Appendix F

Marine Mammals and Megafauna Supporting Information

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

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ORIEL WIND FARM PROJECT

Natura Impact Statement

Appendix F: Marine Mammals and Megafauna – Supporting Information

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1 MARINE MAMMALS AND MEGAFAUNA

1.1 Introduction

This report describes the potential impacts of the Oriel Wind Farm Project (hereafter referred to as “the Project”) on marine mammals and megafauna. Specifically, it considers the potential impact of the offshore infrastructure (offshore wind farm and offshore cable) of the Project below the High-Water Mark (HWM) during the construction, operational and maintenance, and decommissioning phases.

1.2 Purpose

The primary purpose of this report is to provide supporting information on the potential impacts of the Project on marine mammals and megafauna, which is used to inform the assessment of adverse effects in the Natura Impact Statement (NIS). In particular, it:

- Identifies European sites which have relevant marine mammal and megafauna qualifying features and presents the existing environmental baseline established from desk studies, site-specific surveys and consultation (section 1.4 and section 3);

- Identifies potential impacts, their magnitude and their sensitivity on relevant marine mammal and megafauna qualifying features, based on the information gathered (see section 6). An assessment of potential in-combination effects is provided in section 7.

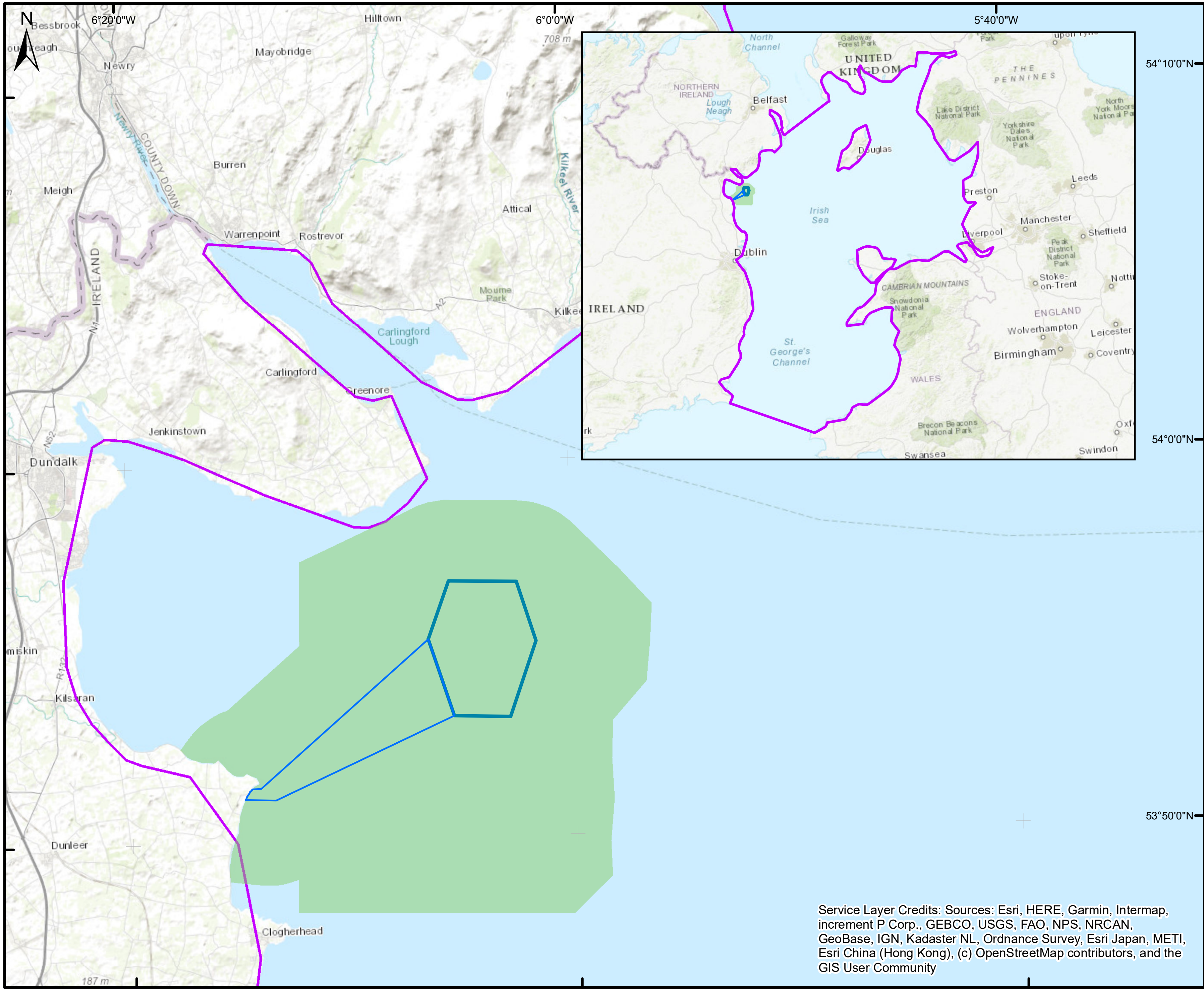
1.3 Zone of Influence

The Zone of Influence (ZoI) varies with each impact source and receptor interaction. The ZoI is contained within the study area, described below.

For the purposes of the Marine Mammal characterisation, two appropriate study areas were defined (Figure 1-1):

- **Marine Mammal and Megafauna Study Area:** this is an area of 319.85 km^2 encompassing the offshore wind farm area and offshore cable corridor plus an appropriate buffer of varying extent (as illustrated in Figure 1-1) and is the area within which the site-specific marine mammal surveys were undertaken. The survey area was determined by the offshore wind farm area plus a minimum 4 km buffer (NatureScot, 2023; DCCAE, 2018) and the same area was carried forward for the most recent site-specific surveys in order to maintain consistency; and

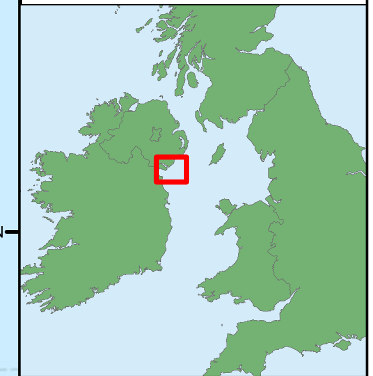
- **Regional Marine Mammal and Megafauna Study Area:** marine mammals are highly mobile and may range over large distances and therefore to provide a wider context, the desktop review considered their ecology, distribution and abundance within the wider Irish Sea. The Regional Marine Mammal and Megafauna Study Area also informs the assessment where the Zone of Influence (ZoI) for a given impact (e.g. subsea noise) may extend beyond the Marine Mammal and Megafauna Study Area.



Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor
- Marine Mammal and Megafauna Study Area
- Regional Marine Mammal Study Area

Data Sources: Client. atlas.marine.ie



Client

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

Oriel Wind Farm Project

Title

Figure 1-1
Marine Mammal and Megafauna Study Area and Regional Marine Mammal and Megafauna Study Area

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1.4 Consultation

Table 1-1 summarises the issues raised relevant to Marine Mammals which have been identified during consultation activities undertaken to date, together with how these issues have been considered in the production of this report.

Table 1-1: Summary of key issues raised during consultation on marine mammals and megafauna.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this appendix
October 2019	National Parks and Wildlife Service (NPWS) – written response to request for data	Provision of baseline data on marine mammals	Detailed baseline characterisation is presented in appendix G: Marine Mammal and Megafauna Technical Report.
October 2019	Cetaceans Strandings Investigation Programme (CSIP) – written response to request for data	Provision of marine mammal strandings data.	
November 2019	Irish Whale and Dolphin Group (IWDG) – written response to request for data	Provision of marine mammal data	
June 2020	NPWS - Meeting	Discussion on 2019/2020 survey methodology including consideration of weather conditions. Discussion of approach to data analyses for density estimates. Presentation of baseline data gathered from site-specific surveys and published records and agreement on study areas. Identification of key marine mammal receptors. No concerns raised by NPWS with respect to any items discussed. Suggestion to look at evidence for presence of orca around the offshore wind farm area.	Field based and desktop methodology presented in section 2. Results of 2019/2020 surveys are presented in section 3. Investigated all marine mammals to identify key species (including orca) and further details are provided in appendix G: Marine Mammal and Megafauna Technical Report. Key marine mammal species presented in section 3.2.
February 2021	IWDG - Meeting	Discussion on baseline characterisation including agreement on key marine mammal species, impacts scoped in and out of assessment and in-combination assessment. Described criteria and output of modelling and noise model used. Discussion of IWDG Best Practice guidance include potential for use of noise abatement methods.	Baseline presented in section 3 including key marine mammal species; impacts presented in section 3.2 and impacts scoped out are in section 4.3. Noise model used has been peer reviewed and validated and presented in section 6.1 and set out in full in appendix C: Subsea Noise Technical Report. Noise abatement measures have not been adopted although mitigation measures applied to reduce potential for injury.
January / February 2023	Members of the public during public consultation	Queries on the potential impacts of the Project on whales, dolphins and seals.	Baseline presented in section 3 including key marine mammal receptors. An assessment of the potential effects of the Project on marine mammals is presented in section 6.
September 2023	Department of Agriculture, Environment and Rural Affairs (DAERA) – response to transboundary scoping consultation	The scoping response emphasised that: transboundary environmental effects should be fully considered, focusing on Marine Protected Areas (MPAs); the Project proposals has the potential to have an adverse effects on harbour seal, grey seal	Relevant Marine Protected Areas (i.e. SACs and SPAs) are listed in Table 3-1 of this report and their relevant qualifying features discussed in relation to the potential impacts arising from the Project in section 6.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this appendix
		and cetaceans (i.e. whales, dolphins, porpoise); recent advise states that when screening features for assessment a 100 km range should be used to screen for grey seals and harbour porpoise; and Murlough SAC, the North Channel SAC and the Maidens SAC should be considered for harbour seal and harbour porpoise.	Harbour porpoise, grey seal, harbour seal and bottlenose dolphin are described in section 3 and potential impacts as a result of the Project are provided in section 6. The Regional Marine Megafauna Study Area within the Report to Inform Screening for Appropriate Assessment (see appendix A) considered European sites in the Irish Sea (i.e. which includes a 100 km range from the Project). The Murlough SAC, and the North Channel SAC were both considered in the Report to Inform Screening for Appropriate Assessment (appendix A) and screened in for further assessment in the Natura Impact Statement (NIS). The Maidens SAC was outside the Regional Marine Megafauna Study Area and has therefore not been considered further.
		The scoping response emphasised that: The project is in proximity to the boundary of several Marine Protected Areas and precautions should be taken to ensure the integrity of these areas will not be damaged by the proposal's activities. Any activity occurring within the designated site but outside the proposed red line boundary are subject to The Conservation (Natural Habitats, etc.) Regulations (Northern Ireland) 1995 (as amended) and the Environment (Northern Ireland) Order 2002 (as amended) and require consent from the Northern Ireland Environment Agency,	Relevant Marine Protected Areas (i.e. SACs) are listed in Table 3-1 of this report and their relevant qualifying features discussed in relation to the potential impacts arising from the Project in section 6.
October 2023	Isle of Man - response to transboundary scoping consultation	The scoping response raised the following; how and where are protected marine sites considered; the validity of baseline survey data.	Protected marine sites (i.e. SACs) are considered in this report under baseline (section 3) and their relevant qualifying features discussed in relation to the potential impacts arising from the Project in section 6. Isle of Man Marine Nature Reserves have not been considered in this report, as they do not qualify as European sites. The supporting information in this report was used to inform the assessment of adverse effects in the NIS. Data validity is discussed in the NIS.

2 METHODOLOGY TO INFORM THE BASELINE

2.1 Desktop study

Information on marine mammals within the both the Marine Mammal and Megafauna Study Area and the Regional Marine Mammal and Megafauna Study Area was collected through a detailed desktop review of existing studies and datasets. These included published reports on the distribution, occurrence, abundance and densities of marine mammals within the Regional Marine Mammal and Megafauna Study Area. The most recently published available data (e.g. seal haul-out counts) were sought to provide additional context to the baseline characterisation. The data sources used are presented in full within appendix G: Marine Mammal and Megafauna Technical Report.

2.2 Field study

In order to inform potential impacts, site-specific surveys were undertaken within the Marine Mammal and Megafauna Study Area, in accordance with the methodology as discussed with NPWS in June 2020 (see Table 1-1 for consultation). A summary of the surveys undertaken to inform potential impacts is outlined in Table 2-1 below with full details provided in appendix G: Marine Mammal and Megafauna Technical Report.

Table 2-1: Summary of site-specific survey data collected.

Title	Extent of survey	Overview of survey	Survey contractor	Date	Reference to further information
Oriel Wind Farm 2006 site-specific boat-based surveys	Offshore wind farm area plus buffer (see Figure 1-1)	Three surveys were conducted over a six-month period in 2006 (March/April; May/June; and July/August). 11 transects spaced 2 km apart were surveyed over a two-day period. Surveys were not conducted by dedicated Marine Mammal Observers (MMOs), but incidental marine mammal observations were recorded.	Aquafact Ltd	March to August 2006	Oriel Windfarm Limited (2007)
Oriel Wind Farm 2018 to 2020 site-specific boat-based surveys	Offshore wind farm area plus buffer (see Figure 1-1)	Monthly boat-based surveys were completed from May 2018 to May 2020 (with the exception of February, March and April 2020 due to COVID restrictions). 11 transects spaced 2 km apart were surveyed over a two-day period each month. Surveys for the first three months were not conducted by dedicated MMOs. Surveys from August 2018 onwards were conducted by dedicated MMOs.	Galway Mayo Institute of Technology and IWDG on behalf of Aquafact Ltd	May 2018 to May 2020	Aquafact Ltd. 2019; Aquafact Ltd., 2020; appendix G: Marine Mammal and Megafauna Technical Report.
Oriel Wind Farm 2020 site-specific aerial surveys	Offshore wind farm area plus buffer (see Figure 1-1)	Monthly digital aerial surveys of seabirds and marine mammals and megafauna along the 11 transects surveyed for the boat-based data (see above).	APEM	April 2020 to September 2020	APEM (2020) (see appendix H: Offshore Ornithology – Supporting Information)
Oriel Wind Farm 2019 to 2020 site-specific Static Acoustic Monitoring (SAM) surveys	Offshore wind farm area and offshore cable corridor (see Figure 1-1)	SAM conducted using self-contained click detectors (C-PODs) at two locations within the wind farm site and two locations within the offshore cable corridor. Duration of deployment differed between locations due to issues with equipment losses.	IWDG	November 2019 to November 2020	O'Brien *et al.* (2020) (see appendix G: Marine Mammal and Megafauna Technical Report)

2.3 Identification of relevant European sites and features (species and habitats)

All designated European sites within the Regional Marine Mammal and Megafauna Study Area and qualifying interests (QIs) that could be affected by the construction, operational and maintenance, and decommissioning phases of the Project were identified using the three-step process described below:

- Step 1: All European sites within the ZoI were identified using a number of sources. These included Ireland's Marine Atlas interactive map application (http://atlas.marine.ie/) the National Parks and Wildlife Service (NPWS) website, the European Nature Information System (EUNIS) designated site database, and for sites in the UK, the Joint Nature Conservation Committee's (JNCC) website and the Department for Environment, Food and Rural Affairs (Defra) MAGIC interactive map applications (http://magic.defra.gov.uk/);
- Step 2: Information was compiled on the relevant QIs for each of these sites as follows:
  - The known occurrence of species within the Regional Marine Mammal and Megafauna Study Area was based on the relevant desktop information and site-specific surveys presented within appendix G: Marine Mammal and Megafauna Technical Report.
- Step 3: Using the above information and expert judgement, sites were included for further consideration if:
  - A designated site directly overlaps with the Regional Marine Mammal and Megafauna Study Area;
  - Sites and associated qualifying features were located within the potential Zone of Influence (ZoI) for impacts associated with the Project (e.g. potential effect ranges of underwater noise as a result of piling activities during construction; see section 6); and
  - Features of a designated site were either recorded as present during recent and historic site-specific surveys within the offshore wind farm area and offshore cable corridor, or identified during the desktop study as having the potential to occur within the offshore wind farm area and offshore cable corridor.

3 BASELINE EVIRONMENT

3.1 Relevant European sites

Relevant European sites which have marine mammal qualifying features, and which have been considered in the marine mammals report for the Project are described in Table 3-1 below.

Table 3-1: Relevant European sites and qualifying features for the Marine Mammals assessment[a].

Designated Site	Closest distance to offshore wind farm area or offshore cable corridor (km)	Relevant qualifying feature
Murlough SAC (UK0016612)	22.0	Annex II Species • Harbour seal (*Phoca vitulina*) (qualifying feature)
Rockabill to Dalkey Island SAC (003000)	30.6	Annex II Species • Harbour porpoise (*Phocoena phocoena*)
Lambay Island SAC (000204)	43.1	Annex II Species • Grey seal (*Halichoerus grypus*) • Harbour seal (*Phoca vitulina*) • Harbour porpoise (*Phocoena phocoena*)
North Channel SAC (UK0030399)	47.8	Annex II Species • Harbour porpoise (*Phocoena phocoena*)
North Anglesey Marine/Gogledd Môn Forol SAC (UK0030398)	56.0	Annex II Species • Harbour porpoise (*Phocoena phocoena*)
Codling Fault Zone SAC (IE003015)	63.0	Annex II Species • Harbour porpoise (*Phocoena phocoena*)
West Wales Marine/Gorllewin Cymru Forol SAC (UK0030397)	136.0	Annex II Species • Harbour porpoise (*Phocoena phocoena*)
Lleyn Peninsula and the Sarnau/Pen Llŷn a`r Sarnau SAC (UK0013117)	139.3	Annex II Species • Bottlenose dolphin (*Tursiops truncatus*) • Grey seal (*Halichoerus grypus*)
Blackwater Bank SAC (IE002953)	145.3	Annex II Species • Harbour porpoise (*Phocoena phocoena*)
Cardigan Bay/Bae Ceredigion SAC (UK0012712)	196.4	Annex II Species • Bottlenose dolphin (*Tursiops truncatus*) • Grey seal (*Halichoerus grypus*) (qualifying feature)
Pembrokeshire Marine/Sir Benfro Forol SAC (UK0013116)	219.3	Annex II Species • Grey seal (*Halichoerus grypus*)

a Note: other qualifying features, including habitats and bird species are not presented here.

3.2 Relevant qualifying features

3.2.1 Harbour porpoise

Harbour porpoise is a qualifying interest of the following SACs: Rockabill to Dalkey Island SAC, 30.6 km to the south of the offshore wind farm area; Lambay Island SAC, 43.1 km south of the offshore wind farm area; North Channel SAC, 47.8 km to the north of the offshore wind farm area; North Anglesey Marine/ Gogledd Môn Forol SAC, 55.9 km from the offshore wind farm area; Codling Fault Zone SAC, 63 km south of the offshore wind farm area; West Wales Marine/Gorllewin Cymru Forol SAC 135.9 km southeast from the offshore wind farm area; and Blackwater Bank SAC, 145.3 km south of the offshore wind farm area.

Harbour porpoise is widely distributed throughout the western Irish Sea and is predominantly found in coastal waters and waters of the continental shelf and slope (e.g. Berrow *et al.*, 2010; Wall *et al.*, 2013). Often living in cool waters, harbour porpoise has a higher metabolic rate than dolphins and therefore needs to feed more frequently and consume more prey per unit body weight, in order to maintain their body temperature and other energy needs. For this reason, porpoises may be highly susceptible to changes in the abundance of prey species or disturbance from foraging areas. Harbour porpoise regularly forage around tidal races, overfalls, and upwelling zones during the ebb phase of the tide (Pierpoint, 2008). This species feeds on a wide variety of fish and generally focus on the most abundant local species. The predominant prey type appears to be bottom-dwelling fish such as sandeels *Ammodytidae*, although shoaling fish such as mackerel *Scomber scombrus* and herring *Clupea harengus* are also taken (Santos and Pierce, 2003; Pierce *et al*., 2007). O'Brien *et al*. (2009) reported that for harbour porpoise stranded and by-caught in the Irish Sea, gadoids and clupeids comprised 95% of their stomach contents.

The ObSERVE aerial surveys suggest that the Irish Sea is an important area year-round for harbour porpoise, with consistently highest summer abundance in the western Irish Sea and Celtic Sea compared to other areas. The maximum density estimated from the ObSERVE surveys was 1.046 animals per km^2 (Rogan *et al*., 2018a). Broadscale data from SCANS-III aerial surveys for Block E (western Irish Sea) estimated the maximum density of harbour porpoise in summer 2016 as 0.239 animals per km^2 (Hammond *et al*., 2021), and the density in summer 2022 from SCANS IV for Block CS-D (which corresponds to SCANS III Block E) was 0.280 animals per km^2 (Gilles *et al*., 2023). Recent, finer-scale density surface estimates (DSE) of harbour porpoise were produced from SCANS-III surveys (Lacey *et al.,* 2022) for those 10x10 km grid cells covering the Marine Mammal and Megafauna Study Area and generated an average density of 0.278 animals per km^2. The average density estimate from Evans and Waggitt (2023) data within 2.5 km^2 grid cells covering the Marine Mammal and Megafauna Study Area was 0.224 animals per km^2. Harbour porpoise was sighted in every month of site-specific surveys within the offshore wind farm area and buffer (2018-2019). Site-specific modelled estimates from recent boat-based surveys provided a monthly average of 0.57 animals per km^2 and a monthly peak of 1.33 animals per km^2 (appendix G: Marine Mammal and Megafauna Technical Report).

The density range carried forward to the assessment was 0.280 animals per km^2 (SCANS-IV Block CS-D; Gilles *et al.,* 2023) to 1.33 animals per km^2 (monthly peak, site-specific surveys at the Project) (see Table 3-2).

The Marine Mammal and Megafauna Study Area falls within the Celtic and Irish Seas (CIS) Management Unit (MU) which extends from the northwest coast of France, to the northwest coast of the Republic of Ireland and east from the southwest coast of Scotland, including the entirety of Irish waters (see Figure 10-19 in appendix G: Marine Mammal and Megafauna Technical Report). The total harbour porpoise abundance for the CIS MU was estimated as 62,517 animals (CV = 0.13, 95% CI = 48,324 to 80,877) (IAMMWG, 2023).

3.2.2 Bottlenose dolphin

Bottlenose dolphin is the qualifying feature of Cardigan Bay/Bae Ceredigion SAC, which lies 196.4 km east of the offshore wind farm area; and a qualifying feature of the Lleyn Peninsula and the Sarnau/Pen Llŷn a`r Sarnau SAC in northern Cardigan Bay, 139.3 km from the offshore wind farm area.

Bottlenose dolphin are found throughout the world's tropical and temperate marine waters and are regularly recorded in Irish coastal and offshore waters (NPWS, 2019) and in all seasons (Berrow *et al.*, 2018; Rogan *et al.*, 2018a). The distribution of sightings indicates a preference for waters overlying the continental shelf and the continental slope plus adjacent deeper ocean waters and topographical basins (NPWS, 2019), but bottlenose dolphin is also encountered in enclosed bays and in close proximity to the Irish coast (Oudejans *et al.*, 2010; Wall *et al.*, 2013; Rogan *et al.*, 2018b).

There is variation in the patterns of habitat use of bottlenose dolphin, even within a population, and generally the distribution of this species is influenced by factors such as tidal state, weather conditions, resource availability, life cycle stage, or season (Hastie *et al*., 2004). Investigations of the feeding habits of bottlenose dolphin in Irish waters reported that this species preys on salmon, garfish *Belone belone*, and eels *Anguilla anguilla* in estuarine environments, whilst pollock, whiting and saithe have been identified from the stomach contents of stranded animals (O'Brien *et al.,* 2009).

Bottlenose dolphin was the most frequently sighted cetacean species during ObSERVE surveys in Irish waters, with more than twice as many sightings during winter compared to summer. However, there were very few sightings in the western Irish sea compared to other regions of the survey. These surveys suggest that the west and southwest of Ireland are likely to be more important in terms of distribution compared to the Irish Sea. Cardigan Bay, in the eastern Irish Sea is occupied by a semi-resident population of about 300 animals, likely to venture throughout the Irish Sea, and occur in the offshore wind farm area. However, no bottlenose dolphin were sighted during site-specific surveys in 2006 or 2018-2019 in the Survey Area. Exploration of broadscale data found that the average density recorded by the ObSERVE surveys (2012) for the Irish Sea was estimated as 0.036 animals per km^2 (Rogan *et al.,* 2018b). SCANS-III surveys (2016) estimated a density of 0.008 animals per km^2 in the western Irish Sea (Hammond *et al*., 2021), while SCANS IV surveys (2022) estimated a density of 0.235 animals per km^2, which authors noted to be orders of magnitude higher than previous estimates within the same survey block (Gilles *et al*., 2023). Finer-scale analyses of the SCANS-III data (DSE in 10x10 km grid cells) estimated that the average density for bottlenose dolphin within the Marine Mammal and Megafauna Study Area (Lacey *et al.,* 2022) was 0.046 animals per km^2. This was two orders of magnitude greater than the fine-scale data from Evans and Waggitt (2023) which predicted 0.0006 animals per km^2 for the 2.5 km^2 grid cells that covered the Marine Mammal and Megafauna Study Area.

There were a wide range of density estimates for bottlenose dolphin within the Marine Mammal and Megafauna Study Area. Conservatively, the density range carried forward to the assessment was 0.046 (SCANS-III DSE; Lacey *et al.,* 2022) to 0.235 (SCANS-IV Block CS-D; Gilles *et al.,* 2023) (see Table 3-2).

The Marine Mammal and Megafauna Study Area falls within the Irish Sea (IS) MU, which occurs to the east of Ireland, from southwest Scotland to the northern coast of Pembrokeshire (see appendix G: Marine Mammal and Megafauna Technical Report). The total bottlenose dolphin abundance for the IS MU was estimated as 293 animals (CV = 0.54, 95% CI = 108 to 793) (IAMMWG, 2023). This abundance estimate did not align with the most recent SCANS IV data which generated much high predictions of bottlenose dolphin density compared with the data sources used to inform the IAMMWG (2023) MU estimates. Therefore, when using SCANS-IV densities to estimate numbers of bottlenose dolphin potentially affected, the appropriate reference population was derived by summing the number of animals in each the two SCANS-IV survey blocks covering the Irish Sea region; a total abundance (representing the Irish Sea population) of 8,326 animals.

3.2.3 Grey seal

Grey seal is a qualifying interest of Lambay Island SAC which lies 43.1 km south of the offshore wind farm area; Lleyn Peninsula and the Sarnau/Pen Llŷn a`r Sarnau SAC which lies 139.3 km southeast of the offshore wind farm area; and Pembrokeshire Marine/Sir Benfro Forol SAC which lies ~ 220 km south-southeast of the offshore wind farm area.

Grey seal is the larger of the two pinniped species which occur around the Irish coast. Grey seals gather in colonies on land (known as haul-outs) where they breed, rest, moult and engage in social activity (Bonner, 1981). Breeding occurs in late August to December and the annual moult between November to April (Kiely *et al.,* 2000). Preferred haul-out locations around the coast of Ireland include uninhabited islands, isolated main beaches, rocky skerries and sea caves (O’Cadhla *et al.*, 2007).

The UK and Ireland are together one of the global hotspots for grey seal. For example, the UK alone supports up to 38% of the world population (SCOS, 2017). Data from NBDC shows that grey seal occur all around the coast of Ireland, including records from the County Louth coast, adjacent to the Project. The distribution around Ireland is concentrated along the Atlantic seaboard with more isolated regional concentrations off the coast of Wexford, Dublin, the Skerries, Clogherhead, Dundalk Bay and Carlingford Lough (O’Cadhla *et al*., 2007; Duck and Morris, 2013; Morris and Duck, 2019). Pup production on the east coast of Ireland is lower compared to the Atlantic coast; most likely due to poor availability of sheltered, undisturbed breeding habitat.

Lambay Island SAC supports the principal breeding colony of grey seal on the east coast of Ireland. Breeding occurs in late August to December and the annual moult between November to April. The closest haul-out sites to the Project are at the mouth of Carlingford Lough (haul-out located 4.5 km from the offshore wind farm area and 6.5 km from the offshore cable corridor), Clogherhead (haul-out located 13.3 km from the offshore wind farm area and 4.1 km from the offshore cable corridor) and Dundalk Bay (haul-out located

15.5 km from the offshore wind farm area and 14.8 km from the offshore cable corridor) (Morris and Duck, 2019). SMRU at-sea usage maps estimated a range of mean densities from 0.11 to 0.40 animals per km^2 for the grid cells that overlap the offshore wind farm area. The mean density estimate for the Marine Mammal and Megafauna Study Area, derived from estimates presented in Carter *et al*. (2022), was 0.372 animals per km^2. Site-specific modelled estimates from recent boat-based surveys provided a monthly average of 0.09 animals per km^2 and a mean monthly peak of 0.21 animals per km^2.

Grey seal numbers are typically counted at haul-out sites during harbour seal August moult surveys. The 2017/18 aerial thermal-imaging August surveys in Ireland estimated a total of 418 grey seals across Irish haul-outs in the East Ireland survey region, and 556 grey seals across Irish haul-outs in the South East Ireland survey region (Morris and Duck, 2019). SCOS (2020) counts estimated a total of 505 grey seals across Northern Ireland haul-outs. Correcting these for the proportion of the population that are estimated to be hauled-out during the survey period (25.15% based on SCOS, 2021) gave corrected population estimates of 1,662 (East Ireland), 2,211 (South East Ireland) and 2,008 (Northern Ireland) animals, totalling 5,882 animals (termed the Grey Seal Reference Population (GSRP) from this point onwards).

3.2.4 Harbour seal

Harbour seal is a qualifying interest of the Lambay Island SAC which lies 43.1 km south of the offshore wind farm area and is a qualifying feature of the Murlough SAC, which lies 21.9 km north of the offshore wind farm area.

Harbour (common) seal is the smaller of the two species of pinniped found in the UK and Ireland, harbour seal breeds in small groups scattered along the coastline and pups are born in June and July having moulted their white coats prior to birth. This allows harbour seal pups to swim within a few hours of birth (SCOS, 2018). During lactation females spend much of their time in the water with their pups, and although they will forage during this period, distances travelled at this time are more restricted than during other periods (Thompson and Härkönen, 2008). Following the spring/summer breeding and nursing season, the annual moult of harbour seal in Ireland occurs from late July through August.

Data collated by NPWS (NPWS, 2019) show a widespread occurrence around much of the Irish coastline, including many enclosed bays and several island and skerries. Areas of particular importance for harbour seal in Irish waters are the southwest of Ireland, southeast of Ireland and the northwest coast of Ireland, with fewer, smaller colonies in the Irish Sea (Cronin *et al.,* 2004). Aerial surveys undertaken around the coast of Ireland in August/September 2003, 2012 and 2018 indicate that in the Irish Sea, Carlingford Lough (~10 km north of the offshore wind farm area) and Lambay Island (~ 43 km south of the offshore wind farm area) are important haul-out sites for harbour seal, in the context of the east coast of Ireland. The closest haul-out sites for harbour seal to the Project are at the mouth of Carlingford Lough (7.9 km from the offshore wind farm area; 10.6 km from the offshore cable corridor), Clogherhead (13.3 km from the offshore wind farm area; 4.1 km from the offshore cable corridor) and Dundalk Bay (15.5 km from the offshore wind farm area; 14.8 km from the offshore cable corridor).

SCOS (2018) reports that harbour seal tend to forage within a maximum of 40 or 50 km of their haul-out sites, but most foraging trips tend to be within shorter ranges. SMRU at-sea usage maps estimated a range of mean densities of 0.24 to 0.43 animals per km^2 in the Project area. To the north and west of the Project area, a small number of the SMRU grid cells were estimated to have higher predicted mean densities, and reach a maximum of 0.61 animals per km^2 with lower values estimated at 0.01 animals per km^2 within the potential Zone of Influence (i.e. for elevations in subsea noise during piling). The mean density estimate for the Marine Mammal and Megafauna Study Area, derived from estimates presented in Carter *et al*. (2022), was 0.280 animals per km^2.

Harbour seal haul-out counts during the 2017/18 aerial thermal-imaging surveys in Ireland estimated a total of 131 animals across haul-outs in the East Ireland survey region and 34 animals across haul-outs in the South East Ireland survey region (Morris and Duck, 2019). Correcting this for the proportion of the population that are estimated to be hauled-out during the survey period (72% based on Lonergan *et al*., 2013) gave minimum harbour seal population estimates of 182 (East Ireland) and 48 (South East Ireland) animals. SCOS (2021) gave a minimum population estimate of 1,405 animals across haul-outs in Northern Ireland (derived from a count of 1,012 harbour seals across haul-out sites and corrected as above (Lonergan *et al.,* 2013). The minimum population estimate for all three regions is therefore given as 1,635 harbour seal (termed the Harbour Seal Reference Population (HSRP) from this point onwards).

3.2.5 Summary of densities

Below presents the summary of density estimates and population assessments for marine mammals in the Marine Mammal Study Area.

Where possible species densities have been taken from modelled estimates using the recent site-specific boat-based data. Modelled estimates were available for harbour porpoise and grey seal. For other cetaceans – bottlenose dolphin - density estimates were drawn from the ObSERVE surveys (Rogan *et al*., 2018a) and the SCANS II blocks (Hammond *et al*., 2013), SCANS III blocks (Hammond *et al*., 2021), SCANS-III DSE (and SCANS IV (Gilles *et al*., 2023) surveys. A range of density values is presented for bottlenose dolphin as the baseline review highlighted two appropriate density estimates for this region; SCANS III and ObSERVE. Densities of harbour seal were derived from estimates presented by Carter *et al*. (2022). A range of density estimate for harbour seal at-sea occurred within the 5x5 km grid cells that overlapped with the maximum potential Zone of Influence of the Project (i.e. for elevations in subsea noise during piling) and a mean for the Marine Mammal Study Area was calculated from this range. For all species, the most precautionary estimate of density has been applied to inform potential impacts.

Table 3-2: Density estimates and population assessments for marine mammals in the Marine Mammal and Megafauna Study Area.

Species	Density estimate for Marine Mammal and Megafauna Study Area (animals/km^2)	Geographic extent for population assessment (e.g. Management Unit (MU))	Estimated population
Harbour porpoise	0.280[1] - 1.33[2]	Celtic and Irish Sea (CIS) MU[3]	**62,517**[3]
Bottlenose dolphin	0.046[4] to 0.235[1]	Irish Sea (IS) MU[4]	**293**[5] to **8,326**[6]
Grey seal	0.372[7]	Minimum population estimate for grey seal across haul-out sites within the East Ireland, South East Ireland and Northern Ireland survey regions (the Grey Seal Reference Population (GSRP))	East Ireland: 1,662[8] South East Ireland: 2,211[8] Northern Ireland: 2,008[9] **GSRP = 5,882**
Harbour seal	0.280[6]	Minimum population estimate for harbour seal across haul-out sites within the East Ireland, South East Ireland and Northern Ireland survey region (the Harbour Seal Reference Population (HSRP))	East Ireland: 182[10] South East Ireland: 48[10] Northern Ireland: 1,405[11] **HSRP = 1,635**

[1] SCANS IV Block CS-D (western Irish Sea) data collected summer 2022 (Gilles *et al*., 2023)

[2] Mean monthly maximum density recorded during Oriel Wind Farm Project site-specific boat-based surveys (2018 - 2020)

[3] IAMMWG, 2023.

[4] SCANS-III Block E (western Irish Sea) density surfaces estimates for the offshore windfarm area and offshore cable corridor (Lacey *et al.,* 2022)

[5] For bottlenose dolphin the IAMMWG, 2023 abundance estimate of 293 animals will only apply where the SCANS-III density surface estimate of 0.046 animals per km^2 is applied.

[6] Abundance estimate derived from SCANS-IV surveys from Block CS-D and Block CS-E, equating to the area covered by the Irish Sea MU. This abundance estimate will only apply where the SCANS-IV density estimate of 0.235 animals per km^2 is applied.

[7] Carter *et al.* (2022) average densities per km^2 (calculated from 25 km^2 cells) for the Marine Mammal and Megafauna Study Area

[8] Based on grey seal haul-out counts during 2017/18 survey (Morris and Duck, 2019) corrected for the proportion of the population that are estimated to be hauled-out during the survey period (scalar of 0.2515 from SCOS, 2021)

[9] Based on grey seal haul-out counts presented in SCOS (2020) corrected for the proportion of the population that are estimated to be hauled-out during the survey period (scalar of 0.2515 from SCOS, 2021)

[10] Based on harbour seal haul-out counts during 2017/18 survey (Morris and Duck, 2019) corrected for the proportion of the population that are estimated to be hauled-out during the survey period (scalar of 0.72 from Lonergan *et al.,* 2013).

[11] Minimum population estimate presented in SCOS (2021) (corrected for the proportion of the population that are estimated to be hauled-out during the survey period (scalar of 0.72 from Lonergan *et al.,* 2013))l.

4 KEY PARAMETERS FOR ASSESSMENT

4.1 Project design parameters

The project description is provided in section 2 of the NIS. Table 4-1 outlines the project design parameters that have been used to inform the assessment of potential impacts of the construction, operational and maintenance and decommissioning phases of the Project on marine mammals.

Due to the potential for unexpected ground conditions and obstructions, the final route and length of the offshore export cable and offshore inter array cables will be confirmed post consent (see design flexibility details in section 2 of the NIS). For the purposes of the assessment presented in section 6, the maximum length of cables (Table 4-1) has been considered to ensure the potential for maximum impact are assessed. Should the final lengths of cables be less than those specified, then the potential for effects will not change the assessment outlined in section 6. An alternative route within the offshore wind farm area of offshore cable corridor will also not change the assessment presented in section 6.

Table 4-1: Project design parameters used for the identification of potential impacts on marine mammals.

Potential impact	Phase[1] C	O	D	Project design parameters	Justification
Injury and/or disturbance to marine megafauna from underwater noise during pile-driving	✓	✗	✗	• 26 monopiles (25 x WTGs and 1 x OSS) of 9.6 m diameter; • Absolute maximum hammer energy of 3,500 kJ; • On average, a maximum of 5 hours piling per pile across all WTG locations (no more than 8 hours at selected locations) with one pile expected to be installed in each 24-hour period; and • Maximum days piling = 26 days.	The spatial extent of noise impacts is driven by key parameters including monopile diameter and hammer size, as well as associated hammer energy required to pile a monopile of this size (see appendix C: Subsea Noise Technical Report). The minimum number of piles within a 24-hour period is likely to lead to the maximum period (number of piling days) over which piling could occur and the maximum within 24 hours would lead to the longest duration on any one day.
Injury and/or disturbance to marine megafauna from elevated underwater noise during routine geophysical surveys	✗	✓	✗	Routine geophysical surveys of wind turbine foundations, inter-array cables and offshore cable: • Multibeam echosounder (MBES) expected to be the only method of geophysical survey to be employed; • Survey campaigns estimated to occur once every five years for 40-year lifetime of Project; • Surveys to be conducted using one survey vessel; • Duration of 14 days per survey; • 42-day duration per survey campaign (three surveys per campaign); • 42 vessel round trips per survey campaign; and • Maximum total of 294 survey vessel round trips for lifetime of Project.	First survey campaign expected to occur in year 5, and final campaign in year 35, equating to seven survey campaigns. Assumes daily vessel trip for every day of each 14-day survey window.

Potential impact	Phase[1] C	O	D	Project design parameters	Justification
Injury and/or disturbance to marine megafauna from vessels and other construction activities	✓	✓	✓	Vessel types include jack-up barges, tug/anchor handlers, cable installation vessels, scour/cable protection installation vessels, guard vessels, survey vessels, crew transfer vessels (CTVs). 475 vessel round trips during the construction phase, 352 vessel round trips per year during the operational and maintenance phase and 475 vessel round trips during the decommissioning phase. Other construction includes: • Monopile drilling at each location with six days drilling for each monopile = cumulative total of 156 days drilling over construction phase; • Cable trenching for inter-array and offshore cable; and • Cable laying for inter-array and offshore cable. Offshore construction may take place over a period of 15 months. Operational and maintenance phase is 40 years. Decommissioning duration assumed to be similar to that for construction.	Greatest range of vessel types and greatest number of round trips.
Changes in the fish and shellfish community affecting marine megafauna prey resources	✓	✓	✓	Project design parameters as described in appendix E: Fish and Shellfish Ecology – Supporting Information for the following impacts: • Temporary subtidal habitat loss/disturbance; • Injury and/or disturbance to fish from underwater noise during pile driving; • Increased suspended sediment concentrations and associated sediment deposition; • Long-term habitat loss; and • Electromagnetic Fields (EMF) from subsea electrical cabling.	See appendix E: Fish and Shellfish Ecology – Supporting Information.

1 C = Construction, O = Operation, D = Decommissioning

4.2 Measures included in the Project

As part of the project design process, a number of measures have been proposed to reduce the potential for impacts on marine mammals and megafauna (see Table 4-2). These measures include designed-in and management measures (controls).

These measures were not taken into account in section 4 of the Stage 1 screening appraisal to inform screening for appropriate assessment (see appendix A: Report to Inform Screening for Appropriate Assessment) in accordance with guidance and prevailing case law but can lawfully be taken into account for the Stage 2 appraisal.

As there is a commitment to implementing these measures, they are considered inherently part of the design of the Project and have therefore been considered in the assessment of potential impacts presented in section 6 below (i.e. the determination of magnitude assumes implementation of these measures). These measures are considered standard industry practice for this type of development.

Table 4-2: Measures included in the Project.

Measures included in the Project	Justification
An Environmental Management Plan (EMP) (see appendix K: Management Plans) will be implemented during the construction, operational and maintenance, and decommissioning phases of the Project. The EMP includes Project specific measures and commitments and a Marine Pollution Contingency Plan (MPCP) which includes key emergency contact details (e.g. Environmental Protection Agency (EPA)). The EMP includes measures such as designated areas for refuelling where spillages can be easily contained, storage of chemicals in secure designated areas in line with appropriate regulations and guidelines, double skinning of pipes and tanks containing hazardous substances, and storage of these substances in impenetrable bunds. In this manner, accidental release of contaminants from vessels will be strictly controlled, thus providing protection for marine life across all phases of the Project. In this manner, accidental release of contaminants from vessels will be strictly controlled, thus providing protection for marine life across all phases of the Project.	Measures will be included to ensure that the potential for release of pollutants from construction, operational and maintenance, and decommissioning plant is minimised.
A Marine Megafauna Mitigation Plan (MMMP) (see appendix K: Management Plans) will be implemented prior to construction. The MMMP sets out the measures to apply in advance of and during piling activity, including the implementation of a mitigation zone, and monitoring by MMOs and Passive Acoustic Monitoring (PAM).	The implementation of an approved MMMP will mitigate for the risk of physical or permanent auditory injury to marine mammals within a 'mitigation zone'. The mitigation zone is determined considering the potential for instantaneous auditory injury based on the initial hammer strike at 10-15% of the maximum hammer energy (i.e. soft-start hammer energy). The use of an approved MMMP will also minimise the potential for collision risk, or potential injury to, marine mammals.
During piling operations, soft starts will be used, following DAHG (2014) guidelines. This will involve the implementation of lower hammer energies (i.e. approximately 10-15% of the maximum hammer energy) at the beginning of the piling sequence before energy input is 'ramped up' (increased) over time to required higher levels (also known as a soft-start).	The soft-start will provide an audible cue to allow marine mammals to flee the area before piling at increased hammer energy commences. The soft/slow-start will help to mitigate any potential auditory injury.
The Applicant commits to implementing phased piling alongside other adjacent offshore wind farms in the western Irish Sea as part of a Piling Strategy. This strategy will be prepared post consent and will set out measures for collaboration with other projects to reduce the potential for an in-combination effect. This will include a stepped strategy which follows the mitigation hierarchy - avoid, reduce, mitigate. Consequently, if phased piling is required a collaborative approach will be explored and information presented to demonstrate how a phased piling approach can contribute to the reduction in underwater sound from piling.	To minimise the potential for permanent auditory injury to marine mammals. To minimise the area of habitat affected by underwater noise at any one time.

Measures included in the Project	Justification
Geophysical surveys undertaken during the operational and maintenance phase will adopt similar measures as for piling operations, including the implementation of an approved MMMP and Vessel Code of Conduct (see appendix K: Management Plans). Measures include the use of a mitigation zone around operations, within which MMOs and PAM will ensure that no marine mammals are present in the vicinity of the geophysical survey vessel, and the use of a soft-start to survey operations, where possible. It is acknowledged that further consultation with the NPWS and wildlife derogation licences may be required.	The implementation of an approved MMMP will mitigate for the risk of physical or permanent auditory injury to marine mammals within a 500 m radial mitigation zone as determined by NPWS guidance (NPWS, 2014)[1]. The soft-start will use a lower-energy output, increasing over a 20-minute period to the maximum data-acquisition energy output to provide an audible cue to allow marine mammals to flee the area before geophysical surveying commences.
A Vessel Code of Conduct (see appendix K: Management Plans) will be issued to all Project vessel operators, requiring them to: • refrain from approaching animals in the water; • keep vessel speed to a minimum, including near haul-outs; and • avoid abrupt changes in course or speed should marine mammals approach the vessel to bow-ride. The Marine Megafauna: Vessel Code of Conduct will be adhered to at all times.	To minimise the potential for collision risk, or potential injury to, marine mammals.
Burial and protection of cables - cables will be buried below the seabed wherever possible, to a minimum burial depth of 0.5 m and a maximum burial depth of 3 m. The appointed contractor will be required prior to the construction phase to submit details on the cable specification and installation methodology. This will include details on the cable laying, including geotechnical data, cable laying techniques and a cable burial risk assessment. Also, in advance of any cable repair, the contractor will be required to submit details on the parameters of the repair or reburial activities and the proposed methodology.	While burial of cables will not reduce the strength of EMF, it does increase the distance between cables and marine mammal receptors, thereby potentially reducing the effect on those receptors.

4.3 Impacts scoped out of the assessment

On the basis of the baseline environment and the project description outlined in section 2 of the NIS, a number of impacts are proposed to be scoped out of the assessment for marine mammals. These impacts are outlined, together with a justification for scoping them out, in Table 4-3.

Table 4-3: Impacts scoped out of the assessment for marine mammals.

Potential impact	Justification
Potential impacts from increased suspended sediment concentrations (SSC) and associated sediment deposition	Whilst increases in SSC as a result of foundation and cable installation (or removal) activities during the construction (or decommissioning) phase may affect marine mammal species through visual impairment, the maximum impact range is not expected to extend beyond a few km from the source (see appendix B: Marine Processes Technical Report), has not been predicted to overlap with any designated sites, nor has the area been identified as important foraging habitat for any qualifying marine mammal features. Whilst the ZoI is within the foraging range of harbour seal and grey seal from haul-outs at Carlingford Lough, Dundalk Bay, the Skerries, Clogherhead, Dublin Bay and Lambay Island, there is other suitable habitat available for foraging during temporary periods of increased suspended sediment.

[1] It is expected that this guidance will be updated in 2024. The final guidance will be included in this measure.

Potential impact	Justification
Injury and/or disturbance to marine mammal species from operational underwater noise	The majority of studies investigating the impact of operational offshore wind farms (within the operational and maintenance phase) on marine mammals and fish conclude that sounds levels in the order of hundreds of metres distance from the wind turbines would likely be audible, but not at a level sufficient to cause injury or behavioural changes (see appendix C: Subsea Noise Technical Report). Norro *et al.* (2011) compared measurements of a range of different foundation methods and turbine ratings in the Belgian part of the North Sea, as well as comparing those to other European waters. The authors found a slight increase in Sound Pressure Level (SPL) compared to the ambient noise measured before the construction of the wind farms. They concluded that even the highest increases found within the dataset (20 to 25 dB re 1µ Pa) are likely to be within the natural range of variation in baseline noise and therefore, even with the long-term nature of this impact (lifespan of the wind farm), the operational noise would not cause a significant adverse impact. In addition, evidence presented by Hastie *et al.* (2015) showed tracked harbour seal moving between operational wind turbines in order to forage. It is predicted therefore that any impact would be highly localised and unlikely to affect marine mammals.
Electromagnetic Fields (EMF) from subsea electrical cabling may disrupt behaviour of marine mammals	Electromagnetic fields could arise during the operational and maintenance phase from the operation of the 41 km of 66 kV inter-array cables and the 16 km of 220 kV HVAC offshore cable. Electric and magnetic fields occur naturally in the marine environment and are a necessity for many marine animals. Electric fields are produced by the natural movement of charges in seawater and by the movement of charges in the bodies of living organisms. Predators, particularly elasmobranchs, use electric fields as important cues to detect and locate prey species (Crampton, 2019). It is understood that many marine animals may use the earth’s magnetic fields for orientation and this can apply to both long distance migrations and local movements (Johnsen and Lohman, 2008). However, the scale to which EMF from subsea cables may interfere with this is likely to be species dependent. For marine mammals, any effects of EMF are likely to be very localised – within the immediate vicinity of the cable – and temporary, most likely leading to short-term, reversible behavioural effects. There is limited evidence to suggest that marine mammals may be affected by EMF from subsea cables. For example, migration of the harbour porpoise in and out of the Baltic Sea necessitates several crossings of High-voltage direct current cables in the Skagerrak and western Baltic Sea without any apparent effect on its migration pattern (Walker, 2001). Marine mammals have been scoped out of further assessment.

5 IMPACT METHODOLOGY

5.1 Overview

The report takes account of the following guidance documents and legislation:

- Guidance for Ecological Impact Assessment in the UK and Ireland. Terrestrial, Freshwater, Coastal and Marine (Chartered Institute of Ecology and Environmental Management (CIEEM) 2022):
  - These guidelines combine the Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater and Coastal, 2nd edition (2016) and the Guidelines for Ecological Impact Assessment in Britain and Ireland: Marine and Coastal (2010).
- Guidance on Environmental Impact Statement (EIS) and NIS Preparation for Offshore Renewable Energy Projects, Department of Communications, Climate Action and Environment (DCCAE, 2017);
- Guidance on Marine Baseline Ecological Assessments and Monitoring Activities for Offshore Renewable Energy Projects Parts 1 and 2 (DCCAE, 2018);
- Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects (Judd, 2012);
- Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters (NPWS, 2014);
- The Habitats Directive 92/43/EEC; and
- European Communities (Birds and Natural Habitats) Regulations 2011, as amended.

5.2 Impact assessment criteria

This section describes the criteria applied in this assessment to assign values to the magnitude of potential impacts and the sensitivity of the receptors.

Magnitude of impact quantifies the amount of change arising from an activity that could lead to alteration in the environment (e.g. piling could lead to an elevation in underwater sound) and the associated outcome or effect on sensitive ecological receptors. The assessment describes the spatial extent over which impacts and effects could occur arising from a particular activity (e.g. area of effect and associated number of animals in a population affected), how long animals are exposed to an activity that could cause an effect in the context of the life-history of a species (i.e. the duration), the frequency of the exposure that could lead to a change (i.e. continuous or intermittent) and whether or not the resultant change in either the receiving environment or features exposed is reversible. The criteria for defining impact magnitude in this report are outlined in Table 5-1 below.

Table 5-1: Definition of terms relating to the magnitude of an impact (EPA.2022; CIEEM, 2022).

Magnitude of impact	Definition
High	The impact could lead to large scale changes to behaviour and distribution, that are extensive in the context of the relevant geographic frame of reference (area/proportion of MU). The duration and frequency of the impact overlap with a sufficient number of reproductive cycles to alter the population trajectory. The effect, which may be either reversible or irreversible in individuals, would be of sufficient severity to affect the long-term viability of the relevant population over a generational scale. (Adverse)
	Long-term benefits to many individuals within the population (e.g. long-term improvement of key habitats) such that there is an increase in the relevant population trajectory over a generational scale. (Beneficial)

Magnitude of impact	Definition
Medium	The impact could lead to large scale changes to behaviour and distribution, that are extensive in the context of the relevant geographic frame of reference (area/proportion of MU). The duration and frequency of the impact are sufficient to overlap with at least one reproductive cycle. The effect, which may be either reversible or irreversible in individuals could result in some population-level effects, but not a level that would alter the relevant population trajectory over a generational scale. (Adverse)
	Life-time benefits to some individuals although not enough to affect the relevant population trajectory over a generational scale. (Beneficial)
Low	The impact could lead to changes to behaviour and distribution in individuals, but which are relatively small in the context of the relevant geographic frame of reference (area/proportion of MU). The duration and frequency of the impact are such that there would be minimal disruption to reproductive cycles. Whilst there may be effects at an individual level which may be either reversible or irreversible, these would not be at a scale that would lead to any measurable population-level effects (Adverse)
	Minor benefit, or positive addition to individuals over a localised scale. (Beneficial)
Negligible	The impact could lead to very minor changes in behaviour and distribution of individuals within the impacted area but not at a level that would be measurable. Effects are likely to be reversible and highly unlikely to result in any population-level effects. (Adverse)
	Very minor benefit, or positive addition to individuals but not at a level that would be measurable. (Beneficial)

The sensitivity of marine mammal qualifying features has been defined by an assessment of the ability of a receptor to adapt to a given impact, its resilience to that impact and its ability to recover back to pre-impact conditions. Resilience is the ability to withstand a perturbation or disturbance by resisting damage. Recoverability is the ability of the same species to return to a state close to that which existed before the activity or event which caused change. It is dependent on the ability of the individuals to recover following cessation of the activity that causes the impact.

Information on these aspects of sensitivity of the marine mammal qualifying features to given impacts has been informed by the best available evidence from scientific research on marine mammals (studies on captive animals as well as observations from field studies). In particular, evidence from field studies of marine mammals during the construction and operation of offshore wind farms (and analogous activities such oil and gas surveys) has been used to inform the assessment of potential impacts.

The criteria for defining receptor sensitivity in this report are outlined in Table 5-2.

Table 5-2: Definition of terms relating to the sensitivity of the receptor.

Sensitivity	Definition
High	Adaptability: Limited ability or unable to adapt behaviour to sustain ecological functioning Resilience: Limited resilience to the effect either in the short or long-term; effect will cause a change in ecological functioning Recoverability: Limited or no ability for the animal to recover from the effect even after cessation of the impact *A receptor is of high sensitivity where adverse effects on multiple key ecological functions (e.g. feeding, breeding, nursing) could occur with limited resilience and limited potential for recovery such that reproduction and survival of individuals would be affected*.

Sensitivity	Definition
Medium	Adaptability: Ability to adapt behaviour to a level where ecological functioning can be sustained to allow individual survival. Resilience: Some resilience to the effect with some impairment of ecological functioning which may affect reproductive success but unlikely to affect survival of individuals. Recoverability: Ability for the animal to recover from the effect although recovery may be slow. *A receptor is of medium sensitivity where adverse effects on one or more key ecological functions (e.g. feeding, breeding, nursing) could be sustained beyond the duration of the impact (some resilience to the effect) but not at a level that would affect individual survival although reproductive success may be affected until the individual has recovered (ability to recover).*
Low	Adaptability: Ability to adapt behaviour such that ecological function can be maintained. Resilience: Resilient to the effect with minor impairment of ecological functioning but unlikely to affect reproduction and survival rates of individuals. Recoverability: Animal is able to return to previous behavioural states/activities once the impact has ceased within a short timeframe (days, weeks). *Low sensitivity is such that adverse effects on ecological functions (e.g. feeding, breeding, nursing) are likely to be very short term and would not affect reproductive success or individual survival.*
Negligible	Very little or no effect on the ecological functioning of individuals.

5.3 European sites

Where Natura 2000 sites (i.e. internationally designated European sites) are considered, this report summarises the potential impacts on the QIs of internationally designated sites as described within section 3.1. The complete assessment of adverse effects on European sites is contained in the NIS for the Project.

6 POTENTIAL IMPACTS

The potential impacts arising from the construction, operational and maintenance and decommissioning phases of the Project are listed in Table 4-1, along with the project design parameters against which each impact has been assessed.

A description of the potential effect on marine mammals and megafauna caused by each identified impact is given below.

6.1 Injury and/or disturbance to marine mammals from underwater noise during pile-driving

Marine mammals, particularly cetaceans, are capable of generating and detecting sound (Au *et al.,* 1974; Bailey *et al.,* 2010) and are dependent on sound for many aspects of their lives (i.e. prey-identification; predator avoidance; communication and navigation). Increases in anthropogenic noise may consequently lead to a potential effect within the marine environment (Parsons *et al.,* 2008; Bailey *et al.,* 2010). Pile-driving during the construction phase has the potential to result in elevated levels of subsea noise that are detectable by marine mammals above background levels and could result in injurious or behavioural effects on qualifying marine mammal features. A detailed underwater noise modelling assessment has been carried out to investigate the potential for injurious and behavioural effects on qualifying marine mammal features as a result of piling (impulsive sounds), using the latest criteria (see appendix C: Subsea Noise Technical Report), which is drawn upon below.

6.1.1 Overview of subsea noise modelling

This section provides an overview of the approach undertaken to model the effects of injury and disturbance to marine mammal species. Full details of this approach are provided in appendix C: Subsea Noise Technical Report.

The parameters modelled were based on the maximum hammer energy being achieved (3,500 kJ) and the maximum duration of piling at any one location (up to one pile installed within a 24-hour period) (see Table 4-1). Note that it is unlikely that the maximum hammer energy would be achieved at all piling locations so this assumption is considered to be very conservative (i.e. on average across all locations, the hammer energies are more likely to reach a maximum of 2,500 kJ). On average, the maximum duration of piling across the wind farm is five hours for a single monopile.

A summary of the parameters modelled in the subsea noise assessment is provided in Table 6-1, noting that measures included in the Project in the form of soft start and ramp up will be implemented as part of the Project, as described previously in Table 4-2.

Table 6-1: Design parameters modelled for a single monopile.

Pile type	Locations	Threshold	Parameter modelled	
			Parameter	Description
Monopile	East and west of the offshore wind farm area	Weighted SEL_{cum} Ramp up during single pile installation (maximum 5 hours duration)	Initiation Soft start Ramp up Standard operation Full power	1 min @ 525 kJ 20 min @ 525 kJ 9 min @ 525 to 2,500 kJ 150 min @ 2,500 kJ 120 min @ 3,500 kJ
		Unweighted SPL_{pk} Ramp up during single pile installation (maximum 5 hours duration)	Initiation Soft start Ramp up Standard operation Full power	1 min @ 525 kJ 20 min @ 525 kJ 9 min @ 525 to 2,500 kJ 150 min @ 2,500 kJ 120 min @ 3,500 kJ

To carry out exposure calculations (SEL_{cum} metric) the noise modelling assessment made a simplistic assumption that an animal would be exposed over a 24-hour period and that there would be no breaks in activity during this time. It was assumed that an animal would swim away from the noise source at the onset of activity at a constant rate and subsequently, conservative species-specific swim speeds were incorporated into the model (see Table 6-2).

Table 6-2: Swim speeds assumed for exposure modelling.

Species	Hearing group	Swim speed (m/s)	Source reference
Harbour porpoise	VHF	1.5	Otani *et al.,* 2000
Harbour seal	PW	1.8	Thompson, 2015
Grey seal	PW	1.8	Thompson, 2015
Bottlenose dolphin	HF	1.52	Bailey and Thompson, 2010

The subsea noise model adopted a number of conservative assumptions that results in a precautionary assessment (see appendix C: Subsea Noise Technical Report). These are summarised below:

- The modelling assumed the maximum hammer energy would be reached at all locations, whereas this is unlikely to be the case, based on examples from other offshore wind farms (e.g. Beatrice Offshore Wind Farm), where the mean actual hammer energy averages were considerably lower than the worst case assessed in the Environmental Statement and only six out of 86 asset locations reached maximum hammer energy (Beatrice, 2018);

- The soft start procedure simulated does not allow for short pauses in piling (e.g. for realignment) and therefore the modelled SEL_{cum} is likely to be an overestimate since, in reality, these pauses will reduce the noise exposure that animals experience whilst fleeing;

- Due to a combination of factors (e.g. dispersion of the waveform, multiple reflections from sea surface and seafloor, and molecular absorption of high frequency energy), impulsive sounds are likely to transition into non-impulsive sounds at distance from the sound source with empirical evidence suggesting such shifts in impulsivity could occur markedly within 10 km from the sound source (Hastie *et al.,* 2019). Since the precise range at which this transition occurs is unknown, noise models still adopt the impulsive thresholds at all ranges which is likely to lead to an overestimate of effect ranges at larger distances (tens of kilometres) from the sound source; and

- The model overestimates the noise exposure an animal receives since it does not account for any time that marine mammals spend at the surface and the reduced sound levels near the surface.

6.1.1.1 Modelling auditory injury

Auditory injury in marine mammals can occur as either a Permanent Threshold Shift (PTS), where there is no hearing recovery in the animal, or as a Temporary Threshold Shift (TTS), where an animal can recover from the tissue damage. Irish guidance recommends that the risk of TTS is included as potential injury as this could have negative effects on the ability of animals to use natural sounds, including communication, navigation, and prey location, and consequently could lead to consequences for an animal's fitness (NPWS, 2014). The most likely response of an animal exposed to noise levels that could induce TTS is, however, to flee the ensonified area. It is therefore considered that there is also a behavioural response (disturbance) that overlaps with potential injury ranges, and animals exposed to noise levels that have the potential to induce TTS are likely to actively avoid hearing damage by moving away from the area.

For marine mammals, injury thresholds are based on both linear (i.e. un-weighted) peak sound pressure levels (SPL_{pk}) and marine mammal hearing-weighted in-combination Sound Exposure Level (SEL_{cum}). The SEL_{cum} takes account of the in-combination sound received by an animal within the ensonified area over the entire piling sequence and is weighted by marine mammal hearing groups based on similarities in known or expected hearing capabilities (Southall *et al.,* 2007*).* Marine mammal hearing groups are described in the latest guidance (Southall *et al*., 2019) as follows:

- **Low-frequency (LF) cetaceans** (i.e. marine mammal species such as baleen whales with an estimated functional hearing range between 7 Hz and 35 kHz). Minke whale is a LF cetacean within the Marine Mammal and Megafauna Study Area although noting that this is not a qualifying species and therefore not considered further in this NIS.

- **High-frequency (HF) cetaceans** (i.e. marine mammal species such as dolphins, toothed whales, beaked whales and bottlenose whales with an estimated functional hearing range between 150 Hz and 160 kHz); bottlenose dolphin is the qualifying marine mammal feature in the HF cetacean group.

- **Very high-frequency (VHF) cetaceans** (i.e. marine mammal species such as true porpoises, Kogia, river dolphins and cephalorhynchid with an estimated functional hearing range between 275 Hz and 160 kHz); harbour porpoise is the qualifying marine mammal feature in the VHF cetacean group.

- **Phocid pinnipeds in water (PW)** (i.e. true seals with an estimated functional hearing range between 50 Hz and 86 kHz); grey seal and harbour seal are the qualifying marine mammal features in the PW group.

The dual criteria (SPL_{pk} and SEL_{cum}) approach was employed in the subsea noise assessment to assess the potential for auditory injury (PTS and TTS) to occur in marine mammals (appendix C: Subsea Noise Technical Report). Firstly, injury ranges were predicted based on exposure to SPL_{pk} from a single hammer strike at different levels (soft start initiation, soft start, ramp up, low energy and full energy). The peak injury thresholds were used to determine potential ranges for instantaneous injury to each species from a single hammer strike to a monopile. Secondly, injury ranges were predicted based on a marine mammal being exposed to impulsive noise from multiple hammer strikes over a prolonged period; the assumption being that a marine mammal exposed to lower noise levels over a prolonged period could experience auditory injury.

Species-specific TTS thresholds developed by NMFS (2018), and those previously presented by Southall *et al.* (2007), define a TTS onset as the exposure required to produce 6 dB of TTS, from either direct measurements or extrapolation of available data. There is currently, however, extremely limited data on impulsive noise TTS onset in marine mammals upon which these thresholds are based (Southall *et al.,* 2019). It has been necessary to determine exposure functions for TTS in order to estimate the levels at which the onset of PTS could occur (as experiments inducing PTS in animals are considered unethical) and predicted exposures of 40 dB of TTS are considered to result in PTS onset (Southall *et al.,* 2007). For the purposes of developing these thresholds, TTS was considered to be “the minimum threshold shift clearly larger than any day-to-day or session-to-session variation in a subject’s normal hearing ability”, and which “is typically the minimum amount of threshold shift that can be differentiated in most experimental conditions” (Southall *et al.,* 2007). Thus, using a threshold for the onset of TTS would typically result in overestimates of potential ranges at which ecologically significant effects could occur. Coupled with the precautionary assumptions in the model, particularly with respect to the SEL_{cum} metric, this means that estimates of TTS are likely to be unrealistic and therefore should be interpreted with caution. Injury (PTS and TTS) criteria (assessment thresholds) are presented in Table 6-3 below.

6.1.1.2 Modelling behavioural disturbance

Beyond the zone of injury, noise levels are such that they no longer result in physical injury but can result in disturbance to marine mammal behaviour. A marine mammal’s response to disturbance will depend on the individual and the context; previous experience and acclimatisation will affect whether an individual exhibits an aversive response to noise, particularly in a historically noisy area. Typically, a threshold approach has been adopted in offshore wind farm assessments in the UK to quantify the scale of the effects. For example, the United States (US) National Marine Fisheries Service (NMFS) (NMFS, 2005) define strong disturbance in all marine mammals as Level B harassment and for impulsive noise suggests a threshold of 160 dB re 1 μPa (root mean square (rms)). This threshold meets the criteria defined by JNCC (2010) as a ‘non-trivial’ (i.e. significant) disturbance and is equivalent to the Southall *et al*. (2007) severity score of five or more on the behavioural response scale. Beyond this threshold the behavioural responses are likely to become less severe (e.g. minor changes in speed, direction and/or dive profile, modification of vocal behaviour and minor changes in respiratory rate (Southall *et al*., 2007)). The NMFS guidelines suggest a precautionary level of 140 dB re 1 μPa (rms) to indicate the onset of low-level marine mammal disturbance effects for all mammal groups for impulsive sound (NMFS, 2005), although this is not considered likely to lead to a ‘significant’ disturbance response.

More recently, to illustrate the variation in behavioural responses of marine mammals, Graham *et al*. (2017) used empirical evidence collected during piling at the Beatrice Offshore Wind Farm (Moray Firth, Scotland) to demonstrate that the probability of occurrence of harbour porpoise (measured as porpoise positive minutes) increased exponentially moving further away from the source. The study showed a 100% probability of disturbance at an (un-weighted) SEL of 180 dB re 1 µPa^{2}s, 50% at 155 dB re 1 µPa^{2}s and dropping to approximately 0% at an SEL of 120 dB re 1 µPa^{2}s. Importantly, Graham *et al*. (2019) demonstrated that the response of harbour porpoise to piling diminished over the piling phase such that, for a given received noise level or at a given distance from the source, there were more detections of animals at the last piling location compared to the first piling location. The dose-response thresholds tie in with the NMFS (2005) criteria since a mild behavioural response is suggested to occur at a threshold of 140 dB re 1 µPa (rms) which is the equivalent of 130 dB 1 µPa^{2}s where a small response (c. 10% of animals) would occur according to the dose-response. Dose-response is an accepted approach to understanding the behavioural effects from piling and has been applied at other UK offshore wind farms (for example Seagreen (Seagreen Wind Energy Ltd, 2012)) and Hornsea Project Three (GoBe, 2018).

Similarly, a telemetry study undertaken by Russell *et al*. (2016) investigating the behaviour of tagged harbour seal during pile driving at the Lincs Offshore Wind Farm in the Wash found that there was a proportional response at different received noise levels. Dividing the study area into a 5 km x 5 km grid, the authors modelled SEL_{ss} levels and matched these to corresponding densities of harbour seal in the same grids during non-piling versus piling periods to show change in usage. The study found that there was a significant decrease in usage (abundance) during piling at predicted received SEL levels of between 142 dB and 151 dB re 1 µPa^{2}s. More recent work undertaken by Whyte *et al.* (2020) to develop dose-response relationships between changes in harbour seal density and predicted received noise levels during piling at the Lincs offshore wind farm in the southern North Sea. The study found significant changes in seal density at 145 dB re 1 µPa^{2}s and above. Below 145 dB re 1 µPa^{2}s there was no significant change in seal density detected, therefore received noise levels of below 145 dB re 1 µPa^{2}s have not been reported on (Whyte *et al.,* 2020). By applying these criteria (see Table 6-4) the magnitude of effect can be quantified with respect to the spatial extent of disturbance, and subsequently the number of animals potentially disturbed. There is, however, a note of caution associated with this approach. Southall *et al*. (2021) highlights that the challenges for developing a comprehensive set of empirically derived criteria for such a diverse group of animals are significant. Extensive data gaps have been identified (e.g. measurements of the effects of elevated noise on baleen whales) which mean that extrapolation from other species has been necessary. Sounds that disturb one species may, however, be irrelevant or inaudible to other species since there are broad differences in hearing across the frequency spectrum for different marine mammal hearing groups. Variance in responses even within a species are well documented to be context and sound-type specific (Ellison *et al*., 2012). In addition, the potential interacting and additive effects of multiple stressors (e.g., reduction in prey, noise and disturbance; contamination, etc.) are likely to influence the severity of responses (Lacy *et al*., 2017).

For these reasons, neither a threshold approach nor a dose-response function was provided in the original guidance (Southall *et al*., 2007) and subsequently the recent recommendations by Southall *et al*. (2021) also steer away from a single overarching approach. Instead, Southall *et al*. (2021) proposes a framework for developing probabilistic response functions for future studies. The paper suggests different contexts for characterising marine mammal responses with distinctions made by sound sources (i.e. pile driving, active sonar, seismic surveys and continuous/industrial noise). Three parallel categories have been proposed within which a severity score from an acute (discrete) exposure can be allocated:

- Survival – defence, resting, social interactions and navigation;
- Reproduction – mating and parenting behaviours; and
- Foraging – search, pursuit, capture and consumption.

Even where studies have been able to assign responses to these categories based on acute exposure there is still limited understanding of how longer term (chronic) exposure could translate into population-level effects. To explore this, Southall *et al*. (2021) reported observations from long term whale watching studies and suggested that there were differences in the ability of marine mammals to compensate for long term disturbance which related to their breeding strategy. Mysticetes are capital breeders - accumulating energy in their feeding grounds and transferring this to calves in their breeding ground – and their ability to compensate for chronic exposure to noise will depend on a range of ecological factors. Such factors include the relative importance of the disturbed area and prey availability within their wider home range, individual exposure history, and the presence of concurrent disturbances in other areas of their range. Animals may be able to compensate for short-term disturbances by feeding in other areas, for example, which would reduce the risk of longer-term population consequences. Christiansen and Lusseau (2015) studied the effect of whale watching on minke whale in Faxafloi Bay, Iceland and found no significant long-term effects on vital rates although years with low sandeel density led to increased exposure to whale watching as whales were forced to move into disturbed areas to forage. Odontocetes, however, may be more vulnerable to whale watching compared to mysticetes due to their more localised, and often, coastal home ranges. Bejder *et al*. (2006) documented a decrease in local abundance of bottlenose dolphin which was associated with an increase in whale watching in a tourist area compared to a control area.

The marine mammals considered in this assessment vary biologically and therefore have different ecological requirements that may affect their sensitivity to disturbance. This point is illustrated by the differences between the two seal species identified as key biological receptors in the baseline. Grey seal are capital breeders (foraging to build up stored fat reserves for lactation) and often make long foraging trips from haul-outs. In contrast, harbour seal are income breeders (feeding throughout the pupping season) and make shorter foraging trips from haul-outs.

In summary, Southall *et al.* (2021) clearly highlights the caveats associated with simple, one-size-fits-all, threshold approaches that could lead to errors in disturbance assessments. Recognising this inherent uncertainty in the quantification of effects the assessment has adopted a precautionary approach at all stages of assessment including:

- Conservative assumptions in the marine mammal baseline (e.g. use of seasonal density peaks) (Table 3-2);
- Conservative assumptions for the project parameters (Table 4-1); and
- Conservative assumptions in the subsea noise modelling (as set out in appendix C: Subsea Noise Technical Report and summarised above).

Relevant assumptions have been described throughout this report and demonstrate that such layering of conservatism is likely to lead to a very precautionary assessment.

A dose-response curve was applied to this assessment to determine the number of animals that may potentially respond behaviourally to received noise levels during piling. Unweighted SEL_{ss} contours were plotted in 5 dB isopleths in decreasing increments from 180 dB to 120 dB re.1 $\mu Pa^2 s$ using the highest modelled received noise level for 4% reducing to 0.5% Conversion Factor (CF) and 1% constant CF.

To adopt the most precautionary approach, the dose-response contours were plotted in Geographical Information System (GIS) for all modelled locations and the location selected for assessment was the one whereby the contours covered the greatest spatial area. The areas within each 5 dB isopleth were calculated from the spatial GIS map and a proportional expected response, derived from the dose-response curve for each isopleth area, was used to calculate the number of animals potentially disturbed. These numbers were subsequently summed across all isopleths to estimate the total number of animals disturbed during piling. The number of animals predicted to respond was based on species specific densities as agreed with statutory consultees (Table 3-2).

For harbour porpoise the dose-response curve was applied from the first location modelled as shown by Graham *et al*. (2017) where the probability of response approaches zero at approximately 120 dB SEL_{ss}. In the absence of species-specific data for other cetacean species the same dose-response curve was assumed to apply to all cetacean qualifying features in this assessment (Figure 6-1).

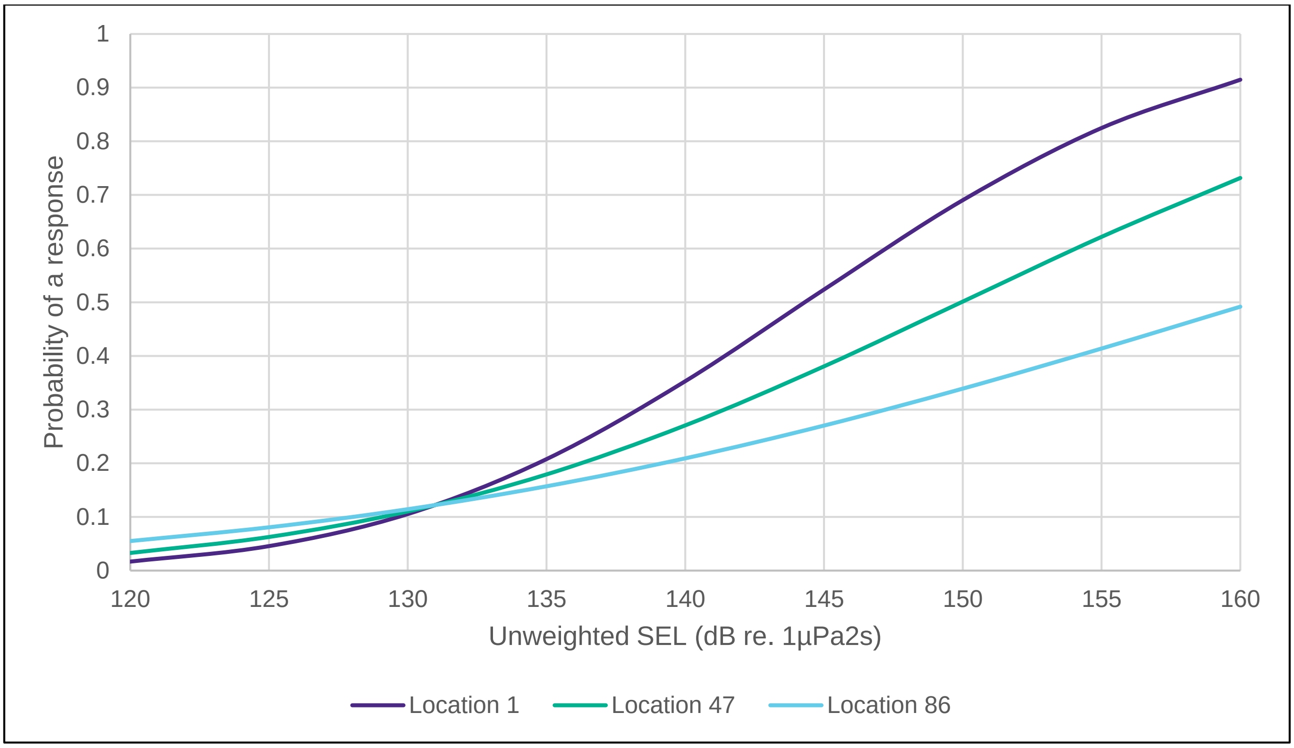


Figure 6-1 The probability of a harbour porpoise response (24h) in relation to the partial contribution of unweighted received single-pulse SEL for the first location piled (purple line), the middle location (green line) and the final location piled (blue line). Harbour porpoise occurrence was considered to have responded to piling when the proportional decrease in occurrence exceeded a threshold of 0.5. (Reproduced with permission from Graham *et al.,* 2019).

For harbour seal and grey seal, subsea noise modelling was undertaken using a dose-response approach with SEL single-strike (SEL_{ss}) contours modelled in 5 dB increments with each isopleth linked to a probability of disturbance as derived from Whyte *et al.* (2020) (Figure 6-2). This approach was recently applied to Awel y Môr Offshore Wind Farm, after consultation with Natural Resource Wales (NRW) (RWE, 2022b). It has been assumed that all seals are displaced at sound exposure levels above 180 dB re 1 µPa^{2}s. This is a conservative assumption since there were no data presented in the study at this level. Furthermore, it is important to note that there is a percentage decrease anomaly in response to either 170 - 175 or 175 - 180 dB re 1 µPa^{2}s. This (undetermined) anomaly likely occurred due to the small number of spatial cells included in the analyses for these categories (n = 2 and 3 respectively, compared to a minimum of 5 spatial cells at other SELs). The harbour seal curve has been applied to grey seal disturbance also, as no corresponding data for grey seal are available, and it is considered to be an appropriate proxy for grey seal given both species are within the same hearing group (PW). Disturbance criteria (assessment thresholds) are presented in Table 6-4 below.

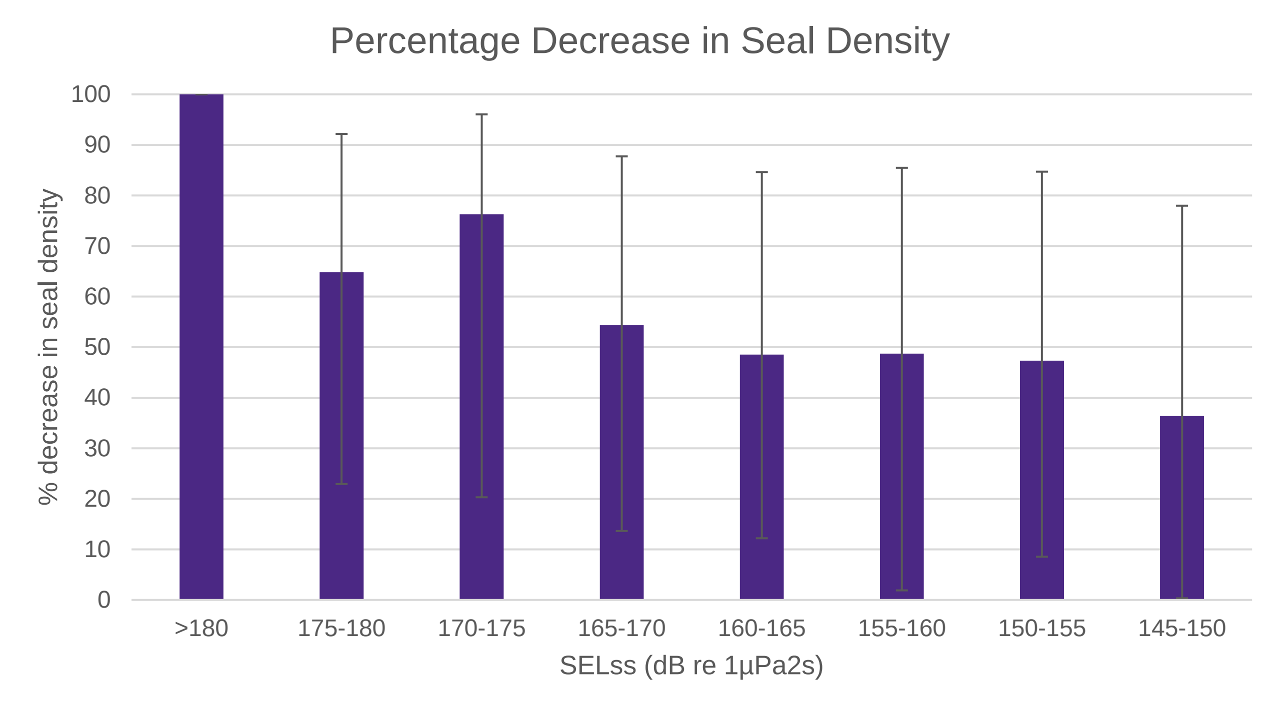


Figure 6-2: Percentage decrease in seal density as a function of estimated Sound Exposure Level (SEL) (showing upper and lower 95% Confidence Intervals (CI) as error bars). (Reproduced with permission from Whyte *et al.,* 2020).

6.1.1.3 Summary of injury and disturbance thresholds

A summary of the criteria (acoustic thresholds) for onset of injury and disturbance used in the marine mammal noise assessment is provided below in Table 6-3.

Table 6-3: Summary of injury (PTS and TTS) onset acoustic thresholds for impulsive noise (NMFS, 2018).

Hearing Group	Injury	
	PTS	TTS
High frequency (HF) cetaceans (bottlenose dolphin)	230 dB re 1 µPa (SPL_{pk})	224 dB re 1 µPa (SPL_{pk})
	185 dB re 1 µPa²s (SEL_{cum})	170 dB re 1 µPa²s (SEL_{cum})
Very high frequency (VHF) cetaceans (harbour porpoise)	202 dB re 1 µPa (SPL_{pk})	196 dB re 1 µPa (SPL_{pk})
	155 dB re 1 µPa²s (SEL_{cum})	140 dB re 1 µPa²s (SEL_{cum})
Phocid pinnipeds in water (PW) (grey seal and harbour seal)	218 dB re 1 µPa (SPL_{pk})	212 dB re 1 µPa (SPL_{pk})
	185 dB re 1 µPa²s (SEL_{cum})	170 dB re 1 µPa²s (SEL_{cum})

Table 6-4: Disturbance criteria for marine mammals used in this study (NMFS, 2005).

Hearing Group	Non-Impulsive Threshold	Impulsive Threshold (other than piling)	Impulsive Threshold (piling)
Mild disturbance (all marine mammals)	-	140 dB re 1µ Pa (rms)	Based on SEL 5 dB contours

Hearing Group	Non-Impulsive Threshold	Impulsive Threshold (other than piling)	Impulsive Threshold (piling)
Strong disturbance (all marine mammals)	120 dB re 1µ Pa (rms)	160 dB re 1µ Pa (rms)	Based on SEL 5 dB contours

6.1.2 Construction phase

The installation of foundations within the offshore wind farm area may lead to injury and/or disturbance to marine mammals from underwater noise during pile driving. The noise assessment considered the installation of 9.6 m diameter monopiles with a hammer energy of 3,500 kJ. The piling parameters and resulting source sound levels for monopiles are described above and set out in Table 6-1.

6.1.2.1 Injury

The subsea noise modelling assessment showed that the injury ranges were larger for piling activities modelled in the east of the offshore wind farm area than the west, with a couple of exceptions where, due to differences in bathymetry, the ranges were similar to those in the west of the offshore wind farm area (see appendix C: Subsea Noise Technical Report). As such only outputs for the east of the offshore wind farm area (as the maximum effect ranges) have been presented here.

6.1.2.1.1 Marine mammal qualifying features

Including soft start and ramp up as a measure included in the Project, the greatest predicted range for PTS (using the SPL_{pk} metric) was for harbour porpoise - a VHF cetacean - with PTS potentially occurring out to 236 m (Table 6-5). For comparison, at the west location the maximum range over which PTS could occur was estimated as 219 m for harbour porpoise, suggesting that the risk of PTS varies from location to location, with 236 m anticipated as the maximum across all locations (Table 1-17 in appendix C: Subsea Noise Technical Report). PTS using the SEL_{cum} metric could occur out to 168 m for harbour porpoise and 19 m for pinnipeds but was not exceeded for bottlenose dolphin, a HF cetacean.

To reduce risk of injury in all marine mammals, and for the purposes of developing the MMMP (see appendix K: Management Plans), a mitigation zone (over which the pre-piling watch should take place) was defined. Based on the dual metric (SPL_{pk} and SEL_{cum}) noise modelling for the mitigation zone has been defined as a minimum of 394 m (i.e. this was the maximum predicted injury range across all marine mammals and both metrics).

The greatest range for TTS, using the SPLpk metric, was predicted for harbour porpoise as a VHF cetacean. TTS in harbour porpoise could occur during piling out to a maximum range of 344 m (Table 6-5). The greatest range for TTS, using the SELcum metric was predicted for harbour porpoise, as a VHF cetacean. TTS in harbour porpoise could occur during piling out to a maximum range of 5,980 m (Table 6-6). As described previously (see section 6.1.1.1), TTS ranges are considered unrealistic due to the thresholds applied and the levels of conservatism built into the model, and are therefore an overestimation of the magnitude of the effects.

For comparison, ranges have also been presented for a scenario without measures included in the Project (i.e. without soft-start initiation ('first strike')) to demonstrate the effectiveness of including these measures to reduce both the PTS and TTS injury ranges (Table 6-6).

Table 6-5: Summary of peak pressure injury ranges for marine mammals due to impact piling of 9.6 m diameter monopiles at the east of the offshore wind farm area (N/E = threshold not exceeded). Note that with the measures included in the Project in place (Table 4-2) the ranges of effect are only relevant for the hammer initiation ('Soft Start – First Strike; 525 kJ); Max Energy ranges have been presented for comparison only.

Hearing group (species)	Threshold (Unweighted Peak)	Range (m)	
		Soft Start - First Strike	Max Energy
HF	PTS - 230 dB re 1 µPa (pk)	41	84

Hearing group (species)	Threshold (Unweighted Peak)	Range (m)	
		Soft Start - First Strike	Max Energy
	TTS - 224 dB re 1 µPa (pk)	59	123
VHF	PTS - 202 dB re 1 µPa (pk)	236	489
	TTS - 196 dB re 1 µPa (pk)	344	713
PW	PTS - 218 dB re 1 µPa (pk)	86	179
	TTS - 212 dB re 1 µPa (pk)	126	261
	TTS - 226 dB re 1 µPa (pk)	52	108

Table 6-6: Summary of the SEL_{cum} injury ranges for marine mammals due to piling of single monopile at the east of the offshore wind farm area (*N/E = threshold not exceeded).* Ranges are shown for piling which includes the measures included in the Project (Table 4-2) (initiation + soft start + ramp up).

Species / Group	Threshold (Weighted SEL_{cum})	Range (m)
HF	PTS - 185 dB re 1 µPa²s	N/E
	TTS - 170 dB re 1 µPa²s	12
VHF	PTS - 155 dB re 1 µPa²s	168
	TTS - 140 dB re 1 µPa²s	5,980
PW	PTS - 185 dB re 1 µPa²s	19
	TTS - 170 dB re 1 µPa²s	1,330

The maximum numbers of marine mammals potentially affected within the modelled ranges for PTS and TTS are presented in Table 6-7 (SPL_{pk}) and Table 6-8 (SEL_{cum}) and are estimated using the most up to date species-specific density estimates (Table 3-2). Estimates of abundance within associated Management Units have been used to present these values as a proportion of the population (Table 3-2). For all assessed marine mammal qualifying features, less than a single individual is likely to experience PTS or TTS as a result of soft start initiation of impact piling based on the SPL_{pk} thresholds for the species (see Table 6-7). Similarly, predictions of the number of animals within the ensonified area that could lead to the onset of PTS using the SEL_{cum} threshold found that for all species less than one animal would be affected (see Table 6-8), other than bottlenose dolphin, where the threshold for PTS was not exceeded. The ranges of effect predicted for TTS using the SEL_{cum} threshold suggest that up to 150 harbour porpoise, up to 2 grey seal and up to 2 harbour seal may be within the ensonified area (Table 6-8). These numbers represent very small proportions of the MU reference populations (i.e. up to 0.239% of the CIS MU for harbour porpoise; 0.031% of the GSRP for grey seal; 0.095% for the HSRP for harbour seal). For bottlenose dolphin, less than one animal would be affected by TTS (Table 6-8).

To reduce the risk of permanent and temporary auditory injury, measures included in the Project will be implemented as part of a MMMP (see appendix K: Management Plans). This will include recording of marine mammal activity (visually and using PAM) over a pre-defined mitigation zone based on the maximum range over which PTS is predicted to occur; in this case a minimum of 236 m (Table 6-5). In addition to the measures included in the Project (see Table 4-2), an Acoustic Deterrent Device (ADD) which has been shown to be effective in deterring marine mammals from proximity to piling which may result in injury (McGarry *et al.,* 2017; Gordon *et al.,* 2019) will be implemented as part of the MMMP, subject to discussion with stakeholders. The use of an ADD is considered as mitigation and discussed later in this section.

Table 6-7: Number of animals potentially affected by PTS (auditory injury) and TTS arising from soft start initiation for piling at a single monopile at the east of the offshore wind farm area based on peak pressure injury ranges (N/E = threshold not exceeded).

Species	Threshold (Unweighted Peak)	Density estimate (animals/km^2)	MU population	Range (m)	Area of sea within zone of injury (km^2)	Number animals within zone of injury	Proportion of MU population (%)
Harbour porpoise	PTS - 202 dB re 1 µPa (pk)	0.280 - 1.330	62,517	236	0.17	< 1	7.85×10^{-5} - 0.0004
	TTS - 196 dB re 1 µPa (pk)			344	0.37	< 1	0.0002 - 0.0008
Bottlenose dolphin	PTS - 230 dB re 1 µPa (pk)	0.046 - 0.235[1]	293 8,326[1]	41	0.005	< 1	8.29×10^{-5} 1.49×10^{-5}
	TTS - 224 dB re 1 µPa (pk)			59	0.01	< 1	0.0002 3.09×10^{-5}
Grey seal	PTS - 218 dB re 1 µPa (pk)	0.372	5,882	86	0.02	< 1	0.0001
	TTS - 212 dB re 1 µPa (pk)			126	0.05	< 1	0.0003
Harbour seal	PTS - 218 dB re 1 µPa (pk)	0.280	1,635	86	0.02	< 1	0.0004
	TTS - 212 dB re 1 µPa (pk)			126	0.05	< 1	0.0009

[1] Density generated using SCANS-IV data has been compared against a reference population estimated by summing the abundance within the Irish Sea SCANS-IV blocks

Table 6-8: Number of animals potentially affected by PTS (auditory injury) and TTS arising from impact piling at a single monopile location at the east of the offshore wind farm area based on SEL injury ranges (including soft start) (N/E = threshold not exceeded).

Species	Threshold (Weighted) SEL_{cum}	Project measure	Density estimate (animals/km^2)	MU population	Range (m)	Area of sea within zone of injury (km^2)	Number animals within zone of injury	Proportion of MU population (%)
Harbour porpoise	PTS – 155 dB re 1 μPa^2s	Soft start	0.280 - 1.330	62,517	168	0.09	< 1	3.97×10^{-5} - 0.0002
	TTS - 140 dB re 1 μPa^2s				5,980	112.29	32 - 150	0.050 - 0.239
Bottlenose dolphin	PTS - 185 dB re 1 μPa^2s	Soft start	0.046 - 0.235[1]	293 8,326[1]	N/E	N/A	N/A	N/A

Species	Threshold (Weighted) SEL_{cum}	Project measure	Density estimate (animals/km²)	MU population	Range (m)	Area of sea within zone of injury (km²)	Number animals within zone of injury	Proportion of MU population (%)
	TTS - 170 dB re 1 µPa²s				12	0.0005	< 1	7.10×10^{-6} 1.28×10^{-6}
Grey seal	PTS - 185 dB re 1 µPa²s	Soft start	0.372	5,882	19	0.001	< 1	6.3×10^{-6}
	TTS - 170 dB re 1 µPa²s				1,330	5.55	2	0.031
Harbour seal	PTS - 185 dB re 1 µPa²s	Soft start	0.280	1,635	19	0.001	< 1	1.94×10^{-5}
	TTS - 170 dB re 1 µPa²s				1,330	5.55	2	0.095

[1] Density generated using SCANS-IV data has been compared against a reference population estimated by summing the abundance within the Irish Sea SCANS-IV blocks

The impact of injury on marine mammal species is predicted to be of local spatial extent, medium-term duration (i.e. maximum duration of piling phase), intermittent (i.e. elevations in subsea noise occur intermittently over the piling phase) and permanent (PTS)/temporary (TTS). It is predicted that the impact will affect marine mammal species directly. The assessment shows that over the ensonified area, only small numbers of animals of all species are likely to occur within the injury zones. These numbers are relatively small in the context of the relevant geographic frames of reference, and would not be at a scale that would lead to any measurable population-level effects. In addition, with measures in place including soft start and an MMMP, the magnitude is therefore, considered to be low for PTS as the range of effect falls within the distance which can be managed via the MMMP and medium for TTS (as the range of effect may extend beyond the distance which can be managed by the MMMP).

6.1.2.2 Disturbance

6.1.2.2.1 Marine mammal qualifying features

Disturbance ranges for all marine mammal species are shown in Figure 6-3 and Figure 6-4 (SEL_{ss} metric), for the installation of monopiles at the east of the offshore wind farm area, as the largest spatial extent. The number of animals predicted to experience potential disturbance as a result of piling at the east of the wind farm (largest spatial extent) are set out for cetaceans and seals in Table 6-9 and Table 6-10, respectively. Predicted number of animals are based on the most up to date species-specific density estimates (Table 3-2) and represent the maximum numbers that may be affected.

Based on a dose-response approach (derived from Graham *et al. (*2017), the most conservative estimate of disturbance predicted that between 153 and 725 harbour porpoise have the potential to be disturbed by piling, representing 0.245% to 1.160% of the MU population. However, this represents the maximum number across the entire range of disturbance responses (from slight changes in behaviour, such as changes in swimming speed or direction through to displacement). Of this, up to 64 harbour porpoise are predicted to experience strong disturbance (above 160 dB re 1µ Pa (rms)) representing 0.101% of the MU population, whilst up to 2,111 are predicted to experience mild disturbance (140 – 160 dB re 1µ Pa (rms)) representing 3.376% of the MU population (Table 6-9).

Disturbance is expected to affect fewer bottlenose dolphin during piling, however the bottlenose dolphin population estimates (n=293, from IAMMWG, 2023; and n=8,326, derived from Gilles *et al.,* 2023) are significantly smaller than the relevant harbour porpoise population (n=62,517). Therefore disturbance, based on a dose-response approach (derived from Graham *et al.,* 2017) of up to 129 animals, represents 1.549% of the SCANS-IV abundance estimate; or, disturbance of up to 26 animals, based on the SCANS-III DSE of 0.046 animals per km^2 represents 8.63% of the Irish Sea MU (see Table 6-9).

Based on a dose-response approach (derived from Whyte *et al.,* 2020) up to 21 grey seal have the potential to be disturbed by piling, representing up to 0.357% of the GSRP. Up to 16 harbour seal have the potential to be disturbed by piling, representing up to 0.979% of the HSRP (dose-response derived from Whyte *et al.,* 2020) (Table 6-10). Of these, up to 18 grey seal and 14 harbour seal have the potential to experience strong disturbance (above 160 dB re 1µ Pa (rms)) representing up to 0.300% and 0.812% of the GSRP and HSRP, respectively. Up to 33 grey seal, and 25 harbour seal have the potential to experience mild disturbance (140 – 160 dB re 1µ Pa (rms)) representing up to 0.551% and 1.491% of the GSRP and HSRP, respectively.

Mild disturbance for seals has previously been considered theoretically to occur over a larger area than strong disturbance, and therefore has the potential to affect larger numbers of each species. However, Whyte *et al.* (2020) showed for harbour seal, that beyond 25 km (below 145 dB re 1µ Pa (rms)) from the piling noise source, no significant changes in seal density were detected. Therefore, modelling has predicted that the range of effect in which strong and mild disturbance could occur is not likely to extend to haul-out sites in the vicinity of the offshore wind farm area for either grey seal (Figure 6-3) or harbour seal (Figure 6-4), regardless of whether piling occurs at the east or the west of the Project. Animals originating from these haul-out sites still have the potential to overlap with these contours but are not expected to experience severe behavioural effects. Barrier effects as a result of installation of monopiles however, could either prevent seals from travelling to forage from haul-out sites, or force seals (particularly harbour seal) to travel greater distances than is usual.

Strong and mild disturbance contours (160 dB re 1µ Pa (rms) and 140 dB re 1µ Pa (rms), respectively) modelled for the Project are predicted to extend to 3.2 km and 17 km from the Project, respectively (see

Figure 6-3 and Figure 6-4). Figure 6-5 shows that the modelled Project disturbance contours of 135 dB re 1µPa SEL_{ss} (= 140 dB re 1µPa SPL_{rms}, mild disturbance) and 150 dB re 1µPa SEL_{ss} (= 160 dB re 1µPa SPL (rms); strong disturbance) do not overlap with any European site with marine mammals listed as a qualifying feature.

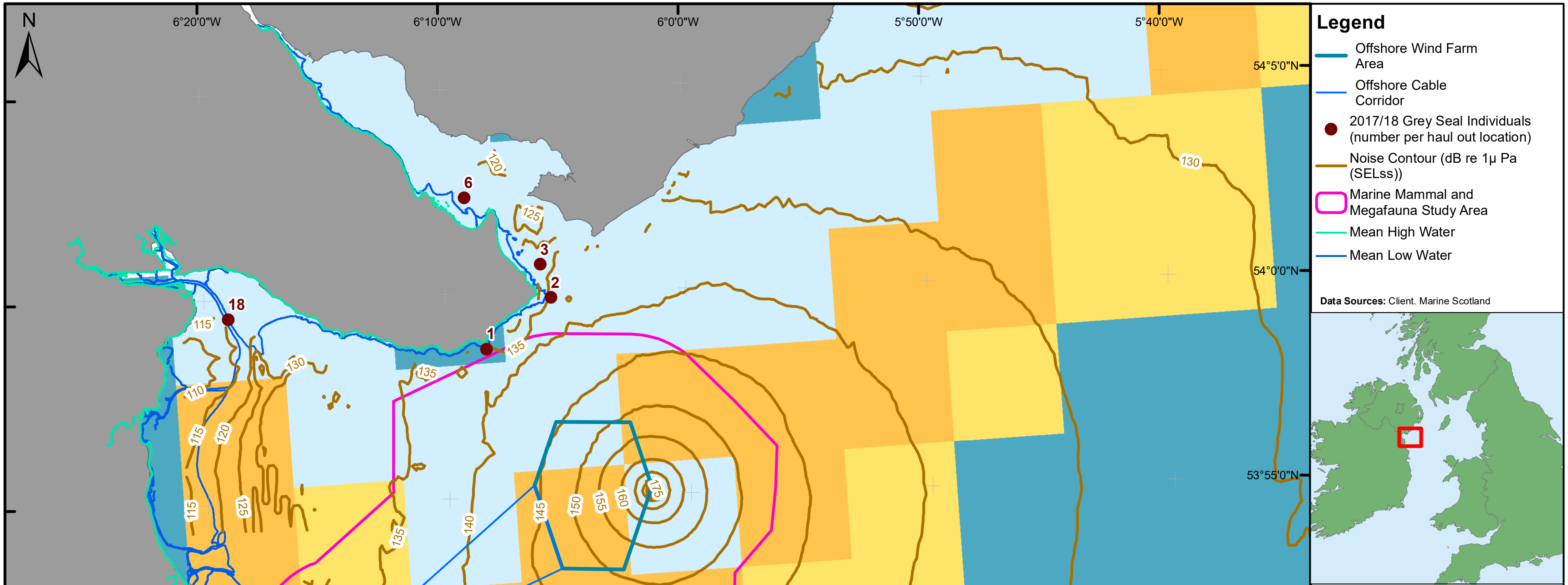
Population modelling was carried out to investigate the potential for underwater noise associated with the installation of monopiles to be a source of disturbance for harbour porpoise, bottlenose dolphin, grey seal and harbour seal. Modelling results for all species demonstrated that there may be a small reduction in population size for the impacted populations, however these changes would not be enough to significantly affect population trajectories over a generational scale (i.e. small changes in the simulated trajectories fall within the expected range of natural variation) (see IPCoD modelling).

The impact of disturbance on marine mammals is predicted to be of regional spatial extent as it extends beyond the boundaries of the offshore wind farm area, medium-term duration, intermittent, and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude of the impact could result in a small but measurable alteration to the distribution of marine mammals but only during piling, which comprises a small fraction of the construction period. In addition, the proportion of the MU populations affected at any one time by strong disturbance (possible displacement) is likely to be small. The magnitude is therefore, considered to be low.

Table 6-9: Number of animals predicted to be disturbed noise contours as a result of impact piling of monopiles at the east of the offshore wind farm area. Also shows number of animals predicted to be disturbed, calculated within unweighted SEL_{ss} noise contours, that equate to strong and mild disturbance thresholds under NMFS (2005).

Species	Density estimate (animals/km²)		MU population		All disturbance responses (5 dB contours (SEL_{ss}); Graham et al., 2017)				Strong disturbance (equivalent to ≥ 160 dB re 1μ Pa (rms); NMFS, 2005)				Mild disturbance (equivalent to 140 – 160 dB re 1μ Pa (rms); NMFS, 2005			
					Number of animals		Proportion of MU population (%)		Number of animals		Proportion of MU population (%)		Number of animals		Proportion of MU population (%)	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Harbour porpoise	0.280	1.330	62,517		153	725	0.245	1.160	14	64	0.021	0.101	445	2,111	0.711	3.376
Bottlenose dolphin	0.046	0.235[1]	293	8,326[1]	26	129	8.63	1.549	3	12	0.751	0.134	74	374	25.133	4.482
Grey seal	0.372	-	5,882		21	-	0.357	-	18	-	0.300	-	33	-	0.551	-
Harbour seal	0.280	-	1,635		16	-	0.979	-	14	-	0.812	-	25	-	1.491	-

[1] Density generated using SCANS-IV data has been compared against a reference population estimated by summing the abundance within the Irish Sea SCANS-IV blocks



Client

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

Oriel Wind Farm Project

Title **Figure 6-3**
Marine mammal disturbance ranges (SELss) for monopiles at the east modelled locations overlaid on grey seal at-sea usage (animals per 5x5 km grid cell) and grey seal sightings at haul outs

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Issue Details

Drawn By: NG	Project No. EOR0822 (MDR1520B)
Checked By: NG	File Ref:
Approved By: AOS	EOR0822_MAM_E_1300_FINAL
Scale: 1:250,000 @ A4	Projection: ITM (IRENET95)
Date: 07/03/2024	Geographic Co-ordinates: ETRS89

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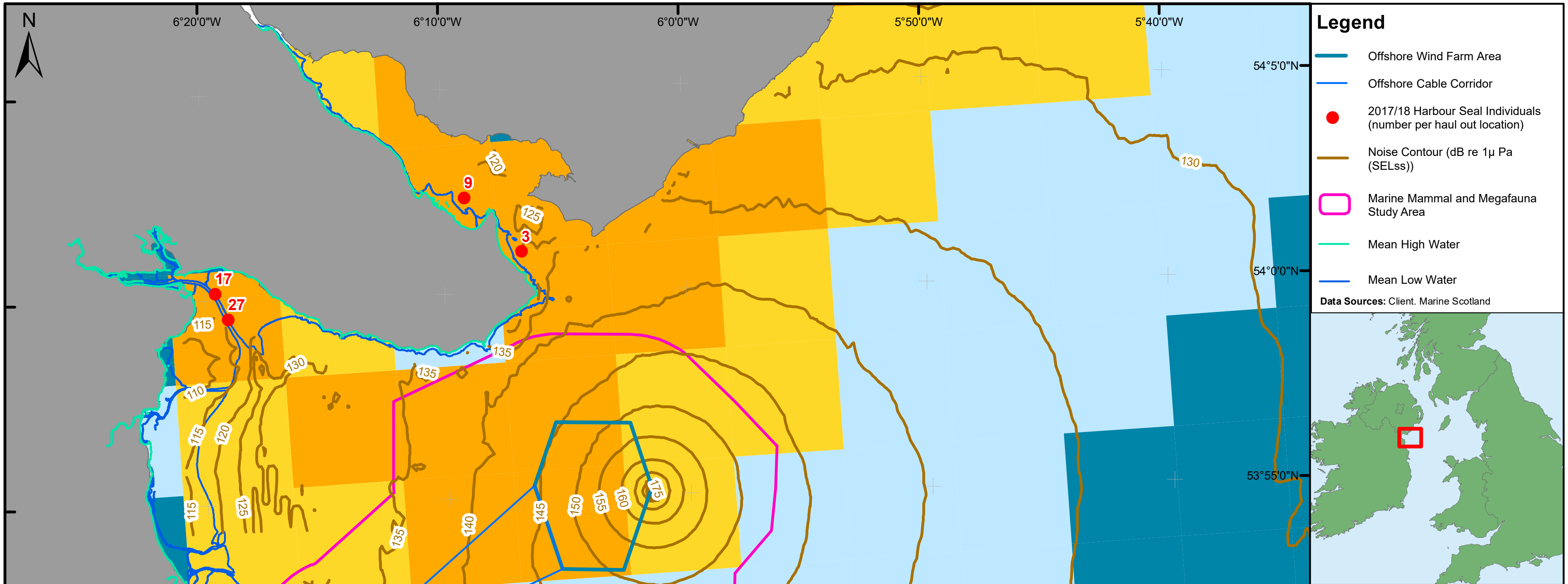

Client
[redacted]

Project

Oriel Wind Farm Project

Title Figure 6-4
Marine mammal disturbance ranges (SELss) for monopiles at the east modelled locations overlaid on harbour seal at-sea usage (animals per 5x5 km grid cell) and harbour seal sightings at haul-outs

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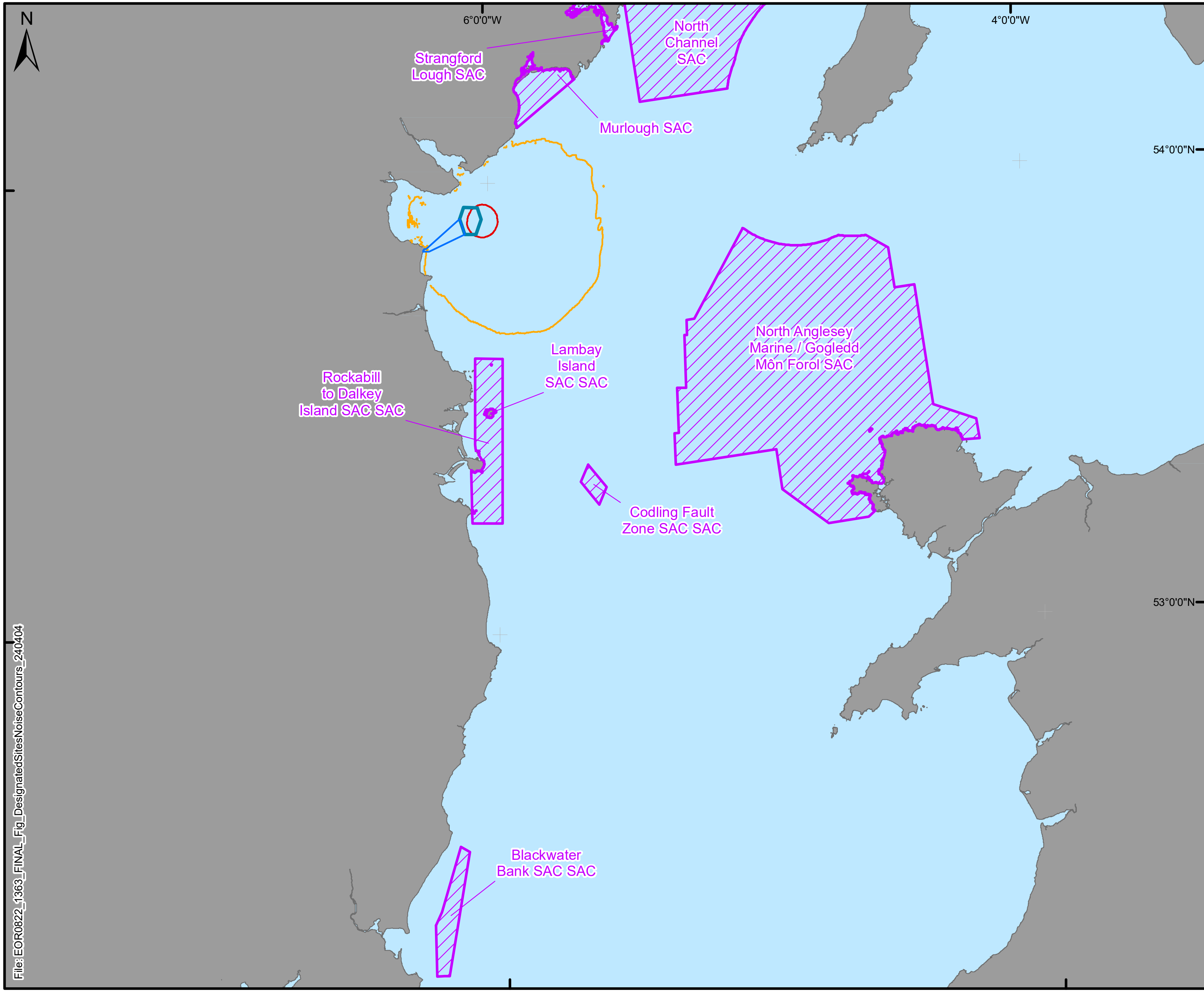
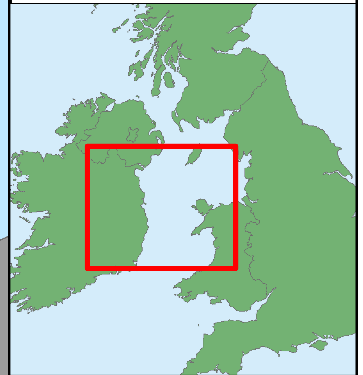


Legend

- Project Offshore Wind Farm Area
- Project Offshore Cable Corridor
- 140 dBrms (mild disturbance)
- 160 dBrms (strong disturbance)
- Designated Special Area of Conservation (SAC)

Data Sources: Client. JNCC, NPWS



Client [redacted]

Project

Oriel Wind Farm Project

Title **Figure 6-5**
Relevant European sites overlaid with modelled marine mammal disturbance contours (SELss) for monopiles at the east modelled location

[redacted]

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Date: 04/04/2024	

6.1.2.3 Sensitivity of the qualifying features

6.1.2.3.1 Injury

6.1.2.3.1.1 Harbour Porpoise

Studies of auditory injury in relation to a typical piling sequence have suggested that hearing impairment as a result of exposure to piling noise is likely to occur where the source frequencies overlap the range of peak sensitivity for the marine mammal species rather than across the whole frequency hearing spectrum (Kastelein *et al*., 2013). Kastelein *et al*. (2013) demonstrated experimentally that for simulated piling noise (broadband spectrum), harbour porpoise's hearing around 125 kHz (the key frequency for echolocation) was not affected. Instead, a measurable threshold shift in hearing was induced at frequencies of 4 to 8 kHz, although the magnitude of the hearing shift was relatively small (2.3 to 3.6 dB at 4 to 8 kHz) due to the lower received SELs at these frequencies. This was due to most of the energy from the simulated piling occurring in lower frequencies (Kastelein *et al*., 2013).

In addition to the frequency characteristics of the source, the duty cycle of fatiguing sounds is also likely to affect the magnitude of a hearing shift. Kastelein *et al*. (2014) suggests that hearing may recover to some extent during inter-pulse intervals. Similarly, Finneran *et al*. (2015) highlights that whilst a threshold shift can accumulate across multiple exposures, the resulting shift (in this study TTS) will be less than the shift from a single, continuous exposure with the same total SEL. Again, this suggests that the ranges predicted by the subsea noise model using the SEL_{cum} metric are likely to be overestimates.

For the purposes of assessing sensitivity to injury, there is a distinction between PTS and TTS. PTS is a permanent and irreversible hearing impairment and therefore it is expected that harbour porpoise is sensitive to this effect as the loss of hearing would affect key life functions (e.g. communication, predator detection, foraging, mating and maternal fitness) and could lead to a change in an animal's health (if chronic) or vital rates (if acute) (Erbe *et al*., 2018). Relating a potential loss in hearing to a biologically significant response is challenging due to a paucity of empirical data, however a potential consequence of a disruption in key life functions is that the health of impacted animals would deteriorate and potentially lead to reduced birth rate in females and mortality of individuals (Costa, 2012). Since PTS is irreversible, harbour porpoise is assessed as having limited resilience, limited ability to adapt behaviour to sustain ecological functioning, and limited ability to recover from the effect in the short and long term, given the potential for the impact to result in a change in both reproduction and survival rate. The sensitivity of harbour porpoise to PTS is therefore considered to be high.

TTS is a temporary and reversible hearing impairment and therefore it is anticipated that any animals experiencing this shift in hearing would recover after they are no longer exposed to elevated noise levels (i.e. they may have moved beyond the injury zone or piling has ceased). The implication of animals experiencing TTS, leading to potential displacement, is not fully understood, but it is likely that aversive responses to anthropogenic noise could temporarily affect life functions as described for PTS. However, due to the reversible nature of TTS, this is less likely to lead to acute effects and will largely depend on recoverability. The degree and speed of hearing recovery will depend on the characteristics of the sound the animal is exposed to, and on the degree of shift in hearing experienced. A study measuring recovery rates of harbour porpoise following exposure to sound source of 75 db re 1 µPa (SEL) over 120 minutes found that recovery to the pre-exposure threshold was estimated to be complete within 48 minutes following exposure (the higher the hearing threshold shift, the longer the recovery) (SEAMARCO, 2011). Scientific understanding of this is limited to the results of controlled exposure studies on small numbers of captive animals (reviewed in Finneran *et a*l., 2015). Extrapolating these results to how animals may respond in the natural environment should be treated with caution as it is not possible to exactly replicate natural environmental conditions, and the small number of test subjects would not account for intraspecific differences (i.e. differences between individuals) or interspecific differences (i.e. extrapolating to other species) in response. Since TTS is reversible, harbour porpoise are assessed having high resilience to the effect with minor impairment of ecological functioning, have an ability to adapt behaviour such that ecological function can be maintained, and high recoverability. The sensitivity of harbour porpoise to TTS is therefore considered to be low.

6.1.2.3.1.2 Bottlenose dolphin

Individual dolphins experiencing PTS would suffer a biological effect that could impact on animals' health and vital rates (Erbe *et al*., 2018). As described for harbour porpoise (above) there are frequency-specific differences in the onset and growth of a noise-induced threshold shift in relation to the characteristics of the noise source and hearing sensitivity of the receiving species. For example, exposure of two captive bottlenose dolphin to an impulsive noise source between 3 and 80 kHz found that there was increased susceptibility to auditory fatigue between frequencies of 10 to 30 kHz (Finneran, 2013). The SEL_{cum} threshold incorporates hearing sensitivities of marine mammals and the magnitude of effects were considerably smaller compared to very high frequency species (e.g. harbour porpoise), highlighting that high frequency species are less sensitive to the frequency components of the piling noise signal. However, given that effects are irreversible (i.e. as noted for harbour porpoise above) and in light of how important sound is for echolocation, foraging and communication in small toothed cetaceans, bottlenose dolphin are of high vulnerability and low recoverability. Bottlenose dolphin have been assessed as having a high sensitivity to PTS.

Again, whilst there are no available species-specific recovery rates for high-frequency cetaceans to TTS, there is no evidence to suggest that recovery will be significantly different to harbour porpoise recovery rates therefore animals can recover their hearing after they are no longer exposed to elevated noise levels (i.e. they may have moved beyond the injury zone or piling has ceased). Bottlenose dolphin would be able to tolerate the effect without any impact on reproduction or survival rates and would be able to return to previous behavioural states or activities once the impacts had ceased. Bottlenose dolphin are therefore assessed as having limited resilience, limited ability to adapt behaviour to sustain ecological functioning, and limited ability to recover from the effect in the short and long term, given the potential for the impact to result in a change in both reproduction and survival rates. The sensitivity of bottlenose dolphin to TTS has therefore been assessed as low.

6.1.2.3.1.3 Seals

Seals are less dependent on hearing for foraging than cetacean species, but may rely on sound for communication and predator avoidance (e.g. Deecke *et al*., 2002). Hastie *et al.* (2015) reported that, based on calculations of SEL of tagged harbour seal during the construction of the Lincs offshore wind farm (Greater Wash, UK), at least half of the tagged seals would have received sound levels from pile driving that exceeded auditory injury thresholds for pinnipeds (PTS). However, population estimates indicated that the relevant population trend is increasing and therefore, although there are many other ecological factors that will influence the population health, this indicated that predicted levels of PTS did not affect sufficient numbers of individuals, by a sufficient amount, to cause a decrease in the population trajectory (Hastie *et al.,* 2015). Hastie *et al.,* however, noted that due to paucity of data on effects of sound on seal hearing, the exposure criteria used are intentionally conservative and therefore predicted numbers of individuals likely to be affected by PTS would also have been highly conservative. However, despite the uncertainty in the ecological effects of PTS on seals, seals rely on hearing much less than cetaceans and therefore would exhibit some tolerance (i.e. the effect is unlikely to cause a change in either reproduction or survival rates). In addition, it has been proposed that seals may be able to self-mitigate (i.e. reduce their hearing sensitivity in the presence of loud sounds in order to reduce their perceived SPL) (Kastelein *et al.,* 2018b). Seals are therefore considered to be of medium vulnerability and low recoverability. Although this evidence suggests a lower sensitivity of pinnipeds to PTS compared to cetaceans, based on uncertainties a precautionary approach has been taken and the sensitivity of grey seal and harbour seal to PTS has therefore been assessed as high.

A study measuring recovery rates of harbour seal following exposure to a sound source of 193 dB re 1 $\mu Pa^2 s$ (SEL_{cum}) over 360 minutes found that recovery from TTS to the pre-exposure baseline was estimated to be complete within 72 minutes following exposure (Kastelein *et al.,* 2018b). These results are similar to recovery rates found in SEAMARCO (2011), which showed that for small TTS values, recovery in seals was very fast (around 30 mins); the higher the hearing threshold shift, the longer the recovery. Therefore, in most cases, reduced hearing for such a short time probably has little effect on the total foraging period of a seal. If hearing is impaired for longer periods (hours or days) the impact is likely to be ecologically significant (SEAMARCO, 2011). The results indicate that harbour seal (and therefore grey seal, using harbour seal as a proxy) are less vulnerable to TTS than harbour porpoise for the noise bands tested. In addition, it is expected that animals would move beyond the injury range prior to the onset of TTS. Given that both grey seal and harbour seal are likely to be able to tolerate the effect without any impact on both reproduction and survival rates and would be able to return to previous behavioural states or activities once the impacts had ceased, seals are assessed as having limited resilience, limited ability to adapt behaviour to sustain ecological functioning, and limited ability to recover from the effect in the short and long term, given the potential for the impact to result in a change in both reproduction and survival rates. The sensitivity of grey seal and harbour seal to TTS has been assessed as low.

6.1.2.3.2 Disturbance

Studies have shown that acoustic disturbance from seismic survey activities may lead to the interruption of normal behaviours (such as feeding or breeding) and avoidance, leading to displacement from the area and exclusion from critical habitats (Goold, 2009; Weller *et al*., 2002; Castellote *et al*., 2010, 2012). Noise may also cause stress which in turn can lead to a depressed immune function and reduced reproductive success (Anderson *et al.,* 2011; DeSoto *et al.,* 2013).

6.1.2.3.2.1 Harbour Porpoise

For the project design parameters (installation of monopiles), whilst the ranges for disturbance for all marine mammals are equal, densities within the Regional Marine Mammal and Megafauna Study Area vary significantly between species. Harbour porpoise, as a species, is particularly vulnerable to disturbance, as individual harbour porpoise needs to forage frequently due to their high metabolic rate. The variance in behavioural responses to increased subsea noise is well documented and is context specific with factors such as the activity state of the receiving animal, nature and novelty of the sound (i.e. previous exposure history), and spatial relation between sound source and receiving animal being important in determining the likelihood of a behavioural response and therefore their sensitivity (Ellison *et al.*, 2012). A recent study on piling at the Beatrice Offshore Wind Farm suggests that harbour porpoise may adapt to increased noise disturbance over the course of the piling phase, thereby showing a degree of tolerance and behavioural adaptation (Graham *et al.*¸2019; see Table 6-1).

A recent article by Southall *et al.* (2021) introduces a behavioural response severity spectrum, building on earlier work presented in Southall *et al.* (2007) and the expanding literature in this area. Southall *et al.* (2021) illustrates the progressive severity of possible responses within three response categories: survival (e.g. resting, navigation, defence), feeding (e.g. search, consumption, energetics), and reproduction (e.g. mating, parenting). For example, at the most severe end of the spectrum (scored 7 to 9), where sensitivity is highest, displacement could occur resulting in movement of animals to areas with an increased risk of predation and/or with sub-optimal feeding grounds. A failure of vocal mechanisms to compensate for noise and interruption of key reproductive behaviour including mating and socialising could occur. In these instances, there would likely be a reduction in an individual's fitness leading to potential breeding failure and impact on survival rates. Acknowledging the limitations of the single step-threshold approach for strong disturbance and mild disturbance (ie. does not account for inter-, or intra-specific variance or context-based variance), harbour porpoise within the area modelled as 'strong disturbance' would be most sensitive to behavioural effects and therefore may have a response score of 7 or above according to Southall *et al.* (2021). At the lower end of the behavioural response spectrum the potential severity of effects reduces and whilst there may be some detectable responses that could result in effects on the short-term health of animals, these are less likely to impact on an animals' survival rate. For example, mild disturbance could lead to effects such as changes in swimming speed and direction, minor disruptions in communication, interruptions in foraging, or disruption of parental attendance/nursing behaviour (Southall *et al.*, 2021).

Although harbour porpoise may be able to avoid the disturbed area and forage elsewhere, there may be a potential effect on reproductive success of some individuals. As mentioned previously, it is anticipated that there would be some adaptability to the elevated noise levels from piling and therefore survival rates are not likely to be affected. Due to the uncertainties associated with the effects of behavioural disturbance on vital rates, harbour porpoise is deemed to be of medium resilience, high adaptability and high recoverability. Therefore, the sensitivity of harbour porpoise to disturbance has, conservatively, been assessed as medium for both strong and mild disturbance (noting that for the latter the sensitivity is likely to be lower).

6.1.2.3.2.2 Bottlenose dolphin

Bottlenose dolphin are not thought to be as vulnerable to disturbance as harbour porpoise, as foraging requirements are less frequent. Bottlenose dolphin likely to be foraging in the area form part of the IS MU, which is far smaller, and therefore any effect on the individual is more likely to have an impact at the population level.

There is scant information regarding the specific sensitivities of these species to disturbance from piling noise. The Southall *et al*. (2021) severity spectrum applies across all marine mammals and therefore it is expected that, as described for harbour porpoise, strong disturbance could result in displacement whilst mild disturbance would result in other, less severe behavioural responses.

Bottlenose dolphin could tolerate the effects of disturbance and whilst there may some impacts on reproduction in the area of 'strong disturbance' there is not likely to be an impact on survival rates with some tolerance built up over the course of the piling. It is anticipated that animals would return to previous activities once the impact had ceased. Bottlenose dolphin are deemed to be of medium resilience, high adaptability and high recoverability. The sensitivity of bottlenose dolphin to disturbance has therefore been assessed as medium.

6.1.2.3.2.3 Seals

Strong disturbance could result in displacement of seals from an area. Mild disturbance constitutes only slight changes in behaviour, such as changes in swimming speed or direction, and is unlikely to result in population-level effects. Although there is likely to be alternative foraging sites for both harbour seal and grey seal, barrier effects as a result of installation of monopiles could either prevent seals from travelling to forage from haul-out sites, (Figure 6-3 and Figure 6-4) or force seals (particularly harbour seal) to travel greater distances than is usual.

As can be seen by SMRU at-sea usage maps for harbour seal (Figure 6-4), the offshore wind farm area appears to overlap with an area of relatively high usage for harbour seal within the Marine Mammal and Megafauna Study Area, which is likely to consist of important foraging grounds for seals originating from haul-out sites at the mouth of Carlingford Lough, Dundalk bay and Clogherhead. Harbour seal may be disturbed/displaced within their usual foraging habitat during periods of piling. This could have a particular impact during lactating periods (June to August), when female harbour seal spend much of their time in the water with their pups, and foraging is more restricted than during other periods (Thompson and Härkönen, 2008). Consequences could include reduced fecundity, reduced fitness, and reduced reproductive success. Although harbour seal may be able to avoid the disturbed area and forage elsewhere, there will be an energetic cost to having to move greater distances to find food, and therefore there may be a potential effect on reproductive success of some individuals. Harbour seal is deemed to be of medium resilience, high adaptability and high recoverability. The sensitivity of harbour seal to disturbance has therefore been assessed as medium.

As can be seen in Figure 6-3, grey seal appear to have a wider at-sea usage within the Regional Marine Mammal and Megafauna Study Area, and based on their likely foraging ranges (up to 100 km from a haul-out site) may be better adapted than harbour seal to seeking alternative foraging habitat; although notably there will still be an energetic cost of having to move greater distances to find food. Strong disturbance will be temporary, and behaviour is expected to resume to baseline levels outside of the periods of piling. It is expected that grey seal will exhibit some tolerance to disturbance and the effect is unlikely to cause a change in either reproduction or survival rates. Grey seal is deemed to be of medium resilience, high adaptability and high recoverability. The sensitivity of grey seal to disturbance has therefore been assessed as medium.

6.2 Injury and/or disturbance to marine mammals from elevated underwater noise during routine geophysical surveys

Routine geophysical surveys are planned to allow inspection of offshore infrastructure foundations, inter-array cables and offshore cable corridor during the operational and maintenance phase of the Project, and these have the potential to cause direct or indirect effects (including injury or disturbance) on marine mammal Qualifying Features of the European Sites presented in Table 3-1. An underwater noise modelling assessment was carried out to investigate the potential for injurious and behavioural effects on marine mammals as a result of geophysical surveys using the latest criteria (appendix C: Subsea Noise Technical Report), which is drawn upon in the assessment below.

Underwater noise modelling for the geophysical surveys was undertaken based upon the likely parameters of the equipment expected to be employed. Here, the Kongsberg EM710 MBES unit has been modelled operating at 105 kHz, 231 dB re 1µPa re 1 m (rms) (see Table 6-10), although this equipment can typically work at a range of signal frequencies, depending on the distance to the seabed and the required resolution. For sonar-like sources the signal is highly directional, acting like a beam, and is emitted in pulses. Sonar-based sources are considered as continuous (non-impulsive) because they generally comprise a single (or multiple discrete) frequency as opposed to a broadband signal with high kurtosis, high peak pressures and rapid rise times (see appendix C: Subsea Noise Technical Report, wherein a full description of the source sound levels for geophysical survey activities is provided).

Table 6-10: Typical sonar-based survey equipment parameters used in assessment

Survey Type	Unit	Frequency (kHz)	Source Level (dB re 1µPa) (rms)	Pulse Rate (s^{-1})	Pulse Width (ms)	Beam Width	Swathe Beamwidth
MBES	Kongsberg EM710	105	231	30	0.2	2°	140°

6.2.1 Operational and maintenance phase

6.2.1.1 Injury

Potential impacts of routine geophysical surveys will depend on the characteristic of the source, survey design, frequency bands and water depth. Sonar-like sources have very strong directivity which effectively means that there is only potential for injury when a marine mammal is directly underneath the sound source. Once the animal moves outside of the main beam, there is no potential for injury. This section provides estimated ranges for injury of marine mammals during the operational and maintenance phase of the Project.

With respect to the spatial range within which there is a potential of PTS occurring to marine mammals as a result of routine geophysical surveys, PTS has the potential to occur out to a maximum of 227 m for harbour porpoise (Table 6-11). For dolphin species PTS is expected to occur out to a maximum of 124 m, and pinniped species out to 34 m, from the sound source. TTS has the potential to occur out to a maximum of 449 m (harbour porpoise). For dolphin species, TTS is expected to occur out to a maximum of 172 m and pinniped species out to 123 m, from the sound source.

Table 6-11: PTS and TTS onset thresholds and potential impact ranges for marine mammal species during non-impulsive MBES geophysical surveys, based on comparison to Southall *et al*. (2019) SEL thresholds.

Species	Hearing group (NMFS, 2018)	SEL threshold (dB re 1 µPa^2s)	Impact range (m)
Bottlenose dolphin	HF	PTS - 198	124
		TTS - 178	172
Harbour porpoise	VHF	PTS - 173	227
		TTS - 153	449
Harbour seal	PW	PTS - 201	34
		TTS - 181	123
Grey seal	PW	PTS - 201	34
		TTS - 181	123

The number of marine mammals with the potential to be injured, within the modelled ranges for PTS and TTS presented in Table 6-11 were estimated using the most up to date species-specific density estimates (Table 3-2). Due to low predicted injury ranges, for all marine mammal species, it is predicted that there is the potential for no more than one animal to experience PTS or TTS as a result of routine geophysical surveys. The geophysical surveys are considered to be short term as inspection of inter- array cables and offshore cables will be undertaken across a survey campaign duration of up to 14 days per survey (i.e. one 14-day survey window for inspection of inter-array cables; one 14-day survey window for inspection of offshore cable), up to a maximum of once every five years over the 40-year lifetime of the Project. Similarly, inspection of offshore wind turbine foundations will be conducted up to a maximum of every five years during the Project lifespan, and each survey campaign will last up to 14 days. If all survey campaigns were to be carried out consecutively, this would represent a maximum of 42 days of geophysical surveying every five years, however actual surveying is not expected to occur for the entire survey window, as time has been included here to account for weather and technical downtime.

Mitigation for injury during surveys using geophysical survey equipment deployed from a conventional vessel will involve the use of MMOs and PAM to ensure that the risk of injury over the defined mitigation zone is reduced in line with NPWS guidance (NPWS, 2014), and a soft start will be applied where possible. The largest injury range was predicted as 449 m (TTS, for harbour porpoise) and it is considered that standard industry measures will be effective at reducing the risk of injury over this distance. Full details of measures and associated procedures are presented in the MMMP (see appendix K: Management Plans).

Overall, with the above measures applied, the magnitude of the impact of routine geophysical surveys is predicted to be of very limited spatial extent, medium-term duration (i.e. maximum duration of geophysical survey) and intermittent. Whilst the impact itself would occur during the operational and maintenance phase only, the effect of PTS should it occur, would be permanent. The effect of TTS and the impact itself (i.e. during the geophysical surveys) is reversible. It is predicted that the impact will affect the receptor directly. The impact could lead to PTS and/or TTS in a small number of animals but this would not be at a scale that would lead to any measurable population-level effects. The magnitude for PTS and TTS is, therefore, considered to be low.

6.2.1.2 Disturbance

The estimated maximum range for onset of disturbance is based on underwater noise levels being greater than the 120 dB re 1 µPa (rms) threshold applicable for all marine mammals (Table 6-4). The disturbance range as a result of geophysical site-investigation surveys will be higher than those presented for PTS, so the predicted range of disturbance, beyond which no animals are expected to experience disturbance, is approximately 1,410 m (see appendix C: Subsea Noise Technical Report). However, considering the high degree of variation between studies relating to the onset of behavioural effects due to non-impulsive sound, it is recommended that any predicted disturbance ranges are viewed as probabilistic, and potentially over-precautionary.

For those animals which may be disturbed, there is likely to be a proportional response, and not all animals will be disturbed to the same extent. Similarly, the life history of an individual, and the context of the reception of sound, will also influence the likelihood of an individual to exhibit an aversive response. It should also be highlighted that these impacts will not be continuous over the operational and maintenance phase, and that routine geophysical surveys will instead be carried out over a period of days within any given survey window. Therefore, given the limited quantitative information available any simplified calculation is likely to produce an overestimation of the number of animals potentially disturbed, particularly given the intermittent and highly directional nature of sound from sonar-based survey methods (like MBES). Nonetheless, an estimate of the number of animals of each sensitive species that may be disturbed by elevated underwater noise during routine geophysical surveys are presented in Table 6-12, based on density estimates presented in Table 3-2.

Table 6-12: Number of animals potentially affected by disturbance arising from geophysical site investigation surveys.

Species	Hearing group (NMFS, 2018)	Estimated density (animals per km^2)	Number animals within zone of disturbance	Percentage of MU (%)
Harbour porpoise	VHF	0.280 – 1.330	2 - 9	0.003 - 0.013
Bottlenose dolphin	HF	0.008 0.036[1]	< 1	0.098 0.018
Grey seal	PW	0.372	3	0.039
Harbour seal	PW	0.280	2	0.107

[1] Density generated using SCANS-IV data has been compared against a reference population estimated by summing the abundance within the Irish Sea SCANS-IV blocks

However, all geophysical surveys will be very short duration (up to several months), activities are likely to be intermittent, and animals are expected to recover quickly after cessation of the survey activities. The magnitude of the impact could result in a minor alteration to the distribution of marine mammals.

The impact of geophysical surveys leading to behavioural effects is predicted to be of local spatial extent, short term duration, intermittent and the effect of disturbance is of high reversibility (with animals returning to baseline levels soon after surveys have ceased). It is predicted that the impact will affect the receptor directly. The impact could lead to changes to behaviour and distribution in a small number of individuals but this would not be at a scale that would lead to any measurable population-level effects. The magnitude is therefore considered to be low.

6.2.1.3 Sensitivity of the qualifying features

6.2.1.3.1 Injury

The maximum range for injury from geophysical surveys (specifically MBES) was predicted to be 227 m for PTS (harbour porpoise) and 449 m for TTS (harbour porpoise). Ruppel *et al*. (2022) categorised marine acoustic sources into four tiers according to their potential to injure marine mammals, with categories determined by physical criteria about the sound source: source level, transmission frequency, directionality, beamwidth, and pulse repetition rate. Those sources in Tier Four were considered unlikely to result in a loss of individuals and included most high-resolution geophysical sources, including MBES. This study also suggested that surveys deploying multiple, simultaneous, non-impulsive *de minimis* sources are unlikely to result in loss of marine mammals.

Although there is some evidence for short-term behavioural responses of marine mammals to underwater noise from geophysical surveys, sonar-based methods such as MBES pose a reduced risk of injury to auditory systems in comparison to seismic sources (Lurton and DeRuiter, 2011). For MBES operating in mid-range and full ocean depth, there is a potential to cause injury to some cetacean species at very close proximity, however in shallower waters such as those in which the Project is located, the frequency range within which MBES systems operate falls outside the hearing threshold of cetaceans and attenuates more quickly than lower frequencies operated at a lower power. It is therefore considered unlikely that geophysical survey equipment could cause injury (JNCC, Natural England and CCW, 2010).

For PTS, marine mammals are assessed as having limited resilience, limited ability to adapt behaviour to sustain ecological functioning, and limited ability to recover from the effect in the short and long term, given the potential for the impact to result in a change in both reproduction and survival rates. The sensitivity of all marine mammals to PTS from elevated underwater sound during geophysical surveys is therefore considered to be high.

For TTS, marine mammals are assessed as having some resilience, have an ability to adapt behaviour such that ecological function can be maintained, and high recoverability. The sensitivity of all marine mammals to TTS from elevated underwater sound during geophysical surveys is therefore considered to be medium.

6.2.1.3.2 Disturbance

The transmission frequencies of many commercial sonar systems (approximately 12 to 1800 kHz) overlap with the hearing and vocal ranges of many species (Richardson *et al*., 1995), and whilst many are high frequency sonar systems with peak frequencies well above marine mammal hearing ranges, it is possible that relatively high levels of sound are also produced as sidebands at lower frequencies (Hayes and Gough, 1992), which may elicit behavioural responses in marine mammals. However, in the context of exposure to sonar-like sound sources, such as MBES, marine mammals may show subtle behavioural responses. Factors such as species, behavioural context, location, and prey availability may also be as important or more important than the acoustic signals themselves (Ruppel *et al*., 2022), and Kates Varghese *et al*. (2020) showed that MBES surveys may be affect vocalisation rate, but neither displacement nor changes in foraging were observed.

MacGillivray *et al*. (2014) compared sound level above hearing threshold as a function of horizontal distance for seven acoustic sources including MBES, Side Scan Sonar (SSS), Sub-bottom Profiler (SBP) and Ultra-high Resolution Seismic (UHRS). Weighting sounds according to hearing sensitivity allows assessment of relative risks associated with exposure and whilst this analysis was not specifically focussed on the potential for behavioural responses, it allowed comparison of modelled acoustic sources. For all species, modelled sensation levels (i.e. potential for disturbance) were lowest for the high-frequency sources (e.g. SSS and MBES) which operate at the upper limits of the audible spectrum. Modelling indicated that odontocetes (such as harbour porpoise and bottlenose dolphin) were most likely to hear sounds from mid-frequency sources (fishery, communication, and hydrographic systems) and pinnipeds from both mid and low-frequency sources.

Studies have largely focused on the effects of multi-array seismic surveys on marine mammals, and therefore evidence for behavioural responses to sonar-like sources (e.g. MBES, SSS, SBPs) is less widely available. Multi-array impulsive sound sources are broadband in character (i.e. produce sound across a wide range of frequencies), unlike sonar-like sources which typically produce more tonal sound either at a discrete frequency or a range of discrete frequencies. However, findings from studies of multi-array impulsive sources may be useful in supporting predictions of behavioural responses of marine mammals to geophysical survey sources in general (including MBES), given the overlap of parameters that typically characterise sound sources (i.e. transmission frequency; source level; pulse duration) (see MacGillivray *et al*., 2014; Ruppel *et al*., 2022).

Whilst evidence on the behavioural responses of marine mammals to MBES is limited, an Independent Scientific Review Panel deemed a 12 kHz MBES to be the most plausible trigger for an extreme behavioural response in melon-headed whale *Peponocephala electra*, which resulted in a 2008 mass stranding in a shallow lagoon in Madagascar, an area where such open-ocean species would not be expected to occur (Southall *et al*., 2013). Whilst an unequivocal cause and effect relationship between MBES and the strandings cannot be concluded, the study highlights that intermittent, repeated sounds of this nature could present a salient and potential aversive stimulus, which suggests that potential for such behavioural responses (or indirect injury) from MBES should be considered in environmental assessments (Southall *et al*., 2013).

Hastie *et al*. (2014) carried out behavioural response tests to two sonar systems (200 kHz and 375 kHz systems) on grey seal at the SMRU seal holding facility. Results showed that both systems had significant effects on seal behaviour. Grey seal spent significantly more time hauled out during the 200 kHz sonar operation and although animals remained swimming during operation of the 375 kHz sonar, they were distributed further from the sonar.

Aside from displacement or avoidance, other behavioural responses have been demonstrated (Wright and Cosentino, 2015). Responses to seismic surveys have included cessation of singing (Melcón *et al*., 2012) and alteration of dive and respiration patterns, which may lead to energetic burdens on the animals (Gordon *et al*., 2003). In some cases, behavioural responses may lead to greater effects than expected, such as strandings (Cox *et al*., 2006; Tyack *et al*., 2006) or interruptions to migration (Heide-Jørgensen *et al*., 2013). However, such responses are highly context-dependent and variable, depending on factors such as the activity of the animal at the time (Robertson *et al*., 2013), prior experience to exposure (Andersen *et al*., 2012), extent or type of disturbance (Melcón *et al*., 2012), environment in which they inhabit (Heide-Jørgensen *et al*., 2013) and the type of survey (as discussed by Ruppel *et al*., 2022).

It is expected that, to some extent, marine mammals will be able to adapt their behaviour to reduce effects associated with elevated levels of underwater noise during geophysical surveys. Marine mammals are assessed as having high resilience to the effect with minor impairment of ecological functioning, have an ability to adapt behaviour such that ecological function can be maintained, and high recoverability. The sensitivity of all marine mammals to disturbance from elevated underwater sound during geophysical surveys is therefore considered to be medium.

6.3 Injury and/or disturbance to marine mammals from vessels and other construction activities

Increased vessel movement during the construction, operational and maintenance, and decommissioning phases has the potential to result in a range of impacts on marine mammals including:

- Injury or death due to collision with vessels;
- Avoidance behaviour or displacement; and

- Masking of vocalisations or changes in vocalisation rate.

Other construction activities, such as pile drilling, have the potential to result in elevated levels of subsea noise that are detectable by marine mammals above background levels and could result in injurious or behavioural effects on qualifying marine mammal features.

6.3.1 Construction phase

The installation of Project infrastructure within the offshore wind farm area and offshore cable corridor may lead to injury and/or disturbance to marine mammals from vessel activities. The project design includes for a maximum 475 vessel round trips during the offshore construction phase (15 months), with vessel types including jack-up barges, tug/anchor handlers, cable installation vessels, scour/cable protection installation vessels, guard vessels, survey vessels, and crew transfer vessels (CTVs). Source sound data for vessels likely to utilised are set out in Table 6-13.

The main drivers influencing the magnitude of the impact are vessel type, speed and ambient noise levels (Wilson *et al.,* 2007). Baseline levels of vessel traffic in the Marine Mammal and Megafauna Study Area are likely to be relatively high. A total of 28 vessels were recorded within a 5 nm buffer of the offshore wind farm area and offshore cable corridor over the month of January 2019 (one to three vessels per day), with 78 vessels recorded over the month of July 2019 (one to six vessels per day), based on AIS data, and comprising of cargo vessels, fishing vessels, service vessels, tankers, recreational vessels and other vessels (see section 2: Project description, of the NIS for information on vessel numbers). A vessel traffic validation exercise undertaken in 2022 found no significant differences in vessel traffic volumes or patterns between 2019 and 2022. Vessel traffic was recorded transiting to/from Clogherhead, Dundalk Harbour and Carlingford Lough. It is highly likely that a proportion of the Project vessels will be stationary or slow moving throughout construction activities for significant periods of time.

Other construction activities with the potential to generate underwater noise, and therefore injury and/or disturbance to qualifying marine mammal features, include pile drilling, cable trenching and cable laying. Pile drilling may be required at each pile location following pile driving. As outlined in Table 4-1, the project design parameters assume up to six days drilling per pile for monopiles, which equates to up to 156 days of drilling over the entire construction phase. The potential impact ranges for drilled piling are expected to be small (or not exceeded) for all marine mammals, due to the low broadband SEL levels expected from these operations, at 160 dB re 1 µPa^{2}s. As outlined in Table 1-25 in appendix C: Subsea Noise Technical Report, the impact ranges for both cable trenching and cable laying are considered to be smaller than that of the vessels which will be used to carry out these activities, therefore the impact ranges for vessels have been assessed as a proxy. Noise impacts as a result of cable trenching and laying are therefore not considered further in this assessment.

Table 6-13: Vessels involved in the construction, operational and maintenance and decommissioning phases of the Project.

Vessel type	Descriptions / assumptions	Data Source	Sound source pressure level at 1 m		
			RMS, dB re 1 µPa	Peak, dB re 1 µPa	SEL(24h), dB re 1 µPa^{2}s
Sand wave clearance	'Gerardus Mercator' trailer hopper suction dredger using DP as proxy	Wyatt (2008)	180	183	229
Boulder clearance	Back-hoe dredger used as proxy	Nedwell *et al.* (2008)	163	166	212
Main Installation Vessels (Jack-up Barge/DP vessel)	'Gerardus Mercator' trailer hopper suction dredger using DP as proxy	Wyatt (2008)	180	183	229
Jack up rig	Jack up rig	Evans (1996)	163	166	212

Vessel type	Descriptions / assumptions	Data Source	Sound source pressure level at 1 m		
			RMS, dB re 1 µPa	Peak, dB re 1 µPa	SEL(24h), dB re 1 µPa^{2}s
Tug/Anchor Handlers	Tug used as proxy	Richardson (1995)	172	175	221
Cable Installation Vessels	'Gerardus Mercator' trailer hopper suction dredger using DP as proxy	Wyatt (2008)	180	183	229
Rock Placement Vessels	'Gerardus Mercator' trailer hopper suction dredger using DP as proxy	Wyatt (2008)	180	183	229
Guard Vessels	Tug used as proxy	Richardson (1995)	172	175	221
Survey Vessels	Offshore support vessel used as proxy	McCauley (1998)	179	182	228
Crew Transfer Vessels	Offshore support vessel used as proxy	McCauley (1998)	179	182	228
Scour / Cable Protection / Seabed Preparation / Installation Vessels	Offshore support vessel used as proxy	McCauley (1998)	179	182	228

A detailed underwater noise modelling assessment has been carried out to investigate the potential for injurious and behavioural effects on qualifying marine mammal features (appendix C: Subsea Noise Technical Report) as a result of increased vessel noise (non-impulsive sound), and pile drilling, using the latest criteria, and is used to inform the assessment presented below.

6.3.1.1 Injury

Injury to all marine mammal species could manifest in the form of injury through collision with vessels or auditory injury (PTS and/or TTS) as a result of increased noise from vessels or pile drilling.

6.3.1.1.1 Auditory injury

To assess potential auditory injury from vessel noise and pile drilling on marine mammal qualifying features, noise modelling was carried out using the dual criteria approach of SPL_{pk} and SEL_{cum} metrics in order to estimate the ranges over which PTS and TTS could occur. Source noise levels were based on worst-case assumptions (see Table 1-22 in appendix C: Subsea Noise Technical Report).

Table 6-14 sets out the predicted ranges for PTS and TTS for marine mammals based on the SEL_{cum} metric (maximum predicted ranges). The exposure metrics for different marine mammal flee speeds were employed, as applied in the assessment of Injury and/or disturbance from underwater noise during pile-driving.

The noise modelling assessment showed that, for all marine mammal groups, and based on the more precautionary ranges modelled (i.e. SEL_{cum}), the threshold for PTS was not exceeded for pile drilling. The threshold for PTS for vessel movements was only exceeded for harbour porpoise, where PTS could occur out to a maximum of < 15 m for five types of vessel (see Table 6-14). In respect of TTS the greatest effect ranges were predicted for harbour porpoise from noise associated with vessels such as survey vessels, CTV and seabed preparation vessels (1,670 m). The thresholds for PTS and TTS for both grey seal and harbour seal are not predicted to be exceeded. Fish may be affected by TTS as a result of pile drilling out to a maximum of 15 m.

Table 6-14: Estimated PTS and TTS ranges for marine mammals during construction (based on SEL_{cum} metric). N/E = thresholds not exceeded.

Source/Vessel	Range (m)					
	High frequency cetacean (bottlenose dolphin)		Very high frequency cetacean (harbour porpoise)		Phocid pinniped (grey seal and harbour seal)	
	PTS	TTS	PTS	TTS	PTS	TTS
Sand wave clearance	N/E	N/E	<15	566	N/E	N/E
Boulder clearance	N/E	N/E	N/E	< 15	N/E	N/E
Installation vessel, construction vessel (DP)	N/E	N/E	<15	566	N/E	N/E
Jack up rig	N/E	N/E	N/E	N/E	N/E	N/E
Tug/anchor handlers	N/E	N/E	N/E	282	N/E	N/E
Rock placement vessel and cable installation vessels	N/E	N/E	<15	566	N/E	N/E
Guard vessels	N/E	N/E	N/E	282	N/E	N/E
Survey vessel and support vessels	N/E	N/E	<15	1,670	N/E	N/E
Crew transfer vessel	N/E	N/E	<15	1,670	N/E	N/E
Scour / Cable Protection / Seabed Preparation / Installation Vessels	N/E	N/E	<15	1,670	N/E	N/E
Pile drilling	N/E	N/E	N/E	40	N/E	N/E

The number of animals potentially affected by PTS or TTS as a result of vessel noise and pile drilling have been calculated based on the most up to date species-specific density estimates (Table 3-2). Where ranges for density estimates have been applied (harbour porpoise, bottlenose dolphin, grey seal and harbour seal), numbers of animals affected have been based on the upper density value as a precautionary approach. There is the potential for up to 12 harbour porpoise to experience TTS at any one time as a result of vessel noise, which equates to < 0.01% of the MU. No other marine mammal species is predicted to experience TTS. In addition, since TTS is a recoverable injury the impact of elevated noise from vessels leading to injury is predicted to be reversible. Whist the numbers of animals likely to be affected at any one time are extremely low, the offshore construction phase is expected to last for 15 months.

As such the magnitude for auditory injury (PTS and TTS) to all marine mammals as a result of vessels involved in the construction phase and pile drilling is deemed to be of local spatial extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the species directly. The magnitude is therefore, considered to be low.

6.3.1.2 Collision

There are different potential outcomes of vessel collision; both fatal and non-fatal injuries have been documented (Laist *et al.,* 2001; Vanderlaan and Taggart, 2007; Cates *et al.,* 2017). Fatal collisions can be seen via carcasses washing up on beaches (Laist *et al.,* 2001; Peltier *et al.,* 2019); carcasses caught on vessel bows (Laist *et al.,* 2001; Peltier *et al.,* 2019); and floating carcasses which have strong evidence of ship strike, such as propeller cuts, significant bruising, oedema, internal bleeding radiating from a specific impact site, fractures and ship paint marks (Jensen and Silber, 2003; Douglas *et al*., 2008). Fatalities from ship strikes, however, often go unreported (Authier *et al.,* 2014). For non-fatal injuries, there is evidence of animals which have survived ship strikes with no discernible injury: animals which survive with non-fatal injuries from propellers have been widely documented (Wells *et al.,* 2008; Luksenburg, 2014).

Guidance provided by NOAA has defined serious injury to marine mammals as '*any injury that will likely result in mortality*' (NMFS, 2005). NMFS clarified its definition of 'serious injury' (SI) in 2012 and stated their interpretation of the regulatory definition of serious injury as any injury that is 'more likely than not' to result in mortality, or any injury that presents a greater than 50% chance of death to the marine mammal (NMFS 2012) (Helker *et al.,* 2017). Non-serious injury is likely to result in short-term impacts and may also have long-term effects on health and lifespan.

Vessel traffic associated with the Project has the potential to lead to an increase in vessel movements within the Marine Mammal and Megafauna Study Area. This increase in vessel movement could lead to an increase in interactions between marine mammals and vessels during offshore construction. Vessels travelling at 7 m/s- or faster are those most likely to cause death or serious injury (as per the NMFS definition) to marine mammals (Laist *et al*., 2001; Wilson *et al*., 2007). With the exception of CTVs, vessels involved in the construction phase are likely to be travelling considerably slower than this, and all vessels will be required to follow a Vessel Code of Conduct (see appendix K: Management Plans) to minimise interaction with marine mammals (Table 4-2). In addition, the noise emissions from vessels involved in the construction phase are likely to deter animals from the potential zone of impact.

As such the magnitude for collision risk as a result of vessels involved in the construction phase for all marine mammal species is deemed to be of local spatial extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the species directly. The magnitude is therefore, considered to be negligible.

6.3.1.3 Disturbance

Increased vessel noise, resulting in avoidance behaviour, displacement or masking of vocalisations is likely to occur only where increased noise from vessel movements associated with the construction phase are greater than the background ambient noise level. As stated above, there are existing levels of vessel traffic within the Marine Mammal and Megafauna Study Area, and therefore ambient noise levels are expected to be relatively high. Disturbance may also arise as a result of pile drilling following piling activity. Disturbance ranges for vessels and for pile drilling, along with predicted number of animals to be disturbed are set out in Table 6-15.

The conservative assumption has been made that all marine mammal species will react to increases in vessel movement to the same extent. In reality, the distance over which effects will occur will vary according to the species and the ambient noise levels; hearing ability, vertical space use and behavioural response differences between species are likely to affect the distance over which effects occur.

Noise modelling was carried out to estimate maximum ranges for the onset of disturbance in marine mammals (see appendix C: Subsea Noise Technical Report), based on exceeding the 120 dB re 1 µPa (rms) threshold applicable for all marine mammals, noting that this threshold is for 'mild disturbance' and therefore is not likely to result in displacement of animals. Survey and support vessels; CTVs; and scour/cable protection, seabed preparation, and installation vessels result in the greatest modelled disturbance out to 8.5 km (~ 227 km^2) for all marine mammal species (Table 6-15). At the lower end of the scale, boulder clearance vessels were predicted to result in disturbance ranges out to 755 m (Table 6-15). Pile drilling activities were predicted to result in disturbance out to 1,083 m (Table 6-15).

The number of marine mammals with the potential to be disturbed by vessels and pile drilling are presented in Table 6-15, based on the most up to date species-specific density estimates (Table 3-2), noting that there is likely to be a proportionate disturbance response of animals within the modelled contours (i.e. not all animals will be disturbed to the same extent) (Graham *et al.,* 2017). As stated previously, the life history of an individual and the context will also influence the likelihood of an individual to exhibit an aversive response to noise.

Harbour porpoise is likely to be the most sensitive species to disturbance from vessel traffic with potentially larger numbers (up to 302 animals) affected compared other species. However, even over the largest disturbance ranges only a small proportion (up to 0.48%) of the harbour porpoise population would be affected at any one time. The proportions of the populations of marine mammals affected by mild disturbance from vessel activity varied between species and was a reflection of the size of the MU population against which the affected numbers were compared. For example up to 54 bottlenose dolphin potentially disturbed represents up to 0.64% of the SCANS-III abundance estimate for the Irish Sea (the IS MU), and up to 11 bottlenose dolphin potentially disturbed represents up to 3.56% of the SCANS-IV abundance estimate for the Irish Sea. Similarly for harbour seal, 64 animals disturbed represents 3.88% of the relevant MU population, and for grey seal 85 animals disturbed represents 1.43% of the relevant MU population.

The impact of disturbance from vessel traffic is predicted to be of local spatial extent, medium term duration, intermittent, and high reversibility. It is predicted that the impact will affect the marine mammal species directly. The magnitude of the impact could lead to measurable changes to behaviour in individuals but is unlikely to directly result in displacement, and therefore in the context of the relevant geographic frames of reference, would not be at a scale that would lead to any measurable population-level effects. The magnitude is therefore, considered to be low.

Table 6-15: Number of animals with the potential to be disturbed by construction vessels and pile drilling within estimated disturbance ranges for marine mammals (continuous sources).

Source	Range (km)	Area (km^2)	Estimated number of marine mammals with the potential to be disturbed							
			Harbour porpoise		Bottlenose dolphin		Grey seal		Harbour seal	
			Number of animals	Proportion of MU population (%)	Number of animals	Proportion of MU population (%)	Number animals	Proportion of MU population (%)	Number animals	Proportion of MU population (%)
Sand wave clearance; Installation vessel, construction vessel (DP); rock placement vessel and cable installation vessels	3.60	40.69	12 - 55	0.018 – 0.086	2 - 10	0.63 – 0.11	15	0.257	12	0.696
Boulder clearance	0.76	1.79	< 1 - 3	0.001 – 0.003	< 1	0.03 – 0.005	< 1	0.011	< 1	0.031
Jack up rig	< 0.02	< 0.001	N/A (threshold not exceeded)							
Tug/anchor handlers; guard vessels	3.40	36.30	11 - 49	0.016 – 0.077	2 - 9	0.57 – 0.10	14	0.229	11	0.621
Survey vessels and support vessels; CTVs; scour / cable protection / seabed preparation	8.50	226.86	64 - 302	0.102 – 0.483	11 - 54	3.56 – 0.64	85	1.434	64	3.885
Pile drilling	1.083	3.68	2 - 5	0.002 – 0.008	< 1	0.06 – 0.01	2	0.023	2	0.063

Where a density range has been presented and the upper and lower density estimates both result in < 1 animal within the zone of injury, only one value (based on the upper density estimate) has been presented for the equivalent proportion of the MU population (%)

6.3.1.3.1 Sensitivity of the qualifying features

6.3.1.3.1.1 Injury (auditory injury and collision risk)

The sensitivity of marine mammal receptors to auditory injury from subsea noise has been assessed as part of the previous impact and is not reiterated here. Both PTS and TTS ranges as a result of vessels and pile drilling involved in the construction phase (non-impulsive sound) (Table 6-14) are far lower than that for piling (impulsive sound) (Table 6-5 and Table 6-6). The sensitivity of all marine mammals to PTS has therefore been assessed as high, and to TTS has been assessed as medium.

There can be consequences to a lack of response to disturbance for all marine mammal qualifying features; behavioural habituation can result in decreased wariness of vessel traffic, which has the potential to result in an increased collision risk (Cates *et al*., 2017). Vessel strikes are known to be a cause of mortality in marine mammals (Carrillo and Ritter, 2010), but it is possible that mortality from vessel strikes is under-recorded (Van Waerebeek *et al*., 2007). Laist *et al*. (2001) reported that collisions between vessels and large whales tended to lead to death, but non-lethal collision has also been reported by Van Waerbeek *et al*. (2007). Therefore, collisions between vessels and cetaceans are not necessarily lethal on all occasions. Collision risk for seals is less understood than for cetaceans, however trauma ascribed to collisions with vessels has been identified in a small proportion of both live stranded (Goldstein *et al*., 1999) and dead stranded seals in the USA (Swails, 2005). In these studies, however, less than 2% of all necropsied seal deaths were identified as resulting from vessel collisions. A study by Onoufriou *et al*. (2016) in the Moray Firth, Scotland showed that seals do not necessarily occupy the same areas as vessels during trips between haul-outs and foraging sites but that seals tended to remain beyond 20 m from vessels (only three instances over 2,241 days of seal activity resulted in passes at less than 20 m).

With the exception of CTVs, vessels involved in the construction phase are likely to be travelling considerably slower than 7 m/s and all vessels will be following the Code of Conduct set out in the MMMP (see appendix K: Management Plans) in order to reduce the risk of collision. It is considered that there is a high likelihood of avoidance from both increased vessel noise and collision risk, with a high potential for recovery (assuming no strikes occur).

Although the risk of injury from construction traffic is relatively low, the consequences of collision risk could be fatal. All marine mammal qualifying features would have limited tolerance to a collision risk, and the effect of the impact could cause a change in both reproduction and survival of individuals, and receptors would have limited ability for the animal to recover from the effect. All marine mammals are assessed as having limited resilience, limited ability to adapt behaviour to sustain ecological functioning, and low recoverability. As such the sensitivity of all marine mammals to collision has been assessed as high.

6.3.1.3.1.2 Disturbance

Disturbance levels for marine mammal species will be dependent on individual hearing ranges and background noise levels within the vicinity. Sensitivity to vessel noise is most likely related to the marine mammal activity at the time of disturbance (IWC, 2006, Senior *et al.,* 2008). For example, resting dolphins are likely to avoid vessels, foraging dolphins will ignore them, and socialising dolphins may approach vessels (Richardson *et al*., 1995).

Marine mammals can both be attracted to, and disturbed by, vessels. Harbour porpoise are particularly sensitive to high frequency noise and are more likely to avoid vessels; Heinanen and Skov (2015) identified that the occurrence of harbour porpoise declines significantly when the number of vessels in a 5 km^2 area exceeds 80 in one day. Other species such as bottlenose dolphin is regularly sighted near vessels and may also approach vessels (e.g. bow-riding). However, dolphins are also known to show aversive behaviours to vessel presence, including increased swimming speed, avoidance, increased group cohesion and longer dive duration (Miller *et al*., 2008). Reactions of marine mammals to vessel noise are often linked to changes in the engine and propeller speed (Richardson *et al*., 1995); Watkins (1986) reported avoidance behaviour in baleen whales from loud or rapidly changing noise sources, particularly where a boat approached an animal. Disturbance is likely to be greater in dolphins and porpoises with presence of smaller fast-moving vessels as they are more sensitive to high frequency noise. Pirotta *et al*. (2015) found that transit of vessels in the Moray Firth resulted in a reduction (by almost half) of the likelihood of recording bottlenose dolphin prey capture buzzes. They also suggest that vessel presence, not just vessel noise, resulted in disturbance. There is, however, evidence of habituation to boat traffic and therefore a slight increase from the existing levels of traffic in the vicinity of the Project may not result in high levels of disturbance. For example, Lusseau *et al*. (2011) (Scottish Natural Heritage (SNH) commissioned report) undertook a modelling study which predicted that increased vessel movements associated with offshore wind development in the Moray Firth did not have a negative effect on the local population of bottlenose dolphin, although it did note that foraging may be disrupted by disturbance from vessels.

Harbour porpoise are distributed widely throughout the Irish Sea and therefore it can be assumed (since they have a requirement to feed regularly) that there is suitable foraging habitat across their range. Therefore, localised disturbance within the Marine Mammal and Megafauna Study Area is unlikely to lead to any population-level effects on this species. Bottlenose dolphin likely to be foraging in the offshore wind farm area form part of the IS MU, which is relatively small, however, the core distribution for this species is in the eastern Irish Sea (Cardigan Bay) and around the west coast of Ireland.

Seals are particularly sensitive to disturbances in regions where vessel traffic overlaps with productive coastal waters (Robards *et al*., 2016). Richardson (2012) reported avoidance behaviour or alert reactions in harbour seal when vessels approach within 100 m of a haul-out (Richardson, 2012). When disturbed, seals that are hauled-out typically flush into the water which could be detrimental during pupping season (e.g. Terhune and Almon, 1983; Johnson and Acevedo-Gutiérrez, 2007). The presence of vessels in foraging grounds could result in reduced foraging success, particularly in harbour seal given reduced foraging ranges (~50 km from haul-outs) when compared to grey seal (~150 km from haul-outs) (SCOS, 2017). However, seals can be curious and have been recorded approaching tour boats that regularly visit an area and may habituate to sounds from tour vessels (Bonner, 1982). The closest haul-out to the offshore wind farm area for both grey seal and harbour seal is 4.5 km to the north at Carlingford Lough, and 10 km to the south at Clogherhead. Vessels could transit to and from the offshore wind farm area from an offshore operations and maintenance (O&M) base located at an existing harbour in County Louth or County Down. Three harbours (Kilkeel, Warrenpoint and Greenore) have suitable facilities and are approximately 1 hour sailing time from the offshore wind farm area. Given the proximity of these haul-outs to existing vessel routes (see section 2: Project description, of the NIS for information on vessel numbers), disturbance at haul-out sites is unlikely to be increased by the construction phase of the Project.

Given the existing levels of traffic in the Marine Mammal and Megafauna Study Area, the additional vessels associated with the Project are unlikely to increase the risk of disturbance to any marine mammal species. It is expected that marine mammals could tolerate the effects of disturbance without any impact on reproduction and survival rates and would return to previous activities once the impact had ceased. All marine mammals are assessed as having high resilience to the effect with minor impairment of ecological functioning, have an ability to adapt behaviour such that ecological function can be maintained, and high recoverability. The sensitivity of all marine mammal species to disturbance has therefore been assessed as low.

6.3.2 Operational and maintenance phase

Operational and maintenance activities may lead to injury and/or disturbance to marine mammal species from vessel activities. The design includes for a maximum of 352 vessel round trips per year over the Project lifetime (see Table 6-13). An overview of the potential for auditory injury and/or disturbance and injury from collisions with vessels to marine mammal species as a result of Project vessels is given above for the construction phase and is not reiterated here.

Vessel types which will be required during the operational and maintenance phase include jack-up vessels, CTVs and survey vessels (Table 6-13) and therefore the size and noise outputs from these vessels will result in a similar maximum adverse spatial parameters as the construction phase.

The impact is predicted to be of local spatial extent, long term duration, intermittent and high reversibility. It is predicted that the impact will affect the marine mammal species directly. The likelihood of a vessel strike occurring is considered to be very low due to avoidance behaviour, particularly where vessels follow defined routes. The magnitude is therefore, considered to be low (for both auditory injury and disturbance from vessel noise) and negligible (collision risk), for all marine mammal qualifying features.

6.3.2.1.1 Sensitivity of the qualifying features

The sensitivity of marine mammals during the operational and maintenance phase is not expected to differ from the sensitivity during the construction phase. Therefore, for all marine mammal species, the sensitivity to PTS is deemed to be high, the sensitivity to TTS is deemed to be medium, and the sensitivity to injury from vessel collisions is deemed to be high.

6.3.3 Decommissioning

The effects of decommissioning activities are expected to be the same or similar to the effects from construction.

6.4 Changes in the fish and shellfish community affecting marine mammal prey resources

Potential effects on the fish assemblages during the construction, operational and maintenance and decommissioning phases of the Project, as identified in appendix E: Fish and Shellfish Ecology – Supporting Information, may have indirect effects on marine mammal species.

The key prey species for marine mammals include a number of clupeids (e.g. herring), gadoids (e.g. cod, whiting), salmon, flatfish and sandeels. The Fish and Shellfish Ecology assessment (see appendix E: Fish and Shellfish Ecology – Supporting Information) identified whitefish (including haddock and cod) and shellfish (including crab, lobster) as important commercial fisheries in the Fish and Shellfish Ecology Study Area. The area was also identified as an important spawning and nursery ground for a number of whitefish species and a recovery ground for cod. High abundances of cod and plaice eggs recorded from the northwest Irish Sea and in particular due east of Dundalk Bay were identified (Roden and Ludgate, 2003). The area is also known as a spawning ground for whiting and herring. Other prey species for marine mammals found in the Fish and Shellfish Ecology Study Area include Atlantic salmon, pollack, mackerel, haddock and European eel.

6.4.1 Construction phase

Potential construction phase impacts on fish and shellfish species include temporary subtidal habitat loss/disturbance, injury and/or disturbance to fish from underwater noise during pile driving, and increased suspended sediment concentrations and associated sediment deposition (appendix E: Fish and Shellfish Ecology – Supporting Information).

Temporary habitat loss could potentially affect spawning, nursery or feeding grounds of fish and shellfish species, with demersal fish and shellfish, and demersal spawning species the most vulnerable. The maximum design parameter assessed in appendix E: Fish and Shellfish Ecology – Supporting Information includes for 709,500 m^2 of temporary habitat loss/disturbance during the construction phase, which equates to 1.3% of the offshore wind farm area and offshore cable corridor, therefore representing a very small proportion of the Project site. Due to the localised nature of the effects and the small proportion of the Fish and Shellfish Ecology Study Area affected, temporary loss of habitat was considered unlikely to diminish ecosystem functions for fish and shellfish species.

Injury and/or disturbance to fish from underwater noise during pile driving could adversely affect fish and shellfish species as a result of mortality, impairment or behavioural effects. The project design parameters assessed in appendix E: Fish and Shellfish Ecology – Supporting Information are the same as assessed here (installation of monopiles via impact/percussive piling with an average maximum hammer energy of 2,500 kJ and absolute maximum hammer energy of 3,500 kJ). Subsea noise modelling showed that mortality or recoverable injury ranges could extend out to a maximum distance of 217 m from the source, as a result of installation of monopiles (SPL_{pk} metric) and TTS could occur out to a maximum distance of 1,750 m as a result of installation of monopiles (SPL_{cum} metric). The potential risk of onset of behavioural effects in fish from installation of piles was based on qualitative criteria set out by Popper *et al.* (2014) and categorises risk of effects in relative terms as “high”, “moderate” or “low” at three distances from the source: “near” (i.e. tens of metres), “intermediate” (i.e. hundreds of metres) or “far” (i.e. thousands of metres). The fish and shellfish assessment reported that proposed piling activities will unlikely result in mortality, but some recoverable injury is possible within 1 km of the piling works (in the most precautionary scenario), particularly for salmonids, scombridae, gadoids and eels, herring, sprat and shads. Behavioural responses were reported to be more likely for gadoids and eels, herring, sprat and shads within hundreds to thousands of metres from the piling source.

An increase in suspended sediment concentrations (SSC) may lead to short term avoidance of affected areas by sensitive fish and shellfish species, although many species are considered to be tolerant of turbid environments and regularly experience changes in the SSC due to the natural variability in the Irish Sea. The project design parameters assessed in appendix E: Fish and Shellfish Ecology – Supporting Information assumed all wind turbine and offshore substation foundations will be installed by drilling 9.6 m diameter piles and installation of inter-array cables through ploughing/jetting. Fish and shellfish species that are likely to be affected by sediment deposition are those that feed or spawn on or near the seabed. Adult fish species are less susceptible to physiological effects from increases in SSC than juveniles. Modelling of SSC associated with the foundation installation showed low levels of suspended sediments with peaks of 100 mg/l extending beyond the offshore wind farm area. The average suspended sediment concentration beyond the immediate vicinity of the offshore wind farm area are generally less than 30 mg/l with most of the sediment plume envelope having a suspended sediment concentration of less than 10 mg/l. Sediment deposition is predicted to be indiscernible from the background due to the limited quantity of material released, with the exception of directly at the drill site where cuttings fall to the seabed.

Therefore, the impact for all marine mammal qualifying features is predicted to be of local spatial extent, short-term duration intermittent and high reversibility. It is predicted that the impact will affect the species indirectly. The magnitude is therefore, considered to be low.

6.4.1.1 Sensitivity of the qualifying features

Marine mammals exploit a suite of different prey items and can travel great distances to forage. It is likely that the effects described for fish and shellfish (appendix E: Fish and Shellfish Ecology – Supporting Information) will occur over a similar, or lesser, extent and duration as those for marine mammals. For example, avoidance behaviour of fish during the construction phase will lead to displacement over potentially smaller ranges than those given for most marine mammals. In addition, as prey moves out of the areas of potential impact, so marine mammals are likely to follow in order to exploit these resources.

The fish and shellfish communities found within the Fish and Shellfish Ecology Study Area were characteristic of the fish and shellfish assemblages in the wider western Irish Sea (see appendix E: Fish and Shellfish Ecology – Supporting Information). Therefore, whilst the offshore wind farm area is located within and close to spawning and nursery grounds (e.g. herring spawning ground) and could potentially be adversely affected by impacts such as temporary habitat loss, underwater noise, and increased SSC, due to the highly mobile nature of marine mammals it is likely that these animals will be able to exploit similar resources elsewhere. Although there could be an energetic cost, particularly to harbour porpoise, grey seal and harbour seal if animals have to travel further to alternative foraging grounds, the impacts are expected to be short-term in nature. It is expected that all marine mammal species would be able to tolerate the effect without any impact on reproduction and survival rates and would be able to return to previous activities once the impact had ceased. All marine mammals are assessed as high resilience to the effect with minor impairment of ecological functioning, have an ability to adapt behaviour such that ecological function can be maintained, and high recoverability. Therefore, the sensitivity of all marine mammal species is considered to be low.

6.4.2 Operational and maintenance phase

Potential operational and maintenance phase impacts on fish and shellfish species include temporary subtidal habitat loss/disturbance, increased suspended sediment concentrations and associated sediment deposition, long-term subtidal habitat loss and EMF from subsea electrical cabling (see appendix E: Fish and Shellfish Ecology – Supporting Information).

Temporary subtidal habitat loss/disturbance could occur as a result of component replacement activities and cable repair/reburial activities. The project design parameter assessed in appendix E: Fish and Shellfish Ecology – Supporting Information is for 387,000 m^2 of temporary habitat loss/disturbance during the operational and maintenance phase, equating to 0.06% of the offshore wind farm area and offshore cable corridor combined, with only a small proportion of the total habitat loss/disturbance likely to be occurring at any one time over the 40-year operational phase of the Project.

Increased SSC could occur as a result of repair or reburial of the inter-array and offshore cables. The project design parameter assessed in appendix E: Fish and Shellfish Ecology – Supporting Information assumed seven inter-array cable repair, seven reburial events and three offshore cable repair and three reburial events over the Project lifetime, using similar methods as those for cable installation activities (i.e. trenching/jetting). The Fish and Shellfish Ecology impact assessment considered that any suspended sediments and associated deposition will be similar to that assessed for the construction phase.

Long-term subtidal habitat loss (for the duration of the 40-year operational and maintenance phase) will occur under all foundation structures, associated scour protection and any required cable protection, and may result in impacts on fish and shellfish species. The project design parameters assessed in appendix E: Fish and Shellfish Ecology – Supporting Information assumed up to 332,060 m^2 of long-term habitat loss, equating to 0.4% of the offshore wind farm area and offshore cable corridor combined. Fish and shellfish species that are reliant upon the presence of suitable sediment/habitat for their survival are considered to be more vulnerable to change. The fish species most vulnerable to habitat loss include sandeel which are demersal spawning species (i.e. eggs are laid on the seabed), as these have specific habitat requirements for spawning (i.e. sandy sediments). However, the proportion of habitat affected within the offshore wind farm area and offshore cable corridor is small and this area is smaller still in the context of the known sandeel habitats and the potential sandeel habitats in the wider Western Irish Sea Fish and Shellfish Ecology Study Area.

Therefore, for temporary habitat loss and increased SSC the impact for all marine mammals is predicted to be of local spatial extent, short term duration, intermittent and high reversibility. For long-term habitat loss, the impact for all marine mammal species is predicted to be of local spatial extent, long term duration, continuous and low reversibility. It is predicted that the impact will affect the species indirectly. The magnitude is therefore considered to be low for both short-term and long-term impacts.

6.4.2.1 Sensitivity of the marine mammal species

The sensitivity of the marine mammal species during the operational and maintenance phase are not expected to significantly differ from the construction phase despite the potential for long-term loss of fish and shellfish habitat. This is due to the very small scale and localised nature of the impact. It is expected that all marine mammal receptors would be able to tolerate the effect without any impact on reproduction and survival rates, and therefore the sensitivity of all marine mammal species is considered to be low.

6.4.3 Decommissioning phase

The effects of decommissioning activities are expected to be the same or similar to the effects from construction.

7 IN-COMBINATION EFFECTS

7.1 Methodology

The in-combination assessment takes into account the impact associated with the Project together with other projects within the ZoI of the Project. The projects selected as relevant to the in-combination assessment presented within this report are based upon the results of a screening exercise (see appendix J: Screening – In-combination Effects). Each project has been considered on a case-by-case basis for screening in or out of this appendix assessment based upon data confidence, effect-receptor pathways and the spatial/temporal scales involved.

The approach to assessment examines the potential for effects associated with the Project alongside the following projects if they fall within the ZoI for relevant European sites:

- Other projects with consent but not yet constructed/construction not completed;
- Other projects in a consent application process but not yet determined (including planning applications, foreshore lease/licence applications, Dumping at Sea Permit applications);
- Other projects currently operational that were not operational when baseline data were collected, and/or those that are operational but have an ongoing impact; and
- Projects, which satisfy the definition of 'relevant maritime usage' under the Maritime Area Planning Act (2021) (i.e. wind farm projects designated as 'Relevant Projects' or 'Phase 1 Projects') including Arklow Bank II, Dublin Array (Bray and Kish banks); North Irish Sea Array, Codling Wind Park (I and II).

The specific projects screened into this in-combination assessment are outlined in Table 7-1 and Figure 7.1.

Collaboration with the other Phase 1 projects has informed the in-combination assessment. This included discussions amongst the project teams on the approach and methodologies regarding alignment of sensitivities and magnitudes where possible. Also the projects commit to implementing phased piling alongside other adjacent offshore wind farms in the western Irish Sea as part of a Piling Strategy should construction programmes overlap.

Cumulative population modelling for the Phase 1 projects in the Irish Sea has been completed and no significant impacts to any marine mammals from disturbance from piling at the five projects is predicted. This information will also be used to inform the piling strategy.

Table 7-1: List of other projects considered within the in-combination assessment.

Project	Status	Distance from offshore wind farm area (km)	Distance from offshore cable corridor (km)	Description of Project	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Project
Offshore Wind Farms							
North Irish Sea Array (NISA)	Maritime Area Consent	16.2	18.1	EIA Scoping report (2021) refers to the construction of an offshore wind farm of up to 500 MW, consisting of 36 turbines with a maximum height of 320 m and rotor diameter of up to 290 m. Offshore substation platforms may be required.[2]	Unknown	Unknown (Design life minimum 35 years)	Potential for overlap with construction and operational and maintenance phases of the Project and therefore potential for physical or temporal overlap.
Dublin Array	Maritime Area Consent	61.2	57	EIA Scoping report (2020) refers to the construction of Bray and Kish offshore wind farm of up to 900 MW, consisting of up to 61 turbines with a maximum. height of 308 m and rotor diameter of up to 285 m and up to three offshore substation platforms.[3]	Unknown	Unknown (Design life minimum 35 years)	Potential for construction and operation phases to overlap with the Project. Potential for in-combination effect associated with underwater noise emissions (i.e. greater area of regional habitat affected).
Codling Wind Park	Maritime Area Consent	61.4	57.2	EIA Scoping report (2020) refers to the construction of up to 140 turbines with a maximum height of 320 m and rotor diameter of up to 288 m (up to 1,500 MW). The project will also contain up to five offshore substation platforms.[4]	Unknown	Unknown (Design life minimum 35 years)	Potential for overlap with construction and operational and maintenance phases of the Project and therefore potential for physical or conceptual overlap.
Arklow Bank Wind Park	Maritime Area Consent	107.1	104.7	EIA Scoping Report (2023): The project will include between 37 and 56 turbines and up to two Offshore Substations (OSS)	Unknown	Unknown (Design life minimum 35 years)	Potential for construction and operation phases to overlap with the Project. Potential for in-combination effect associated

[2] Project website https://northirishseaarray.ie/: states that wind farm will consist of 35 to 46 turbines.

[3] Project website: https://dublinarray.com/project-information/key-facts/: states between 39 and 50 turbines (total project capacity 824 MW) individual tip heights between approximately 270 m and 310 m.

[4] Project website: https://codlingwindpark.ie/the-project/: states max energy output 1300 MW, 100 turbines, turbine tip height max 320 m.

Project	Status	Distance from offshore wind farm area (km)	Distance from offshore cable corridor (km)	Description of Project	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Project
				and foundation substructures. The area in which the proposed wind turbines, inter-array cables and OSS will be located on Arklow Bank covers an area of seabed approximately 64 km^2.[5]			with underwater noise emissions (i.e. greater area of regional habitat affected).
Morgan Offshore Wind Project: Generation Assets	Planning	119	119	Offshore Wind Farm (1.5 GW capacity) in English waters. Scoping report indicates up to 107 turbines and up to eight offshore substations. Application not yet submitted.	Unknown	Unknown	Potential for overlap with construction and operational phases of the Project and therefore potential for physical or conceptual overlap.
Mona Offshore Wind Project	Planning	127	131	Offshore Wind Farm (1.5 GW capacity) in Welsh and English waters. Scoping report indicates up to 107 turbines and up to eight offshore substations. Application not yet submitted.	Unknown	Unknown	Potential for overlap with construction and operational and maintenance phases of the Project and therefore potential for physical or conceptual overlap.
Awel y Môr Offshore Wind Farm	Application	142	145	Offshore Wind Farm (500 MW capacity) in Welsh waters. Application submitted but not awarded.	01/01/2026 - 31/12/2029	01/01/2030 – 31/12/2055	Potential for overlap with construction and operational activities of the Project to overlap with construction and operational activities of Awel y Môr Offshore Wind Farm.
Morecambe Offshore Windfarm: Generation Assets	Pre-application	155	155	Offshore Wind Farm (Maximum 960 MW capacity) in English waters. Scoping report indicates up to 40 turbines and up to two offshore substations. Application not yet submitted.	Unknown	Unknown	Potential for overlap with construction and operation phases of the Project and therefore potential for physical or conceptual overlap.
Site investigations							
Mainstream Renewable Power Ltd.	Planning	15	18.1	Foreshore Licence application for site investigation works off County Dublin. Surveys include Geophysical, Geotechnical,	N/A	Unknown (subject to award of licence).	Potential for construction phase of the Project to overlap with surveys and site investigation activities for other projects.

[5] Project website https://www.sserenewables.com/: states between 36 and 60 turbines (up to 800 MW) along with one to two OSS and foundation substructures, a network of inter-array cabling and two offshore export cables.

Project	Status	Distance from offshore wind farm area (km)	Distance from offshore cable corridor (km)	Description of Project	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Project
				Metocean and Ecological site investigations.			Potential for in-combination effect of subsea noise emissions (i.e. greater area of regional habitat affected). Other site investigation surveys screened out due to large distances from Project (i.e. all other site investigation surveys are 45 km or greater from Project) and since effects are likely to be very localised and short term there is considered to be no physical or conceptual effect-receptor pathway.
Lir Offshore Array	Planning	4.2	0.8	Foreshore Licence application for site investigation works off County Dublin. Surveys include Geophysical, Geotechnical, Metocean and Ecological site investigations.	N/A	Unknown (subject to award of licence)	
MaresConnect Electrical Interconnector	Planning	24.6	23.4	Site investigation surveys for the proposed MaresConnect electrical interconnector between RoI and Wales.	N/A	Unknown (subject to award of licence)	
26 additional site investigation surveys located between 45.3 km and 287 km from the Project							For the impact of *injury and/or disturbance to marine mammal species from vessel activities* there is the potential for overlap with construction and operational phases of the Project and therefore potential for physical or conceptual overlap. For the impact of *injury and/or disturbance to marine mammals from elevated underwater noise during geophysical surveys* there is considered to be no potential for overlap due to distance from the Project (> 45 km).

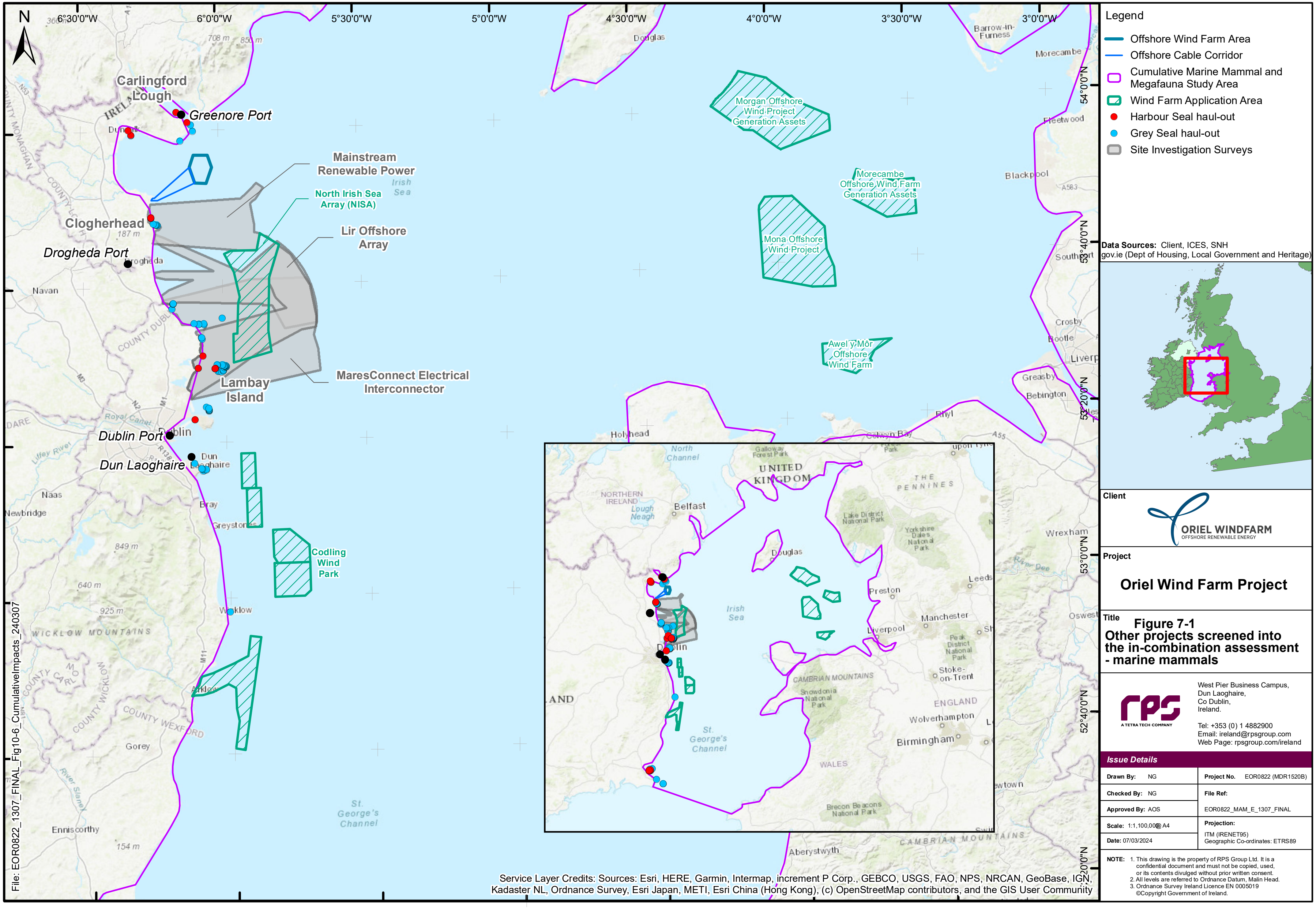

Figure 7-1
Other projects screened into the in-combination assessment - marine mammals

Table 7-2 presents the relevant project design parameters from Table 4-1, which are used to assess the potential in-combination effects of the Project with the other projects identified in Table 7-1 (where information is available).

Impacts have been carried forward for assessment where there is potential for an effect to occur from the Project alone over a scale that could impact in-combination with other plans or projects within the Regional Marine Mammal and Megafauna Study Area. Therefore, three impacts are assessed here: 1) injury/ disturbance to marine megafauna from underwater noise during pile-driving; 2) injury/ disturbance to marine megafauna from elevated noise during routine geophysical surveys; and 3) injury/disturbance to marine megafauna from vessel activities. Effects on marine mammals arising from the impact of changes in the fish and shellfish community are considered to be localised to within the offshore wind farm area and offshore cable corridor and unlikely to lead to in-combination effects with other plans or projects.

Table 7-2: Project design parameters considered for the in-combination assessment of potential impacts on Marine Mammals.

Potential impact	Phase			Project Design Parameters	Justification
	C	O	D		
Injury and/or disturbance to marine mammal species from underwater noise during pile-driving.	✓	✗	✗	Design parameters as described for the Project (Table 4-1) assessed in-combination with the following other projects: **Offshore wind farms** • Dublin Array – piling of up to 61 foundations; • NISA - piling of up to 36 foundations. • Arklow Bank Wind Park (Phase 2) – piling of up to 62 foundations; • Codling Wind Park – piling of up to 140 foundations; • Awel y Môr Offshore Wind Farm – piling of up to 50 foundations; • Mona Offshore Wind Project – piling of up to 115 foundations; • Morgan Offshore Wind Project Generation Assets: – piling of up to 115 foundations; and • Morecambe Offshore Windfarm Generation Assets – piling of up to 42 foundations.	Maximum potential for in-combination effects from underwater noise from construction operations within the Regional Marine Mammal and Megafauna Study Area.
Injury and/or disturbance to marine mammals from elevated underwater noise during routine geophysical surveys	✗	✓	✗	Design parameters as described for the Project (Table 4-1) assessed in-combination with the following other projects: **Site investigation surveys** • Mainstream Renewable Power Ltd. – site investigation surveys; • Lir Offshore Array Ltd. – site investigation surveys; and • MaresConnect Electrical Interconnector – site investigation surveys.	Maximum potential for in-combination effects of underwater noise from routine survey operations within the Regional Marine Mammal and Megafauna Study Area. Site investigation surveys more than 45 km from the Project have been screened out as having no potential for in-combination effects.
Injury and/or disturbance to marine mammal species from vessel activities.	✓	✓	✓	Design parameters as described for the Project (Table 4-1) assessed in-combination with the following other projects:	Maximum potential for in-combination effects from vessel activity associated with

Potential impact	Phase C	Phase O	Phase D	Project Design Parameters	Justification
				Offshore wind farms • Dublin Array – vessel traffic during all phases; • NISA - vessel traffic during all phases; • Arklow Bank Wind Park (Phase 2) – vessel traffic during all phases; • Codling Wind Park – vessel traffic during all phases; and • Awel y Môr Offshore Wind Farm – vessel traffic during all phases. • Mona Offshore Wind Project – vessel traffic during all phases; • Morgan Offshore Wind Project Generation Assets: – vessel traffic during all phases; and • Morecambe Offshore Windfarm – vessel traffic during all phases. **Site investigation surveys** • Mainstream Renewable Power Ltd. – site investigation surveys; • Lir Offshore Array Ltd. – site investigation surveys; and • MaresConnect Electrical Interconnector – site investigation surveys. • Up to 26 additional site investigation surveys ranging from 45.3 km and 287 km from the Project that have the potential to overlap temporally.	construction and maintenance works within the Regional Marine Mammal and Megafauna Study Area.

7.2 In-combination assessment

A description of in-combination effects upon marine mammal species arising from each identified impact is given below.

7.2.1 Possibility of Injury and/or disturbance to marine mammal species from underwater noise during piling-driving / drilling

7.2.1.1 Construction Phase

The installation of foundations within the offshore wind farm area, together with the projects identified in Table 7-2, may lead to either spatial effects (where piling phases overlap) and/or temporal effects (a longer duration of piling compared to the Project alone). Other projects screened into the assessment within the Regional Marine Mammal and Megafauna Study Area include the following offshore wind farms: Dublin Array, Arklow Bank Wind Park (Phase 2), NISA, Codling Wind Park, Awel y Môr Offshore Wind Farm, Mona Offshore Wind Project, Morgan Offshore Wind Project Generation Assets and Morecambe Offshore Windfarm Generation Assets.

The maximum predicted injury ranges for the Project are presented below in Table 7-3, along with project parameters and predicted injury ranges for those projects where quantitative information is available.

Table 7-3: Piling parameters and injury ranges for Oriel Wind Farm Project and screened-in projects located in the eastern Irish Sea (with the implementation of measures included in projects).

Project	Reference	Distance from Oriel Oriel Wind Farm Project (km)	Scenario	Maximum PTS range (km)		Maximum TTS range (km)	
Oriel Wind Farm Project	Section 4.1	-	3,500 kJ 5 – 8 hrs per pile 26 monopiles	0.236	0.168	0.344	5.98
Morgan Offshore Windfarm Generation Assets	Morgan Offshore Wind Ltd. (2023)	119.5	5,500 kJ 9.5 hrs per pile 70 piles	0.99	5.47	TTS ranges not presented	
Mona Offshore Wind Farm	Mona Offshore Wind Ltd. (2023)	127.0	5,500 kJ 9.5 hrs per pile 70 monopiles	0.96	5.36	TTS ranges not presented	
Awel y Môr Offshore Wind Farm	RWE (2022)	142.4	5,000 kJ 3.2 hours per pile 50 monopiles	0.64	10	1.5	30
Morecambe Offshore Windfarm Generation Assets	Morecambe Offshore Windfarm Ltd (2023)	151.3	5,000 kJ 4.5 hours per pile 42 monopiles	0.66	4.4	1.6	24

For projects where quantitative information is available (Morgan Offshore Wind Project Generation Assets, Mona Offshore Wind Project, Awel y Môr Offshore Wind Farm and Morecambe Offshore Windfarm Generation Assets) ranges presented for PTS are up to 0.99 km for the SPL_{pk} metric and up to 5.47 km for the SEL_{cum} metric. TTS ranges presented are up to 1.6 km for the SPL_{pk} metric and up to 30 km for the SEL_{cum} metric. Assuming that projects adopt standard industry measures to mitigate the risk of PTS there is no potential for an in-combination effect of PTS. TTS to some extent will also be mitigated through the adoption of standard industry measures, but even with the possibility of a residual effect, TTS is reversible. In addition, projects in the eastern Irish Sea are located more than 119 km from the Project and therefore there is considered to be no potential for overlap of injury ranges.

For projects in the western Irish Sea (Dublin Array, Arklow Bank Wind Park (Phase 2), NISA and Codling Wind Park), no quantitative information on PTS or TTS ranges is available. It is considered that PTS ranges and TTS ranges would be in the same order of magnitude, or less than those presented in Table 7-3. Whilst there is greater potential for overlap of injury ranges with projects located in the western Irish Sea, the closest project is located approximately 16 km away (NISA). Therefore, assuming that all projects screened in to the in-combination assessment adopt standard industry measures to mitigate the risk of PTS it is considered that there is no potential for in-combination effects for injury from elevated underwater noise during piling. The focus of in-combination effects is therefore on the potential for disturbance of marine mammals. The modelled disturbance contours for piling at the east and west of the Project are set out in Figure 6-3 and Figure 6-4 and the numbers of animals potentially affected by disturbance as a result of piling at the Project are set out in Table 6-9.

Injury to marine mammal species is considered unlikely to lead to in-combination effects as the effect ranges are considered to be very localised and, with mitigation in place, are unlikely to lead to potential effects. There is the potential for an in-combination effect of disturbance from piling at the Project with other projects in the Regional Marine Mammal and Megafauna Study Area (see Figure 7-1), including Awel y Môr Offshore Wind Farm, Mona Offshore Wind Project, Morgan Offshore Wind Project Generation Assets, Morecambe Offshore Wind Project Generation Assets, Dublin Array, Arklow Bank Wind Park (Phase 2), NISA and Codling Wind Park.

For in-combination projects where detailed information is available, piling is expected to take place for up to 201 days for piling of monopiles at Awel y Môr Offshore Wind Farm (over the 1-year piling phase in 2028); 35 days for piling of monopiles at both Mona Offshore Wind Project and Morgan Offshore Wind Project Generation Assets (over the respective 2-year construction phases in 2027 and 2028); and 42 days for piling of monopiles at Morecambe Offshore Wind Project Generation Assets (over the 2-year piling phase in 2027 and 2028). These timelines are, however, indicative and may be subject to change. Piling at each of these projects will occur as a discrete stage within the overall construction phase and therefore the periods of piling may not coincide.

It has been assumed that construction phases for both offshore wind farm projects could overlap temporally with the construction phase of the Project, with potential for piling operations to coincide.

The maximum predicted disturbance ranges for the Project are presented below in Table 7-4, along with disturbance ranges for those projects where quantitative information is available. The Awel y Môr Offshore Wind Farm did not consider effects on harbour seal, as this species was scoped out. Given that the in-combination assessment for piling is provided on species-by-species basis, harbour seal will not be considered further for this project. There were no estimates available for the number of animals likely to be affected during piling for Dublin Array, Arklow Bank Wind Park (Phase 2), NISA or Codling Wind Park, and therefore a quantitative in-combination assessment was not possible for these projects.

Table 7-4: Maximum number of animals with the potential to be disturbed (applying a dose-response disturbance approach) as a result of piling at Oriel Wind Farm Project and screened-in projects located in the eastern Irish Sea (projects for which quantitative information is available).

Project	Reference	Distance from Oriel Wind Farm Project (km)	Animals with the potential to be disturbed							
			Harbour porpoise		Bottlenose dolphin		Grey seal		Harbour seal	
			Number animals	Proportion of MU	Number animals	Proportion of MU	Number animals	Proportion of MU	Number animals	Proportion of MU
Oriel Wind Farm Project	Section 6.1.2	-	725	1.160%	26 (SCANS III) 129 (SCANS IV)	8.63% 1.549%	21	0.357%	16	0.979%
Morgan Offshore Windfarm Generation Assets	Morgan Offshore Wind Ltd. (2023)	119.49	1,370	2.19%	16	5.28%	48	0.08 – 0.35%	< 1	0.005%
Mona Offshore Wind Farm	Mona Offshore Wind Ltd. (2023)	127.04	587	0.94%	17	5.69%	92	0.15 – 0.68%	< 1	0.03%
Awel y Môr Offshore Wind Farm	RWE (2022)	142.37	275	0.44%	23	7.9%	81	1.60%	Species not assessed	
Morecambe Offshore Windfarm Generation Assets	Morecambe Offshore Windfarm Ltd (2023)	151.25	1,279	2.0%	< 1	0.000017%	11	0.098 – 0.99%	3	0.19%

For those projects where quantitative information is available (projects in the eastern Irish Sea), the numbers of animals predicted to be affected by individual projects represent relatively small proportions of respective MUs (Table 7-4). If piling were to coincide at these projects there is potential for a larger area of available habitat within the wider Irish Sea to be affected at any one time. However, these projects are located more than 119 km from the Project (Table 7-4). Strong and mild disturbance contours (160 dB re 1µ Pa (rms) and 140 dB re 1µ Pa (rms), respectively) modelled for the Project are predicted to extend to ~3.2 km and ~17 km from the Project, respectively (see Figure 6-3, Figure 6-4 and Figure 6-5). Therefore, the likelihood for overlap of either strong or mild disturbance contours of the Project with those from projects where noise modelling has been undertaken (projects in the eastern Irish Sea) is negligible.

The remaining projects considered are located between 16 and 107 km from the Project, in the western Irish Sea. Whilst quantitative information is not available for these projects, the proximity to the Project of the closer projects means there is potential for a larger number of marine mammals to be at any one time. Assuming similar disturbance ranges for those modelled for the Project, there is potential for overlap of mild disturbance contours with proximal projects (e.g. NISA at approximately 16 km distance). As previously described (see section 6.1.2.3) at this lower end of the behavioural response spectrum animals are unlikely to be displaced from their habitat; behavioural responses are expected to be less severe (such as changes in swimming speed or direction) and are unlikely to result in population-level effects. Temporally, the duration of disturbance within the western Irish Sea would be greatest where piling occurs sequentially at these wind farms. As described previously (section 6.1), piling represents only a fraction of the overall construction phase of the Project with a total of 208 hours over 26 days of piling over the 15-month offshore construction period (i.e. piling occurs for ~7.5% of the total construction period). In addition, as stated previously, for the Project alone (see section 6.1.2.2.1) and shown in Figure 6-5, the modelled Project disturbance contours of 135 dB re 1µPa SEL_{ss} (= 140 dB re 1µPa SPL_{rms}, mild disturbance) and 150 dB re 1µPa SEL_{ss} (= 160 dB re 1µPa SPL (rms); strong disturbance) do not overlap with any European site with marine mammals listed as a qualifying feature (Figure 6-5). Therefore, there is considered to be limited potential for the Project to contribute to an in-combination effect on SACs.

The impact of piling at four offshore wind farms in the western Irish Sea (in addition to the Project) and four offshore wind farms in the eastern Irish Sea may lead to potential in-combination behavioural effects on sensitive marine mammal species. The maximum adverse spatial scenario would be where piling occurs concurrently at all nine project sites (recognising the unlikelihood of this occurring), whilst the maximum adverse temporal scenario would be where piling occurs sequentially. All project sites are, however, located beyond the distances within which there would likely be overlap of strong disturbance contours during piling at these project sites (i.e. closest offshore wind farm is approximately 16 km from the Project). Whilst the in-combination effect is predicted to be of regional spatial extent and medium term, and the impact will affect the receptor directly, the effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels within hours/days after piling have ceased). Disturbance would occur as a series of short-term, intermittent events and there is evidence from the published literature to suggest that recoverability would be rapid following cessation of piling. The impact could result in some measurable changes to individuals that are disturbed (i.e. interruption of feeding or breeding and/or displacement to alternative area) but there are no long-term population-level consequences of disturbance anticipated.

As previously highlighted, if piling were to coincide at these wind farms there is potential for a greater number of individuals to be affected at any one time leading to a greater maximum spatial scenario. Whilst the Project is expected to contribute low levels of disturbance to any in-combination effect, in order to minimise the level of disturbance in the Irish Sea, a Piling Strategy will be implemented, alongside an MMMP which sets out a final project design prior to construction as well as options for potential management measures that may be implemented to ensure any effects are reduced to an acceptable level, such as phased piling.

As stated in section 6.1.2.2.1, population modelling was carried out for the Project alone for harbour porpoise, bottlenose dolphin, grey seal and harbour seal. Modelling results for all species demonstrated that there may be negligible reductions in population sizes for the impacted populations. Such small changes would not be enough to significantly affect population trajectories over a generational scale and would fall within the expected range of natural variation. A collaboration of Phase 1 projects in the Irish Sea has led to the completion of in-combination population modelling, to provide support to the understanding of whether piling at phase 1 projects will result in long term population level effects on marine mammal species (for which population modelling is possible within the interim Population Consequences of Disturbance (iPCoD) framework. The modelling confirmed that no significant impacts to any marine mammals from disturbance from piling at the five projects is predicted. This information will be used to inform the piling strategy.

As such, the magnitude for disturbance to all marine mammals as a result of in-combination piling activity is deemed to be of local/regional spatial extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

7.2.1.1.1 Sensitivity of qualifying features

The species likely to be affected include harbour porpoise, bottlenose dolphin, grey seal, and harbour seal. Most species will range widely throughout the Irish Sea and therefore will readily move between areas to exploit prey resources.

Potentially the most vulnerable species is the harbour seal, which has a greater degree of site-fidelity within the Regional Marine Mammal and Megafauna Study Area compared to the other species and ranges relatively short distances from haul-out sites on foraging trips. Key haul-outs for harbour seal on the east coast of Ireland are largely restricted to Dundalk Bay, Strangford Lough and Wexford Harbour (Baines, 1997) although there are small numbers recorded in the Dublin area, mainly on the north Dublin islands and coast and on Dalkey Island to the south of Dublin Bay (Cronin *et al.,* 2004). Therefore, harbour seal are most likely to be affected in-combination during piling at both the Project and at Dublin Array, although in the latter case only small numbers of animals may be affected. Results of a behavioural study on tagged seals during the construction of a wind farm in the Greater Wash, UK, showed that seals were not excluded from the wind farm during the overall construction phase but that there were reduced levels of activity up to 25 km from piling sites (Russell *et al.,* 2016). Displacement ranged from between 4.7 km up to 40.5 km from the piling source, but seals recovered quickly and returned to the wind farm site within two hours of cessation of piling (Russell *et al*., 2016). A population model developed by Thompson *et al.* (2013) looking at the effect of strong disturbance (displacement) on the harbour seal within the Moray Firth during cumulative piling at two offshore wind farms suggests that even where a large proportion of the population may be affected (43.2%), recovery would be likely within a generational scale. As described above, Dublin Array is located approximately 60 km from the Project and therefore there is unlikely to be any spatial overlap in disturbance effects. Harbour seal tend to forage within close proximity to haul-outs (40 to 50 km; see section 3.2.4) and therefore would be unlikely to be affected by concurrent piling at the two wind farms in a single foraging trip.

Grey seal also show site-fidelity to haul-outs within the Regional Marine Mammal and Megafauna Study Area although the foraging range for this species is greater compared to harbour seal, with individuals typically travelling distances of up to 100 km to feeding grounds. The key haul-outs for grey seal on the east coast of Ireland are at Wexford Harbour, Clogherhead, Dundalk Bay and Carlingford Lough. Lambay Island SAC, 43.1 km south of the offshore wind farm area, supports the principal breeding colony of grey seal on the east coast of Ireland. The sensitivity of grey seal to piling is expected to be similar to that described above for harbour seal with reduced levels of activity within the area of disturbance. Due to the distances travelled it is possible that an individual may be affected at more than one project during in-combination piling.

Harbour porpoise is the most frequently recorded of the marine mammals within the Irish Sea and also during site-specific surveys at the Project (section 3.2.1) and at Dublin Array (Saorgus Energy Ltd., 2012). Therefore, this is the species most likely to be encountered within the wind farm areas during piling and where in-combination effects could lead to potential larger numbers of animals disturbed or displaced compared to piling at the Project alone. Harbour porpoise has a relatively high metabolic rate which makes this species potentially vulnerable to disturbance if individuals are unable to obtain sufficient levels of prey intake. This may be more of an issue in-combination, where potentially multiple areas may be affected at any one time or if the same individual is disturbed over a longer period (e.g. if it is exposed sequentially at all three wind farms). However, as described previously (section 6), harbour porpoise range widely and exploit a suite of prey resources throughout their range. The wind farm areas considered in this In-Combination assessment are not highlighted as being of specific importance for harbour porpoise in the context of the Regional Marine Mammal and Megafauna Study Area and therefore it is assumed that individuals can move to other areas as alternative habitats. Even in the event that animals are displaced into less-optimal habitat, the duration of effect is likely to be limited to the pile-driving activity only, with recovery occurring rapidly following cessation of the piling. An Agent Based Model (ABM) developed to look at the effect of in-combination piling at offshore wind farms in the North Sea on harbour porpoise provides evidence to suggest that, even where multiple wind farms are piling together, there would be no long-term population effect on this species (Nabe-Neilson *et al.*, 2018).

For bottlenose dolphin, the sensitivity is considered to be lower than that described for harbour seal and harbour porpoise above. This is because this species is wide ranging and therefore avoidance of the disturbed area only represents a small proportion of their available habitat. In addition, the densities of bottlenose dolphin are low within the western Irish Sea (see appendix G: Marine Mammal and Megafauna Technical Report) suggesting that only small numbers may be present within the disturbed areas during piling.

Harbour seal, grey seal and harbour porpoise are assessed as having moderate resilience, have some ability to adapt behaviour such that ecological function can be maintained, and high recoverability. In-combination, harbour seal and grey seal may be more sensitive if a larger area of habitat near key haul-outs is ensonified during piling. For harbour porpoise, this species may be more sensitive from the in-combination piling scenario if disturbance displaces animals into sub-optimal habitat and reduces potential foraging time, particularly if the same individuals are potentially affected by piling at all considered wind farms. Based on the ecology and distribution of these three species, it is considered likely that they would have the ability to adapt behaviour such that, whilst reproduction rates of some individuals may be affected, it is unlikely that survival rates would be affected and all three marine mammal species are able to return to previous behavioural states/activities once the impact has ceased. The sensitivities of these receptors are, therefore, cautiously considered to be medium.

Bottlenose dolphin is assessed as having high resilience to the effect with minor impairment of ecological functioning, has an ability to adapt behaviour such that ecological function can be maintained, and high recoverability. Due to the potentially small numbers affected and the ability of marine mammal species to avoid small areas of disturbance in the context of their wider available habitat, it is considered unlikely that this species will be more sensitive to the in-combination effects of piling compared to piling at the Project alone. These species are therefore likely to tolerate the effect without any impact on reproduction and survival rates and are able to return to previous behavioural states/activities once the impact has ceased. The sensitivity of bottlenose dolphin is therefore, considered to be low.

7.2.2 Injury and/or disturbance to marine mammals from elevated underwater noise during geophysical surveys

7.2.2.1 Operational and maintenance phase

Geophysical surveys associated with routine inspection of the Project offshore assets, together with geophysical site investigation surveys associated with projects identified in Table 7-1, may increase the potential for auditory injury or disturbance to marine mammals. Surveying operations will commence in year five and have a five-year periodicity. Projects and plans screened into the assessment within the Regional Marine Mammal and Megafauna Study Area include Mainstream Renewable Power site investigation surveys, Lir Offshore Array site investigation surveys, MaresConnect site investigation surveys and routine geophysical surveys at NISA.

The potential for marine mammal receptors to experience auditory injury as a result of underwater noise due to geophysical surveys associated with the Project would be expected to occur only within the vicinity of operational geophysical survey equipment: up to 227 m for PTS and 449 m for TTS for harbour porpoise. The risk of both PTS and TTS is expected to be reduced further by the implementation of measures discussed in Table 4-2. The potential for marine mammal receptors to experience disturbance as a result of underwater noise due to geophysical surveys associated with the Project would be expected to occur at greater distances (out to 1,410 m) than for injury.

Quantitative information on injury and disturbance ranges for site investigation surveys at Mainstream Renewable Power, Lir Offshore Array and MaresConnect is available in respective Foreshore Licence applications. Although the equipment to be employed for geophysical site investigation surveys of the Project assets is expected to be restricted to MBES methods only, a range of geophysical survey equipment for other in-combination projects has been assessed, employing multiple equipment types with a range of operational parameters. For Mainstream Renewable Power, injury and disturbance ranges are predicted to be similar to those for the Project (up to 200 m for harbour porpoise for PTS, and up to 2,000 m for harbour porpoise for both TTS and disturbance). For MaresConnect, the results of noise modelling demonstrated that for harbour porpoise in particular, the onset of PTS is predicted to arise from between 17 m and 23 m from the source and potential behavioural effects are predicted to occur within 2.4 km and 2.5 km. The same level of information is not available for the Lir project but ranges are expected to be similar to those presented for the other two projects. Quantitative information is not available for NISA but it is expected that injury and disturbance ranges would be of a similar magnitude to the Project. It is expected that injury ranges for all in-combination projects would be further reduced by the implementation of measures, and therefore the potential for in-combination impacts would be further reduced

Routine geophysical surveying of the offshore assets of the Project is planned to occur every five years, commencing in year five, and survey campaigns are expected to be a maximum total duration of 42 days (assuming three consecutive 14-day surveys, see Table 4-1). There is therefore potential for temporal overlap with the other site investigation surveys included in Table 7-1. However, there is expected to be a low probability that these would coincide temporally given the low frequency and short duration of survey campaigns for the Project.

As a conservative approach it is assumed as a worst-case scenario that up to two geophysical site investigation surveys could overlap with the Project geophysical surveys at any one point. There are limitations on the number of survey vessels that could carry out such surveys at any one time and therefore it is highly unlikely that all surveys associated with projects set out in Table 7-1 would overlap temporally.

Sonar-like geophysical survey systems have very strong directivity which effectively means that there is only potential for injury when a marine mammal is directly underneath the sound source or directly within the swathe. Once the animal moves outside of the main beam, there is significantly reduced potential for injury. The closest site investigation survey to the Project is Mainstream Renewable Power (0.8 km to the south of the Project) and the closest wind farm project with the potential for geophysical surveys to be undertaken during its operational and maintenance phase is NISA (16.2 km to the south of the Project). In the unlikely event that surveys were to overlap temporally between the Project and NISA, the distance between these projects is significantly greater than the maximum spatial range over which injury or disturbance associated with geophysical survey methods is likely to occur.

As such the magnitude for injury and/or disturbance from elevated underwater noise during geophysical surveys for all marine mammals is deemed to be of local spatial extent and short-term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

7.2.2.1.1 Sensitivity of the qualifying features

The species with the potential to be affected by injury and/or disturbance from elevated underwater noise during geophysical surveys for projects described in Table 7-1 are those identified as key sensitive qualifying features for the Project alone. These include harbour porpoise, bottlenose dolphin, grey seal and harbour seal. These species range widely throughout the Irish Sea and therefore are assessed as having limited resilience, limited ability to adapt behaviour to sustain ecological functioning, and limited ability to recover from the effect in the short and long term, given the potential for the impact to result in a change in both reproduction and survival rate. The sensitivity of marine mammals to PTS from elevated underwater sound during geophysical surveys is therefore, considered to be high.

Marine mammals are assessed as having some resilience, have an ability to adapt behaviour such that ecological function can be maintained, and high recoverability. The sensitivity of marine mammals to TTS from elevated underwater sound during geophysical surveys is therefore, considered to be medium.

Marine mammals are assessed as having some resilience, have an ability to adapt behaviour such that ecological function can be maintained, and high recoverability. The sensitivity of marine mammals to disturbance from elevated underwater sound during surveys is therefore considered to be medium.

7.2.3 Injury and/or disturbance to marine mammal species from vessel activities

7.2.3.1 Construction phase

Vessel traffic associated with the construction of the Project, together with vessel traffic associated with the projects identified in Table 7-1, may increase the potential for injury (vessel noise or collision risk) and/or disturbance (vessel noise) to marine mammals. Other projects screened into the assessment within the Regional Marine Mammal and Megafauna Study Area include the following offshore wind projects: Dublin

Array, Arklow Bank Wind Park (Phase 2), NISA, Codling Wind Park, Awel y Môr Offshore Wind Farm, Mona Offshore Wind Project, Morgan Offshore Wind Project Generation Assets and Morecambe Offshore Windfarm Generation Assets. Other projects screened in include the Setanta Wind Park, North East Wind, Lir Offshore Array, Banba, and MaresConnect site investigations (Table 7-1).

The types of vessels involved in construction activities at the Dublin Array, Arklow Bank Wind Park (Phase 2), NISA, Codling Wind Park, Awel y Môr Offshore Wind Farm, Mona Offshore Wind Project, Morgan Offshore Wind Project Generation Assets and Morecambe Offshore Windfarm Generation Assets are anticipated to be similar to those identified for construction of the Project, such as jack-up vessels, tug/anchor handers, cable installation vessels, scour/cable protection installation vessel, guard vessels, survey vessels and CTVs. The number of return trips for vessels involved in construction activities at the Project are provided in Table 4-1. Vessels travelling to/from the Project would originate from an offshore operations and maintenance (O&M) base located at an existing harbour in County Louth or County Down and would follow existing shipping routes when in transit. Three harbours (Kilkeel, Warrenpoint and Greenore) have suitable facilities and are approximately 1 hour sailing time from the offshore wind farm area.

This assessment considered injury resulting from both vessel noise and collision risk due to the uplift in traffic associated with projects screened in to the in-combination assessment. The assessment for the Project alone (see section 6.3) both PTS and TTS were not exceeded for high frequency cetaceans, or for seals. For harbour porpoise the PTS range was very small (< 15 m for all vessel types and sound sources). For TTS the maximum range was 1.67 km (for survey and support vessels, CTVs, and scour/cable protection/seabed preparation/installation vessels (see Table 6-14).

For offshore wind projects in the western Irish Sea, no publicly available information on which to base quantitative assessment was identified for Arklow Bank Wind Park (Phase 2), NISA, Codling Wind Park and Dublin Array. The Awel y Môr assessment summarised that in the context of 57 vessels per day recorded within the study area, at the busiest time of year, the introduction of vessels during the construction of the wind farm would not be a novel impact for marine mammals present in the area. Whilst quantitative information is not available for other projects screened into the cumulative assessment it is expected that predicted ranges would be similar to those reported for the Project.

Quantitative information was available for offshore wind projects in the eastern Irish Sea. The Awel y Môr assessment summarised that in the context of 57 vessels per day recorded within the study area, at the busiest time of year, the introduction of vessels during the construction of the wind farm would not be a novel impact for marine mammals present in the area. The Mona Offshore Wind Project identified a maximum of 80 vessels on site at any one time, a maximum of 2,004 return trips per year and maximum disturbance ranges of 22 km. The Morgan Offshore Wind Project Generation Assets identified a maximum of 63 vessels on site at any one time, and a maximum of 1,878 return trips per year, and maximum disturbance ranges of 22 km. Both projects concluded that a slight increase from the existing levels of traffic in the vicinity of the respective project areas may not result in high levels of disturbance. The Morecambe Offshore Windfarm Generation Assets anticipated up to 30 vessels on site at any one time, with 150 return trips for delivery of main components and installation over the construction phase, and 2,778 return trips per year for support vessels. Disturbance ranges were not modelled, but assessment for all species was based on a disturbance impact range of 2 km (based upon studies by Brandt *et al*. 2018 and Benhemma-Le Gall *et al*. (2021).

The number of vessels associated with geotechnical and geophysical site investigation surveys in the Irish Sea is anticipated to be small (one or two per project) and typically the duration of surveys will be relatively short (weeks to a few months). There are up to 26 site investigation surveys identified in the screening area for marine mammals. Surveys typically occur over short durations (typically up to 2 months) and therefore as a conservative approach it is assumed as a worst-case scenario that up to two surveys (in addition) could overlap with the Project geophysical surveys (associated with routine inspection of the Project offshore assets) at any one point. There are limitations on the number of survey vessels that could carry out such surveys at one time and therefore it is highly unlikely that all would overlap temporally.

As such, the magnitude for auditory injury to all marine mammals as a result of in-combination vessel activity is deemed to be of local spatial extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

As described above (section 6.3) injury to marine mammals is more likely to arise from vessels travelling in excess of 7 m/s (Wilson *et al.,* 2007) or 14 knots (Laist *et al.,* 2001), however, vessels involved in the construction or survey of each project are likely to be travelling considerably slower than this, and therefore collision risk is expected to be lower than that posed by commercial shipping activity. Vessel traffic associated with offshore wind farm construction and site investigation surveys will be localised to within the project areas and will likely follow existing shipping lanes to/from port. Therefore, even with an in-combination increase in vessel traffic, the type of vessels involved and transit routes is unlikely to impose a greater risk to marine mammals. As such the magnitude for collision risk as a result of vessels involved in the construction phase for all qualifying marine mammal species is deemed to be of local spatial extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be negligible.

Disturbance from vessel noise may result in an in-combination effect on sensitive marine mammal species. As described for the Project alone, there is potential for a fleeing response (based on the TTS threshold) to occur over very localised ranges depending on the vessel (up to maximum of 1,670 m across all vessel types and species groups). Behavioural effects could occur over greater ranges as a result of vessel noise, and the use of the conservative NMFS threshold of 120 dB re 1 μPa (rms) led to predicted ranges of disturbance from construction vessels at the Project between 755 m and 8.5 km depending on vessel type. The increase in number of vessels associated with the other projects screened into this assessment is anticipated to be relatively small in context of the existing levels of vessel activity in the area (from shipping, fishing and recreational traffic) and the magnitude of the impact would be largely localised to within project sites.

Awel y Môr Offshore Wind Farm, Mona Offshore Wind Project, Morgan Offshore Wind Project Generation Assets, Morecambe Offshore Windfarm Generation Assets, Dublin Array, Arklow Bank Wind Park (Phase 2), Statkraft, NISA, Codling Wind Park are located considerable distances from the Project and therefore there is unlikely to be any spatial overlap in the vessel activity at these project sites. Site investigation surveys at Mainstream Renewable Power and Lir Offshore Array would be carried out in close proximity to the offshore wind farm area, however, these surveys would only lead to a very small uplift in vessel numbers (e.g. up to two vessels per survey).

In terms of disturbance, the impact could result in a small but measurable alteration to the distribution of marine mammals but, due to the localised nature of the impact in each of the in-combination project areas, reduction in reproductive success of affected animals is considered unlikely. The impact is predicted to be of local spatial extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Injury (collision risk and auditory injury) and disturbance would occur as a series of short-term, intermittent events. Implementation of a Code of Conduct for vessel operators, particularly in proximity to seal haul-outs, would reduce the risk of injury from collision with construction vessels. A suite of different marine mammal species are common to all project areas considered in this assessment, and therefore may be sensitive to in-combination behavioural effects from vessels. However, given the existing baseline levels of vessel activity in the area, it is anticipated that animals would be tolerant to small increases and would recover rapidly following cessation of the activity.

7.2.3.1.1 Sensitivity of receptor

The species likely to be affected are those identified as key sensitive receptors for the Project and at least one other wind farm, and include: harbour porpoise, bottlenose dolphin, grey seal, and harbour seal.

There are interspecific differences in the potential sensitivity of cetaceans to vessels (collision risk and disturbance) with some species actively avoiding vessels, whilst other are attracted towards them (see section 6.3). Harbour porpoise was highlighted as being particularly sensitive to vessel noise and avoidance is likely (Heinanen and Skov, 2015). Similarly, bottlenose dolphin reduce their activity in response to both the presence of vessels and the noise arising from vessel movements (Pirotta *et al.,* 2015). However, the link between vessel movements and reduced marine mammal activity is not straightforward to establish due to intrinsic factors that may also contribute to a variance in distribution and abundance (e.g. changes in prey distribution and natural seasonal fluctuations). A six-year monitoring programme undertaken off the coast of County Mayo, in an area identified as being important for cetaceans, showed that vessel activity associated with the construction of a gas pipeline may lead to a decrease in the presence of common dolphin (as a mid frequency cetacean) but that such effects would be short-lived as the broad seasonal patterns in abundance of this species remain unchanged (Culloch *et al.*, 2016). In addition, despite the known sensitivity of harbour porpoise to vessel noise (i.e. active avoidance of vessels; Hermannsen *et al*. 2014, Dyndo *et al*. 2015), there was no detectable decrease in the numbers of harbour porpoise associated with an increase in vessel activity during pipeline construction (Culloch *et al.,* 2016). For species that actively avoid vessels it is anticipated that the risk of injury from collision would be low.

The sensitivity of seals to vessel traffic was described previously and highlighted that the presence of boats near seal haul-outs could lead to disruption of foraging and potentially reduced pupping success. Key harbour seal and grey seal haul-outs nearest the Project were identified as 4.5 km north at Carlingford Lough, 10 km south at Clogherhead and 43.1 km south at Lambay Island (Figure 6-1). Harbour seal and grey seal at sea within the vicinity of the haul-outs on the east coast of Ireland are likely to be exposed to existing high levels of vessel activity to/from busy ports in the area (e.g. Dublin, Dun Laoghaire, and Greenore Harbour; Figure 6-1). Both collision risk and disturbance are anticipated to be higher in the vicinity of haul-out sites, particularly for young seals that have no previous experience of vessel traffic. Vessels associated with the Project will follow a Code of Conduct as part of the MMMP which includes, *inter alia*, limiting the speed of vessels near haul-outs, avoiding sudden changes in direction, and refraining from approaching animals in the water.

On the east coast of Ireland, and within the vicinity of the other projects screened into this assessment, there are small numbers of harbour seal recorded in the Dublin area, mainly on the north Dublin islands and coast and on Dalkey Island to the south of Dublin Bay (Cronin *et al.,* 2004). With small foraging ranges, harbour seal may be sensitive to an in-combination increase in vessel activity near key haul-outs. The offshore wind farm area is 43.1 km from Lambay Island SAC, designated for harbour porpoise, grey seal but also with a small population of harbour seal, therefore it is likely that grey seal and harbour seal from this SAC may venture to the north and may potentially occur in the vicinity of the Project as well as moving to other project areas. With greater foraging ranges, grey seal, in particular, may be sensitive to an uplift in vessel activity as they move between haul-outs and key foraging areas on the east coast of Ireland. As described above, however, seals in these areas (near busy ports) are already exposed to existing levels of baseline vessel activity and therefore are likely to be tolerant to small uplifts in vessel traffic.

Due to the small and localised nature of the uplift in vessel activity compared to baseline levels, it is considered unlikely that marine mammal will be more sensitive to the in-combination effects of injury or disturbance compared to the Project alone.

In terms of injury from vessel traffic (auditory injury and collision risk) it is assumed that vessels will follow a Code of Conduct for vessel operators, therefore reducing the risk. However, although the risk of injury from construction traffic is relatively low, the consequences of collision risk, in particular, could be fatal. All qualifying marine mammal species would have limited tolerance to a collision risk, and the effect of the impact could cause a change in both reproduction and survival of individuals, and receptors would have limited ability for the animal to recover from the effect. All marine mammal species have therefore been assessed as having limited resilience, limited ability to adapt behaviour to sustain ecological functioning, and limited ability to recover from the effect. As such the sensitivity of all marine mammal species to injury has been assessed as high.

In terms of disturbance from vessel traffic, the qualifying marine mammal features are likely to tolerate the effect without any impact on reproduction and survival rates and are able to return to previous behavioural states/activities once the impact has ceased. All marine mammal species have therefore been assessed as having high resilience to the effect with minor impairment of ecological functioning, have an ability to adapt behaviour such that ecological function can be maintained, and high recoverability. The sensitivities of all marine mammal species are therefore, considered to be low.

7.2.3.2 Operational and maintenance phase

Vessel traffic associated with the operational and maintenance phase of the Project, together with vessel traffic associated with the projects identified in Table 7-1, may increase the potential for injury and/or disturbance to marine mammal species. Other projects screened into the assessment within the Regional Marine Mammal and Megafauna Study Area include the Dublin Array, Arklow Bank Wind Park (Phase 2), NISA, Codling Wind Park, Awel y Môr Offshore Wind Farm, Mona Offshore Wind Project, Morgan Offshore Wind Project Generation Assets, Morecambe Offshore Windfarm Generation Assets, the Setanta Wind Park, North East Wind, Lir Offshore Array, Banba and MaresConnect site investigations (Table 7-1).

The magnitude of the impact is not expected to differ from that presented for the construction phase. The magnitude of the impact for all receptors is therefore considered to be low for auditory injury and disturbance and negligible for collision risk.

7.2.3.2.1 Sensitivity of the receptor

The sensitivity of the receptors during the operational and maintenance phase is not expected to differ from that presented for the construction phase. The sensitivity of the impact for all marine mammals is therefore considered to be low for auditory injury and disturbance and high for collision risk.

7.2.3.3 Decommissioning phase

The effects of decommissioning activities are expected to be the same or similar to the effects from construction.

7.2.3.4 Future monitoring

No marine mammals monitoring to test the predictions made within the in-combination impact assessment is considered necessary.

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