetaceans in the Norwegian Sea and their relationship with potential prey. Frontiers in Ecology and Evolution 2.

NPWS. 2019. The Status of EU Protected Habitats and Species in Ireland. Volume 1: Summary Overview. Unpublished NPWS report. Edited by: Deirdre Lynn and Fionnuala O'Neill.

Paxton, C., L. Scott-Hayward, M. Mackenzie, E. Rexstad, and L. Thomas. 2016. Revised Phase III Data Analysis of Joint Cetacean Protocol Data Resources.

Pirotta, E., B. E. Laesser, A. Hardaker, N. Riddoch, M. Marcoux, and D. Lusseau. 2013. Dredging displaces bottlenose dolphins from an urbanised foraging patch. Marine Pollution Bulletin 74:396-402.

Ramp, C., J. Delarue, P. J. Palsbøll, R. Sears, and P. S. Hammond. 2015. Adapting to a warmer ocean—seasonal shift of baleen whale movements over three decades. PLoS ONE 10:e0121374.

Richardson, J., and B. Wursig. 1990. Reactions of Bowhead Whales, Balaena mysticetu, to Drilling and Dredging Noise in the Canadian Beaufort Sea. Marine Environmental Research 29:26.

Risch, D., M. Castellote, C. W. Clark, G. E. Davis, P. J. Dugan, L. E. Hodge, A. Kumar, K. Lucke, D. K. Mellinger, and S. L. Nieukirk. 2014. Seasonal migrations of North Atlantic minke whales: novel insights from large-scale passive acoustic monitoring networks. Movement Ecology 2:24.

Risch, D., B. Wilson, and P. Lepper. 2017. Acoustic Assessment of SIMRAD EK60 High Frequency Echo Sounder Signals (120 & 200 kHz) in the Context of Marine Mammal Monitoring.

Robinson, K. P., S. M. Eisfeld, M. Costa, and M. P. Simmonds. 2010. Short-beaked common dolphin (Delphinus delphis) occurrence in the Moray Firth, north-east Scotland. Marine Biodiversity Records 3.

Robinson, S. P., L. Wang, S.-H. Cheong, P. A. Lepper, F. Marubini, and J. P. Hartley. 2020. Underwater acoustic characterisation of unexploded ordnance disposal using deflagration. Marine Pollution Bulletin 160:111646.

Rogan, E., P. Breen, M. Mackey, A. Cañadas, M. Scheidat, S. Geelhoed, and M. Jessopp. 2018. Aerial surveys of cetaceans and seabirds in Irish waters: Occurrence, distribution and abundance in 2015-2017. Department of Communications, Climate Action & Environment and National Parks and Wildlife Service (NPWS), Department of Culture, Heritage and the Gaeltacht, Dublin, Ireland. 297pp.

Rose, A., M. J. Brandt, R. Vilela, A. Diederichs, A. Schubert, V. Kosarev, G. Nehls, M. Volkenandt, V. Wahl, A. Michalik, H. Wendeln, A. Freund, C. Ketzer, B. Limmer, M. Laczny, and W. Piper. 2019. Effects of noise-mitigated offshore pile driving on harbour porpoise abundance in the German Bight 2014-2016 (Gescha 2). IBL Umweltplanung GmbH, Institut für Angewandte Ökosystemforschung Gmb, BioConsult SH GmbH & Co KG, Husum.

Ruppel, C. D., T. C. Weber, E. R. Staaterman, S. J. Labak, and P. E. Hart. 2022. Categorizing Active Marine Acoustic Sources Based on Their Potential to Affect Marine Animals. Journal of Marine Science and Engineering 10:1278.

Russell, D., E. Jones, and C. Morris. 2017. Updated Seal Usage Maps: The Estimated at-sea Distribution of Grey and Harbour Seals. Scottish Marine and Freshwater Science Vol 8, No 25.

Russell, D. J., S. M. Brasseur, D. Thompson, G. D. Hastie, V. M. Janik, G. Aarts, B. T. McClintock, J. Matthiopoulos, S. E. Moss, and B. McConnell. 2014. Marine mammals trace anthropogenic structures at sea. Current Biology 24:R638-R639.

Russell, D. J., G. D. Hastie, D. Thompson, V. M. Janik, P. S. Hammond, L. A. Scott‐Hayward, J. Matthiopoulos, E. L. Jones, and B. J. McConnell. 2016a. Avoidance of wind farms by harbour seals is limited to pile driving activities. Journal of Applied Ecology 53:1642-1652.

Russell, D. J. F., G. D. Hastie, D. Thompson, V. M. Janik, P. S. Hammond, L. A. S. Scott-Hayward, J. Matthiopoulos, E. L. Jones, and B. J. McConnell. 2016b. Avoidance of wind farms by harbour seals is limited to pile driving activities. Pages 1642-1652 Journal of Applied Ecology.

Sarnocinska, J., J. Teilmann, J. B. Dalgaard, F. v. Beest, M. Delefosse, and J. Tougaard. 2019. Harbour porpoise (Phocoena phocoena) reaction to a 3D seismic airgun survey in the North Sea. Frontiers in Marine Science 6:824.

Scheidat, M., J. Tougaard, S. Brasseur, J. Carstensen, T. van Polanen Petel, J. Teilmann, and P. Reijnders. 2011. Harbour porpoises (Phocoena phocoena) and wind farms: a case study in the Dutch North Sea. Environmental Research Letters 6:1-10.

Schoeman, R. P., C. Patterson-Abrolat, and S. Plön. 2020. A global review of vessel collisions with marine animals. Frontiers in Marine Science 7:292.

Schwacke, L. H., T. A. Marques, L. Thomas, C. Booth, B. C. Balmer, A. Barratclough, K. Colegrove, S. De Guise, L. P. Garrison, and F. M. Gomez. 2021. Modeling population impacts of the Deepwater Horizon oil spill on a long ‐ lived species with implications and recommendations for future environmental disasters. Conservation Biology.

SCOS. 2022. Scientific Advice on Matters Related to the Management of Seal Populations: 2021.

Shell. 2017. Bacton Near Shore Pipeline Inspection Survey – Noise Assessment.

Sinclair, R., S. Kazer, M. Ryder, P. New, and U. Verfuss. 2023. Review and recommendations on assessment of noise disturbance for marine mammals. NRW Evidence Report No. 529, 143pp, Natural Resources Wales, Bangor.

SNH. 2017a. A Guide to Best Practice for Watching Marine Wildlife SMWWC - Part 2. Scottish Natural Heritage.

SNH. 2017b. The Scottish Marine Wildlife Watching Code SMWWC - Part 1. Scottish Natural Heritage.

Southall, B., J. J. Finneran, C. Reichmuth, P. E. Nachtigall, D. R. Ketten, A. E. Bowles, W. T. Ellison, D. Nowacek, and P. Tyack. 2019. Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. Aquatic Mammals 45:125-232.

Southall, B. L., A. E. Bowles, W. T. Ellison, J. J. Finneran, R. L. Gentry, C. R. J. Greene, D. Kastak, D. R. Ketten, J. H. Miller, P. E. Nachtigall, W. J. Richardson, J. A. Thomas, and P. L. Tyack. 2007. Marine mammal noise exposure criteria: initial scientific recommendations. Aquatic Mammals 33:411-414.

Stöber, U., and F. Thomsen. 2021. How could operational underwater sound from future offshore wind turbines impact marine life? The Journal of the Acoustical Society of America 149:1791-1795.

Teilmann, J., J. Carstensen, R. Dietz, S. M. C. Edrén, and S. M. Andersen. 2006a. Final report on aerial monitoring of seals near Nysted Offshore Wind Farm.

Teilmann, J., J. Tougaard, and J. Carstensen. 2006b. Summary on harbour porpoise monitoring 1999-2006 around Nysted and Horns Rev Offshore Wind Farms.

Thompson, P. M., K. L. Brookes, I. M. Graham, T. R. Barton, K. Needham, G. Bradbury, and N. D. Merchant. 2013. Short-term disturbance by a commercial two-dimensional seismic survey does not lead to long-term displacement of harbour porpoises. Proceedings of the Royal Society B-Biological Sciences 280:1-8.

Thompson, P. M., I. M. Graham, B. Cheney, T. R. Barton, A. Farcas, and N. D. Merchant. 2020. Balancing risks of injury and disturbance to marine mammals when pile driving at offshore windfarms. Ecological Solutions and Evidence 1:e12034.

Todd, V. L., I. B. Todd, J. C. Gardiner, E. C. Morrin, N. A. MacPherson, N. A. DiMarzio, and F. Thomsen. 2015. A review of impacts of marine dredging activities on marine mammals. ICES Journal of Marine Science: Journal du Conseil 72:328-340.

Tougaard, J. 2021. Thresholds for behavioural responses to noise in marine mammals. 225, Aarhus University, DCE – Danish Centre for Environment and Energy.

Tougaard, J., S. Buckland, S. Robinson, and B. Southall. 2013. An analysis of potential broad-scale impacts on harbour porpoise from proposed pile driving activities in the North Sea. Report of an expert group convened under the Habitats and Wild Birds Directive - Marine Evidence Group MB0138. 38pp.

Tougaard, J., A. J. Wright, and P. T. Madsen. 2015. Cetacean noise criteria revisited in the light of proposed exposure limits for harbour porpoises. Marine Pollution Bulletin 90:196-208.

Waggitt, J. J., P. G. H. Evans, J. Andrade, A. N. Banks, O. Boisseau, M. Bolton, G. Bradbury, T. Brereton, C. J. Camphuysen, J. Durinck, T. Felce, R. C. Fijn, I. Garcia-Baron, S. Garthe, S. C. V. Geelhoed, A. Gilles, M. Goodall, J. Haelters, S. Hamilton, L. Hartny-Mills, N. Hodgins, K. James, M. Jessopp, A. S. Kavanagh, M. Leopold, K. Lohrengel, M. Louzao, N. Markones, J. Martinez-Cediera, O. O'Cadhla, S. L. Perry, G. J. Pierce, V. Ridoux, K. P. Robinson, M. B. Santos, C. Saavedra, H. Skov, E. W. M. Stienen, S. Sveegaard, P. Thompson, N. Vanermen, D. Wall, A. Webb, J. Wilson, S. Wanless, and J. G. Hiddink. 2019. Distribution maps of cetacean and seabird populations in the North-East Atlantic. Journal of Applied Ecology 57:253-269.

Wall, D., C. Murray, J. O'Brien, L. Kavanagh, C. Wilson, C. Ryan, B. Glanville, D. Williams, I. Enlander, I. O'Connor, and M. D. 2013. Atlas of the Distribution and Relative Abundance of Marine Mammals in Irish Offshore Waters: Atlas of the Distribution and Relative Abundance of Marine Mammals in Irish Offshore Waters: 2005 -2011. Irish whale and Dolphin Group, Merchants Quay, Kilrish, Co Clare.

Williamson, M. J., M. T. I. ten Doeschate, R. Deaville, A. C. Brownlow, and N. L. Taylor. 2021. Cetaceans as sentinels for informing climate change policy in UK waters. Marine Policy 131:104634.

Wisniewska, D. M., M. Johnson, J. Teilmann, L. Rojano-Doñate, J. Shearer, S. Sveegaard, L. A. Miller, U. Siebert, and P. T. Madsen. 2016. Ultra-high foraging rates of harbor porpoises make them vulnerable to anthropogenic disturbance. Current Biology 26:1441-1446.

Wisniewska, D. M., M. Johnson, J. Teilmann, L. Rojano‐Doñate, J. Shearer, S. Sveegaard, L. A. Miller, U. Siebert, and P. T. Madsen. 2018. Response to "Resilience of harbor porpoises to anthropogenic disturbance: Must they really feed continuously?". Marine Mammal Science 34:265-270.