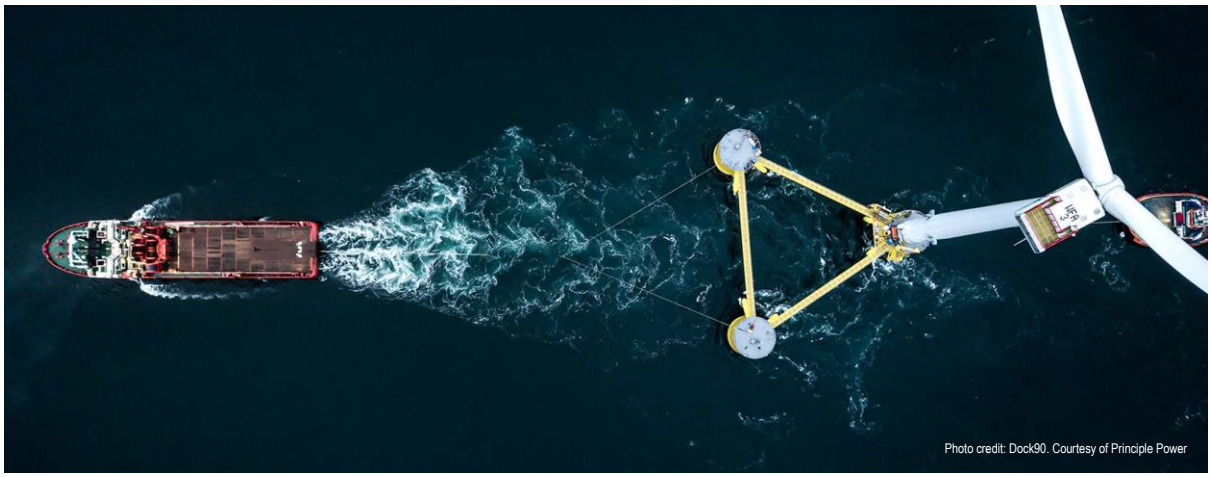

Project Erebus Environmental Statement
Chapter 12: Marine Mammals

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Acronyms

Term	Definition
ADD	Acoustic Deterrent Device
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas
BACI	Before and After Control Impact
BGW	Blue Gem Wind
CEA	Cumulative Effects Assessment
CITES	Convention of International Trade in Endangered Species
CSIP	Cetacean Strandings Investigation Programme
DAS	Digital Aerial Surveys
DEB	Dynamic Energy Budget
DEPONS	Disturbance Effects on the Harbour Porpoise Population in the North Sea
DTAGs	Digital Acoustic Recording Tags
ECC	Export Cable Corridor
EDR	Effective Deterrence Range
EEA	European Economic Area
EIA	Environmental Impact Assessment
EPS	European Protected Species
ES	Environmental Statement
FLOW	Floating Offshore Wind
FOWF	Floating Offshore Wind Farm
HF	High Frequency
ICES	International Council for the Exploration of the Sea
IPC	Infrastructure Planning Commission
JNCC	Joint Nature Conservation Committee
LDP	Local Development Plan
LF	Low Frequency
MCZ	Marine Conservation Zone

Term	Definition
MDS	Maximum Design Scenario
MFE	Mass Flow Excavator
MMMP	Marine Mammal Mitigation Protocol
MU	Management Unit
NEQ	Net Explosive Quantity
NPS	National Policy Statement
O&M	Operations and Maintenance
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
OWF	Offshore Wind Farm
PCoD	Population Consequences of Disturbance
PDV	Phocine Distemper Virus
PPW	Planning Policy Wales
ROV	Remotely Operated Vehicle
RMU	Regional Management Unit
SAC	Special Area of Conservation
SBE	Simply Blue Energy
SNCB	Statutory Nature Conservation Body
SPA	Special Protection Area
SSSI	Sites of Special Scientific Interest
TSHD	Trailer Suction Hopper Dredger
UXO	Unexploded Ordnance
VHF	Very High Frequency
VMP	Vessel Management Plan
WNMP	Welsh National Marine Plan
WTG	Wind Turbine Generator

Glossary

Term	Definition
Permanent Threshold Shift (PTS)	A total or partial permanent loss of hearing at a particular frequency caused by some kind of acoustic trauma. PTS results in irreversible damage to the sensory hair cells of the ear and, thus, a permanent reduction of hearing acuity at that frequency.
Sound Exposure Level (SEL)	The constant sound level acting for one second, which has the same amount of acoustic energy, as indicated by the square of the sound pressure, as the original sound. It is the time-integrated, sound-pressure-squared level. SEL is typically used to compare transient sound events having different time durations, pressure levels, and temporal characteristics.
Sound Pressure Level (SPL)	The sound pressure level or SPL is an expression of the sound pressure using the decibel (dB) scale and the standard reference pressures of 1 µPa for water.
Temporary Threshold Shift (TTS)	Temporary loss of hearing at a particular frequency as a result of exposure to sound over time. The mechanisms underlying TTS are not well understood, but there may be some temporary damage to the sensory cells. The duration of TTS varies depending on the nature of the stimulus, but there is generally recovery of full hearing over time.
Threshold	The threshold generally represents the lowest signal level an animal will detect in some statistically predetermined percent of presentations of a signal
Unweighted sound level	Sound levels which are ‘raw’ or have not been adjusted in any way, for example to account for the hearing ability of a species.
Weighted sound level	A sound level which has been adjusted with respect to a ‘weighting envelope’ in the frequency domain, typically to make an unweighted level relevant to a particular species. The overall sound level has been adjusted to account for the hearing ability of marine mammals.

Chapter 12 Marine Mammals

12.1 Introduction

12.1.1.1 The proposed Project Erebus (the Project) is a demonstration scale Floating Offshore Wind (FLOW) development in the Celtic Sea region. The Applicant, Blue Gem Wind, is a joint venture between Simply Blue Energy (SBE) and TotalEnergies, set up to create a new low carbon offshore energy sector in the region; that contributes to climate change targets, supply chain diversification and energy security.

12.1.1.2 This assessment has been undertaken by SMRU Consulting. The Chapter has been led by Rachael Sinclair (MRes Marine Mammal Science), who has 10 years' experience in the marine mammal field, and 8 years' experience in marine mammal consultancy, of which 6 years has focussed on offshore windfarm Environmental Impact Assessment (EIA). Rachael was supported by Anna Stevens (MSc Marine Biology) and Katarina Klementisova (MSc Marine Biology).

12.1.1.3 The array area is located approximately 35 km southwest of the Pembrokeshire coastline, covering an area of 43.5 km^2 in water depths of between 65-85 m. The array area is located outside of the 12 nm limit, but all elements of the Project, array area, offshore export cable corridor and landfall, fall within Welsh territorial waters or the Welsh Zone.

12.1.1.4 The Project comprises six to ten Wind Turbine Generators (WTG) with a total generating capacity up to 100 MW. Each WTG is housed on a semi-submersible floating platform with a mooring system comprising a maximum of five catenary mooring lines, up to 870 m in length, and a range of foundation options including drag embedment anchors, driven piles, drilled piles and/or suction piles. Up to 10 dynamic array cables are proposed, with a lazy wave configuration from the semi-submersible floating platform to the seabed. The offshore export cable, up to 49 km in length, links the array area to landfall at West Angle Bay, Pembrokeshire.

12.1.1.5 This chapter assesses the potential effects on marine mammal ecology from the offshore works (including construction, operation and maintenance (O&M), and decommissioning) associated with the Project.

12.1.1.6 This chapter has been informed by the following chapters:

- Chapter 4: Proposed Development Description;
- Chapter 6: Marine and Coastal Processes;
- Chapter 7: Marine Sediment and Water Quality;
- Chapter 10: Fish and Shellfish Ecology;
- Volume 3, Technical Appendix 12.1: Marine Mammal and Turtle Baseline; and
- Volume 3, Technical Appendix 12.2: Underwater Noise and Vibration Technical Report.

12.2 Legislation, Policy and Guidelines

12.2.1.1 The Project is seeking a Section 36 consent with deemed planning permission under the Electricity Act 1989 from Welsh Ministers, administered by Planning and Environment Decisions Wales (PEDW), and a Marine Licence under the Marine and Coastal Access Act 2009 (MCAA) issued by Natural Resources Wales (NRW).

12.2.1.2 A detailed overview of the relevant policy and legislation for the Project is provided in Chapter 5: Policy and Legislation. This section outlines the legislation, policy and guidance that is relevant to the assessment of the potential impacts on marine mammals associated with the construction, operation and maintenance and decommissioning of the Project.

12.2.2 Legislation

12.2.2.1 Relevant legislation and guidance documents have been reviewed and taken into account as part of this assessment. The Planning Act 2008, Marine Works (Environmental Impact Assessment; EIA) Regulations 2007 (as amended), the Infrastructure Planning (EIA) Regulations 2017 (collectively referred to as 'the EIA Regulations'), and the Environment Act 1995 are considered along with the legislation relevant to marine mammal ecology, listed below.

Habitats Directive

12.2.2.2 All cetaceans in Northern European waters are listed under Annex IV of the EU Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (the Habitats Directive), as European Protected Species (EPS) of Community Interest and in need of strict protection. The harbour porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops truncatus*), harbour seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*), have protection under Annex II as species of Community Interest whose conservation requires the designation of Special Areas of Conservation (SACs). Both grey seals and harbour seals are also listed under Annex V of the Habitats Directive, which requires any exploitation to be managed.

EU Directive 2008/56/EC – Marine Strategy Framework Directive

12.2.2.3 The Marine Strategy Framework Directive (MSFD) provides a legislative framework for an ecosystem-based approach to the management of activities which supports the sustainable use of marine goods and services. The aim of the Directive is to achieve 'Good Environmental Status' by 2020 across Europe's marine environment. Annex I of the MSFD includes the following requirements that are relevant to marine mammals:

- Biological diversity is maintained;
- The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic, and climatic conditions;
- All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity;
- Concentrations of contaminants are at levels not giving rise to pollution effects; and
- Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

Bonn Convention

12.2.2.4 The Convention on the Conservation of Migratory Species of Wild Animals (the Bonn Convention) requires signatories to conserve migratory species and their habitats by providing strict protection for endangered migratory species (Appendix I of the Convention), and lists migratory species which would benefit from multilateral Agreements for conservation and management (Appendix II). There are 16 cetacean species listed under Appendix I of the Bonn Convention, including common dolphins (*Delphinus delphis*).

Bern Convention

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

Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) 1994

12.2.2.6 Migrating cetaceans regularly cross national boundaries. Their protection can only effectively be achieved by means of international cooperation. The aim of ASCOBANS is to promote close cooperation between countries with a view to achieving and maintaining a favourable conservation status for small cetaceans throughout the Agreement Area, covering the Baltic, Northeast Atlantic, Irish and North Seas.

Wildlife and Countryside Act, 1981

12.2.2.7 All cetacean species and turtles are protected within the 12 nm territorial waters, under Schedule 5 of the Wildlife and Countryside Act 1981. The act makes it an offence to intentionally (or recklessly) kill, injure or take any wild animal listed on Schedule 5 of the Act, and prohibits interference with places used for shelter or protection, or intentionally disturbing animals occupying such places.

UK Biodiversity Action Plan and the UK Post-2010 Biodiversity Framework, 2012

12.2.2.8 The UK Biodiversity Action Plan (UK BAP) was published in 1994 as a response to the 1992 Rio de Janeiro Convention on Biological Diversity. The UK BAP identifies biological resources in the UK and plans for their conservation. This was succeeded in 2012 by the UK Post-2010 Biodiversity Framework, in response to the Convention on Biological Diversity's Strategic Plan for Biodiversity 2011-2020 (published in 2010) and the EU Biodiversity Strategy (published in 2011). The UK Post-2010 Biodiversity Framework describes how the UK can meet the Aichi Biodiversity Targets. The UK BAP identifies priority species that are the most threatened and require conservation. These UK BAP priority species include the cetacean, seal and marine turtle species present in UK waters. This list of priority species is still used to inform statutory lists of priority species in the UK.

Conservation of Seals Act, 1970

12.2.2.9 Both grey and harbour seal species are protected under the Conservation of Seals Act (1970) which provides closed seasons during which it is an offence to take or kill any seal except under licence. Following the Phocine Distemper Virus (PDV) outbreak in 1999, an Order was issued under the Conservation of Seals Act providing year-round protection to both grey and harbour seals on the east and southeast coast of England, from Berwick to Newhaven (under the Conservation of Seals (England) Order 1999).

Other relevant legislation

12.2.2.10 Other legislation also of relevance is listed below:

- The Environment (Wales) Act 2016;
- Convention for the Protection of the Marine Environment of the North-East Atlantic OSPAR Convention 1992; and
- Convention of International Trade in Endangered Species (CITES) 1975.

12.2.3 Policy

National Policy Statements

12.2.3.1 Although this Project is seeking Section 36 consent under the Electricity Act 1989 and a Marine Licence under the Marine and Coastal Access Act (MCAA) 2009, as opposed to a Development Consent Order (DCO), its size (up to 100 MW) is similar to the minimum threshold (100 MW) for Nationally Significant Infrastructure Projects (NSIPs). As such, guidance relevant to NSIPs is considered relevant to use for this Project. National Policy Statements (NPSs) were developed to provide guidance in the determination of NSIPs. Those relevant for the assessment of impacts on marine mammals include[1]:

- The Overarching National Policy Statement (NPS) for Energy (EN-1) (July 2011) (DECC 2011b) (Table 12.1); and
- The Overarching National Policy Statement (NPS) for Renewable Energy Infrastructure (EN-3) (July 2011) (DECC 2011a) (Table 12.1).

12.2.3.2 Even though the NPSs listed above specifically relate to Nationally Significant Infrastructure Projects (NSIP), and the Project is not classified as an NSIP, a review of EN-1 and EN-3 has still been undertaken.

12.2.3.3 Details of specific policies within EN-1 and EN-3 used to inform this assessment are provided in Table 12.1 below. The specific assessment requirements for marine mammals detailed, together with an indication of the paragraph numbers of the chapter where each is addressed.

[1] A period of consultation on a set of revised energy NPS's, managed by the Department of Business, Energy and Industrial Strategy (BEIS), ended on 29th November 2021.

Table 12.1 – National Policy Statement Context

NPS Requirements	NPS Reference	ES Reference
Where the development is subject to EIA the applicant should ensure that the Environmental Statement (ES) clearly sets out any effects on internationally, nationally and locally designated sites of ecological or geological conservation importance, on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity. .	EN-1, Section 5.3.3	The potential effects of the Project have been assessed in regard to international, national and local sites designated for ecological or geological features of conservation importance (see Sections 12.6.2, 12.6.3 and 12.6.4).
The applicant should provide environmental information proportionate to the infrastructure where EIA is not required to help the Infrastructure Planning Commission (IPC) consider thoroughly the potential effects of a proposed project	EN-1, Section 5.3.3	Direct or indirect effects on features of relevant Special Area of Conservation (SAC) and Special Protection Area (SPA) sites are also considered in the Habitats Regulations Assessment Screening Report and, where relevant, will be included in the Volume 3, Technical Appendix 8.3: Report to Inform Appropriate Assessment. Important protected areas for marine mammals within their respective Management Units (MUs) are detailed in, Volume 3, Technical Appendix 12.1: Marine Mammal and Turtle Baseline.
Many Sites of Special Scientific Interest (SSSI) are also designated as sites of international importance and will be protected accordingly. Those that are not, or those features of SSSIs not covered by an international designation, should be given a high degree of protection. All National Nature Reserves are notified as SSSIs	NPS EN-1 Section 5.3.10	The potential impacts on SSSIs will be outlined in Volume 3, Technical Appendix 8.3: Report to Inform Appropriate Assessment.

NPS Requirements	NPS Reference	ES Reference
Marine Conservation Zones (MCZs) introduced under the Marine and Coastal Access Act 2009 are areas that have been designated for the purpose of conserving marine flora and fauna, marine habitat or features of geological or geomorphological interest. The Secretary of State[2] is bound by the duties in relation to MCZs imposed by Sections 125 and 126 of the Marine and Coastal Access Act 2009.	NPS EN-1, Section 5.3.12	The only MCZ which is considered to be at risk of effect from the construction, operation or decommissioning of the Project is the Skomer MCZ for grey seals. This has been assessed in Volume 3, Technical Appendix 8.1: Marine Conservation Zone Assessment and Volume 3, Technical Assessment 8.3: Report to Inform Appropriate Assessment.
Development proposals provide many opportunities for building-in beneficial biodiversity or geological features as part of good design. When considering proposals, the IPC should maximise such opportunities in and around developments, using requirements or planning obligations where appropriate.	NPS EN-1, Section 5.3.15	Designated measures to be adopted as part of the Project are presented in Section 12.4.9.
Many individual wildlife species receive statutory protection under a range of legislative provisions.	NPS EN-1, Section 5.3.16	Relevant marine mammal policy and legislation is listed in Section 12.2.
Other species and habitats have been identified as being of principal importance for the conservation of biodiversity in England and Wales and thereby requiring conservation action. The Secretary of State should ensure that these species and habitats are protected from the adverse effects of development by using requirements or planning obligations.	NPS EN-1, Section 5.3.17	All species receptors, including those of principal importance for the conservation of biodiversity in Wales are summarised in Section 12.5. Full details are provided in Volume 3, Technical Appendix 12.1: Marine Mammal and Turtle Baseline.
Assessment of offshore ecology and biodiversity should be undertaken by the applicant for all stages of the lifespan of the proposed Offshore Wind Farm (OWF) and in accordance with the appropriate policy for OWF EIAs.	NPS EN-3, Section 2.6.64	Construction, operation, maintenance and decommissioning phases of the Project have been assessed in Sections 12.6.2, 12.6.3 and 12.6.4.

[2] In the case of the Project, this is the NRW Marine Licencing Team. Note: The Project is not a NSIP/DCO project.

NPS Requirements	NPS Reference	ES Reference
The applicant should include appropriate mitigation measures as an integral part of the proposed development. In particular, the applicant should demonstrate that: • During construction, they will seek to ensure that activities will be confined to the minimum areas required for the works; • During construction and operation best practice will be followed to ensure that risk of disturbance or damage to species or habitats is minimised, including as a consequence of transport access arrangements. Habitats will, where practicable, be restored after construction works have finished.	NPS EN-1, Section 5.3.18	Embedded mitigation measures to be adopted as part of the Project are presented in Section 12.4.9.
Consultation on the assessment methodologies should be undertaken at early stages with the statutory consultees as appropriate.	NPS EN-3, Section 2.6.65	Consultations with relevant statutory and non-statutory stakeholders have been conducted throughout the Project (see Table 12.3 for a summary of the consultations regarding marine mammals).
Any relevant data that has been collected as part of post-construction ecological monitoring from existing, operational OWFs should be referred to where appropriate.	NPS EN-3, Section 2.6.66	Relevant data collected during post construction monitoring from other OWF projects have informed the assessment of the Project in Sections 12.6.2, 12.6.3 and 12.6.4.
The assessment should include the potential of the scheme to have both positive and negative effects on marine ecology and biodiversity.	NPS EN-3, Section 2.6.67	Both potential positive and negative effects of the Project on marine mammals have been assessed in Sections 12.6.2, 12.6.3 and 12.6.4.
The Secretary of State should consider the effects of a proposal on marine ecology and biodiversity taking into account all relevant information made available to it.	NPS EN-3, Section 2.6.68	The potential effects on marine mammal ecology are presented within this chapter, with the assessment of effects presented within Sections 12.6.2, 12.6.3 and 12.6.4.

NPS Requirements	NPS Reference	ES Reference
Mitigation may be possible in the form of careful design of the development itself and the construction techniques employed.	NPS EN-3, Section 2.6.70	Embedded mitigation measures to be adopted as part of the Project are presented in Section 12.4.9.
Ecological monitoring is likely to be appropriate during the construction and operational phases to identify the actual impact so that, where appropriate, adverse effects can then be mitigated and to enable further useful information to be published relevant to future projects.	NPS EN-3, Section 2.6.71	The requirement for marine mammal monitoring has been assessed in Sections 12.6.2, 12.6.3 and 12.6.4.
Where necessary, assessment of the effects on marine mammals should include details of: • Likely feeding areas/birthing sites; • Known migration or commuting routes; • Duration of the disturbing activity including cumulative /in-combination; • Effects with other plans or projects; • Baseline noise levels; • Predicted noise levels in relation to mortality, permanent threshold shift (PTS) and temporary threshold shift (TTS); • Soft-start noise levels according to proposed hammer and pile design; and • Operational noise.	NPS EN-3, Section 2.6.92	The effects on marine mammals have been assessed in Sections 12.6.2, 12.6.3, 12.6.4 and 12.10.
The applicant should discuss any proposed piling activities with the relevant body. Where assessment shows that noise from offshore piling may reach noise levels likely to lead to an offence as described in 2.6.91 above, the applicant should look at possible alternatives or appropriate mitigation before applying for a license.	NPS EN-3, Section 2.6.93	The proposed piling activity is discussed in Section 12.6.

NPS Requirements	NPS Reference	ES Reference
The Infrastructure Planning Commission (IPC) should be satisfied that the preferred methods of construction, in particular the construction method needed for the proposed foundations and the preferred foundation type, where known at the time of application, are designed so as to reasonably minimise significant disturbance effects on marine mammals. Unless suitable noise mitigation measures can be imposed by requirements to any development consent, the IPC may refuse the application.	NPS EN-3, Section 2.6.94	The maximum potential impact associated with construction, operation and maintenance and decommissioning of the Project are assessed in Section 12.4.8. Mitigation measures to minimise this potential disturbance are discussed in Sections 12.6.2, 12.6.3 and 12.6.4.
Fixed submerged structures such as foundations are likely to pose little collision risk for marine mammals and the IPC is not likely to have to refuse to grant consent for a development on the grounds that offshore wind farm foundations pose a collision risk to marine mammals.	NPS EN-3, Section 2.6.96	The potential for collision risk is assessed in Sections 12.6.2, 12.6.3 and 12.6.4.
Monitoring of the surrounding area before and during the piling procedure can be undertaken.	NPS EN-3, Section 2.6.97	Monitoring conducted prior to development is discussed in Section 12.4.4, and in further detail in Volume 3, Technical Appendix 12.1: Marine Mammal and Turtle Baseline. Monitoring to be conducted during piling procedures is described in Section 12.4.9 with further detail provided in Volume 3, Technical Appendix 12.3: Draft Marine Mammal Mitigation Plan.

Welsh National Marine Plan

12.2.3.4 The Welsh National Marine Plan (WNMP) was published on 12 November 2019 and contains policy across a range of considerations (including nature conservation, sustainable use, seascape, and coastal communities and economic growth). The WNMP includes sector objectives for renewable energy to support decarbonisation of the Welsh economy and the use of marine renewable energy generation (including OWFs). Policies with specific reference to marine mammals are included in Table 12.2 below.

Table 12.2 - Requirements from the Welsh National Marine Plan relevant to Marine Mammals

Policy Description	Reference	ES Reference
Proposals should demonstrate that they have considered man-made noise impacts on the marine environment and, in order of preference: a. avoid adverse impacts; and/or b. minimise impacts where they cannot be avoided; and/or c. mitigate impacts where they cannot be minimised. If significant adverse impacts cannot be avoided, minimised or mitigated, proposals must present a clear and convincing case for proceeding.	ENV_05: Underwater noise	The potential impact of underwater noise is assessed in 12.6.2 (construction), 12.6.3 (operation) and 12.6.4 (decommissioning). Mitigation measures to minimise disturbance from underwater noise are discussed in Sections 12.6.2, 12.6.3 and 12.6.4.
Proposals potentially affecting important feeding, breeding (including spawning and nursery) and migration areas or habitats for key fish and shellfish species of commercial or ecological importance should demonstrate how they, in order of preference: a. avoid adverse impacts on those areas; and/or b. minimise adverse impacts where they cannot be avoided; and/or c. mitigate adverse impacts where they cannot be minimised. If significant adverse impacts cannot be avoided, minimised or mitigated, proposals must present a clear and convincing case for proceeding.	ENV_07: Fish Species and Habitats	The impact assessment for fish species is provided in Chapter 10: Fish and Shellfish Ecology. This was used to inform the indirect impacts on marine mammals: see Section 12.6.2.130 (construction), 12.6.3.37 (operation) and 12.6.4.16 (decommissioning).
Proposals should demonstrate that they have assessed potential cumulative effects and should, in order of preference: a. avoid adverse effects; and/or b. minimise effects where they cannot be avoided; and/or c. mitigate effects where they cannot be minimised. If significant adverse effects cannot be avoided, minimised or mitigated, proposals must present a clear and convincing case for proceeding. Proposals that contribute to positive cumulative effects are encouraged.	GOV_01: Cumulative effects	A full cumulative impact assessment is provided for marine mammals in 12.10 Cumulative Assessment.

Future Wales – The National Plan

12.2.3.5 Future Wales – the National Plan 2040 is Wales' national development framework, setting the direction for development in Wales to 2040. Whilst it does not specifically relate to marine mammals, it is a development plan with a strategy for addressing key national priorities through the planning system, including sustaining and developing a vibrant economy, achieving decarbonisation and climate-resilience, developing strong ecosystems and improving the health and well-being of Wales' communities.

12.2.4 Guidance

12.2.4.1 Recognisance has been taken of the following best practice guidelines/guidance:

- Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects by Southall *et al.* (2019);
- Policy paper: Marine environment: unexploded ordnance clearance joint interim position statement. Published 16 November 2021;
- Beatrice Offshore Wind Farm: An interim estimate of the probability of porpoise displacement at different unweighted single-pulse sound exposure levels by Graham *et al.* (2017a);
- Estimating the effects of pile driving sounds on seals: Pitfalls and possibilities by Whyte *et al.* (2020);
- The protection of marine European Protected Species from injury and disturbance. Guidance for the marine area in England and Wales and the UK offshore marine area (JNCC *et al.* 2010);
- PINS Advice note 7: EIA: Process, Preliminary Environmental Information and Environmental Statements[3];
- PINS Advice note 17: Cumulative Effects Assessment[4];
- The Protection of Marine EPS from Injury and Disturbance: Draft Guidance for the Marine Area in England and Wales and the UK Offshore Marine Area (JNCC *et al.* 2010);
- Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine (CIEEM 2019);
- Environmental Impact Assessment for offshore renewable energy projects – guide (British Standards Institute 2015);
- Approaches to Marine Mammal Monitoring at Marine Renewable Energy Developments Final Report (Macleod *et al.* 2010);
- Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects (Judd 2012);
- Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs (JNCC *et al.* 2020);
- JNCC guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC 2010a); and

[3] https://infrastructure.planninginspectorate.gov.uk/legislation-and-advice/advice-notes/advice-note-seven-environmental-impact-assessment-process-preliminary-environmental-information-and-environmental-statements/

[4] https://infrastructure.planninginspectorate.gov.uk/legislation-and-advice/advice-notes/advice-note-17/

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

12.3 Consultation and Scoping

12.3.1.1 An EIA Scoping Report (MarineSpace Ltd 2019) was produced and submitted to NRW in October 2019. NRW consulted with a number of statutory bodies and key stakeholders upon the contents. NRW provided a formal Scoping Response in January 2020. The comments from NRW pertaining to this chapter have been presented in Table 12.3. These comments have been addressed fully in this chapter, with the location of the relevant information highlighted in the response column for ease of location.

Table 12.3 – Summary of Consultation Relating to Marine Mammals

Consultee	Response	Applicant Action
NRW (Scoping Opinion) January 2020	We request potential risk to marine mammal features from entanglement must be scoped into, and subsequently assessed within, the designated site assessment in the submitted ES. Impacts on Skomer MCZ should be the same as those for SAC with grey seal features and as such should include impacts within the operational phase. When scoping sites for marine mammal features, we recommend that all sites within the relevant marine mammal management unit are screened into the assessment. As such, in addition the following sites should be included: • North Anglesey Marine SAC; • Pen Llyn a'r Sarnau SAC.	This has been assessed in Volume 3, Technical Appendix 8.1: Marine Conservation Zone Assessment and Volume 3, Technical Assessment 8.3: Report to Inform Appropriate Assessment.
	There is a potential requirement for UXO detonation. Should UXO be discovered in the development area more detailed consideration or underwater noise modelling may subsequently be required.	Assessment of low-order UXO clearance is provided (see assessment of PTS and disturbance from UXO – Section 12.6.2.2 *et seq.*).
	Recommend using SCANS III as the most up to date information on the bottlenose dolphin population rather than the cited Cardigan Bay SAC, 2019. We would also recommend Lohrengel *et al.* (2018) for information on the Cardigan Bay bottlenose population but note that SCANS III would give a more proportionate estimate of the wider population likely to be found in the project development area.	Assessment used the Lohrengel *et al.* (2018) density estimate (0.063 dolphins/km^2) which is slightly higher than the SCANS III estimate (0.0605 dolphins/km^2).
	Recommend consulting SCOS (2018) and Büche and Stubbings (2019) for information on the grey seal populations.	SCOS (2021) and Büche and Stubbings (2019) have been included in Volume 3, Technical Appendix 12.1.

Consultee	Response	Applicant Action
NRW (Scoping Opinion) January 2020	We agree that entanglement risk from mooring lines and ghost fishing should be scoped in and recognise that it is difficult to quantify. However, we would be cautious with concluding that it is not likely to be significant at this stage and would encourage careful consideration of this risk as it has the potential to be of significant concern. A useful reference to inform the assessment is: https://www.nature.scot/snh-commissioned-report-791-understanding-potential-marine-megafauna-entanglement-risk-renewable	Assessment of entanglement has been informed by information obtained from the Project engineers alongside published information including Benjamins *et al.* (2014), Harnois *et al.* (2015) and Garavelli (2020). See Section 12.6.3.
	Advocate using the MMMUs as the appropriate screening scale for HRA for all Annex II marine mammal features as we consider areas of sea beyond the boundaries of the SAC to be functionally linked habitat that may support the populations of the SAC. Thus, impacts occurring outside the boundary of the SAC may affect animals moving from or between SACs. Buffer distances that may be appropriate for one type of underwater sound are not appropriate to be arbitrarily applied to other impacts such as wider UXO injury/disturbance, or potential entanglement which does not have an impact footprint beyond the array, but could impact on animals passing through the array	This has been assessed in Volume 3, Technical Appendix 8.3: Report to Inform Appropriate Assessment.
	For the purposes of the noise assessment, you must include a review of behavioural dose response relationships of marine mammals to noise sources.	A review of behavioural responses to underwater noise sources is included in Sinclair *et al.* (2021). The reasoning for selecting the dose-response curves used in this assessment is detailed in the Assessment Methodology Section 12.4.
JNCC Scoping Advice November 2019	Full consideration of potential impacts to marine mammals should be included within the ES, addressing any Habitats Regulations and European Protected Species legislative requirements.	A comprehensive impact assessment has been undertaken in Sections 12.6.2, 12.6.3 and 12.6.4 and in Volume 3, Technical Appendix 8.3: Report to Inform Appropriate Assessment.

Consultee	Response	Applicant Action
JNCC Scoping Advice November 2019	A desk-based noise assessment should be undertaken in the EIA regarding construction/installation activities including UXO clearance as it is unknown if this will be required at that stage; however, if clearance is required we would expect a full assessment of potential risks to marine mammals to accompany the required marine licence application including noise modelling to inform the assessment of the risk of injury as well as a detailed mitigation plan.	A desk based underwater noise assessment has been completed, see Volume 3, Technical Appendix 12.2: Underwater Noise and Vibration Technical Report with further detail presented in Volume 3, Technical Appendix 12.1: Marine Mammal and Turtle Baseline and in Sections 12.6.2, 12.6.3 and 12.6.4.
	Bristol Channel & West Wales SACs will have to be scoped into an the HRA as it appears that the cable route pass through at least one of these sites.	This has been assessed in Volume 3, Technical Appendix 8.3: Report to Inform Appropriate Assessment.
	Given the choice of foundation, i.e. floating, the risk of entanglement to marine mammals will need to be assessed.	Entanglement effects are assessed in Section 12.6.3.6
	On Page 163 (6-56), where it states 'vessels will travel at speeds below thresholds that cause injury' we would seek clarification on the thresholds that are being referred to.	Collision with vessels is assessed in Section 12.6.2.103.
	Page 170 (6-63) needs to make clear where it is referring to marine mammal injury thresholds and where it is referring to fish injury thresholds. This is currently not clear.	No action required.
Project introduction meeting with NRW/JNCC July 2020	Highlighted the importance of sea state within the digital aerial surveys. Recommended that the Project engages with Natural England due to Lundy Island.	Meeting arranged with Natural England to introduce the Project
Project introduction meeting with The Wildlife Trusts/The Wildlife Trust of South and West Wales July 2020	Results of aerial surveys to date were presented. Entanglement and barrier effects were discussed.	No immediate actions were required as a consequence but highlighted the importance of monitoring during the project life cycle. Entanglement and barrier effects are detailed in Section 12.6.3.6 and 12.6.3.1 respectively.

Consultee	Response	Applicant Action
Project introduction meeting with Natural England September 2020	Identified that the array may actually have a positive effect on seals as they could use it as a foraging area.	Natural England's comments noted and considered during the EIA.
NRW and JNCC response to Erebus Cumulative Effects Assessment: Stage 1 Version 0.5 March 2021	Within their response to the proposed zones of influence (ZOIs) for the cumulative effects assessment JNCC confirmed they are content that a 26km Effective Deterrent Range (EDR) can be used as the ZOI for disturbance from UXO clearance. However NRW advised they could not confirm if 26km is appropriate without more detail regarding potential risk from UXO.	In recognition of the disparity between opinions of JNCC and NRW approach to assessment is amended to base EDR on the site-specific modelling outcomes of Volume 3, Technical Appendix 12.2: Underwater Noise and Vibration Technical Report. Cumulative Effect Assessment is considered further in Section 12.10.
NRW comments to technical note which introduced the proposed approach to subsea noise assessment April 2021	Several points required clarification/expansion on the Subacoustech INSPIRE model, UXO clearance and SPEAR model. More information was required on the UXO worst case scenario modelled within the Greenlink ES.	Meeting arranged to discuss in more detail. Underwater noise is considered further in Volume 3, Technical Appendix 12.2: Underwater Noise and Vibration Technical Report and Sections 12.6.2, 12.6.3 and 12.6.4.
NRW/JNCC response to Erebus Cumulative Effects Assessment: Stage 1 Version 2.0 May 2021	NRW and JNCC both welcomed the use of marine management units for the screening of sites for all pathways for marine mammals.	Geographic extent for selection of other projects to be considered within the cumulative effects assessment will be based on the species-specific marine mammal management unit. All projects within this spatial extent which meet the other screening criteria set out Section 12.9.3 will be taken forward for cumulative effects assessment.
Revised Technical Note issued to NRW/JNCC/The Wildlife Trusts May 2021	Acknowledged receipt.	No action required

Consultee	Response	Applicant Action
Meeting to introduce the proposed approach to subsea noise assessment with NRW/JNCC/The Wildlife Trust May 2021	Clarification and confidence gained on both the INSPIRE and SPEAR model.	Greenlink ES modelled a 794 kg explosive. This could possibly be found within the St George's Channel area. The Project offshore consent boundary does not overlap the channel but modelling results have been included for reference. Further details can be found in Volume 3, Technical Appendix 12.2: Underwater Noise and Vibration Technical Report and Section 12.4.7.1.
Meeting with JNCC/NRW to discuss approach to deflagration modelling August 2021	Agreed that it is acceptable for the Project proposes to re-run the model looking at smaller charges as a proxy for deflagration and this will form the basis of the impact assessment for marine mammals and fish.	Further information is presented in Volume 3, Technical Appendix 12.2: Underwater Noise and Vibration Technical Report, Sections 12.6.2, 12.6.3 and 12.6.4 and 12.4.7.1 and Chapter 10: Fish and Shellfish Ecology.
NRW response to Erebus marine mammal, basking shark and turtle baseline summary Briefing Note August 2021	Recommended additional sources of grey seal pupping data around Pembrokeshire: Bull *et al.* (2017a), Bull *et al.* (2017b), Lock *et al.* (2017), Morgan *et al.* (2018) and NRW (2018).	These refences have been included in the Volume 3, Technical Appendix 12.1: Marine Mammal and Turtle Baseline.
JNCC response to Erebus marine mammal, basking shark and turtle baseline summary Briefing Note August 2021	While we agree with screening out of Risso's dolphins and leatherback turtles from the quantitative assessment, we still expect them to be discussed in the EIA.	Risso's dolphins and leatherback turtles have been scoped out of the impact assessment (see Volume 3, Technical Appendix 12.1: Marine Mammal and Turtle Baseline). These species have been discussed in brief within the impact assessment.

Consultee	Response	Applicant Action
NRW response to Erebus marine mammal, basking shark and turtle baseline summary Briefing Note August 2021	NRW advisory suggest that Risso's be scoped into the assessment. The final survey results may provide additional information, and it is also possible that other organisations such as Sea Trust or other regional groups may hold data which will be of value in quantifying the assessment. Densities may be low, but the project site is within the Risso's range, so carrying out an impact assessment which uses the available data would be a reasonable and precautionary approach.	Only 1 Risso's dolphin was sighted during the 24 months of HiDef site-specific surveys (SMRU Consulting was not confident of species ID). Sea Trust Wales has seen Risso's dolphins but only in very low numbers, and no density estimate is available (see Volume 3, Technical Appendix 12.1: Marine Mammal and Turtle Baseline). Therefore, the Applicant considers that there is insufficient evidence to scope Risso's dolphins into the impact assessment.
NRW response to approach to developing marine mammal density estimate to be assessed in the EIA August 2021	We welcome the approach to present a range of density estimates and establish the most appropriate one for use in assessment, in line with NRWs previous advice. Key issues identified: - It is possible to survey for seal haul out effectively. Several references for such survey data have been provided - 'MU' data source should be specified - The decision tree / quality assessment mechanism is not clear, and should be provided to justify the decisions reached - SeaTrust or other regional groups may hold data which will be of value in quantifying the assessment. - Agree with screening out of Risso's dolphins/leatherback turtles from quantitative but expect them to eb discussed in EIA	Additional data sources were reviewed as set out in NRWs response and marine mammal density estimates are considered further in Section 12.5 and Table 12.10. SeaTrust were also contacted to sources additional regional data to inform the impact assessment. Risso's dolphins and leatherback turtles are discussed in Section 12.5.1.3.
JNCC response to approach to developing marine mammal density estimate to be assessed in the EIA August 2021	- Refer to sources other than SCANS data - Agree with screening out of Risso's dolphins/leatherback turtles from quantitative but expect them to be discussed in EIA	Additional data sources have been reviewed are considered further in Section 12.5 and Table 12.10. Risso's dolphins and leatherback turtles are discussed in Section 12.5.1.3.
SeaTrust October 2021	SeaTrust shared marine mammal data for the Project area	The additional data has informed Section 12.5.

12.4 Assessment Methodology and Significance Criteria

12.4.1.1 Detailed discussion on the EIA methodology can be found in Chapter 2: Overview of EIA Methodology. Effects on marine mammals are based on the potential impacts identified within the EIA Scoping Report, and any additional potential impacts which have been identified via consultation with key stakeholders.

12.4.1.2 This assessment has been based on the existing environment, as detailed in Section 12.5 and the PDE as detailed in Chapter 4: Proposed Development Description. Specific parameters that have been the basis of this assessment are provided in Section 12.6.1.1.

12.4.1.3 Impacts have been assessed for the following 3 distinct phases of the project:

- Construction;
- Operation (and maintenance); and
- Decommissioning.

12.4.2 Study Area

12.4.2.1 The marine mammal Study Area varies depending on the species, considering individual species ecology and behaviour. For all species, the study area covers the Project array area and offshore Export Cable Corridor (ECC) and is extended over an appropriate area considering the scale of movement and population structure for each species. For each species, the area considered in the assessment is largely defined by the appropriate species Management Unit (MU). The study area for marine mammals has been defined at two spatial scales: the MU scale for species specific population units, and the marine mammal survey areas for an indication of the local densities of each species.

12.4.2.2 The Project is located within the following MUs for each species:

- Common dolphin: Celtic and Greater North Seas MU;
- Harbour porpoise: Celtic and Irish Seas MU;
- Bottlenose dolphin: Offshore Channel and SW England MU;
- Risso's dolphin: Celtic and Greater North Seas MU;
- Minke whale: Celtic and Greater North Seas MU; and
- Grey seals:
  - OSPAR Region III: Celtic Seas (interim MU, proposed by NRW 2020);
  - Within the Wales MU and adjacent to the Southwest England MU (SCOS 2021).

12.4.3 Desk Study

12.4.3.1 The baseline characterisation for marine mammals is described in detail in Volume 3, Technical Appendix 12.1: Marine Mammal and Turtle Baseline. The baseline characterisation has been informed by numerous data sources, which comprise a combination of desk-based review of existing data sources and consideration of site-specific survey data (see Section 12.4.4 for details).

12.4.3.2 Existing data sources used to inform this assessment are listed in Table 12.4.

Table 12.4 –Data Sources Examined to Inform the Baseline Characterisation for Marine Mammals

Data Source	Date	Summary	Coverage
Site-specific surveys (HiDef Aerial Surveying Ltd 2021) (HiDef Aerial Surveying Ltd 2020)	Oct 2019–Sep 2021	Aerial surveys	The Project site and 4 km buffer
Valorous site-specific surveys	Mar-May 2021	Aerial surveys	Project Valorous and 4 km buffer
SCANS III (Hammond *et al.* 2021)	Jun and Jul 2016	Aerial and vessel visual surveys a	All European Atlantic waters. The Project site is located in block D
SCANS II (Hammond *et al.* 2013)	Jun and Jul 2005	Aerial and vessel visual surveys	All European Atlantic waters. The Project site is located in block P
ObSERVE (Rogan *et al.* 2018)	Summer/Winter 2015 Summer/Winter 2016	Visual aerial surveys	Offshore waters within and beyond Ireland's continental shelf
Welsh Marine Atlas (Baines and Evans 2012)	1990 – 2009	Aerial, vessel and land-based visual surveys	The coastline of Wales
Bottlenose dolphin monitoring in Cardigan Bay (Lohrengel *et al.* 2018)	2011 - 2016	Line transect surveys and photo-ID surveys	Cardigan Bay SAC and wider Cardigan Bay
JCP Phase III (Paxton *et al.* 2016)	1994 - 2010	Aerial, vessel and land-based surveys	UK waters
Harbour porpoise densities (Heinänen and Skov 2015)	1994 - 2011	Vessel and aerial surveys	UK waters
MERP maps (Waggitt *et al.* 2020)	1980 - 2018	Collation of data from JCP (aerial and vessel)	European Atlantic Waters
Seal at-sea density (Carter *et al.* 2020)	2005-2019	Density surface based on telemetry and count data	UK waters, Republic of Ireland
Seal pup counts (Wilkie and Zbijewska 2020)	1989 - 2019	Seal pup count data	Skomer Marine Conservation Zone (MCZ)

Data Source	Date	Summary	Coverage
Seal pup counts (Bull *et al.* 2017b)	1983-2015	Grey seal pup count data	Skomer, Wales
Seal pup counts (Bull *et al.* 2017a)	1993-2015	Grey seal pup count data	Marloes peninsula, Wales
Seal pup production (Lock *et al.* 2017)	1992-2015	Grey seal pup production	Skomer MCZ and Marloes peninsula, Wales
Seal pup production (Morgan *et al.* 2018)	2015-2016	Grey seal pup production	Ynys Dewi / Ramsey Island, Wales
Seal status (NRW 2018)	2017	Grey seal indicative condition assessment	Pembrokeshire Marine SAC
TURTLE database (Pierpoint and Penrose 2002)	2000-2020	Live and dead stranding data and at-sea sightings	UK waters, Republic of Ireland
INTERREG Irish Sea Leatherback Turtle Project (Houghton *et al.* 2006)	2003-2005	Aerial surveys and telemetry data	Irish Sea
Sea Trust Wales	Apr-Oct 2005-2021	Vessel based surveys (no effort)	Wider Pembrokeshire area

Limitations of Baseline Data

12.4.3.3 These data are limited by the lack of fine spatial and temporal scales surveyed, with many of the areas surveyed not directly overlapping with the array area. However, they do provide a good indication of the species present in the vicinity of the Project and are complimented by the site-specific surveys which provide a more contemporary estimate at both fine temporal and spatial scale.

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

12.4.3.5 Further details on any limitations to the assessment are provided in Section 12.4.11.

12.4.4 Site Visit/Surveys

12.4.4.1 Site-specific surveys were conducted by HiDef Aerial Surveying Limited to augment the desk-based data, in order to obtain more recent and robust density and abundance estimates for the key marine mammal species relevant to the Project. These surveys comprised high-resolution digital video aerial surveys for marine megafauna, ornithological and human activity over the proposed array area and 4 km buffer (HiDef Aerial Surveying Ltd 2020, 2021).

12.4.4.2 A total of 24 surveys have been completed, on a monthly basis from October 2019 to September 2021. These surveys were designed to follow transects 1 km apart across the Project site, including a 4 km buffer around the array area, comprising a total survey area of 200.11 km^2. Full details of the site-specific survey methodology used is presented in, Volume 3, Technical Appendix 12.1: Marine Mammal Technical Report.

12.4.5 Assessment of PTS

12.4.5.1 Exposure to loud sounds can lead to a reduction in hearing sensitivity (a shift in hearing threshold), which is generally restricted to particular frequencies. This threshold shift results from physical injury to the auditory system and may be temporary (TTS) or permanent (PTS). The PTS and TTS onset thresholds used in this assessment are those presented in Southall *et al.* (2019)Southall *et al.* (2019). The method used to calculate PTS-onset impact ranges for both 'instantaneous' PTS (SPL_{peak}), and 'cumulative' PTS (SEL_{cum}, over 24 hours) are detailed in Volume 3, Technical Appendix 12.2: Underwater Noise and Vibration Technical Report.

12.4.5.2 It is worth noting that, although measuring the same effect (PTS or TTS), the values given by the SPL_{peak} criteria and SEL_{cum} criteria are describing separate physical processes. The SPL_{peak} measures the instantaneous level at the loudest part of installation, when the maximum blow energy is being used. The SEL_{cum} measures the total sound received over the entire piling operation, including soft start and ramp up, and gives a starting range where a receptor fleeing from the noise source would have to be outside to avoid receiving the criterion level. In some cases this can result in a situation where the impact range from the single strike SPL_{peak} criterion is calculated to have greater impact ranges than the multiple strike SEL_{cum} criteria.

12.4.6 Assessment of TTS

12.4.6.1 The ranges that indicate TTS-onset were modelled and are presented in this impact assessment. However, as TTS-onset is defined primarily as a means of predicting PTS-onset, there is currently no threshold for TTS-onset that would indicate a biologically significant amount of TTS; therefore it was impossible to carry out a quantitative assessment of the magnitude or significance of the impact of TTS on marine mammals. The current set of TTS-onset threshold would result in a significant overestimate of the impact, due to the extremely large resulting impact ranges representing the smallest measurable amount of TTS.

12.4.7 Assessment of Disturbance

Unexploded Ordnance

12.4.7.1 The Project is seeking consent for one Unexploded Ordnance (UXO) detonation via deflagration (low-order). This is presented as the realistic worst case scenario throughout the Environmental Statement and has formed the basis of the assessment undertaken in Chapter 10: Fish and Shellfish Ecology and this chapter.

12.4.7.2 Deflagration (low-order) is the Projects preferred method for UXO clearance and based on current industry knowledge and precedent set by other offshore wind farms, e.g. Sofia Offshore Wind Farm (Sofia Offshore Wind Farm UXO Clearance Marine License Application (Sofia Offshore Wind Farm UXO Clearance Marine License Application, MLA/2020/00489; GoBe 2021), is considered the realistic worst case scenario.

12.4.7.3 In line with the recommendations outlined within the recent position statement on UXO clearance (Department for Environment Food & Rural Affairs *et al.* 2021), the impact assessment also includes an assessment for high-order detonations, though this is considered unlikely to occur in practice. High order UXO detonation, as an absolute worst case, has been modelled and reported in Volume 3, Technical Appendix 12.2: Underwater Noise and Vibration Technical Report and is presented in the impact assessment here for marine mammals. However, this has been considered for completeness and is not deemed realistic as the Project intends to employ deflagration (low-order) as the clearance method.

12.4.7.4 This approach is informed by the UXO Threat and Risk Assessment (6-Alpha Associates, 2020) completed to inform project specific geotechnical surveys, which provides an assessment of potential threat sources and the likelihood of contamination across the Project array area and export cable corridor. The Project is also cognisant of the recently consented Marine Licence for the Greenlink Interconnector and the UXO approach adopted for the cable route in Welsh waters, i.e. the same as proposed for the Project.

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

Low-order UXO clearance

12.4.7.6 There is no guidance available on which thresholds should be used to assess disturbance from low-order UXO clearance. Current risk assessments conducted to support UXO Marine Licence Applications that are including deflagration as the preferred method, are assuming an Effective Deterrence Range (EDR) of 5 km (e.g. Sofia offshore wind farm[5]). As a consequence, due to the absence of formal guidance, this approach has been adopted here for the assessment of disturbance from low-order detonation of UXOs at the Project.

High-order clearance

12.4.7.7 Since there is no dose-response function available that appropriately reflects the behavioural disturbance from UXO detonation, other behavioural disturbance thresholds have been considered instead.

12.4.7.8 There is guidance available on the EDR that should be applied to assess the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs in England, Wales & Northern Ireland (JNCC et al. 2020). This guidance advises that an effective deterrence range of 26 km around the source location is used to determine the impact area from UXO detonation with respect to disturbance of harbour porpoise in SACs.

[5] Sofia Offshore Wind Farm UXO Clearance Marine License Application (GoBe 2021) MLA/2020/00489

12.4.7.9 Some recent assessments of UXO clearance activities have used the TTS-onset threshold to indicate the level at which a 'fleeing' response may be expected to occur in marine mammals (e.g. Seagreen and Neart na Goithe). This is a result of discussion in Southall et al. (2007) which states that in the absence of empirical data on responses, the use of the TTS-onset threshold may be appropriate for single pulses (like UXO detonation)

12.4.7.10 In the absence of agreed thresholds to assess the potential for behaviour disturbance in marine mammals from UXO detonations, the impact assessment for high-order UXO clearance presents results for each of the following behavioural disturbance thresholds:

- 26 km EDR; and
- TTS-onset thresholds.

Pile driven anchors

12.4.7.11 The assessment of disturbance from pile driven anchors was based on the current best practice methodology, making use of the best available scientific evidence. This incorporates the application of a species-specific dose-response approach rather than a fixed behavioural threshold approach. Noise contours at 5 dB intervals were generated by noise modelling and were overlain on species density surfaces to predict the number of animals potentially disturbed. This allowed for the quantification of the number of animals that will potentially respond.

12.4.7.12 Compared with the EDR and fixed noise threshold approaches, the application of a dose-response curve allows for more realistic assumptions about animal response varying with dose, which is supported by a growing number of studies. A dose-response curve is used to quantify the probability of a response from an animal to a dose of a certain stimulus or stressor (Dunlop *et al.* 2017) and is based on the assumption that not all animals in an impact zone will respond. The dose can either be determined using the distance from the sound source or the received weighted or unweighted sound level at the receiver (Sinclair *et al.* 2021).

12.4.7.13 Using a species-specific dose-response approach rather than a fixed behavioural threshold to assess disturbance is currently considered to be the best practice methodology and the latest guidance provided in Southall *et al.* (2019) is that *"Apparent patterns in response as a function of received noise level (sound pressure level) highlighted a number of potential errors in using all-or-nothing "thresholds" to predict whether animals will respond. Tyack and Thomas (2019) subsequently and substantially expanded upon these observations. The clearly evident variability in response is likely attributable to a host of contextual factors, which emphasizes the importance of estimating not only a dose-response function but also characterizing response variability at any dosage"*.

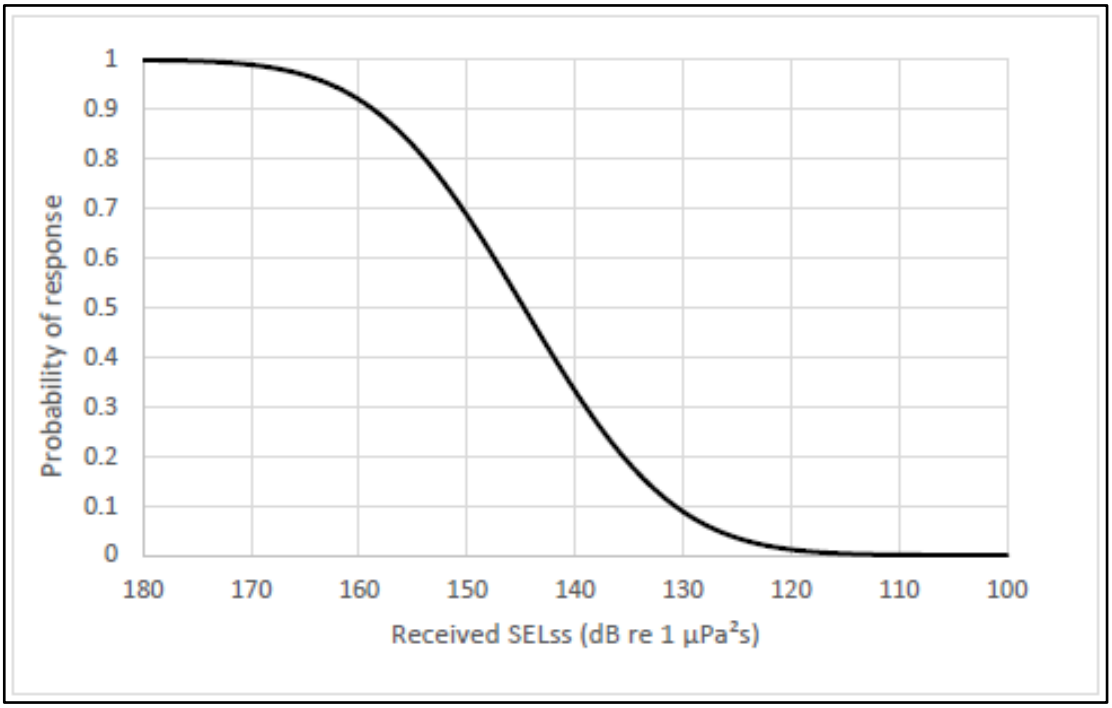
Harbour porpoise dose-response curve

12.4.7.14 The harbour porpoise response to piling at the Project is likely to be similar to that at the Beatrice Offshore Windfarm, given the similarity in the types of piles installed: Beatrice installed 2.2 m diameter, up to 60 m long steel piles, with a hammer energy of between 167-1,048 kJ, while the Project intends to install 2.5 m diameter, up to 55 m long steel piles, with a hammer energy of up to 800 kJ.

12.4.7.15 Therefore, to estimate the number of porpoise predicted to experience behavioural disturbance as a result of pile driving, this impact assessment uses the porpoise dose-response curve presented in Graham *et al.* (2017a) (Graphic 12.1).

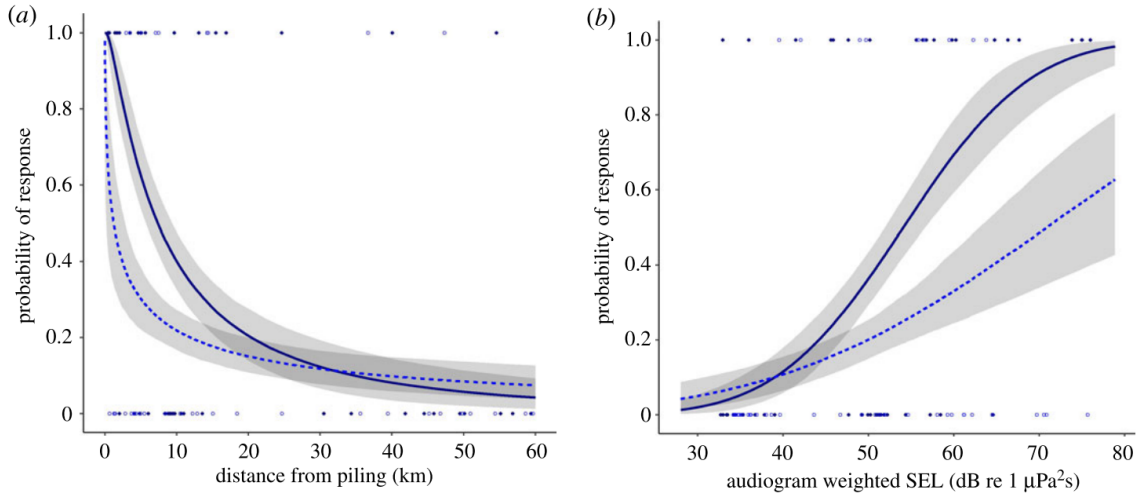
12.4.7.16 The Graham *et al.* (2017a) dose-response curve was developed using data on harbour porpoise collected during the first six weeks of piling during Phase 1 of the Beatrice Offshore Wind Farm monitoring program. Changes in porpoise occurrence (detection positive hours per day) were estimated using 47 CPODs[6] placed around the wind farm site during piling and compared with baseline data from 12 sites outside of the wind farm area prior to the commencement of operations, to characterise this variation in occurrence. Porpoise were considered to have exhibited a behavioural response to piling when the proportional decrease in occurrence was greater than 0.5. The probability that porpoise occurrence did or did not show a response to piling was modelled along with the received single-pulse sound exposure levels piling source levels based on the received noise levels (Graham *et al.* 2017a).

12.4.7.17 Since the initial development of the dose-response curve in 2017, additional data from the remaining pile driving events at Beatrice Offshore Windfarm have been processed and are presented in Graham et al. (2019). The passive acoustic monitoring showed a 50% probability of porpoise response (a significant reduction in detection relative to baseline) within 7.4 km at the first location piled, with decreasing response levels over the construction period to a 50% probability of response within 1.3 km by the final piling location (Graphic 12.2) (Graham et al., 2019). Therefore, using the dose-response curve derived from the initial piling events for all piling events in the impact assessment is precautionary, as evidence shows that porpoise response is likely to diminish over the construction period.



Graphic 12.1 Relationship between the proportion of animals responding and the received single strike SEL (SELss), based on passive acoustic monitoring results obtained during Phase 1 of the Beatrice Offshore Wind Farm monitoring program (Graham *et al*., 2017a)

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



Graphic 12.2 The probability of a harbour porpoise response (24 h) in relation to the partial contribution of (a) distance from piling and (b) audiogram-weighted received single-pulse SEL for the first location piled (solid navy line) and the final location piled (dashed blue line). Obtained from Graham *et al.* (2019)

Predicted assuming the number of AIS vessel locations within 1 km ¼ 0; confidence intervals (shaded areas) estimated for uncertainty in fixed effects only. Harbour porpoise occurrence was considered to have responded to piling when the proportional decrease in occurrence (DPH) exceeded a threshold of 0.5. Points show actual response data for the first location piled (filled navy circles) and the final location piled (open blue circles).

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

12.4.7.19 Various studies have shown that other cetacean species show comparatively less of a disturbance response from underwater noise compared with harbour porpoise. For example, through an analysis of 16 years' of marine mammal observer data from seismic survey vessels, Stone *et al.* (2017) found a significant reduction in porpoise detection rates when large seismic airgun arrays were actively firing, but not for bottlenose dolphins. While the strength and significance of responses varied between porpoise and other dolphin species for different measures of effect, the study emphasised the sensitivity of the harbour porpoise (Stone *et al.* 2017).

12.4.7.20 In the Moray Firth, bottlenose dolphins have been shown to remain in the impacted area during both seismic activities and pile installation activities (Fernandez-Betelu *et al.* 2021) which highlights a lack of complete displacement response. Likewise, other high-frequency cetacean species, such as striped and common dolphins, have been shown to display less of a response to underwater noise signals and construction-related activities compared with harbour porpoise (e.g. Kastelein *et al.* 2006, Culloch *et al.* 2016).

12.4.7.21 There is simply no disturbance threshold (effective disturbance range or dose-response curve) for any other cetacean species included in this assessment. Therefore, in the complete absence of an alternative, the assessment for all cetacean species has used the porpoise dose-response curve. This is considered to be highly precautionary and as such the number of animals predicted to experience behavioural disturbance is considered to be a large over-estimate and should be interpreted with a large degree of caution.

Harbour seal dose-response curve

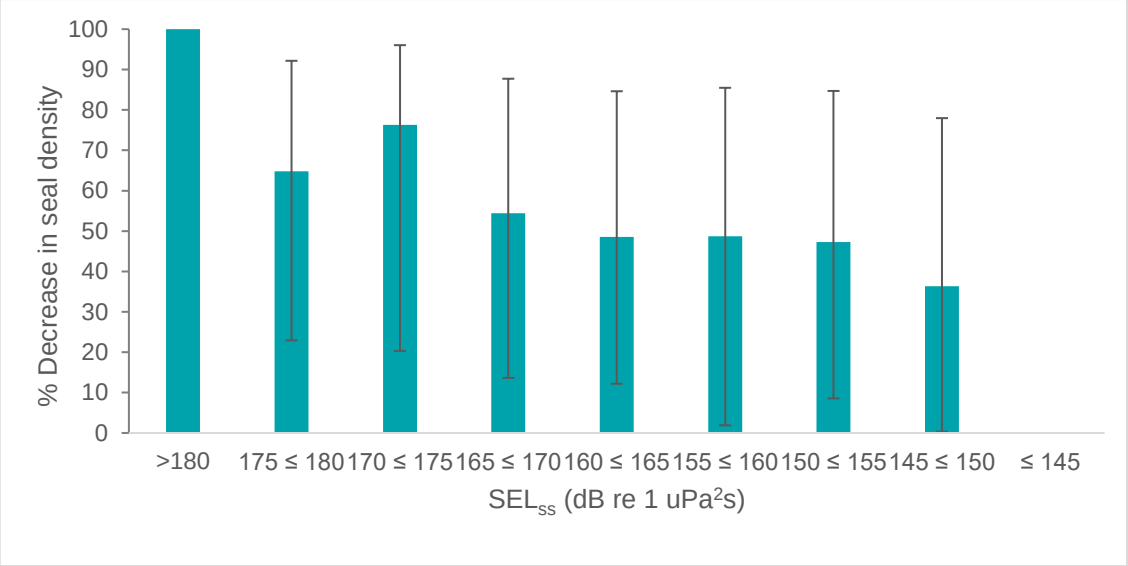
12.4.7.22 For grey seals, the dose-response curve adopted was based on the data presented in Whyte *et al.* (2020) (Graphic 12.3).

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

12.4.7.24 In the Whyte *et al.* (2020) dose-response curve it has been assumed that all seals are displaced at sound exposure levels above 180 dB re 1 μPa^2s. This is a conservative assumption since there were no data presented in the study for harbour seal responses at this level. It is also important to note that the percentage decrease in response in the categories 170≤175 and 175≤180 dB re 1 μPa^2s is slightly anomalous (higher response at a lower sound exposure level) due to the small number of spatial cells included in the analysis for these categories (n= 2 and 3 respectively).

12.4.7.25 Given the large confidence intervals on the data, this assessment presents the mean number of seals predicted to be disturbed alongside the 95% Confidence intervals, for context.

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



Graphic 12.3 Predicted decrease in seal density as a function of estimated sound exposure level, error bars show 95% Confidence Interval (from Whyte *et al.* 2020)

Other construction activities

12.4.7.27 There is currently no guidance on the thresholds to be used to assess disturbance of marine mammals from drilling, dredging or vessel activity. Therefore, the Project impact assessment provides a qualitative assessment for these impacts. The assessment is based on the limited evidence that is available in the existing literature for that impact pathway and species combination, where available.

12.4.8 Assessment of Potential Effect Significance

12.4.8.1 The criteria for determining the significance of effects is a two-stage process that involves defining the sensitivity of the receptors and the magnitude of the impact. This section describes the criteria applied in this chapter to assign values to the sensitivity of receptors (Table 12.5) and the magnitude of potential impacts (Table 12.6).

12.4.8.2 Please note, the definitions for magnitude and sensitivity used in this chapter differ from those presented in Chapter 2: Overview of EIA Methodology as they have been developed by SMRU Consulting specifically for marine mammals, based on experience with marine mammal impact assessments over the last few years. Both sensitivity and magnitude are assessed on a 4-level scale to align with the guidance: High, Medium, Low and Negligible (see Chapter 2: Overview of EIA Methodology).

12.4.8.3 Information about the Project and the project activities for all stages of the Project life cycle (construction, O&M and decommissioning) have been combined with information about the environmental baseline to identify the potential interactions between the Project and the environment, known as potential impacts. The potential impacts are then assessed to give a level of significance of effect upon the receiving environment/receptors.

12.4.8.4 The outcome of the assessment is to determine the significance of these effects against predetermined criteria (Table 12.7).

Sensitivity

12.4.8.5 The sensitivity of a marine mammal receptor is defined by both its potential vulnerability to an impact from the proposed development, its recoverability, and the value or importance of the receptor. The criteria for defining marine mammal sensitivity in this chapter are outlined in Table 12.5.

Table 12.5 – Sensitivity Levels for Marine Mammal Receptors

Sensitivity	Description
High	No ability to adapt behaviour so that individual vital rates (survival and reproduction) are highly likely to be significantly affected. No tolerance – effect will cause a significant change in individual vital rates (survival and reproduction). No ability for the animal to recover from any impact on vital rates (reproduction and survival rates).
Medium	Limited ability to adapt behaviour so that individual vital rates (survival and reproduction) may be significantly affected. Limited tolerance – effect may cause a significant change in individual vital rates (survival and reproduction). Limited ability for the animal to recover from any impact on vital rates (reproduction and survival rates).
Low	Ability to adapt behaviour so that individual vital rates (survival and reproduction) may be affected, but not at a significant level. Some tolerance – no significant change in individual vital rates (survival and reproduction). Ability for the animal to recover from any impact on vital rates (reproduction and survival rates).
Negligible	Receptor is able to adapt behaviour so that individual vital rates (survival and reproduction) are not affected. Receptor is able to tolerate the effect without any impact on individual vital rates (survival and reproduction). Receptor is able to return to previous behavioural states/activities once the impact has ceased.

Magnitude

12.4.8.6 The magnitude of potential impacts on a marine mammal receptor is defined by a series of factors including the spatial extent of any interaction, the likelihood, duration, frequency and reversibility of a potential impact. The criteria for defining magnitude in this chapter are outlined in Table 12.6).

Table 12.6 – Magnitude Levels for Marine Mammal Receptors

Magnitude	Description
High	The impact would affect the behaviour and distribution of sufficient numbers of individuals, with sufficient severity, to affect the favourable conservation status and/or the long-term viability of the population at a generational scale (Adverse).
Medium	Temporary changes in behaviour and/or distribution of individuals at a scale that would result in potential reductions to lifetime reproductive success to some individuals, although not enough to affect the population trajectory over a generational scale. Permanent effects on individuals that may influence individual survival but not at a level that would alter population trajectory over a generational scale (Adverse).
Low	Short-term and/or intermittent and temporary behavioural effects in a small proportion of the population. Reproductive rates of individuals may be impacted in the short term (over a limited number of breeding cycles). Survival and reproductive rates very unlikely to be impacted to the extent that the population trajectory would be altered (Adverse).
Negligible	Very short term, recoverable effect on the behaviour and/or distribution in a very small proportion of the population. No potential for any changes in the individual reproductive success or survival, therefore no changes to the population size or trajectory (Adverse).

Significance of Effect

12.4.8.7 The significance of the effect upon marine mammals is determined by correlating the magnitude of the impact and the sensitivity of the receptor, as presented in Table 12.7. On this basis potential impacts are assessed as of negligible, minor, moderate and major significance (definitions are provided in Chapter 2: Overview of EIA Methodology).

12.4.8.8 For the purposes of this assessment, any effects with a significance level of major and/or moderate have been deemed significant in EIA terms, while those of minor or negligible are deemed non-significant.

Table 12.7 – Effect Significance Matrix

		Sensitivity			
		High	**Medium**	**Low**	**Negligible**
Magnitude	**High**	Major	Major	Moderate	Minor
	Medium	Major	Moderate	Minor	Minor
	Low	Moderate	Minor	Minor	Negligible
	Negligible	Minor	Minor	Negligible	Negligible

Sensitivity to PTS

12.4.8.9 The ecological consequences of PTS for marine mammals are uncertain. At a Department for Business, Energy & Industrial Strategy (BEIS) funded expert elicitation workshop held at the University of St Andrews (March 2018), experts in marine mammal hearing discussed the nature, extent and potential consequence of PTS to UK marine mammal species (Booth and Heinis 2018). This workshop outlined and collated the best and most recent empirical data available on the effects of PTS on marine mammals. A number of general points came out in discussions as part of the elicitation. These included that PTS did not mean animals were deaf, that the limitations of the ambient noise environment should be considered, and that the magnitude and frequency band in which PTS occurs are critical to assessing the effect on vital rates.

12.4.8.10 Southall *et al.* (2007) defined the onset of PTS as a non-recoverable elevation of the hearing threshold of 6 dB. Based upon TTS growth rates obtained from the scientific literature, it has been assumed that the onset of PTS occurs after TTS has grown to 40 dB. The growth rate of TTS is dependent on the frequency of exposure, but is nevertheless assumed to occur as a function of an exposure that results in 40 dB of TTS, i.e. 40 dB of TTS is assumed to equate to 6 dB of PTS.

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

- *Overall experts indicated that the effects of a 6 dB PTS in the 2-10 kHz band was unlikely to have a large effect on survival or fertility of the species of interest;*
- *Effects were considered to be smallest for porpoises and seals and slightly larger in bottlenose dolphins, though experts noted that the broader range of plausible outcomes for dolphins was due to potential uncertainty in how the defined PTS would impact dolphins (which use lower frequency for communications and for some foraging calls), not necessarily that they were definitely more sensitive; and*

- *It should be noted, however, that for all species experts indicated that the most likely predicted effect on survival or fertility as a result of 6 dB PTS was likely to be very small (i.e. <5 % reduction in survival or fertility)*.

12.4.8.12 The probability distributions for the expected reduction in vital rates are presented in Table 12.8. While the results of the expert elicitation acknowledges that PTS-onset could result in changes to survival and fertility rates, the expected decline in these vital rates is so low that it is not considered to be significant for the individual.

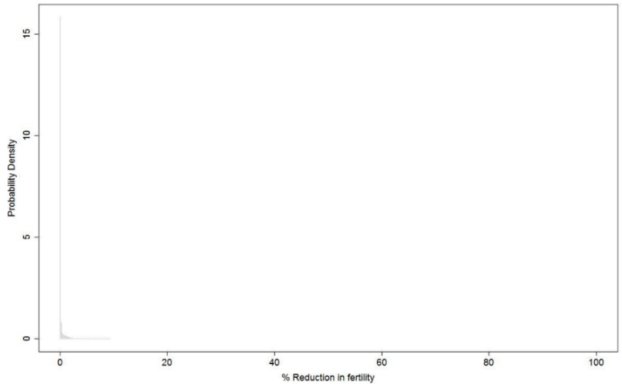
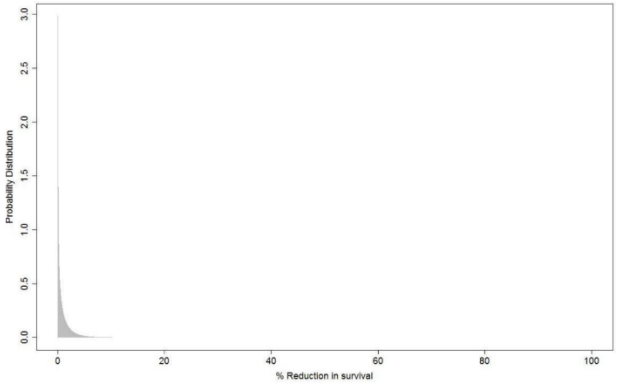
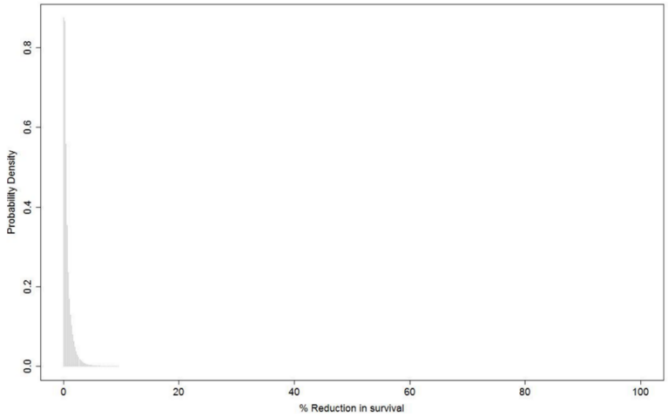
12.4.8.13 Minke whales were not included in the expert elicitation. However, it is considered that the low frequency noise produced during piling may be more likely to overlap with the hearing range of low frequency cetacean species such as minke whales. For minke whales, Tubelli et al. (2012) estimated the most sensitive hearing range as the region with thresholds within 40 dB of best sensitivity, to extend from 30 to 100 Hz up to 7.5 to 25 kHz, depending on the specific model used. Therefore a 2 10 kHz notch of 6 dB will only affect a small region of minke whale hearing.

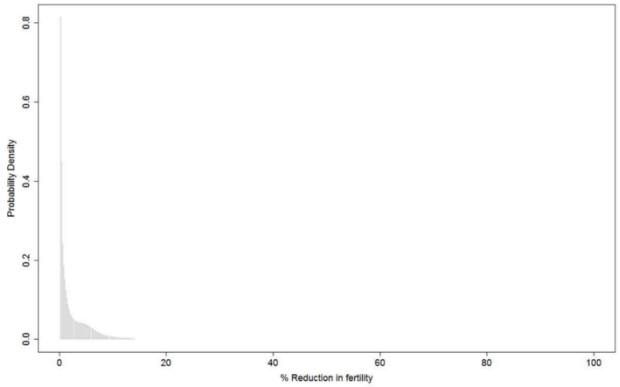
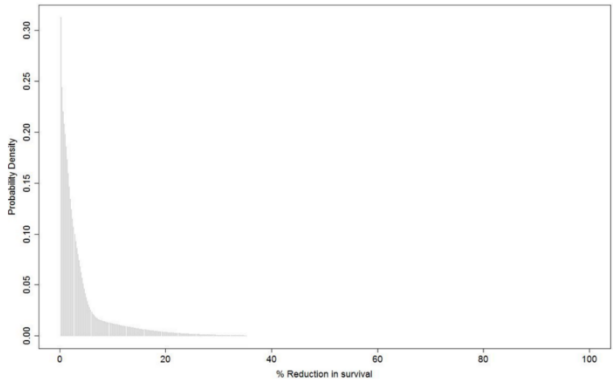
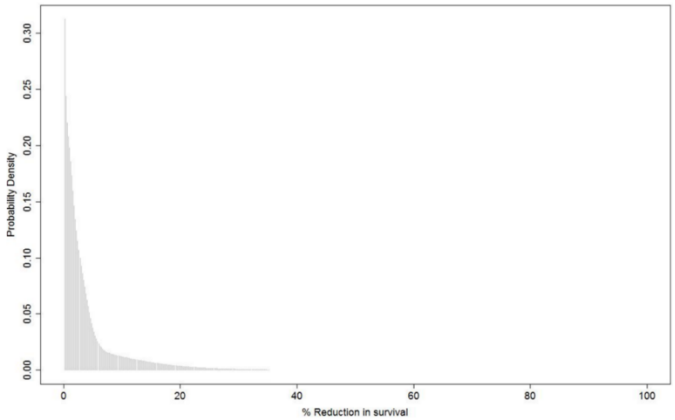
12.4.8.14 In addition, minke whale communication signals have been demonstrated to be below 2 kHz (Edds-Walton 2000, Mellinger et al. 2000, Gedamke et al. 2001, Risch et al. 2013, Risch et al. 2014). Like other mysticete whales, minke whales are also thought to be capable of hearing sounds through their skull bones (Cranford and Krysl 2015). Therefore, it is still expected that a PTS-onset at such a small region of the hearing range in unlikely to significantly effect individual vital rates.

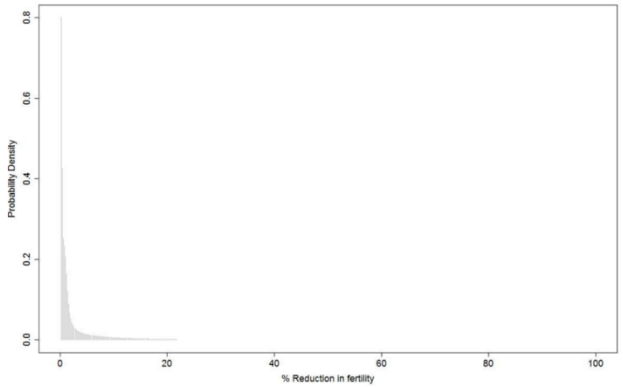
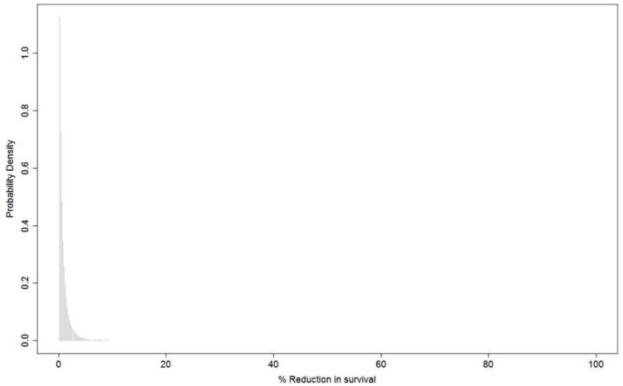
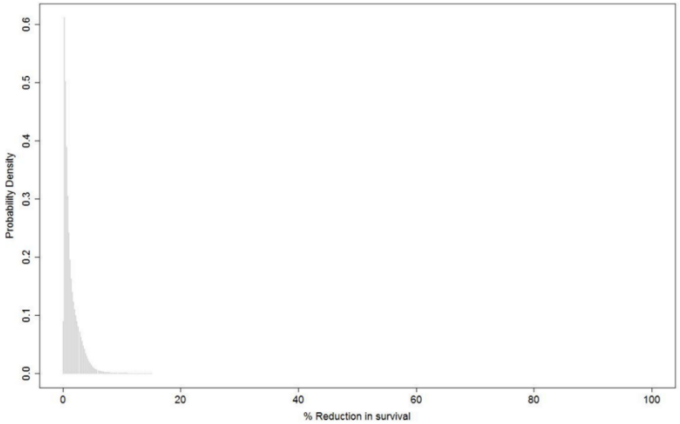
12.4.8.15 When considering the potential effects of PTS-onset, it is important to consider that data collected during wind farm construction have demonstrated that porpoise detections around the pile driving site decline several hours prior to the start of pile driving, and it is assumed that this is due to the increase in other construction related activities and vessel presence in advance of the actual pile driving (Brandt et al. 2018, Graham et al. 2019, Benhemma-Le Gall et al. 2020). Therefore, the presence of construction related vessels prior to the start of piling can act as a local scale deterrent and, therefore, reduce the risk of auditory injury. Assumptions that animals are present in the vicinity of the pile driving at the start of the soft start are therefore likely to be overly conservative.

12.4.8.16 In conclusion, given the results of the expert elicitation, which combined our best knowledge on the effects of PTS-onset on marine mammals, the sensitivity of all marine mammal species to PTS-onset is considered to be Low, whereby individual vital rates (survival and reproduction) may be affected, but not at a significant level.

Table 12.8 Summary of the results of the expert elicitation on the effects of a 6 dB of PTS within a 2-10 kHz band (Booth and Heinis 2018)

	Fertility	**Survival – mature females**	**Survival – calves/juveniles**
Harbour porpoise	Experts estimated that the median decline in an individual mature female harbour porpoise's fertility was 0.09%.  Probability distribution showing the consensus distribution for the effects on fertility of a mature female harbour porpoise as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band.	Experts estimated that the median decline in an individual mature female harbour porpoise's survival was 0.01%.  Probability distribution showing the consensus distribution for the effects on survival of a mature female harbour porpoise as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band	Experts estimated that the median decline in an individual harbour porpoise juvenile or dependent calf survival was 0.18%.  Probability distribution showing the consensus distribution for the effects on survival of juvenile or dependent calf harbour porpoise as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band.

Bottlenose dolphins	Experts estimated that the median decline in an individual mature female bottlenose dolphin's fertility was 0.43%.  Probability distribution showing the consensus distribution for the effects on fertility of mature female bottlenose dolphin as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band.	Experts estimated that the median decline in an individual mature female bottlenose dolphin's survival was 1.6%.  Probability distribution showing the consensus distribution for the effects on survival of mature female bottlenose dolphin as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band.	Experts estimated that the median decline in an individual bottlenose dolphin juvenile survival was 1.32%. Experts estimated that the median decline in an individual bottlenose dolphin dependent calf survival was 2.96%.  Probability distribution showing the consensus distribution for the effects on survival of juvenile or dependent calf bottlenose dolphin as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band.

Harbour & grey seals	Experts estimated that the median decline in an individual mature female seal's fertility was 0.27%.  Probability distribution showing the consensus distribution for the effects on fertility of a mature female (harbour or grey) seal as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band.	Experts estimated that the median decline in an individual mature female seal's survival was 0.39%.  Probability distribution showing the consensus distribution for the effects on survival of a mature female (harbour or grey) seal as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band.	Experts estimated that the median decline in an individual seal pup/juvenile survival was 0.52%.  Probability distribution showing the consensus distribution for the effects on survival of juvenile or dependent pup (harbour or grey) seal as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band.

Dolphin sensitivity to pile driving disturbance

12.4.8.17 The hearing range of common dolphins is currently estimated from their sound production, and has been labelled medium-high frequency, spanning between 150 Hz to 160 kHz (Finneran 2016, Houser *et al.* 2017). There are few studies investigating the effects of pile driving on common dolphins, which could relate to their occupation of deeper waters, contrasting with the shallower habitat in which offshore construction frequently occurs. However, an analysis of pile driving activity in Broadhaven Bay, Ireland, found construction activity to be associated with a reduction in the presence of minke whales and harbour porpoise, but not with common dolphins (Culloch *et al.* 2016).

12.4.8.18 Conversely, increased vessel presence during the construction period was associated with a decrease of common dolphins in the surrounding area. While there is little information on the impacts of pile driving on common dolphins, there are a few studies documenting the impacts of seismic activity. Although the noise produced by airguns differs in its duration and cumulative acoustic energy levels, it may be similar in its frequency range to the low-frequency noise produced by pile driving. In general, there is contrasting evidence for the response of common dolphins to seismic surveys. While some research indicates no change in the occurrence or sighting density of common dolphins when exposed to seismic activity (Stone *et al.* 2017, Kavanagh *et al.* 2019), Goold (1996) found a reduction in common dolphin presence within 1 km of ongoing seismic surveys near Pembrokeshire.

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

12.4.8.20 Bottlenose dolphins have been shown to be displaced from an area as a result of the noise produced by offshore construction activities; for example, avoidance behaviour in bottlenose dolphins has been shown in relation to dredging activities, piling and seismic surveys (Pirotta *et al.* 2013, Graham *et al.* 2017b, Fernandez-Betelu *et al.* 2021). In a study on bottlenose dolphins in the Moray Firth (in relation to the construction of the Nigg Energy Park in the Cromarty Firth), small effects of pile driving on dolphin presence have been observed, however, dolphins were not excluded from the vicinity of the piling activities (Graham *et al.* 2017b). In this study the median peak-to-peak source levels recorded during impact piling were estimated to be 240 dB re 1µPa (range 8 dB) with a single pulse source level of 198 dB re 1 μPa^2s.

12.4.8.21 The pile driving resulted in a slight reduction of the presence, detection positive hours and the encounter duration for dolphins within the Cromarty Firth; however, this response was only significant for the encounter durations. Encounter durations decreased within the Cromarty Firth (though only by a few minutes) and increased outside of the Cromarty Firth on days of piling activity. These data highlight a small spatial and temporal scale disturbance to bottlenose dolphins as a result of impact piling activities.

12.4.8.22 Further recent studies of bottlenose dolphins at two locations in the Moray Firth during seismic activity and piling was conducted by Fernandez-Betelu *et al.* (2021), at a medium to small temporal scale using Before and After Control Impact (BACI) analysis. Predicted maximum received noise levels (unweighted single pulse SEL) during activities were 141 dB re1 μPa^2s

12.4.8.23 At the smaller temporal scale, BACI analysis actually showed a short-term increase in dolphin detections at one location, in line with previous studies that found that behavioural alterations due to noise exposure last less than a day. At the medium temporal scale, the results were inconsistent between offshore activities. This suggested that the effect of impulsive noise was less important in affecting the occurrence of dolphins in the study area than natural drivers such as prey abundance and oceanographic processes, meaning there was no significant disturbance. The study did, however, suggest that distant impulsive noise may cause modifications to bottlenose dolphin vocalisation which has the potential to affect foraging and individual vital rates (Fernandez-Betelu *et al.* 2021), indicating disturbance could occur over the wider area.

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

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

Porpoise sensitivity to pile driving disturbance

12.4.8.26 Previous studies have shown that harbour porpoises are displaced from the vicinity of piling events. For example, studies at wind farms in the German North Sea have recorded large declines in porpoise detections close to the piling (>90% decline at noise levels above 170 dB) with decreasing effect with increasing distance from the pile (25% decline at noise levels between 145 and 150 dB) (Brandt *et al.* 2016). The detection rates revealed that porpoise were only displaced from the piling area in the short term (1 to 3 days) (Brandt *et al.* 2011, Dähne *et al.* 2013, Brandt *et al.* 2016, Brandt *et al.* 2018). Harbour porpoise are small cetaceans which makes them vulnerable to heat loss and requires them to maintain a high metabolic rate with little energy remaining for fat storage (e.g. Rojano-Doñate *et al.* 2018). This makes them vulnerable to starvation if they are unable to obtain sufficient levels of prey intake.

12.4.8.27 Studies using Digital Acoustic Recording Tags (DTAGs) have shown that porpoise tagged after capture in pound nets foraged on small prey nearly continuously during both the day and the night on their release (Wisniewska *et al.* 2016). However, Hoekendijk *et al.* (2018) point out that this could be an extreme short term response to capture in nets, and may not reflect natural harbour porpoise behaviour. Nevertheless, if the foraging efficiency of harbour porpoise is disturbed, or if they are displaced from a high-quality foraging ground, and are unable to find suitable alternative feeding grounds, they could potentially be at risk of changes to their overall fitness, if they are not able to compensate and obtain sufficient food intake in order to meet their metabolic demands.

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

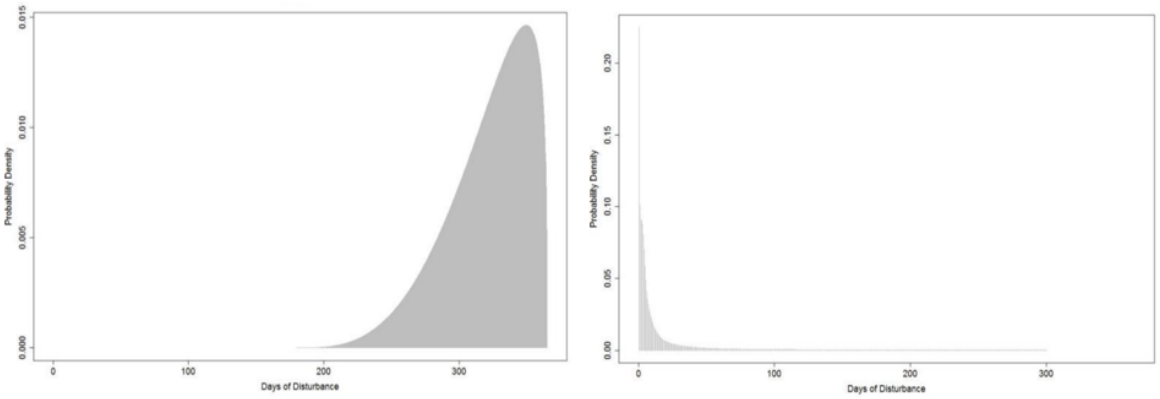
12.4.8.29 Monitoring of harbour porpoise activity at the Beatrice Offshore Wind Farm during pile driving activity has indicated that porpoises were displaced from the immediate vicinity of the pile driving activity – with a 50% probability of response occurring at approximately 7 km (Graham *et al.*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

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

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

12.4.8.32 The expert consensus was that first year calf survival (post-weaning) and fertility were the most likely vital rates to be affected by disturbance, but that juvenile and adult survival were unlikely to be significantly affected as these life-stages were considered to be more robust. There was also consensus that the final third of the year was the most critical for harbour porpoises as they reach the end of the current lactation period and the start of new pregnancies, therefore it was thought that significant impacts on fertility would only occur when animals received repeated exposure throughout the whole year. Experts agreed it would likely take high levels of repeated disturbance to an individual before there was any effect on that individual's fertility (Graphic 12.4 left), and that it was very unlikely an animal would terminate a pregnancy early.

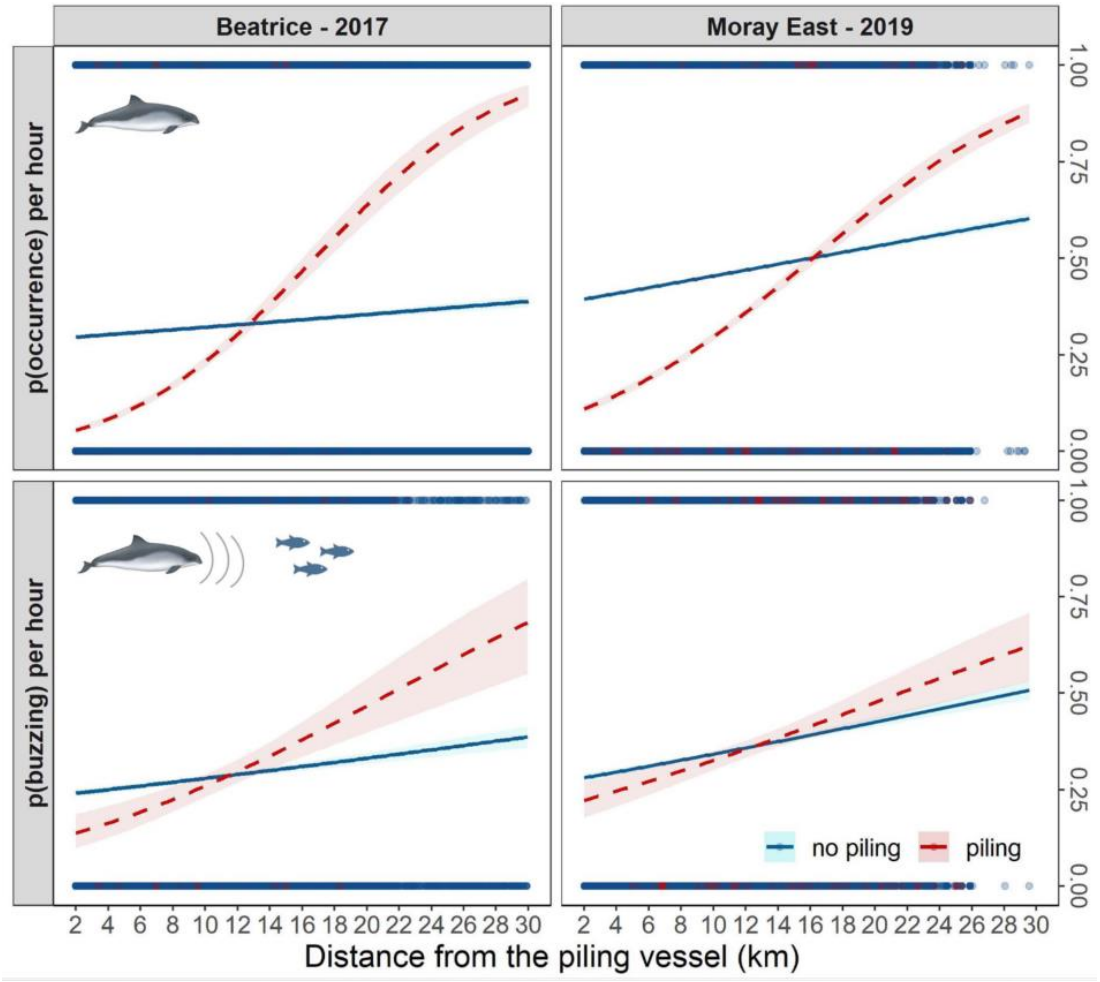
12.4.8.33 The experts agreed that calf survival could be reduced by only a few days of repeated disturbance to a mother/calf pair during early lactation (Graphic 12.4 right); however, it is highly unlikely that the same mother-calf pair would repeatedly return to the area in order to receive these levels of repeated disturbance.



Graphic 12.4 Probability distributions showing the consensus of the expert elicitation for harbour porpoise disturbance from piling (Booth *et al.* 2019)

Left: the number of days of disturbance (i.e. days on which an animal does not feed for six hours) a pregnant female could 'tolerate' before it has any effect on fertility. Right: the number of days of disturbance (of six hours zero energy intake) a mother/calf pair could 'tolerate' before it has any effect on survival.

12.4.8.34 A recent study by Benhemma-Le Gall *et al.* (2021) provided two key findings in relation to harbour porpoise response to pile driving. Porpoise were not completely displaced from the piling site: detections of clicks (echolocation) and buzzing (associated with prey capture) in the short-range (2 km) did not cease in response to pile driving, and porpoise appeared to compensate: detections of both clicks (echolocation) and buzzing (associated with prey capture) increased above baseline levels with increasing distance from the pile, which suggests that those porpoise that are displaced from the near-field, compensate by increasing foraging activities beyond the impact range (Graphic 12.5). Therefore, porpoise that experience displacement are expected to be able to compensate for the lost foraging opportunities and increased energy expenditure of fleeing.



Graphic 12.5 The probability of harbour porpoise occurrence and buzzing activity per hour during (dashed red line) and out with (blue line) pile-driving hours, in relation to distance from the pile-driving vessel at Beatrice (left) and Moray East (right). Obtained from Benhemma-Le Gall *et al.* (2021)

12.4.8.35 While much of the evidence base included within this section is from studies of animals in the North Sea, it is expected that harbour porpoise in the Irish and Celtic Seas would respond in a similar way and, therefore, the data are considered to be applicable.

12.4.8.36 While experts considered there to be the potential for effects on adult fertility, it is expected that individuals are expected to be able to compensate for temporary displacement. Therefore, harbour porpoise have been assessed as having a Low sensitivity to disturbance and resulting displacement from foraging grounds (Ability to adapt behaviour so that individual vital rates (survival and reproduction) may be affected, but not at a significant level).

Minke whale sensitivity to pile driving disturbance

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

12.4.8.38 Since minke whales are known to forage in UK waters in the summer months, there is the potential for displacement to impact on reproductive rates. Due to their large size and capacity for energy storage, it is expected that minke whales will be able to tolerate temporary displacement from foraging areas much better than harbour porpoise. Therefore, it has been assumed that minke whales have a Low sensitivity to disturbance from pile driving.

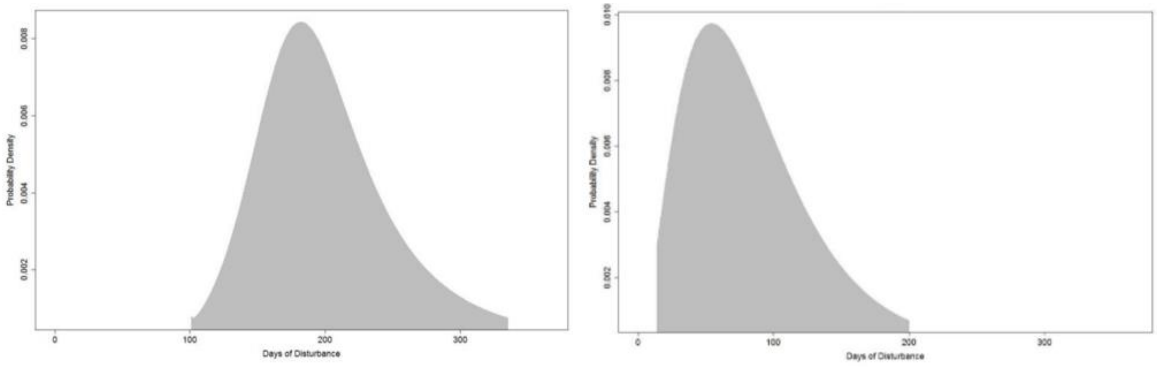
Grey seal sensitivity to pile driving disturbance

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

12.4.8.40 The expert elicitation workshop in Amsterdam in 2018, (Booth *et al.* 2019) concluded that grey seals were considered to have a reasonable ability to compensate for lost foraging opportunities due to their generalist diet, mobility, life history and adequate fat stores, and that the survival of 'weaned of the year' animals, and fertility, were determined to be most sensitive parameters to disturbance (i.e. reduced energy intake). However, in general, experts agreed that grey seals would be much more robust than harbour seals to the effects of disturbance, due to their larger energy stores and more generalist and adaptable foraging strategies. It was agreed that grey seals would require moderate-high levels of repeated disturbance before there was any effect on fertility rates to reduce fertility (Graphic 12.6 left). The 'weaned of the year' were considered to be most vulnerable following the post-weaning fast, and that during this time it might take ~60 days of repeated disturbance before there was expected to be any effect on 'weaned-of-the-year' survival (Graphic 12.6 right), however there was a lot of uncertainty surrounding this estimate.

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

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



Graphic 12.6 Probability distributions showing the consensus of the expert elicitation for grey seal disturbance from piling (Booth *et al.* 2019)

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

Dolphin sensitivity to vessels

12.4.8.43 Relatively few studies document the impacts of marine construction or investigation on common dolphins, but there is some evidence of the impacts of vessel traffic and boat noise on common dolphins. While the direct impacts of vessel noise on common dolphins are rather under-researched, the presence of vessel activity has been found to alter their behavioural states and has been linked to disturbance. In New Zealand, Markov chain models were used to assess the impacts of tourism on the behaviour of common dolphins. Foraging and resting bouts were significantly disrupted by boat interactions, with less time spent in these states. In addition, post-disturbance activity indicated a shift from foraging states to milling and socialising and returns to foraging took significantly longer (Stockin *et al.* 2008, Meissner *et al.* 2015). While the aforementioned studies relate to short term impacts, a long-term study of common dolphins in the waters around Ischia island, Italy, found declines that could have resulted from a combination of habitat degradation and disturbance from increasing traffic.

12.4.8.44 The surrounding area has been listed as one of the noisiest in the Mediterranean due to a range of marine traffic, commercial and seismic surveys, and drilling activity (Mussi *et al.* 2019). Conversely, some research suggests that common dolphins may be altering their communication to compensate for high levels of anthropogenic noise.

12.4.8.45 It has been suggested that a difference in the frequency of whistles between two populations of common dolphins, one in the Celtic sea, and one in the English Channel, may reflect a shift in acoustic characteristics to counter masking caused by high levels of vessel traffic in the latter location (Ansmann *et al.* 2007). Recently, for both Atlantic spotted dolphins and short-beaked common dolphins, the presence of high noise levels was associated with an increase in the maximum whistle frequency, indicating vocal compensation for potential masking in a noisy environment (Papale *et al.* 2015).

12.4.8.46 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 likely to be rapid recovery from disturbance from vessel presence and vessel noise, as they recorded little pre-emptive disturbance or recovery time following disturbance. There is evidence of bottlenose dolphin habituation to boat traffic, particularly in relation to larger vessel types (Sini *et al.* 2005). Lusseau *et al.* (2011) undertook a modelling study which predicted that increased vessel movements associated with offshore wind development in the Moray Firth did not have a negative effect on the local population of bottlenose dolphin. They hypothesise that this was because most of the vessels were commercial ones, which have more predictable patterns of movement than recreational vessels; and are, thus, less likely to disrupt the feeding behaviour of dolphins than recreational or tourist activity.

12.4.8.47 Therefore, both common and bottlenose dolphins have been assumed as having a Low sensitivity to disturbance from vessels.

Porpoise sensitivity to vessels

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

12.4.8.49 Data collected during windfarm construction have demonstrated that porpoise detections around the pile driving site decline several hours prior to the start of pile driving, and it is assumed that this is due to the increase in other construction related activities and vessel presence in advance of the actual pile driving (Brandt *et al.* 2018, Benhemma-Le Gall *et al.* 2021). Porpoise displacement has been observed up to 4 km from construction vessels (Benhemma-Le Gall *et al.* 2021).

12.4.8.50 Studies also found that during periods of no piling during Moray East and Beatrice windfarm construction that buzz inter-click intervals were up to 22.7% lower in closer proximity to piling vessels (Benhemma-Le Gall *et al.* 2021) indicating a decrease in porpoise activity near the vessels. Therefore, because the dose-response relationships relating displacement to piling are based on data collected over periods including such vessel activity, these local responses to novel activity such as pile driving vessels have effectively already been included in the assessment of underwater noise related to pile driving above. The presence of construction related vessels prior to the start of piling may actually act as a local scale deterrent for harbour porpoise, thereby reducing the risk of auditory injury. Assumptions that harbour porpoise are present in the vicinity of the pile driving at the start of the soft start are therefore likely to be overly conservative.

12.4.8.51 Land-based surveys in Swansea Bay, Wales, found a significant correlation between porpoise sightings and the number of vessels present, with 26% of the interactions considered to be negative (moving away or prolonged dives), occurring within distances of up to 1 km between the animal and the vessel. The type of vessel was relevant, as smaller motorised boats (jet-ski, speed boat, small fishing vessels), were associated with more negative behaviours than larger ships (Oakley *et al.* 2017).

12.4.8.52 Heinänen and Skov (2015) suggested that harbour porpoise density was significantly lower in areas with vessel transit rates of greater than 20,000 ships/year (80 per day).

12.4.8.53 Therefore, harbour porpoise are assessed as having a Low sensitivity to disturbance from vessels.

Minke whale sensitivity to vessels

12.4.8.54 There is limited information available on the responses of minke whales to vessels. Whale watching vessels that specifically target minke whales have been shown to cause behavioural responses in minke whales and repeated exposure can result in a decrease in foraging activity (Christiansen *et al.* 2013). However, these are vessels which specifically target and follow minke whales, so it is unknown whether minke whales respond to more general ship traffic. Due to their large size and capacity for energy storage, it is expected that minke whales will be able to tolerate temporary displacement much better than harbour porpoise. The sensitivity of minke whales to vessel disturbance is therefore assessed as Low.

Grey seal sensitivity to vessels

12.4.8.55 Jones *et al.* (2017a) present an analysis of the predicted co-occurrence of ships and seals at sea which demonstrates that, UK wide, there is a large degree of predicted co-occurrence, particularly within 50 km of the coast, close to seal haul-outs. There is no evidence relating decreasing seal populations with high levels of co-occurrence between ships and animals. In fact, in areas where seal populations are showing high levels of growth (e.g. southeast England) ship co-occurrences are highest (Jones *et al.* 2017a). Thomsen *et al.* (2006) estimate that both harbour and grey seals will respond to both small (~2 kHz) and large (~0.25 kHz) vessels at approximately 400 m.

12.4.8.56 The sensitivity of grey seals to disturbance from vessels is therefore assessed as Negligible.

Sensitivity summary

12.4.8.57 Through the use of literature reviews on the potential impacts of underwater noise on marine mammals, the sensitivity of each species to PTS-onset and behavioural disturbance from pile driving and vessel activity has been assessed. While much of the evidence base included within this section is from studies of animals in the North Sea, it is expected that marine mammals in the Irish and Celtic Seas would respond in a similar way, and, therefore, the data are considered to be applicable. Given the definitions of marine mammal sensitivity provided in Table 12.5, all marine mammals have been assessed as having a low sensitivity to PTS-onset, and either a low or negligible sensitivity behavioural disturbance from pile driving and vessel activity (Table 12.9).

Table 12.9 – Sensitivity Levels for Marine Mammal Receptors

Species	PTS from piling	Disturbance from piling	Disturbance from vessels
Dolphin (common and bottlenose)	Low	Low	Low
Harbour porpoise	Low	Low	Low
Minke whale	Low	Low	Low
Grey seal	Low	Negligible	Negligible

12.4.9 Standard Mitigation

12.4.9.1 A range of standard mitigation measures have already been applied to the Project as part of the over-arching site selection and iterative design process (see below and Chapter 3: Site Selection and Alternatives). These have been introduced in order to minimise potential impacts of the Project on any affected marine mammal receptors.

12.4.9.2 Standard mitigation measures which the Project has already implemented, or is committed to in the future, in order to minimise potential impacts on marine mammals are listed below:

- Additional data sets were sourced from NRW under licence to inform the original site selection process. These included: Bottlenose dolphin monitoring in Cardigan Bay 2014-2016 (NRW Evidence Report 191) (Lohrengel et al, 2018); Bottlenose dolphin and harbour porpoise monitoring in Cardigan Bay & Pen Llŷn a'r Sarnau Special Area of Conservation 2011-2013 (NRW Evidence Report 4) (Feingold et al, 2013); Seal Sites in Wales (CCW Report 131) (Baines et al, 1995); Atlas of Marine Mammals of Wales (CCW MM Report 68) (Baines et al, 2012); and Wales' grey seal photo-identification database: EIRPHOT (1992-2016) (Lle, 2019b). None of the data sets identified significant levels of marine mammal activity within the area of search (see Chapter 3: Site Selection and Alternatives, Section 3.7.2 for more information);
- Implementation of a piling Marine Mammal Mitigation Plan (MMMP) (see Volume 3, Technical Appendix 12.3: Draft Marine Mammal Mitigation Plan);
- Implementation of a UXO MMMP reflecting the Projects intention to seek one UXO detonation via deflagration (low order) (see Volume 3, Technical Appendix 12.3: Draft Marine Mammal Mitigation Plan);

- Implementation of a Vessel Management Plan (VMP) which adopts best practice vessel handling protocols (e.g. following the Codes of Conduct provided by the WiSe Scheme[7], the Scottish Marine Wildlife Watching Code[8], or the Guide to best practice for watching marine wildlife[9]);
- Implementation of a decommissioning MMMP, subject to a separate Marine Licence application prior to decommissioning; and
- Code of Construction Practice.

12.4.10 Assessment for Residual Effect Significance

12.4.10.1 The assessments and conclusions on the significance of effects presented in Section 12.6 assume that these standard mitigation measures listed above have been successfully implemented. It is not anticipated that significant environmental effects will remain after these standard measures have been factored in and, therefore, no additional project-specific mitigation measures are required to further reduce the residual significance of effects.

12.4.11 Limitations to Assessment

12.4.11.1 There are a number of limitations relating to the underwater noise modelling and impact assessment for the Project. Broadly, these relate to predicting exposure of animals to underwater noise, predicting the response of animals to underwater noise and predicting potential population consequences of disturbance from underwater noise. In such instances, the impact assessment has taken a precautionary approach, and as such, detail on the level of potential over-estimation is detailed in the results. Further details of such limitations are set out below.

Exposure to noise

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

12.4.11.3 The propagation of underwater noise is relatively well understood and modelled using standard methods. However, there are uncertainties regarding the amount of noise actually produced by each pulse at source and how the pulse characteristics change with range from the source. There are also uncertainties regarding the position of receptors in relation to received levels of noise, particularly over time, and understanding how position in the water column may affect received level. Noise monitoring is not always carried out at distances relevant to the ranges predicted for effects on marine mammals, so effects at greater distances remain un-validated in terms of actual received levels.

[7] https://www.wisescheme.org/
[8] https://www.nature.scot/scottish-marine-wildlife-watching-code-smwwc-part-1
[9] https://www.nature.scot/guide-best-practice-watching-marine-wildlife-smwwc-part-2

12.4.11.4 Furthermore, the extent to which ambient noise and other anthropogenic sources of noise may mask signals from the offshore wind farm construction are not specifically addressed. The dose-response curves for porpoise include behavioural responses at noise levels down to 120 dB SEL_{ss} which may be indistinguishable from ambient noise at the ranges these levels are predicted.

12.4.11.5 It is important to note that the SEL_{cum} thresholds were determined with the assumption that the amount of sound energy an animal is exposed to within 24 hours will have the same effect on its auditory system, regardless of whether it is received all at once or in several smaller doses spread over a longer period (called the equal-energy hypothesis), the sound keeps its impulsive character, regardless of the distance to the sound source, the fleeing swim speeds are representative and that SEL_{cum} levels do not vary within the water column.

12.4.11.6 These assumptions lead to a conservative determination of the impact ranges and it is considered that the calculated SEL_{cum} PTS-onset impact ranges are highly over precautionary and unlikely to be realised.

12.4.11.7 It is also worth noting that, although measuring the same effect (PTS or TTS), the values given by the SPL_{peak} criteria and SEL_{cum} criteria are describing separate physical processes. The SPL_{peak} measures the instantaneous level at the loudest part of installation when the maximum blow energy is being used. The SEL_{cum} measures the total sound received over the entire piling operation, including soft start and ramp up, and gives a starting range where a receptor fleeing from the noise source would have to be outside to avoid receiving the criterion level. In some cases, this can result in a situation where the impact range from the single strike SPL_{peak} criterion is calculated to have greater impact ranges than the multiple strike SEL_{cum} criteria.

PTS onset

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

TTS magnitude and sensitivity

12.4.11.9 Exposure to loud sounds can result in a reduction in hearing sensitivity. This reduction in sensitivity (threshold shift) can be permanent or temporary. Reductions in hearing sensitivity may affect an animal's ability to forage, avoid predation and communicate, but the TTS onset ranges alone do not allow assessment of the magnitude or significance of the likely consequences for individuals and, ultimately, populations, of the predicted extent over which any TTS might occur. The magnitude of the consequence is likely to be related to the duration and magnitude of the TTS. However, the current TTS onset thresholds are inappropriate to determine a biologically significant level of TTS.

12.4.11.10 TTS is, by definition, temporary, and the duration of effect at the threshold for TTS onset is likely to be short and, therefore, unlikely to cause any major consequences for an animal. An impact range which encompasses such a large variation in the predicted effect on individuals is extremely difficult to interpret in terms of the potential consequences for individuals.

12.4.11.11 It is important to bear in mind that the quantification of the spatial extent over which any impact is predicted to occur in the environmental assessment process, is done so in order to inform an assessment of the potential magnitude and significance of an impact. Because the TTS thresholds are not intended to indicate a level of impact of concern, *per se*, but are used to enable the prediction of where PTS might occur, they should not be used for the basis of any assessment of impact significance. Therefore, whilst the impact of TTS will be examined in some aspects of the ES, the magnitude and sensitivity and consequent significance of the effect will not be assessed.

Predicting response

12.4.11.12 There are limited empirical data available to confidently predict the extent to which animals may experience auditory damage or display responses to noise. The current methods for prediction of behavioural responses are based on received sound levels, but it is likely that factors other than noise levels alone will also influence the probability of response and the strength of response (e.g. previous experience, behavioural and physiological context, proximity to activities, characteristics of the sound other than level, such as duty cycle and pulse characteristics). However, at present, it is impossible to adequately take these factors into account in a predictive sense. This assessment makes use of the monitoring work that has been carried out during the construction of the Beatrice Offshore Wind Farm and therefore uses the most recent and site-specific information on disturbance to harbour porpoise as a result of pile driving noise.

12.4.11.13 There is also a lack of information on how observed effects (e.g. short-term displacement around pile-driving activities) manifest themselves in terms of effects on individual fitness, and ultimately population dynamics (see Section 12.4.8 on marine mammal sensitivity to disturbance and the recent expert elicitation conducted for harbour porpoise and both seal species) in order to attempt to quantify the amount of disturbance required before vital rates are impacted.

Swimming speed

12.4.11.14 All marine mammals were modelled to swim away at the onset of piling, at a swimming speed of 1.5 m/s, apart from minke whales which were modelled to flee at 3.25 m/s. There are data to suggest that these selected swim speeds are precautionary and that animals are likely to flee at much higher speeds, at least initially. Minke whales have been shown to flee from Acoustic Deterrent Devices (ADDs) at a mean swimming speed of 4.2 m/s (McGarry *et al.* 2017). A recent study by Kastelein *et al.* (2018) showed that a captive harbour porpoise responded to playbacks of pile driving sounds by swimming at speeds significantly higher than baseline mean swimming speeds, with greatest speeds of up to 1.97 m/s, which were sustained for the 30 minute test period. In another study, van Beest *et al.* (2018) showed that a harbour porpoise responded to an airgun noise exposure with a fleeing speed of 2 m/s. These recent studies have demonstrated porpoise and minke whale fleeing, swim at speeds greater than those used in the fleeing model in this assessment, which makes the modelled speeds used precautionary.

Proportion impacted

12.4.11.15 It is also important to note that it is expected that only 18-19% of animals are predicted to actually experience PTS at the PTS-onset threshold level. This was the approach adopted by Donovan *et al.* (2017) to develop their dose response curve implemented into the SAFESIMM (Statistical Algorithms For Estimating the Sonar Influence on Marine Megafauna) model, based on the data presented in Finneran *et al.* (2005).

12.4.11.16 Therefore, where PTS-onset ranges are provided, it is not expected that all individuals within that range will experience PTS. Therefore, the number of animals predicted to be within PTS-onset ranges are precautionary.

Duration of impact

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

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

Density

12.4.11.19 There are uncertainties relating to the ability to predict the responses of animals to underwater noise, and the prediction of the numbers of animals potentially exposed to levels of noise that may cause an impact is uncertain. Given the high spatial and temporal variation in marine mammal abundance and distribution in any particular area of the sea, it is difficult to confidently predict how many animals may be present within the range of noise impacts. All methods for determining at sea abundance and distribution, suffer from a range of biases and uncertainties, and no single method or data source will provide a complete prediction of future conditions. Furthermore, multiple density estimates were available for all receptors, covering different spatial extents. In all instances, the highest density estimate has been used in this impact assessment, as a precautionary approach, to present worst case scenario impacts.

Cumulative exposure – impulsive characteristics

12.4.11.20 There is likely to be much more uncertainty associated with the prediction of levels of cumulative exposure, due to the difficulty in predicting the true levels of sound exposure over long periods of time as a result of uncertainties about responsive movement, the position of animals in the water column, extent of recovery between pulses or in breaks in piling, and the extent to which pulsed sound loses its pulse like characteristics over time. To account for this uncertainty, model parameters are generally highly conservative and therefore the resulting predictions are precautionary and unlikely to be realised.

12.4.11.21 Southall Southall *et al.* (2019) acknowledge that as a result of propagation effects, the sound signal of certain sound sources (e.g. pile driving) loses its impulsive characteristics, and could potentially be characterised as non-impulsive, beyond a certain distance.

12.4.11.22 The changes in noise characteristics with distance generally result in exposures becoming less physiologically damaging with increasing distance, as sharp transient peaks become less prominent (Southall *et al.* 2017). The Southall *et al.* (2019) updated criteria proposed that, while keeping the same source categories, the exposure criteria for impulsive and non-impulsive sound should be applied based on the signal features likely to be perceived by the animal, rather than those emitted by the source. Methods to estimate the distance at which the transition from impulsive to non-impulsive noise are currently being developed (Southall *et al.* 2019).

12.4.11.23 Using the criteria of signal duration[10], rise time[11], crest factor[12] and peak pressure[13] divided by signal duration[14], Hastie *et al.* (2019) estimated the transition from impulsive to non-impulsive characteristics of pile driving noise during the installation of offshore wind turbine foundations at the Wash and in the Moray Firth. Hastie *et al.* (2019) showed that the noise signal experienced a high degree of change in its impulsive characteristics with increasing distance. Southall *et al.* (2019) state that mammalian hearing is most readily damaged by transient sounds with rapid rise-time, high peak pressures, and sustained duration relative to rise-time. Therefore, of the four criteria used by Hastie *et al.* (2019), the rise-time and peak pressure may be the most appropriate indicators to determine the impulsive/non-impulsive transition.

12.5 Baseline Conditions

12.5.1.1 A technical report has been prepared to provide a detailed characterisation of the receiving baseline (see Volume 3, Technical Appendix 12.1: Marine Mammal and Turtle Technical Report) with a summary of the key findings provided here. This chapter should, therefore, be read alongside the technical appendix which assesses the range of species and the abundance and density of marine mammals and turtles that may be present, informed by the 24 months of Digital Aerial Surveys (DAS), surveys covering the marine mammal MUs that include the Project array area, and data collected across previous offshore wind farm projects (see Sections 12.4.3 and 12.4.4 for details of sources used).

12.5.1.2 The data available have confirmed the likely presence of common dolphins, harbour porpoise, bottlenose dolphins, minke whales and grey seals in the vicinity of the Project site (array area and ECC) and, therefore, these species should be considered within the quantitative impact assessment. The most robust and relevant density estimates within each MU were determined for each receptor and have been carried forward into this assessment (Table 12.10)

12.5.1.3 The data provided very limited evidence of Risso's dolphin presence at the site (array area and ECC) and, therefore, this species has been scoped out of quantitative impact assessment. Leatherback turtles have also been scoped out of quantitative impact assessment due to their absence from site-specific DAS and no available density estimates for the species due to insufficient sightings.

[10] Time interval between the arrival of 5% and 95% of total energy in the signal.
[11] Measured time between the onset (defined as the 5th percentile of the cumulative pulse energy) and the peak pressure in the signal.
[12] The decibel difference between the peak sound pressure level (i.e. the peak pressure expressed in units of dB re 1 µPa) of the pulse and the root-mean-square sound pressure level calculated over the signal duration.
[13] The greatest absolute instantaneous sound pressure within a specified time interval.
[14] Time interval between the arrival of 5% and 95% of total energy in the signal.

Table 12.10 - Species, MU size and density estimate recommended for use in the Project quantitative impact assessment

Species	MU	MU size	MU reference	Density (#/km^2)	Density reference
Common dolphin	Celtic and Greater North Seas	102,656	IAMMWG (2021)	1.61 within the Survey Area. 0.3743 beyond the Survey Area.	HiDef site-specific surveys (HiDef Aerial Surveying Ltd 2020, 2021). SCANS III block D (Hammond *et al.* 2021)
Harbour porpoise	Celtic and Irish Seas	62,517	IAMMWG (2021)	0.4	HiDef site-specific surveys (HiDef Aerial Surveying Ltd 2020, 2021)
Bottlenose dolphin	Offshore Channel and Southwest England	10,947	IAMMWG (2021)	0.063	Wider Cardigan Bay surveys (Lohrengel *et al.* 2018)
Minke whale	Celtic and Greater North Seas	20,118	IAMMWG (2021)	0.0112	SCANS III block D (Hammond *et al.* 2021)
Grey seal	OSPAR region III	66,100	NRW (2020)	Grid cell specific	Carter *et al.* (2020)
	Wales and Southwest England MUs combined	6,090	SCOS (2020)		

12.5.1.4 A single MU is implemented for common dolphin: Celtic and Greater North Seas. It is estimated that the MU comprises 102,656 common dolphin (95% CI: 58,932 – 178,822, CV: 0.29) (estimated using data from SCANS III and ObSERVE) (IAMMWG 2021). They are known to have a largely offshore distribution centred upon the Celtic Deep at the southern end of the Irish Sea. This high-density area extends eastwards towards the coast and islands of west Pembrokeshire (Baines and Evans 2012). This was substantiated by the site-specific DAS where common dolphin was the most abundant marine mammal species, totalling 1,929 sightings (HiDef Aerial Surveying Ltd 2020, 2021) and an average corrected density of 1.61 dolphins/km^2 over the 24 months. Common dolphins were also observed in high numbers in several other studies in the Irish Sea (Paxton *et al.* 2016, Rogan *et al.* 2018, Waggitt *et al.* 2020). Site specific DAS found no clear seasonal pattern in presence, although surveys conducted by Baines and Evans (2012) indicated the species has a large summer distribution in the area, moving out of the area from January to March.

12.5.1.5 Given the results of the site-specific DAS, it was determined that this was the best density estimate to take forward to impact assessment for common dolphins, since it is the most fine-scale and up-to-date data available. However, it must be acknowledged that the density estimate is only applicable to the area included within the DAS. It cannot be assumed that the density estimate within the DAS area is the same as beyond it, especially when considering impacts with large footprints, such as disturbance from piling. Therefore, the impact assessment has adopted two density estimates in order to estimate the number of common dolphins impacted. For the portion of the impact footprint that is within the DAS area, the DAS density estimate will be used. For the remainder of the impact footprint, that is located beyond the limits of the DAS area, the SCANS III density estimate will be used. In the absence of fine scale and more recent data in the wider area, the SCANS III density estimate is considered to be the most robust to use.

12.5.1.6 Harbour porpoise within the Celtic Sand Irish Seas MU have an estimated abundance of 62,517 (95% CI: 48,324 – 80,877, CV: 0.13) (estimated using data from SCANS III and ObSERVE) (IAMMWG 2021, 2021 in prep). This abundance estimate represents a significant decrease from the previous estimate using the SCANS II and CODA data which was 104,695 porpoise (95% CI: 56,774 – 193,065, CV: 0.32) (IAMMWG 2015). There are currently 15 SACs designated for harbour porpoises within the Celtic and Irish Seas MU, indicating this is an area of importance for the species, with the West Wales Marine SAC/ Gorllewin Cymru Forol SAC and Bristol Channel Approaches SAC/ Dynesfeydd Môr Hafren SAC being of closest proximity to the Project. They were present during site specific DAS, with 83 sightings recorded over the 24 months (HiDef Aerial Surveying Ltd 2020, 2021) and an average corrected density of 0.4 porpoise/km^2 over the 24 months. Porpoise were also recorded in proximity to the site during SCANS III and JCP surveys (Paxton *et al.* 2016, Hammond *et al.* 2017).

12.5.1.7 Given the results of the site-specific DAS, it was determined that this was the best density estimate to take forward to impact assessment for harbour porpoise, since it is the most fine-scale and up-to-date data available. As shown in the marine impact assessment, the disturbance contours for pile driving extend far beyond the Survey Area. However, other density estimates in the general Bristol Channel and adjacent Irish Sea area are similar (0.31-0.44 porpoise/km^2) and therefore in this case, the density estimate of 0.4 porpoise/km^2 is considered to be appropriate to apply to the entire impact range, and not just the site specific Survey Area.

12.5.1.8 Bottlenose dolphins within the Offshore Channel and Southwest England MU have an estimated abundance of 10,947 (95% CI: 6,727-17,814) (estimated using data from SCANS III and ObSERVE) (IAMMWG 2021). There were 8 sightings of bottlenose dolphins during the 24 months of site-specific DAS (HiDef Aerial Surveying Ltd 2020, 2021) indicating their presence, albeit in low numbers. It is anticipated that bottlenose dolphins in this area may exhibit seasonal variation in abundance, being present in highest abundances during the summer (Paxton *et al.* 2016). Due to the large known home ranges of this species, it is reasonable to assume that the density estimate for this species in proximity to the Project site is similar to those in the wider Cardigan Bay area (Lohrengel *et al.* 2018). Therefore, the average sighting rate of 0.063 dolphins/km^2 presented by Lohrengel *et al.* (2018) has been taken forward to the quantitative impact assessment for the Project. This is considered to be highly precautionary given the much lower density estimates obtained for the general area DAS and from the JCP dataset. There are no SACs designated for bottlenose dolphins within the Offshore Channel and Southwest England MU.

12.5.1.9 However, there are currently two bottlenose dolphin SACs in the Irish Sea, including the Llyn Peninsula and the Sarnau SAC/ Pen Llŷn a'r Sarnau SAC and the Cardigan Bay SAC/ Bae Ceredigion SAC. While the Project is not within the Irish Sea MU, given the close proximity to the MU boundary and the ranging patterns of bottlenose dolphins it is important for the HRA to consider the potential for connectivity between the Project and these SACs.

12.5.1.10 Minke whale abundance is also analysed within the Celtic and Greater North Seas MU and is estimated at 20,118 (95% CI: 14,061 – 28,786, CV: 0.18) (estimated using data from SCANS III and ObSERVE) (IAMMWG 2021). Minke whale presence within UK waters is known to be seasonal, with migrations leading to peaks in minke whale abundance during the summer months (Baines and Evans 2012, Paxton *et al.* 2016). During the 24 months of site-specific DAS, 3 sightings of minke whales were recorded, all of which were in June (HiDef Aerial Surveying Ltd 2020, 2021), with further sightings made in proximity to the site during the SCANS III and JCP surveys (Paxton *et al.* 2016, Hammond *et al.* 2017), confirming their presence in the area. The most reliable and recent density estimate for this species in the vicinity of the Project is the SCANS III survey at 0.0112 whales/km^2.

12.5.1.11 Grey seal abundance has been examined within two MUs: the OSPAR Region III: Celtic Seas abundance is estimated at 66,100 (NRW 2020) and the Wales and Southwest England MUs combined is estimated at 6,090 (SCOS 2020, 2021). The large variability between these two estimates can be attributed to the differing sizes of the MUs and differing survey effort and analysis methods used. Only four grey seals were observed during the 24 months of site-specific DAS (HiDef Aerial Surveying Ltd 2020, 2021), but were reported in proximity to the Project in studies conducted by Baines and Evans (2012).

12.5.1.12 Seasonal variation in grey seal presence was observed with sightings peaking in proximity to the Project from April to June, and again from October to December. Lowest sightings of grey seals in proximity to the Project were reported from January to March (Baines and Evans 2012). There are several known haul-out sites along the Welsh coast, with connectivity throughout the Celtic and Irish Seas established using photo-ID (Langley *et al.* 2018) and telemetry data (provided by SMRU). There are also confirmed haul-out and breeding sites in Wales at Ramsey Island, Skomer MCZ, north Pembrokeshire and north Wales (SCOS 2020, 2021), with Skomer MCZ being in closest proximity to the Project.

12.5.1.13 Data from 1989 – 2019 on pup production in the Skomer MCZ would suggest that pup production within this area is on the rise (Wilkie and Zbijewska 2020), highlighting the area as an important breeding site for grey seals. This trend has also been noted at other monitored sites and several North Pembrokeshire coastal sites over the past decade (Bull *et al.* 2017a, Bull *et al.* 2017b, Lock *et al.* 2017, Morgan *et al.* 2018). There are three SACs in Welsh waters that include grey seals as a feature: the Llyn Peninsula and the Sarnau SAC, the Cardigan Bay SAC and the Pembrokeshire Marine SAC. The density estimates used in the impact assessment are the grid cell specific estimates based on the habitat preference maps.

12.5.2 Evolution of baseline conditions

12.5.2.1 The Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended) require that a "*description of the relevant aspects of the current state of the environment (baseline scenario), and an outline of the likely evolution thereof without implementation of the project, as far as natural changes from the baseline scenario can be assessed with reasonable effort on the basis of the availability of environmental information and scientific knowledge"* is included within the ES (EIA Regulations, Schedule 3, Paragraph 3).

12.5.2.2 From the point of assessment, over the course of the development and operational lifetime of the Project (operational lifetime anticipated to be up to 25 years from first power), long-term trends mean that the condition of the baseline environment is expected to evolve. This section provides a qualitative description of the evolution of the baseline environment, on the assumption that the Project is not constructed, using available information and scientific knowledge of marine mammal ecology.

12.5.2.3 It is challenging to predict the future trajectories of marine mammal populations. Some UK marine mammal populations have undergone periods of significant change in parts of their range, with a limited understanding of the driving factors responsible. For example, there is uncertainty about whether a reduction in pup mortality or an increase in fecundity is the cause of the recent exponential growth of grey seals in the North Sea (Russell *et al.* 2017). Additionally, there is no appropriate monitoring at the right temporal or spatial scales to really understand the baseline dynamics of some marine mammal populations, including all cetacean species included in this assessment.

12.5.2.4 JNCC provides the UK report on the conservation status of species. The latest assessments were conducted in 2019 and were submitted to the European Commission as part of the 2019 UK Reporting under Article 17 of the EU Habitats Directive. Overall, most species included in this baseline characterisation have an unknown conservation status, apart from grey seals which have a Favourable status (Table 12.11). Whilst assessed as having a Favourable future prospect, the latest large scale surveys (SCANS III and ObSERVE combined) estimate of harbour porpoise abundance in the Celtic and Irish Seas MU is now 62,517 (05% CI: 48,324 – 80,877, CV: 0.13) (IAMMWG 2021 in prep) which is 60% lower than the previous estimate of 104,695 (95% CI: 56,774 – 193,065, CV: 0.32) (IAMMWG 2015). The updated estimates do not discuss the potential reasons behind the decline in abundance in the Celtic and Irish Sea MU.

12.5.2.5 The potential impacts of climate change on marine mammals were reviewed and synthesised by Evans and Bjørge (2013) and they concluded that this topic remains poorly understood. In the UK, changes are predicted to manifest in relation to changes in prey abundance and distribution as a result of warmer sea temperatures. The authors also concluded that species likely to be most affected in the future will be those that have relatively narrow habitat requirements and that shelf sea species like the harbour porpoise, white-beaked dolphin and minke whale may come under increased pressure with reduced available habitat, if their range shifts northwards. In addition, sea level rise and an increase in storm frequency and associated wave surges could affect the availability of haul out sites for seals and increased storm frequency and associated conditions could also lead to increased pup and calf mortality (Prime 1985, Gazo *et al.* 2000, Lea *et al.* 2009).

Table 12.11 – Conservation status of the key species outlined in this report

Species	Range	Population	Habitat	Future prospects	Conservation Status	Overall trend	Reference
Common dolphin	FV	XX	XX	XX	XX	XX	JNCC (2019b)
Harbour porpoise	FV	XX	XX	FV	XX	XX	JNCC (2019c)
Bottlenose dolphin	FV	XX	XX	XX	XX	XX	JNCC (2019a)
Minke whale	FV	XX	XX	XX	XX	XX	JNCC (2019e)

Species	Range	Population	Habitat	Future prospects	Conservation Status	Overall trend	Reference
Grey seal	FV	FV	FV	FV	FV	+	JNCC (2019d)
FV = Favourable, U1 = Unfavourable-Inadequate, XX = Unknown, + = Improving							

12.6 Potential Environmental Effects

12.6.1.1 Table 12.12 presents the key parameters (from the main project design envelope) that have been used to inform each assessment in the Chapter.

Table 12.12 - Project Design Envelope Parameters Relevant to Marine Mammals

Potential Pathway Change / Impact	Realistic Worst Case Scenario	Justification
Construction		
PTS from UXO Disturbance from UXO	The Project is seeking consent for one UXO detonation via deflagration (low-order). This is presented as the realistic worst case scenario throughout the ES and is based on current industry knowledge and precedent set by other offshore wind farms, eg. Sofia Offshore Wind Farm (Sofia Offshore Wind Farm UXO Clearance Marine License Application (GoBe, 2021) MLA/2020/00489). Low order detonation: • 2 kg net explosive quantity (NEQ) • Assumed 5 km effective deterrence range (EDR) High order detonation • 525 kg device	Maximum number of detonations via deflagration (low-order) within the PDE High order detonation of up to 525 kg device also modelled and assessed, although judged to be a unrealistic worst case scenario
PTS from pile driving Disturbance from pile driving	35 piled anchors • Diameter: 2.5 m • Length: 55 m • Penetration depth: 52 m • Hammer energy: 800 kJ • Piling duration: 114 min per pile (incl. soft-start and ramp-up) • Total piling time for 35 anchors: 66.5 hours • Maximum 2 piles installed per day. • Total 18 days piling • Overall offshore construction duration: 8 months • Installation of moorings and anchors: 44 days	Maximum number of piles and hammer energy used to install piles represents the PTS and disturbance maximum design scenario.

Potential Pathway Change / Impact	Realistic Worst Case Scenario	Justification
	• Hookup of floating platforms: 30 days • Main offshore array works: 60 days total	
PTS from other construction activities Disturbance from other construction activities	Mooring installation: • 35 mooring lines • drag embedment anchors: 12 hours per mooring line • Suction pile: 12 hours per mooring line • 5 months total Offshore export cable installation: • Total duration = 152 days (based on sandwave levelling, boulder clearance, PLGR, multipass, installation, post-lay burial and protection installation) Array cables • Total duration = 88 days Landfall HDD: • Dredging for offshore trench section • Option for sheet piles and cofferdam installed by impact driving (300 kJ), vibro-driving or pressing Source levels (SEL_{cum} dB re 1 µPa @ 1 m RMS): • Vessel movement (large): 168 • Vessel movement (medium): 161 • Backhoe dredging: 165 • Suction dredging:186 • Cable laying: 171 • Trenching: 172 • Rock placement: 172 • Drag embedment anchors: 171 • Suction pile installation: 192 • Drilling:170.1 Overall offshore construction duration: 8 months	Maximum potential methods and durations for underwater noise impacts.
Disturbance from vessels Collision with vessels	Mooring installation: • 35 mooring lines • drag embedment anchors: 12 hours per mooring line • Suction pile: 12 hours per mooring line • 5 months total Offshore export cable installation: • Total duration = 152 days (based on sandwave levelling, boulder clearance,	The maximum numbers of vessels and associated vessel movements represents the maximum potential for collision risk and disturbance.

Potential Pathway Change / Impact	Realistic Worst Case Scenario	Justification
	PLGR, multipass, installation, post-lay burial and protection installation) Array cables • Total duration = 88 days Overall offshore construction duration: 8 months	
Disturbance at seal haul-outs	Landfall: • Options: open-cut trench and HDD • Cofferdam/sheet piles installed by impact driving, vibro-driving or pressing • Cofferdam piling: max 300 kJ per blow • Cofferdam duration: 12 weeks Vessels: • See Disturbance from vessels Overall construction at landfall = 5 months	Construction activity located near seal haul-out sites.
Indirect impacts on prey	Assessment is based on the maximum design scenario (MDS) presented in Chapter 10: Fish and Shellfish Ecology.	
Operation and Maintenance		
Barrier effects Entanglement and Collision	10 WTG • array area 43.5 km^2 35 catenary mooring lines • 870 m length mooring line • 800 m mooring radius (hull to anchor) • 60 m length mooring rope • 810 m mooring chain • 25 mooring clumps per line 10 inter-array cables • Formation: Lazy Wave • Length: 6.022 km each • Length: 23.9 km total • Diameter: 300 mm	The maximum scale of the mooring lines and inter-array cables represents the maximum potential for barrier effects, entanglement and collision.
Disturbance from vessels Collision with vessels	Vessel quantities per year: 2 x 12 hr day (CTV) (transit 1.5-2 hrs)	The maximum numbers of vessels and associated vessel movements represents the maximum potential for collision risk and disturbance.

Potential Pathway Change / Impact	Realistic Worst Case Scenario	Justification
Disturbance at seal haul-outs	See Disturbance from vessels	O&M activity located near seal haul-out sites.
Indirect impacts on prey	Assessment is based on the MDS presented in Chapter 10: Fish and Shellfish Ecology.	
Decommissioning		
Disturbance from removal of structures	Assumed to be the same or less than installation.	
Disturbance from vessels	Assumed to be the same or less than installation.	The maximum numbers of vessels and associated vessel movements represents the maximum potential for collision risk and disturbance.
Collision with vessels		
Disturbance at seal haul-outs	Assumed to be the same or less than installation.	Decommissioning activity located near seal haul-out sites.
Indirect impacts on prey	Assessment is based on the MDS presented in Chapter 10: Fish and Shellfish Ecology.	

12.6.2 Construction Phase

12.6.2.1 The offshore construction process will consist of the following stages:

- *Pre-construction survey*: to gather information on route debris, boulders, presence of UXO, seabed features and sediment depth;
- *Preliminary activities*: UXO clearance, boulder clearance, pre-lay grapnel run, sandwave levelling;
- *Main Cable Installation*: pre-lay trenching, cable plough, post lay burial, cable protection;
- *Mooring System Pre-Lay*: using Anchor Handling and Tug Supply vessels and specialist Remote Operated Vehicles (ROVs), the anchors and mooring lines will be laid one after another for each unit. Due to water depths on site, all vessels will be Dynamically Positioned (DP Class) with no vessel anchor deployment required;
- Following deployment, the pre-installed/tensioned mooring system and cable ends will be buoyed off temporarily, for later recovery and attachment to the WTG/substructure assembly following its arrival on site;

- The full array cable length will likely be pre-laid, after the moorings, and left on site in so called “wet storage” ready for the “first-end pull in” operations;
- *Offshore Tow and Mooring Hook-Up*: After the cable is laid-up and the semi-submersible floating platform (with WTG) has arrived at the site for its installation, the pull-in operation will take place. The mooring hook-up requires the use of the onboard winch to pull in the mooring line itself; and
- *Duration of works*: predicted that inclusive of 50% weather and transit times to/from local ports to site, the installation of all the moorings/anchors will take up to 30 days. The hook-up of the maximum number (10) of semi-submersible floating platforms, also inclusive of transit to/from local ports to site and 50% weather downtime, is predicted to take an additional 30 days. Therefore, the main works in the array area will take up to 60 days.

PTS and Disturbance from UXO

12.6.2.2 The Project is seeking consent for one UXO detonation via deflagration (low-order). This is presented as the realistic worst case scenario throughout the Environmental Statement and has formed the basis of the impact assessment undertaken.

12.6.2.3 However, in line with the recommendations outlined within the recent position statement on UXO clearance[15] this impact assessment includes an assessment for high-order detonations, though this is considered unlikely to occur in practice.

12.6.2.4 Deflagration (low-order) is the Project’s preferred method for UXO clearance and, based on current industry knowledge and precedent set by other offshore wind farms (e.g. Sofia Offshore Wind Farm (Sofia Offshore Wind Farm UXO Clearance Marine Licence Application) (GoBe, 2021) MLA/2020/00489), is considered the realistic worst case scenario. High order UXO detonation, as an absolute worst case, has been modelled and reported in Volume 3, Technical Appendix 12.2: Underwater Noise and Vibration Technical Report. However, this has been considered for completeness and is not deemed realistic as the Project intends to employ deflagration (low-order) as the clearance method.

12.6.2.5 This approach is informed by the UXO Threat and Risk Assessment (6-Alpha Associates, 2020) completed to inform project specific geotechnical surveys, which provides an assessment of potential threat sources and the likelihood of contamination across the Project array area and offshore export cable corridor.

12.6.2.6 The Project is also cognisant of the recently consented Marine Licence for the Greenlink Interconnector and the UXO approach adopted for the cable route in Welsh waters, i.e. the same as proposed for the Project.

12.6.2.7 Furthermore, a pre-installation (post-consent) geophysical survey will also be carried out and include a magnetometer survey, designed to identify any potential UXO targets in the vicinity of the planned cable route. If a UXO target is identified the intention would be to route around the UXO and avoid interacting with it. The offshore export cable corridor has sufficient width, built in, to allow this occur. However, if it is not possible to route around the UXO a more detailed assessment of the specific target would be undertaken (potentially via ROV) to determine UXO risk and only if no alternative existed, would the Project undertake UXO clearance via deflagration (low-order). This is considered the realistic worst case.

[15] DEFRA Policy Paper: Marine environment: unexploded ordnance clearance joint interim position statement. Published 16 November 2021

12.6.2.8 If the survey identifies more than one UXO target requiring clearance, the Project would engage with the Regulators and apply for a variation to allow additional UXO clearance via deflagration (low-order).

12.6.2.9 Current advice from the SNCBs is that Southall *et al.* (2019) should be used for assessing the PTS impacts from UXO detonation on marine mammals. However, the suitability of these criteria for UXO is under discussion, due to the lack of empirical evidence from UXO detonations using these metrics, in particular the range dependent characteristics of the peak sounds, and whether current propagation models can accurately predict the range at which these thresholds are reached.

Low-Order UXO Detonation – PTS

12.6.2.10 The modelling conducted for UXO clearance activities is presented in Volume 3, Technical Appendix 12.2: Underwater Noise and Vibration Technical Report.

12.6.2.11 The PTS-onset impact ranges for low-order UXO detonations are negligible (Table 12.13). The number of marine mammals expected to experience PTS-onset is <1 for all species and charge sizes, apart from 2 kg NEQ, which could impact 5 harbour porpoise. Given the evidence available that suggests harbour porpoise are likely to be temporarily displaced by vessel activity out to 4 km (e.g. Benhemma-Le Gall *et al.* 2021), it is highly unlikely that even one individual would be present within the maximum 1.9 km PTS-onset impact range. Therefore, PTS-onset from low-order UXO clearance is considered to result in a **negligible** effect, which is not significant in EIA terms.

Table 12.13 – PTS-onset impact ranges and number of animals predicted to experience PTS-onset for low-order UXO detonation[16]

Threshold	Species	Metric	0.1 kg NEQ	0.25 kg NEQ	0.5 kg NEQ	2 kg NEQ
Unweighted SPL_{peak}						
219 dB (LF)	Minke whale	Range km	0.13	0.17	0.22	0.35
		#	<1	<1	<1	<1
230 dB (HF)	Dolphins	Range km	0.04	0.06	0.07	0.11
		# CD	<1	<1	<1	<1
		# BND	<1	<1	<1	<1
202 dB (VHF)	Porpoise	Range km	0.73	0.99	1.2	1.9
		#	<1	1	2	5
218 dB (PCW)	Seals*	Range km	0.14	0.19	0.24	0.39
		#	<1	<1	<1	<1

[16] Note, while not presented quantitatively here, the impact range for Risso's dolphins would be the same as for the other dolphin species. Given the fact that no density estimate was available for Risso's dolphins, no predicted number of impacted animals is included. Though it is expected that the density and thus resulting number of animals impacted would be less than that for bottlenose dolphins.

Threshold	Species	Metric	0.1 kg NEQ	0.25 kg NEQ	0.5 kg NEQ	2 kg NEQ
Weighted SEL_{ss}						
183 dB (LF)	Minke whale	Range km	0.14	0.23	0.32	0.63
		#	<1	<1	<1	<1
185 dB (HF)	Dolphins	Range km	<0.01	<0.01	<0.01	<0.01
		# CD	<1	<1	<1	<1
		# BND	<1	<1	<1	<1
155 dB (VHF)	Porpoise	Range km	0.05	0.08	0.11	0.2
		#	<1	<1	<1	<1
185 dB (PCW)	Seals*	Range km	0.03	0.04	0.06	0.11
		#	<1	<1	<1	<1
* Seal density was 0.041 seals/km^2 which is the average density across all habitat preference map grid cells within the array area and ECC						

Low-Order UXO Detonation – Disturbance

12.6.2.12 Recent UXO clearance licence applications have assumed an effective deterrence range of 5 km around the source location to determine the impact area from low-order UXO clearance (e.g. GoBe 2021). In the absence of agreed metrics and given a lack of empirical data on the likelihood of response to low-order detonations, this 5 km radius (area of 78.5 km^2) has been applied for all species.

12.6.2.13 Low-order UXO detonation is predicted to have the greatest impact on common dolphin (Table 12.14). However, the magnitude of impact is Low, with 126 individuals predicted to be impacted, equating to 0.12% of the MU. Predicted disturbance for all other species is also low, with it being estimated that five bottlenose dolphin (0.05% of the MU), 31 harbour porpoise (0.05% of the MU), one minke whale (0.00% of the MU) and three grey seals (0.05% of the MU) will experience behavioural disturbance as a result low-order UXO clearance.

12.6.2.14 Given the low number and percentage of the respective MUs expected to be disturbed by low-order clearance of a UXO, the effect on all marine mammal receptors is considered to be **negligible**, which is not significant in EIA terms.

Table 12.14 – Disturbance from low-order UXO clearance[17]

Species	Density (#/km^2)	Area (km^2)	# Disturbed	MU	% MU Disturbed	Mag.	Sens.	Significance
Common dolphin	1.61	78.5	126	102,656	0.12%	Neg.	Low	Negligible
Bottlenose dolphin	0.063	78.5	5	10,947	0.05%	Neg.	Low	Negligible
Harbour porpoise	0.4	78.5	31	62,517	0.05%	Neg.	Low	Negligible
Minke whale	0.0112	78.5	1	20,118	<0.01%	Neg.	Low	Negligible
Grey seal	0.041*	78.5	3	66,100	0.005%	Neg.	Neg.	Negligible
* Average density across all habitat preference map grid cells within the array area and ECC								

High-Order UXO Detonation – PTS

12.6.2.15 In line with the recommendations outlined within the recent position statement on UXO clearance (Department for Environment Food & Rural Affairs *et al.* 2021), this impact assessment includes an assessment for high-order detonations, though this is considered unlikely to occur in practice.

12.6.2.16 The site specific UXO Threat and Risk Assessment Report carried out for Erebus (6 Alpha Associates, 2020) concluded that the maximum realistic worst case charge weight that can be expected to be presented in the Erebus study area is 331 kg (ferrous mass).

12.6.2.17 For a UXO charge weight of 525 kg NEQ, the predicted PTS-onset impact range is 13 km for harbour porpoise (Table 12.15), which equates to disturbance to 283 individual porpoises, which is 0.45% of the MU. Given that the maximum expected UXO charge weight expected in the study area is only 331 kg, then the PTS-onset impact range for harbour porpoise would be between 9.8 km (for a 240 kg charge) and 13 km (for a 525 kg charge).

12.6.2.18 As stated in Volume 3, Technical Appendix 12.2: Underwater Noise and Vibration Technical Report, there are considerable assumptions behind this calculation: "*assumes no degradation of the UXO and no smoothing of the pulse over that distance, which is very precautionary… it is likely that the long-range smoothing of the pulse peak would reduce its potential harm and the maximum 'impulsive' range for all species is very precautionary*".

12.6.2.19 Subacoustech therefore advises that "*it is likely that the long-range smoothing of the pulse peak would reduce its potential harm and the maximum 'impulsive' range for all species is very precautionary and unlikely in practice*". Given this, the impact range of up to 12 km for harbour porpoise is considered to be unrealistic.

[17] Note, while not presented quantitatively here, the impact range for Risso's dolphins would be the same as for the other dolphin species. Given the fact that no density estimate was available for Risso's dolphins, no predicted number of impacted animals is included. However, it is expected that the density and thus resulting number of animals impacted would be less than that for bottlenose dolphins.

12.6.2.20 Given that UXO detonation is a single event, it is expected that any effects to vital rates would unlikely be significant. Therefore the sensitivity of marine mammals is expected to be low.

12.6.2.21 Given the high levels of precaution in the assessment, and the low number and percentage of the respective MUs expected to experience PTS-onset from high-order clearance of a UXO, the effect on all marine mammal receptors is considered to be **negligible**, which is not significant in EIA terms. However, there is a risk of PTS-onset to European Protected Species, and as such, this needs to be considered in the MMMP and an EPS license may be required.

Table 12.15 – PTS-onset impact ranges and number of animals predicted to experience PTS-onset for high-order UXO detonation[18]

Threshold	Species	Metric	25 kg	55 kg	120 kg	240 kg	525 kg
Unweighted SPL_{peak}							
219 dB (LF)	Minke whale	Range km	0.81	1.0	1.3	1.7	2.2
		#	<1	<1	<1	<1	<1
230 dB (HF)	Dolphins	Range km	0.26	0.34	0.45	0.56	0.73
		# CD	<1	1	1	2	3
		# BND	<1	<1	<1	<1	<1
202 dB (VHF)	Porpoise	Range km	4.6	6.0	7.7	9.8	13
		#	27	45	75	121	212
218 dB (PCW)	Seals*	Range km	0.90	1.1	1.5	1.9	2.5
		#	<1	<1	<1	<1	1
Weighted SEL_{ss}							
183 dB (LF)	Minke whale	Range km	2.1	3.2	4.6	6.5	9.5
		#	<1	<1	<1	2	3
185 dB (HF)	Dolphins	Range km	0.01	0.02	0.03	0.04	0.05
		# CD	<1	<1	<1	<1	<1
		# BND	<1	<1	<1	<1	<1
155 dB (VHF)	Porpoise	Range km	0.56	0.74	0.95	1.1	1.4
		#	<1	1	1	2	2
185 dB (PCW)	Seals*	Range km	0.38	0.56	0.83	1.1	1.6
		#	<1	<1	<1	<1	<1

High-Order UXO Detonation – Disturbance (26 km EDR)

12.6.2.22 Under the assumption that a high-order detonation has a 26 km EDR, the maximum impact in terms of number of individuals impacted is predicted to occur for common dolphins, where 1,042 individuals may be disturbed, which represents 1.02% of the MU (Table 12.16). For both bottlenose dolphins and harbour porpoise just over 1% of the MU is predicted to experience behavioural disturbance and for both minke whales and grey seals <1% of the MU is predicted to experience behavioural disturbance.

12.6.2.23 It is noted in the JNCC *et al.* (2020) guidance that *"…a one-off explosion would probably only elicit a startle response and would not cause widespread and prolonged displacement…*". Therefore, it is not expected that disturbance from a single high-order UXO detonation would result in any significant impacts, and that disturbance from a single noise event would not be sufficient to result in any changes to the vital rates of individuals.

12.6.2.24 Therefore, given the low proportion of the MU predicted to be impacted, and the very short-term duration of the impact (1 clearance event on a single day), the magnitude of impact is assessed as a low, where short-term and/or intermittent and temporary behavioural effects are expected in a small proportion of the population, any impact to vital rates of individuals may occur only in the short term (over a limited number of breeding cycles, <1 in this case) and where any changes to individual vital rates are very unlikely to occur to the extent that the population trajectory would be altered.

Table 12.16 – Disturbance from high-order UXO clearance – 26 km EDR

Species	Area (km^2)	Density (#/km^2)	# Animals	MU	% MU
Minke whale	2,123.72	0.0112	24	20,118	0.12%
Common dolphin	2,123.72	1.61 within survey area, 0.3743 beyond	1,042	102,656	1.02%
Bottlenose dolphin	2,123.72	0.063	134	10,947	1.22%
Harbour porpoise	2,123.72	0.4	849	62,517	1.36%
Grey seals	2,123.72	0.041	87	66,100	0.13%

12.6.2.25 Using TTS-onset as a proxy for disturbance, for a UXO charge weight of 525 kg NEQ, the maximum predicted TTS-onset impact range is 103 km for minke whales (Table 12.17), which equates to disturbance to 373 individual whales, which is 1.85% of the MU. For harbour porpoise, the maximum predicted TTS-onset impact range is 23 km for, which equates to disturbance to 665 individual porpoise, which is 1.06% of the MU.

12.6.2.26 For all other species, a UXO charge weight of 525 kg NEQ is predicted to result in TTS-onset to <1% of the equivalent species MU. Given that the maximum UXO charge weight expected in the study area is only 331 kg, then the PTS-onset impact range for a 331 kg charge would be lower than this.

12.6.2.27 TTS-onset as a proxy for disturbance is expected to over-estimate the actual biological consequences. Southall *et al.* (2007) states that "*This approach is expected to be precautionary because TTS at onset levels is unlikely to last a full diel cycle or to have serious biological consequences during the time TTS persists*". Therefore, the number of animals predicted to experience TTS-onset here will overestimate the actual number of animals that will be expected to display any disturbance response.

12.6.2.28 Given the low proportion of the MU predicted to be impacted, and the very short-term duration of the impact (1 clearance event on a single day), the magnitude of impact is assessed as a low, where short-term and/or intermittent and temporary behavioural effects are expected in a small proportion of the population, any impact to vital rates of individuals may occur only in the short term (over a limited number of breeding cycles, <1 in this case) and where any changes to individual vital rates are very unlikely to occur to the extent that the population trajectory would be altered.

Table 12.17 – Disturbance from high-order UXO clearance – TTS-onset

Threshold	Species	Metric	25 kg	55 kg	120 kg	240 kg	525 kg
Unweighted SPL_{peak}							
213 dB (LF)	Minke whale	Range km	1.5	1.9	2.5	3.2	4.1
		#	<1	<1	<1	<1	1
224 dB (HF)	Dolphins	Range km	0.49	0.64	0.83	1	1.3
		# CD	1	2	3	5	9
		# BND	<1	<1	<1	<1	<1
196 dB (VHF)	Porpoise	Range km	8.5	11	14	18	23
		#	91	152	246	407	665
212 dB (PCW)	Seals*	Range km	1.6	2.1	2.8	3.5	4.6
		#	<1	1	1	2	3
Weighted SEL_{ss}							
168 dB (LF)	Minke whale	Range km	29	41	57	76	103
		#	30	59	114	203	373
170 dB (HF)	Dolphins	Range km	0.15	0.21	0.3	0.39	0.53
		# CD	0	0	0	1	1
		# BND	0	0	0	0	0
140 dB (VHF)	Porpoise	Range km	2.4	2.8	3.2	3.5	4
		#	7	10	13	15	20
170 dB (PCW)	Seals*	Range km	5.2	7.4	11	14	20
		#	3	7	16	25	52

12.6.2.29 Given that disturbance from a UXO detonation is a single event, it is expected that effects to vital rates would be unlikely, and that if there were to be effects, that they would unlikely be significant. Therefore, the sensitivity of marine mammals is expected to be low.

12.6.2.30 The magnitude of the impact has been assessed as Low and the sensitivity of marine mammal receptors as Low. Therefore, disturbance from high-order UXO detonation is concluded to result in a **minor adverse** effect, which is not significant in EIA terms.

PTS-onset from pile driving

12.6.2.31 The assessment below focuses on underwater noise from the pile-driving of anchors for the semi-submersible floating platform mooring system.

12.6.2.32 Table 12.18 presents the PTS-onset impact area, impact range and number of each receptor within the PTS-onset impact area predicted to be impacted on each day of piling activities. Only the worst-case is presented here for two modelling locations: WTG01 (NW) and WTG10 (E).

12.6.2.33 The largest instantaneous PTS-onset impact range (unweighted SPL_{peak}) for impact piling is estimated at 280 m for harbour porpoise at both WTG locations. For all other marine mammal receptors, the maximum range was <50 m. The largest cumulative PTS-onset impact range (weighted SEL_{cum}) for impact piling is estimated at 2.7 km for minke whale at WTG10 (E). For all other marine mammal receptors, the maximum range was <100 m. In all modelled scenarios, <1 animal is expected to be within its respective PTS-onset impact range.

12.6.2.34 PTS-onset impact range predictions assume that all animals within the PTS-onset range are impacted, which will overestimate the true number of impacted animals, as only 18-19% of the animals are predicted to actually experience PTS at the PTS-onset threshold level, meaning that the low numbers predicted are already highly conservative. In addition, the sound is modelled as being fully impulsive, irrespective of distance from the pile, which is highly precautionary and results in predictions that are unlikely to be realised.

12.6.2.35 The Project will also be adhering to a piling MMMP (Volume 3, Technical Appendix 12.3: Marine Mammal Mitigation plan) which will further reduce the risk of PTS to negligible levels. Therefore, PTS-onset from piling for is assessed as having a **negligible** effect, which is not significant in EIA terms.

Table 12.18 – PTS-onset impact ranges for impact piling – worst case (800 kJ)[19]

Threshold	Species	Parameter	WTG01 (NW)	WTG10 (E)
Instantaneous PTS: Unweighted SPL_{peak}				
219 dB (LF)	Minke whale	Area	< 0.01 km^2	< 0.01 km^2
		Max Range	< 50 m	< 50 m
		# Whales	<1	<1

[19] Note, while not presented quantitatively here, the impact range for Risso's dolphins would be the same as for the other dolphin species. Given the fact that no density estimate was available for Risso's dolphins, no predicted number of impacted animals is included. However, it is expected that the density and thus resulting number of animals impacted would be less than that for bottlenose dolphins.

Threshold	Species	Parameter	WTG01 (NW)	WTG10 (E)
230 dB (HF)	Common and Bottlenose dolphins	Area	< 0.01 km^2	< 0.01 km^2
		Max Range	< 50 m	< 50 m
		# Common dolphins	<1	<1
		# Bottlenose dolphins	<1	<1
202 dB (VHF)	Harbour porpoise	Area	0.25 km^2	0.25 km^2
		Max Range	280 m	280 m
		# Porpoise	<1	<1
218 dB (PCW)	Grey seal	Area	< 0.01 km^2	< 0.01 km^2
		Max Range	< 50 m	< 50 m
		# Seals	<1	<1
Cumulative PTS: Weighted SEL_{cum}				
183 dB (LF)	Minke whale	Area	8.2 km^2	12 km^2
		Max Range	2.2 km	2.7 km
		# Whales	<1	<1
185 dB (HF)	Common and Bottlenose dolphins	Area	< 0.1 km^2	< 0.1 km^2
		Max Range	< 100 m	< 100 m
		# Common Dolphins	<1	<1
		# Bottlenose dolphins	<1	<1
155 dB (VHF)	Harbour porpoise	Area	< 0.1 km^2	< 0.1 km^2
		Max Range	< 100 m	< 100 m
		# Porpoise	<1	<1
185 dB (PCW)	Grey seal	Area	< 0.1 km^2	< 0.1 km^2
		Max Range	< 100 m	< 100 m
		# Seals	<1	<1

TTS-onset from pile driving

12.6.2.36 Table 12.19 presents the TTS-onset impact area, impact range and number of each receptor within the TTS-onset impact area. Only the worst-case is presented here for two modelling locations: WTG01 (NW) and WTG10 (E).

12.6.2.37 The largest instantaneous TTS-onset impact range (unweighted SPL_{peak}) for impact piling is estimated at 730 m for harbour porpoise at both WTG locations. For all other marine mammal receptors, the maximum range was ≤60 m. The largest cumulative TTS-onset impact range (weighted SEL_{cum}) for impact piling is estimated at 41 km for minke whale at WTG10 (E). The cumulative TTS-onset impact range was also large for harbour porpoise with a maximum range of 22 km, and for grey seals at a maximum range of 6.8 km, but was negligible for dolphins at <100 m.

12.6.2.38 As outlined in Section 12.4.11, there are no thresholds to determine a biologically significant effect from TTS-onset. Therefore, whilst the predicted ranges and area for the onset of TTS are presented in Table 12.19, no assessment of the number of animals, magnitude, sensitivity or significance of effect can be given. This approach was agreed with members of Marine Mammals and Marine Ecology Expert Topic Group (21st September 2020).

Table 12.19 – TTS-onset impact ranges for impact piling – worst case (800 kJ)[20]

Threshold	Species	Parameter	WTG01 (NW)	WTG10 (E)
Instantaneous TTS: Unweighted SPL_{peak}				
213 dB (LF)	Minke whale	Area	0.01 km^2	0.01 km^2
		Max Range	< 50 m	50 m
		# Whales	<1	<1
224 dB (HF)	Common and Bottlenose dolphins	Area	< 0.01 km^2	< 0.01 km^2
		Max Range	< 50 m	< 50 m
		# Common dolphins	<1	<1
		# Bottlenose dolphins	<1	<1
196 dB (VHF)	Harbour porpoise	Area	1.7 km^2	1.7 km^2
		Max Range	730 m	730 m
		# Porpoise	<1	<1
212 dB (PCW)	Grey seal	Area	0.01 km^2	0.01 km^2
		Max Range	60 m	60 m

[20] Note, while not presented quantitatively here, the impact range for Risso's dolphins would be the same as for the other dolphin species. Given the fact that no density estimate was available for Risso's dolphins, no predicted number of impacted animals is included. Though it is expected that the density and thus resulting number of animals impacted would be less than that for bottlenose dolphins.

Threshold	Species	Parameter	WTG01 (NW)	WTG10 (E)
Instantaneous TTS: Unweighted SPL_{peak}				
		# Seals	<1	<1
Cumulative TTS: Weighted SEL_{cum}				
168 dB (LF)	Minke whale	Area	3,100 km^2	3,400 km^2
		Max Range	40 km	41 km
		# Whales	35	38
170 dB (HF)	Common and Bottlenose dolphins	Area	< 0.1 km^2	< 0.1 km^2
		Max Range	< 100 m	< 100 m
		# Common Dolphins	<1	<1
		# Bottlenose dolphins	<1	<1
140 dB (VHF)	Harbour porpoise	Area	1,000 km^2	1,100 km^2
		Max Range	20 km	22 km
		# Porpoise	400	440
170 dB (PCW)	Grey seal	Area	110 km^2	120 km^2
		Max Range	6.5 km	6.8 km
		# Seals	<1	<1

Disturbance from pile driving

12.6.2.39 Table 12.20 presents the number of animals predicted to be disturbed on each piling day using the dose-response approach and the percentage of the MU this represents. In total there are anticipated to be 18 days in which piling could occur (assuming 2 piles are installed in a day), and thus 18 days of potential disturbance.

Table 12.20 – Disturbance impact for impact piling using the dose-response approach[21]

Species	Density (#/km^2)	Worst Case (800 kJ)		Most likely (600 kJ)		Magnitude
		WTG01 (NW)	WTG10 (E)	WTG01 (NW)	WTG10 (E)	
Minke whale MU: 20,118	0.0112	53 0.3%	55 0.3%	46 0.2%	48 0.2%	Neg.
Common dolphin MU: 102,656	DAS and SCANS III (1.61 & 0.3743)	1,987 1.94%	2,067 2.01%	1,747 1.70%	1,818 1.77%	Low
Bottlenose dolphin MU: 10,947	0.063	296 2.7%	310 2.8%	256 2.3%	269 2.5%	Low
Harbour porpoise MU: 62,517	0.4	1,879 3.00%	1,967 3.15%	1,628 2.60%	1,706 2.73%	Low

Species	Density (#/km^2)	Worst Case (800 kJ)		Most likely (600 kJ)		Magnitude
		WTG01 (NW)	WTG10 (E)	WTG01 (NW)	WTG10 (E)	
Grey seal MU: 6,090 MU: 66,100	Grid cell specific	15 (1-31) 0.3% (0.0-0.5) 0.0% (0.0-0.0)	18 (1-37) 0.3% (0.0-0.6) 0.0% (0.0-0.1)	10 (1-21) 0.2% (0.0-0.3) 0.0% (0.0-0.0)	12 (1-24) 0.2% (0.0-0.4) 0.0% (0.0-0.0)	Neg.

Common Dolphin

12.6.2.40 The disturbance contours for pile driving extend far beyond the Survey Area. Therefore, while the density estimate of 1.61 dolphins/km^2 (obtained from the site-specific surveys) is appropriate to use for the portion of the contour that is within the Survey Area, it is not appropriate to assume that the density estimate across the whole contour is the same as within the survey area. For the portions of the impact contours that are located outside the survey area, a regional scale density estimate must be assumed.

12.6.2.41 The impact contours from pile driving are mainly located within SCANS III Block D (0.3743 dolphins/km^2), with some portions of the contours extending into SCANS III Block E (0.0000 dolphins/km^2) and ObSERVE Stratum 4 (0.170 dolphins/km^2)[22].

[21] Note, while not presented quantitatively here, the impact range for Risso's dolphins would be the same as for the other dolphin species. Given the fact that no density estimate was available for Risso's dolphins, no predicted number of impacted animals is included. However, it is expected that the density and thus resulting number of animals impacted would be less than that for bottlenose dolphins.

[22] Averaged across the 4 seasons surveyed (S1: 0.044, S2: 0.637, S3: 0.000, S4: 0.000 dolphins/km^2)

12.6.2.42 The Since the density estimate for SCANS III block D was the highest of these, it was assumed that all areas outside of the survey area should precautionarily be assumed to have a density of 0.3,743 dolphins/km^2.

Table 12.21 – Number of animals predicted to be present within and outside of the Survey Area and the resulting number of animals predicted to be impacted (800 kJ at WTG10 (E))

Impact contour SEL_{ss}	Area of contour (km^2)	Within Survey Area		Outside Survey Area		Total Animals Present	Proportion Expected to Respond	Total Number Impacted
		Area (km^2)	# Animals (1.61/km^2)	Area (km^2)	# Animals (0.3743/km^2)			
180+	1	1	2	0	0	2	0.9994	2
175<180	3	3	5	0	0	7	0.9973	5
170<175	13	13	21	0	0	28	0.9898	21
165<170	51	50	80	1	0	107	0.9685	78
160<165	172	81	130	91	34	207	0.9192	151
155<160	464	52	83	412	154	264	0.8266	196
150<155	1,045	0	0	1,045	391	391	0.6849	268
145<150	1,981	0	0	1,981	741	741	0.5090	377
140<145	3,176	0	0	3,176	1,189	1,189	0.3312	394
135<140	4,222	0	0	4,222	1,580	1,580	0.1852	293
130<135	5,247	0	0	5,247	1,964	1,964	0.0878	172
125<130	6,116	0	0	6,116	2,289	2,289	0.0349	80
120<125	6,898	0	0	6,898	2,582	2,582	0.0115	30
Total number of common dolphins predicted to experience behavioural disturbance								**2,067**

12.6.2.43 It is predicted that, under the worst-case scenario (800 kJ at WTG10 (E)), 2,067 common dolphins may experience disturbance on each day of pile driving, equating to 2.01% of the MU. Using the maximum most likely scenario (600 kJ at WTG10 (E)), this is reduced to 1,818 animals per piling day at 1.77% of the MU (Table 12.20).

12.6.2.44 The movement patterns of common dolphins in UK waters are poorly understood, and as such, it is not known how much repeated disturbance an individual dolphin would be expected to receive. At one extreme, it could be assumed that there is no movement/turn-over of common dolphins in the area, and thus the same 2,067 dolphins would be expected to be disturbed repeatedly on 18 piling days. At the other end of the extreme, it could be assumed that there is high turn-over of dolphins in the area and a dolphin would only remain in the area long enough to experience disturbance from 1 day of piling.

12.6.2.45 This assumption is based on the fact that common dolphins are generally thought to be wide-ranging, capable of travelling large distances, based on tag and genetic data (e.g. Evans 1982, Natoli *et al.* 2006, Genov *et al.* 2012). This would result in up to 37,206 dolphins being disturbed, but only for a single day each. Based on the current evidence on the effects of disturbance on dolphin species, it is not expected that exposure to a single day of pile driving would result in any changes to vital rates.

12.6.2.46 Therefore, the worst case scenario would consist of the same animals being repeatedly exposed, thus increasing the potential for the repeated disturbance to result in changes to vital rates. However, given the low proportion of the MU predicted to be impacted repeatedly, and the very short-term duration of the impact (piling over a maximum of 18 days), the magnitude of impact is assessed as a low, where short-term and/or intermittent and temporary behavioural effects are expected in a small proportion of the population, any impact to vital rates of individuals may occur only in the short term (over a limited number of breeding cycles, <1 in this case) and where any changes to individual vital rates are very unlikely to occur to the extent that the population trajectory would be altered.

12.6.2.47 A key source of precaution in this assessment is that the harbour porpoise dose-response curve and harbour porpoise EDRs have been used for common dolphins, as there is no common dolphin-specific equivalent. Harbour porpoise have a lower auditory injury threshold (i.e. higher hearing sensitivity) than common dolphins (Southall *et al.* 2019) and are considered to be particularly responsive to anthropogenic disturbance, with playback experiments showing avoidance reactions to very low levels of sound (Tyack 2009) and multiple studies showing that porpoise respond (avoidance and reduced vocalisation) to a variety of anthropogenic noise sources to distances of multiple kilometres (e.g., Brandt *et al.* 2013, Thompson *et al.* 2013, Tougaard *et al.* 2013, Brandt *et al.* 2018, Sarnocinska *et al.* 2019, Thompson *et al.* 2020, Benhemma-Le Gall *et al.* 2021).

12.6.2.48 Studies have shown that dolphin species show comparatively less of a disturbance response from underwater noise compared to harbour porpoise. High-frequency cetacean species such as common, bottlenose, and striped dolphins, have been shown to display less of a response to underwater noise signals and construction-related activities compared to harbour porpoise (e.g. Kastelein *et al.* 2006, Culloch *et al.* 2016). Through an analysis of 16 years' of marine mammal observer data from seismic survey vessels, Stone *et al.* (2017) found a significant reduction in porpoise detection rates when large seismic airgun arrays were actively firing, but not for bottlenose dolphins.

12.6.2.49 While the strength and significance of responses varied between porpoise and other dolphin species for different measures of effect, the study emphasised the sensitivity of the harbour porpoise (Stone *et al.* 2017). In the Moray Firth, bottlenose dolphins have been shown to remain in the impacted area during both seismic activities and pile installation activities (Fernandez-Betelu *et al.* 2021) which highlights a lack of complete displacement response. Considering the above, it can be concluded that using porpoise response data as a proxy for common dolphins is likely to result in an over-estimate of the response for common dolphins.

12.6.2.50 As stated in paragraph 12.4.8.19, common dolphins have been assessed as having a low sensitivity to disturbance from piling, where it is expected that they have the ability to adapt behaviour so that individual vital rates (survival and reproduction) may be affected, but not at a significant level.

12.6.2.51 The magnitude of the impact has been assessed as low and the sensitivity of common dolphin receptors as low. Therefore, disturbance from piling activities is concluded to result in a **minor adverse** effect, which is not significant in EIA terms.

Bottlenose Dolphin

12.6.2.52 It is predicted that, as the worst-case scenario (800 kJ at WTG10 (E)), 310 bottlenose dolphins may experience disturbance per piling day, equating to 2.8% of the MU. Using the maximum most likely scenario (600 kJ at WTG10 (E)), this is reduced to 269 animals per piling day at 2.5% of the MU (Table 12.20). As stated above, the worst case scenario would consist of the same animals being repeatedly exposed, thus increasing the potential for the repeated disturbance to result in changes to vital rates. However, given the low proportion of the MU predicted to be impacted repeatedly, and the very short-term duration of the impact (piling over a maximum of 18 days), the magnitude of impact is assessed as Low.

12.6.2.53 Where short-term and/or intermittent and temporary behavioural effects are expected in a small proportion of the population, any impact to vital rates of individuals may occur only in the short term (over a limited number of breeding cycles, <1 in this case) and where any changes to individual vital rates are very unlikely to occur to the extent that the population trajectory would be altered.

12.6.2.54 As stated above for common dolphins, a source of precaution is that the harbour porpoise dose-response curve and harbour porpoise EDRs have been used for bottlenose dolphins, as there is no bottlenose dolphin-specific equivalent. Harbour porpoise have a lower auditory injury threshold (i.e. higher hearing sensitivity) than bottlenose dolphins (Southall *et al.* 2019) and are considered to be particularly responsive to anthropogenic disturbance, with playback experiments showing avoidance reactions to very low levels of sound (Tyack 2009) and multiple studies showing that porpoise respond (avoidance and reduced vocalisation) to a variety of anthropogenic noise sources to distances of multiple kilometres (e.g., Brandt *et al.* 2013, Thompson *et al.* 2013, Tougaard *et al.* 2013, Brandt *et al.* 2018, Sarnocinska *et al.* 2019, Thompson *et al.* 2020, Benhemma-Le Gall *et al.* 2021).

12.6.2.55 Studies have shown that dolphin species show comparatively less of a disturbance response from underwater noise compared to harbour porpoise (e.g. Kastelein *et al.* 2006, Culloch *et al.* 2016, Stone *et al.* 2017, Fernandez-Betelu *et al.* 2021). Considering the above, it can be concluded that using porpoise response data as a proxy for bottlenose dolphins is likely to result in an over-estimate of the response for bottlenose dolphins.

12.6.2.56 As stated in paragraph 12.4.8.25, bottlenose dolphins have been assessed as having a low sensitivity to disturbance from piling, where it is expected that they have the ability to adapt behaviour so that individual vital rates (survival and reproduction) may be affected, but not at a significant level.

12.6.2.57 The magnitude of the impact has been assessed as low and the sensitivity of bottlenose dolphin receptors as low. Therefore, disturbance from piling activities is concluded to result in a **minor adverse** effect, which is not significant in EIA terms.

Harbour Porpoise

12.6.2.58 It is predicted that, as the worst-case scenario (800 kJ at WTG10 (E)), 1,967 harbour porpoise may experience disturbance from impact piling, equating to 3.15% of the MU. Using the maximum most likely scenario (600 kJ at WTG10 (E)), this is reduced to 1,706 animals at 2.73% of the MU (Table 12.20). As stated above, the worst case scenario would consist of the same animals being repeatedly exposed, thus increasing the potential for the repeated disturbance to result in changes to vital rates. However, given the low proportion of the MU predicted to be impacted repeatedly, and the very short-term duration of the impact (piling over a maximum of 18 days), the magnitude of impact is assessed as low.

12.6.2.59 Where short-term and/or intermittent and temporary behavioural effects are expected in a small proportion of the population, any impact to vital rates of individuals may occur only in the short term (over a limited number of breeding cycles, <1 in this case) and where any changes to individual vital rates are very unlikely to occur to the extent that the population trajectory would be altered.

12.6.2.60 As stated in paragraph 12.4.8.36, harbour porpoise have been assessed as having a low sensitivity to disturbance from piling, where it is expected that individual vital rates (survival and reproduction) may be affected, but not at a significant level.

12.6.2.61 The magnitude of the impact has been assessed as low and the sensitivity of harbour porpoise receptors as low. Therefore, disturbance from piling activities is concluded to result in a **minor adverse** effect, which is not significant in EIA terms.

Minke Whale

12.6.2.62 It is predicted that, as the worst-case scenario (800 kJ at WTG10 (E)), 55 minke whale may experience disturbance from impact piling, equating to 0.3% of the MU. Using the maximum most likely scenario (600 kJ at WTG10 (E)), this is reduced to 48 animals at 0.2% of the MU (Table 12.20). Given the small proportion of the MU that may be affected and the very short-term duration of the impact (piling over a maximum of 18 days), the magnitude of impact is assessed as negligible.

12.6.2.63 Minke whales have been assessed as having a low sensitivity to disturbance from piling, where it is expected that individual vital rates (survival and reproduction) may be affected.

12.6.2.64 The magnitude of the impact has been assessed as negligible and the sensitivity of minke whales as low. Therefore, disturbance from piling activities is concluded to result in a **negligible** effect, which is not significant in EIA terms.

Grey Seal

12.6.2.65 It is predicted that, as the worst-case scenario (800 kJ at WTG10 (E)), a mean of 18 (95% CI: 1-37) grey seals may experience disturbance from impact piling, equating to 0.3% of the MU. Using the maximum most likely scenario (600 kJ at WTG10 (E)), this is reduced to 12 (95% CI: 1-24) animals at 0.2% of the MU (Table 12.20). Given the small proportion of the MU that may be affected and the very short-term duration of the impact (piling over a maximum of 18 days), the magnitude of impact is assessed as negligible.

12.6.2.66 Grey seal has been assessed as having a negligible sensitivity to disturbance from piling. Therefore, as the magnitude of the impact has been assessed as negligible and the sensitivity of grey seals to disturbance from piling activities is negligible, it is concluded to result in a **negligible** effect, which is not significant in EIA terms.

Summary

12.6.2.67 In summary, the impact of disturbance from pile driven anchors is predicted to be of **negligible** to **minor adverse** across all marine mammal species (Table 12.22), which is not significant in EIA terms.

Table 12.22 – Summary of disturbance effects from pile driven anchors

Species	Max % MU impacted per piling day	Magnitude	Sensitivity	Significance of Effect
Minke whale	0.3%	Negligible	Low	Negligible
Common dolphin	2.01%	Low	Low	Minor adverse
Bottlenose dolphin	2.8%	Low	Low	Minor adverse
Harbour porpoise	3.15%	Low	Low	Minor adverse
Grey seal	0.3%	Negligible	Negligible	Negligible

PTS and Disturbance from other construction activities

12.6.2.68 A simple assessment of the noise impacts from non-piling noise is presented in Volume 3, Technical Appendix 12.2: Underwater Noise and Vibration Technical Report. The expected or potential noise sources at the Project array area are considered in this assessment as other construction activities. These include:

- Vessel movements – large and medium vessels;
- Seabed preparation - two types of dredging, backhoe and suction;
- Cable installation – noise from cable laying vessel and trenching machinery;
- Cable protection – noise from rock placement;
- Installation of drag embedment anchors;
- Suction pile installation; and
- Drilling to install foundation piles.

12.6.2.69 The PTS impact ranges of all sources were assessed for both fleeing and stationary receptors as per Southall *et al.* (2019). The fleeing animal model assumes that a receptor, when exposed to high noise levels, will swim away from the noise source. For this, a constant fleeing speed of 3.25 ms^{-1} has been assumed for the low frequency cetaceans (LF) group based on data for minke whale (Blix and Folkow 1995) and for all other receptors a constant rate of 1.5 ms^{-1} has been assumed for fleeing, which is a cruising speed for a harbour porpoise (Otani *et al.* 2000).

12.6.2.70 *Drag embedment anchors:* Drag embedment anchors are currently the primary option for the mooring system for the Project. Drag embedment anchors hold in position through the resistance between the seabed substrate, the anchor and the attached platform. The drag embedment anchor will penetrate the seabed to a depth from 8 to 25 m, depending on the sediment thickness, with no surficial expression visible once installed. Each mooring line will be attached to at least one drag embedment anchor, which will equate to 20 to 35 drag embedment anchors. Where required for increased load capacity, a piggyback option consisting of two drag embedment anchors, one in front of the other along the mooring line, will be used on the upwind mooring lines only.

12.6.2.71 *Suction pile anchors:* Suction pile anchors/foundations are often used on deep water projects in the oil and gas industry. The suction pile uses gravity to initially penetrate the seabed with seawater entering the main structure. The remaining seawater within the pile is then pumped out creating further suction and penetration into the seabed. Suction piles can then be supplemented by additional concrete weight on the top of the anchor to provide additional stability (combined gravity anchor).

12.6.2.72 *Cable laying:* One offshore export cable will be required, consisting of a three core HVAC, 66 kV cable either as a single or bundled subsea cable with a fibre optic cable. Installation may be undertaken in a number of methods along the route, including surface lay, plough, Mass Flow Excavator (MFE), jetting, Trailer Suction Hopper Dredger (TSHD) and rock cutting or trenching.

PTS Result

12.6.2.73 Using the non-impulsive weighted SEL_{cum} PTS-onset thresholds for stationary receptors from Southall *et al.* (2019) resulted in estimated PTS impact ranges that were variable between marine mammal groups and non-piling construction activity (Table 12.23) PTS impact ranges were from <10 m to 820 m for VHF cetaceans, <10 m to 50 m for HF cetaceans, <10 m to 90 m for LF cetaceans and <10 m to 60 m for phocids.

12.6.2.74 For all marine mammal groups, suction pile dredging had the largest estimated PTS impact range. These are the worst-case scenario PTS impact ranges, as these values mean that animals would have to stay within these very small ranges for 24 hours before they experienced injury.

12.6.2.75 This is an extremely unlikely scenario, as it is far more likely that any marine mammal within the injury zone would move away from the vicinity of the vessel and the construction activity. Therefore, PTS impact ranges for fleeing receptors have also been presented (Table 12.23). This resulted in PTS impact ranges of <10 m for all marine mammal groups for all non-piling construction activity; a marine mammal receptor would have to be within 10 m of the continuous noise source at the start of the activity to acquire the necessary exposure to induce PTS.

12.6.2.76 The magnitude of impact of non-piling construction noise under the maximum design scenario is judged to be negligible. These noise sources will have a local spatial extent, short-term duration, and are intermittent, meaning that, with the most precautionary estimates, a marine mammal would have to remain within close proximity (<820 m) for a 24-hour period for PTS-onset to occur.

12.6.2.77 With a combination of negligible magnitude of impact and negligible/low sensitivity to this impact by all the species considered in this assessment, a **negligible** effect is predicted, which is not significant in EIA terms.

Table 12.23 – Summary of the source level (SEL_{cum} dB re 1 µPa @ 1 m RMS) and PTS-onset impact ranges (m) for the different construction noise sources using the non-impulsive criteria from Southall *et al.* (2019) for marine mammals assuming a stationary receptor (S) or a fleeing receptor (F)

Noise source	Source Level	VHF		HF		LF		PCW	
		S	F	S	F	S	F	S	F
Vessel movement (large)	168	<10	<10	<10	<10	10	<10	<10	<10
Vessel movement (medium)	161	<10	<10	<10	<10	<10	<10	<10	<10
Backhoe dredging	165	<10	<10	<10	<10	<10	<10	<10	<10
Suction dredging	186	400	<10	30	<10	40	<10	30	<10
Cable laying	171	40	<10	<10	<10	10	<10	<10	<10
Trenching	172	40	<10	<10	<10	20	<10	<10	<10
Rock placement	172	530	<10	<10	<10	30	<10	<10	<10
Drag embedment anchors	171	70	<10	<10	<10	<10	<10	<10	<10
Suction pile installation	192	820	<10	50	<10	90	<10	60	<10
Drilling	170.1	<10	<10	<10	<10	<10	<10	<10	<10

12.6.2.78 *Sheet piling:* Sheet piling/cofferdam may be installed at the landfall, to provide trench shuttering to minimise the extent of the excavation works, and provide safe trench support from the seaward side of the inshore area to the onshore duct entry point (e.g. above MHWS). Trench support systems typically are required be installed to at least 1/3 of the pile dimensions (3 m depth approximately). It is anticipated the length of sheet piles will vary from 6 m to 16 m in length, resulting in a 100 m corridor extending from the beach to the intertidal area.

12.6.2.79 For the pile driving of sheet piles, the worst-case assumption hammer energy is 300 kJ, of which, only 30-50% is transferred into the sheet pile. The underwater noise modelling process for sheet piles is the same as that for the anchor piles presented above – just with a smaller hammer energy. While modelling specifically for sheet piling has not been conducted here, it can be assumed that, given the lower hammer energies used, the predicted impact ranges for PTS-onset, TTS-onset and disturbance will be less than those presented for impact pile driving of the anchors. Given that PTS-onset for piling has been assessed as being of a negligible magnitude (see Section 12.6.2.31 et seq.) and is anticipated to be of a lesser extent as a result of sheet piling, the significance of this effect has also been assessed as **negligible**, which is not significant in EIA terms.

TTS Result

12.6.2.80 Using the non-impulsive weighted SEL_{cum} TTS-onset thresholds for stationary receptors from Southall *et al.* (2019) resulted in estimated TTS impact ranges that were highly variable between marine mammal groups and non-piling construction activity (Table 12.24). TTS impact ranges for LF cetaceans had the greatest degree of variation, ranging from 30 m to 9.9 km, with rock placement having the largest TTS impact range. For HF cetaceans, it ranged from <10 m to 570 m, with suction pile installation having the largest TTS impact range. For VHF cetaceans, the impact range was from 20 m to 1,300 m, with rock placement having the largest TTS impact range. For phocids, the TTS impact range was from <10 m to 610 m with suction pile installation having the largest TTS impact range. These are the worst-case scenario.

12.6.2.81 These values of TTS impact ranges, mean that animals would have to stay within these ranges for 24 hours before they experienced a TTS in hearing, which is an extremely unlikely scenario, as it is far more likely that any marine mammal within the injury zone would move away from the vicinity of the vessel and the construction activity. Therefore, TTS impact ranges for fleeing receptors have also been presented (Table 12.24). This resulted in TTS impact ranges of <10 m for HF cetaceans, LF cetaceans and phocids for all non-piling construction activity. The TTS impact range was also <10 m for the majority of non-piling construction activities for LF cetaceans, with the exception of suction dredging (230 m), rock placement (990 m) and suction pile installation (780 m).

12.6.2.82 As outlined in Section 12.4.11, there are no thresholds to determine a biologically significant effect from TTS-onset. Therefore, whilst the predicted ranges and area for the onset of TTS are presented in Table 12.24, no assessment of the number of animals, magnitude, sensitivity or significance of effect can be given. This approach was agreed with members of Marine Mammals and Marine Ecology Expert Topic Group (21st September 2020).

Table 12.24 – Summary of the source level (SEL_{cum} dB re 1 µPa @ 1 m RMS) and TTS-onset impact ranges (m) for the different construction noise sources using the non-impulsive criteria from Southall *et al.* (2019) for marine mammals assuming a stationary receptor (S) or a fleeing receptor (F)

Noise source	Source level	VHF		HF		LF		PCW	
		S	F	S	F	S	F	S	F
Vessel movement (large)	168	480	<10	<10	<10	140	<10	40	<10
Vessel movement (medium)	161	130	<10	<10	<10	30	<10	<10	<10
Backhoe dredging	165	20	<10	20	<10	30	<10	<10	<10
Suction dredging	186	460	<10	280	<10	3,300	230	300	<10
Cable laying	171	480	<10	20	<10	1,300	<10	60	<10
Trenching	172	500	<10	20	<10	1,200	<10	<10	<10
Rock placement	172	1,300	<10	230	<10	9,900	990	270	<10
Drag embedment anchors	171	60	<10	70	<10	690	<10	20	<10

Noise source	Source level	VHF		HF		LF		PCW	
		S	F	S	F	S	F	S	F
Suction pile installation	192	930	<10	570	<10	5,600	780	610	<10
Drilling	170.1	130	<10	<10	<10	160	<10	30	<10

Disturbance Result

12.6.2.83 In general, there is little evidence on the impact of disturbance of marine mammals from other construction activities such as rock placing, dredging, trenching etc.

12.6.2.84 *Seabed preparation – sandwave levelling (dredging):* Dredging, which may be used to level sandwaves along the export cable route, can be described as a continuous broadband sound source, with the main energy below 1 kHz, however the frequency and sound pressure level can vary considerably depending on the equipment, activity, and environmental characteristics (Todd *et al*., 2015). The source level (SPL at 1 metre from the sound source) of dredging has been described to vary between 172-190 dB re 1 µPa, with a frequency range of 45 Hz to 7 kHz (Evans, 1990; Thompson *et al*., 2009; Verboom, 2014).

12.6.2.85 There are some studies which have reported potential disturbance ranges from dredging activities, and these are summarised in Table 12.25. Unfortunately most other studies on the effects of dredging on marine mammals have been inconclusive with varying responses reported (Marley *et al.* 2017). Should any disturbance occur, it is expected that the disturbance would be limited to a maximum of 5 km impact radius and that any animals that are displaced would be expected to return once the dredging works had ceased. It is anticipated that these activities may take up to 15 days, therefore this is of very short-term duration. The magnitude of this impact is judged to be negligible due to the short-term duration and localised scale.

12.6.2.86 As the sensitivity of the marine mammal species assessed ranges from Low/Negligible, a **negligible** effect is predicted, which is not significant in EIA terms.

Table 12.25 – Summary of the potential for disturbance from dredging on marine mammal species and number of animals predicted to be impacted. A 5 km EDR is assumed

Species	Evidence	5 km EDR
Harbour porpoise	Dredging at a source level of 184 dB re 1 µPa at 1 m would result in avoidance up to 5 km from the dredging site (Verboom 2014). Conversely, Diederichs *et al.* (2010) found much more localised impacts; using Passive Acoustic Monitoring there was short term avoidance (~3 hours) at distances of up to 600 m from a trailing suction hopper dredger, but no significant long-term impacts. Modelling potential impacts of dredging using a case study of the Maasvlakte port expansion (assuming maximum source levels of 192 dB re 1 µPa) predicted a disturbance range of 400 m, while a more conservative approach predicted avoidance of harbour porpoise up to 5 km (McQueen *et al.* 2020).	9 porpoise (0.01% MU)

Species	Evidence	5 km EDR
Bottlenose dolphin	Increased dredging activity at Aberdeen Harbour was associated with a reduction in bottlenose dolphin presence and, during the initial dredge operations, bottlenose dolphins were absent for five weeks (Pirotta *et al.* 2013). In an urbanised estuary in Western Australia, bottlenose dolphin responses to dredging varied between sites. At one site no bottlenose dolphins were sighted on days when backhoe dredging was present, while dolphins remained using the other site (Marley *et al.* 2017).	5 dolphins (0.05% MU)
Common dolphin	In northwest Ireland, construction related activity (including dredging) did not result in any evidence of a negative impact to common dolphins (Culloch *et al.* 2016).	167 dolphins (0.16% MU)
Minke whale	In northwest Ireland, construction related activity (including dredging) has been linked to reduced minke whale presence (Culloch *et al.* 2016).	1 whale (<0.01% MU)
Grey seal	Based on the generic threshold of behavioural avoidance of pinnipeds (140 dB re 1 µPa SPL) (Southall *et al.* 2007), acoustic modelling of dredging demonstrated that disturbance could be caused to individuals between 400 m to 5 km from site (McQueen *et al.* 2020).	3 seals (0.05% MU)

12.6.2.87 *Cable installation***:** The underwater noise generated during cable installation is a combination of the noise generated by the cable laying vessel and the trenching machinery. To the Applicant's knowledge, there are no data available for the effect of cable installation and trenching on marine mammals.

12.6.2.88 Therefore, it has been assumed that deterrence ranges would be similar to those from dredging and, as such, would be within 5 km, and it is expected that any animals that are displaced would be expected to return once the cable installation works had ceased. It is anticipated that it will take up to a maximum of 49 days under the worst-case scenario). This medium-term duration and local scale disturbance is expected to result in a low magnitude of impact.

12.6.2.89 As the sensitivity of the marine mammal species assessed ranges from low/negligible, a **minor adverse** effect is predicted, which is not significant in EIA terms.

12.6.2.90 *Rock placement:* There is very little information on the impacts of rock placing on marine mammals. A previous assessment using the 90 dB_{ht} disturbance threshold (strong avoidance reaction by virtually all individuals) predicted impact ranges for minke whales, harbour porpoise and bottlenose dolphins to be <100 m for rock placement (Barham *et al.* 2014).

12.6.2.91 It is expected that rock protection work along the entire export cable route would take 20 days and would be focussed in very localised areas at any one time. It is expected that any animals that are displaced would be expected to return once the rock placement works had ceased. Therefore, the magnitude of impact is judged to be low.

12.6.2.92 As the sensitivity of the marine mammal species assessed ranges from low/negligible, a **minor adverse** effect is predicted, which is not significant in EIA terms.

12.6.2.93 *Drag embedment anchors:* It is expected that vessel noise would be the primary source of disturbance during installation of drag embedment anchors. It is anticipated to take 30 hours to install each anchor (this includes anchor laying, pulling into position and load testing), which would result in a maximum of 79 days assuming 63 anchors. Vessel disturbance is assessed separately in Section 12.6.2.110 *et seq*.

12.6.2.94 *Suction pile installation:* There are limited data available on the noise generated by suction pile installation, where the primary source of noise is expected to be the underwater suction pumps. Data collected during the installation of the Borkum Riffgrund 2 offshore wind farm found that the noise from suction pumps could not be heard at distances above 500 m (Koschinski and Luderann 2020). If displacement occurs, it is expected that any animals would return once the suction pile installation works had ceased.

12.6.2.95 It is expected that it would take up to a maximum of 30 hours to install the suction piles (including deployment of anchor, removal of water for suction piling and pre-laying of the mooring chain), which results in a maximum of 1,050 hours in total for 35 mooring lines (44 days). This is judged to result in a low magnitude of impact.

12.6.2.96 As the sensitivity of the marine mammal species assessed ranges from low/negligible, a **minor adverse** effect is predicted, which is not significant in EIA terms.

12.6.2.97 *Drilling:* There is little information available specifically on the potential disturbance of marine mammals by drilling activity. The research that is currently available was conducted at least 20 years ago, but it is suggested that noise from drilling may cause disturbance for at least some species of marine mammals. A survey of the literature suggests evidence of disturbance of baleen whales, for example drilling and dredging playback experiments found half of the exposed bowhead whales responded to noise levels of 115 dB re 1 µPa, and in some cases, calling, foraging and dive patterns were altered (Richardson and Wursig 1990).

12.6.2.98 A low magnitude of impact is predicted and it is expected that any animals that are displaced would be expected to return once the drilling works had ceased.

12.6.2.99 As the sensitivity of the marine mammal species assessed ranges from low/negligible, a **minor adverse** effect is predicted, which is not significant in EIA terms.

12.6.2.100 *Sheet piling:* For the pile driving of sheet piles at landfall, the worst-case assumption hammer energy is 300 kJ, of which, only 30-50% is transferred into the sheet pile. The underwater noise modelling process for sheet piles is the same as that for the anchor piles presented above – just with a smaller hammer energy. While modelling specifically for sheet piling has not been conducted here, it can be assumed that, given the lower hammer energies used, the predicted impact ranges for disturbance will be less than those presented for impact pile driving of the anchors (see 12.6.2.39 *et seq*.). Therefore, the impact is expected to be of low magnitude for common dolphins, bottlenose dolphins and harbour porpoise, and negligible magnitude for the other marine mammal species. At worse, this results in **minor adverse** effect, which is not significant in terms of the EIA regulations.

12.6.2.101 *Vessels:* vessel disturbance is assessed separately in Section 12.6.2.110 *et seq*.

12.6.2.102 In conclusion, the predicted level of disturbance from other construction activity (dredging, cable laying, rock placement, drag embedment anchors, suction pile anchors, drilling and sheet piling) is predicted to result in a **negligible** to **minor adverse** effect, which is not significant in EIA terms.

Collision with vessels

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

12.6.2.104 There is currently a lack of information on the frequency of occurrence of vessel collisions as a source of marine mammal mortality, and there is little evidence from marine mammals stranded in the UK, that injury from vessel collisions is an important source of mortality. The UK Cetacean Strandings Investigation Programme (CSIP) documents the annual number of reported strandings and the cause of death for those individuals examined at post-mortem. The CSIP data shows that very few strandings have been attributed to vessel collisions[23], therefore, while there is evidence that mortality from vessel collisions can and does occur, it is not considered to be a key source of mortality highlighted from post-mortem examinations.

12.6.2.105 Harbour porpoises, dolphins and seals are relatively small and highly mobile, and given observed responses to noise, are expected to detect vessels in close proximity and largely avoid collision. Predictability of vessel movement by marine mammals is known to be a key aspect in minimising the potential risks imposed by vessel traffic (Nowacek *et al.* 2001, Lusseau 2003, 2006).

12.6.2.106 As shown in Volume 3, Technical Appendix 16.1: Navigational Risk Assessment, the Project site (array area and offshore export cable corridor) and surrounding areas experience a wide range of existing vessel activity, including passenger vessels, tankers, cargo vessels, tug & service vessels, fishing vessels, and recreational vessels. The greatest shipping density occurs within the approaches to Milford Haven, with relatively few transits within the array area as compared to across the offshore export cable corridor, particularly closer to shore (see Volume 3, Technical Appendix: 16.1 Navigational Risk Assessment, Figure 23 which shows the annualised vessel density for a 10 km buffer around the Project). Therefore, the presence of vessels associated with the Project is not a novel impact pathway for marine mammals in the area.

12.6.2.107 The embedded mitigation of a vessel management plan will ensure that vessel traffic moves along predictable routes and will define how vessels should behave in the presence of marine mammals. It is highly likely that a proportion of vessels will be stationary or slow moving throughout construction activities, for significant periods of time. Therefore, the actual increase in vessel traffic moving around the array area, and to/from port to the site, will occur over short periods of the offshore construction activity. It is anticipated that there will be a maximum of 6 vessels for on site at any one time over the 8-month construction period (Table 12.12). The adoption of a vessel management plan during construction will minimise the potential for any impact. Therefore, the risk of vessel collisions occurring as a result of construction traffic is of negligible magnitude.

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

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

12.6.2.109 The magnitude of the impact has been assessed as negligible and the sensitivity of receptors as high. Therefore, collisions from vessels is concluded to result in a **minor adverse** effect, which is not significant in EIA terms.

Disturbance from vessels

12.6.2.110 Vessel noise levels from construction vessels will result in an increase in non-impulsive, continuous sound in the vicinity of the Project array, typically in the range of 10-100 Hz (although higher frequencies may also be produced) (Sinclair *et al.* 2021) with an estimated source level of 161–168 SEL_{cum} dB re 1 µPa@1m (RMS).

12.6.2.111 As shown in Volume 3, Technical Appendix 16.1: Navigational Risk Assessment, the Project site (array area and offshore export cable corridor) and surrounding areas experience a wide range of existing vessel activity, including passenger vessels, tankers, cargo vessels, tug & service vessels, fishing vessels, and recreational vessels. The greatest shipping density occurs within the approaches to Milford Haven, with relatively few transits within the array area as compared to across the cable route, particularly closer to shore (see Volume 3, Technical Appendix 16.1: Navigational Risk Assessment, Figure 23 in which shows the annualised vessel density for a 10 km buffer around the Project). Therefore, the presence of vessels associated with the Project is not a novel impact pathway for marine mammals in the area. It is anticipated that there will be a maximum of 6 vessels for on site at any one time over the 8 month construction period (Table 12.12) and will, therefore, not result in a significant increase in vessel traffic in the area.

12.6.2.112 Heinänen and Skov (2015) suggested that harbour porpoise density was significantly lower in areas with vessel transit rates of greater than 80 per day (within a 5 km^2 area). It is not anticipated that vessel traffic in the Project area, will exceed this figure, even considering the addition of the Project construction traffic. Therefore, the impact is expected to be of low magnitude.

12.6.2.113 Harbour porpoise have a high frequency generalised hearing range (275 Hz-160-kHz) and, therefore, the majority of additional vessel traffic noise will fall below their range of hearing. However, they are known to exhibit an avoidance response to vessels that contain low levels of high frequency components (Dyndo *et al.* 2015).

12.6.2.114 Studies have shown that, whilst there may be short-term effects on foraging, harbour porpoise show a quick recovery time to responses to vessel traffic, remaining in heavily trafficked areas (Wisnieska 2013). There appears to be little fitness cost to exposure to vessel noise, and any local scale responses taken to avoid vessels. It is also likely that porpoise may become habituated where vessel movements are regular and predictable.

12.6.2.115 Previous modelling of bottlenose dolphin in the Moray Firth, in response to increased vessel traffic from offshore wind development, found it to have no negative impact on the local population (Lusseau *et al.* 2011). There is also evidence of bottlenose dolphins becoming habituated to increased boat traffic, particularly larger commercial vessels which have predictable patterns of movement and do not actively disrupt feeding behaviour, as a recreational or tourist vessel may (Sini *et al.* 2005).

12.6.2.116 As both HF cetaceans with similar hearing abilities, it is anticipated that bottlenose and common dolphins will react similarly to construction vessel traffic. The generalised hearing range of high frequency cetaceans 150 Hz–160 kHz (Southall *et al.* 2019) is also above the anticipated frequency range of much of the construction vessel noise.

12.6.2.117 Minke whales have a low frequency generalised hearing range of 7 Hz–35 kHz which falls within the expected frequency range of construction vessel traffic. They have been shown to exhibit a decrease in foraging activity in response to whale watching vessels (Christiansen *et al.* 2013). However, these vessels were specifically following minke whales and, therefore, it is not known how they would respond to construction vessels that would be following a pre-determined route and not directly interacting with the animals. As generalist feeders with a varied diet, it is not expected that any temporary displacement resulting from vessel activity in relation to the Project will lead to any significant effect on individual energy budgets and, subsequently, fitness.

12.6.2.118 Evidence suggests that any behavioural changes and displacement are likely to be temporary and that some species (harbour porpoise and bottlenose dolphin particularly) may even become habituated to the construction vessel presence due to their more predictable movements and therefore exhibit less of a response over time. Based on modelling conducted by Southall *et al.* (2019), all cetacean functional hearing groups would have to be <100 m from a medium vessel for a 24-hour period to experience either TTS or PTS. The same was also true for a large vessel with the exception of VHF cetaceans which may experience TTS at 200 m over 24 hours (Table 12.24). These impacts are unlikely, as it is far more likely that any marine mammal within the injury zone would move away from the vicinity of the vessel and the construction activity.

12.6.2.119 Data collected during windfarm construction have demonstrated that porpoise detections around the pile driving site decline several hours prior to the start of pile driving, and it is assumed that this is due to the increase in other construction related activities and vessel presence in advance of the actual pile driving (Brandt *et al.* 2018, Benhemma-Le Gall *et al.* 2021). Porpoise displacement has been observed up to 4 km from construction vessels (Benhemma-Le Gall *et al.* 2021). It is expected that other cetacean species will be displaced to a similar extent.

12.6.2.120 The sensitivity of all cetacean species under consideration to vessel disturbance has, therefore, been assessed as low.

12.6.2.121 Grey seals have been shown to respond to both small (~2 kHz) and large (~0.25 kHz) vessels at approximately 400 m (Thomsen *et al.* 2006) due to their wide range of hearing from 50 Hz–86 kHz (Southall *et al.* 2019). However, they are frequently observed in areas of high vessel traffic, particularly within 50 km of the coast close to seal haul-outs(Jones *et al.* 2017b).

12.6.2.122 The co-occurrence of grey seals and vessel traffic has also not been linked to any adverse impact on population size. In water, grey seals would have to remain within 100 m of a large or medium vessel for 24 hours to experience a PTS or TTS injury, which is again unlikely as it is anticipated a seal within the injury zone would move away from the vicinity of the vessel and the construction activity. Therefore, the sensitivity to grey seals from construction vessel disturbance has been assessed as negligible.

12.6.2.123 The magnitude of disturbance from vessels has been assessed as low and the sensitivity of receptors as low for cetaceans and Negligible for grey seals. Therefore, the significance of the effect has been assessed as **minor adverse** for cetaceans and **negligible** for grey seals, neither of which is significant in EIA terms.

Disturbance at seal haul-outs

12.6.2.124 The presence of vessels close to the coast and additional noise from onshore/landfall construction of the offshore export cable corridor has the potential to lead to the disturbance of coastal and onshore habitats used by seals as haul-out sites.

12.6.2.125 The main grey seal breeding sites in Wales are located at Ramsey Island, Skomer MCZ, north Pembrokeshire and north Wales (SCOS 2021), with Skomer MCZ being in closest proximity to both the Project site, >10 km from the landfall site (West Angle Bay). It is expected that the location of the landfall site (West Angle Bay) is too far from the nearest key grey seal haul-out/breeding site to cause any disturbance to the seal haul-outs.

12.6.2.126 A study of grey seal mothers found that they responded to vessel disturbance by moving into the water more due to boat speed, than as a result of the distance, although movement into the water was generally observed to occur at distances of between 20 m and 70 m, with no detectable disturbance at 150 m (Strong and Morris 2010, Wilson 2014). In other studies, grey seals have also been reported to move into the water when vessels are at a distance of approximately 200 m to 300 m (Wilson 2014).

12.6.2.127 Disturbance on grey seal breeding beaches also has the potential to interrupt mother-pup bonding and there is the potential for separation and energetic loss, although this disturbance is thought to be of a lesser extent for grey seals than harbour seals (Wilson 2014). However, a degree of habituation has also been observed in grey seals in response to frequent non-harassing vessels (Strong and Morris 2010). For example, on breeding beaches on Ramsey Island, frequent tour boat vessel traffic occurs, yet no reduction in reproductive rate has occurred (Strong and Morris 2010), indicating that seals may become habituated to the regular vessel traffic during construction.

12.6.2.128 There is the potential for vessels moving between port and the array area to cause disturbance to grey seal haul-outs. However, it is not expected that any vessels would pass close enough to the haul-out or be travelling at sufficient speed to result in any disturbance.

12.6.2.129 The impact, should it occur, is predicted to be of local spatial extent, short term duration, intermittent and is reversible, with no potential for survival and reproductive rates to be impacted to the extent that the population trajectory would be altered. The magnitude is therefore considered to be negligible. Furthermore, grey seals have a negligible sensitivity to disturbance from vessels. Therefore, a **negligible** effect is predicted, which is not significant in EIA terms.

Indirect impacts on prey

12.6.2.130 Given that marine mammals are dependent on fish prey, there is the potential for indirect effects on marine mammals as a result of impacts upon fish species or the habitats that support them. The key prey species for each marine mammal receptor are listed in Table 12.26.

Table 12.26 – Key prey species of the marine mammal receptors (bold = species identified as present in the Project area in Chapter 10: Fish and Shellfish Ecology)

Species	Region	Key prey species	Reference
Common dolphin	UK	Seabass, goby, cod, cephalopods, mackerel, lanternfish, blue whiting	Brophy *et al.* (2009)
Harbour porpoise	Scotland	Whiting, sandeel, haddock, saithe, pollock, Norway pout, poor-cod, cod, ling, blue whiting	Santos *et al.* (2004)
	Ireland	Poor-cod, whiting, herring	Berrow and Rogan (1995), Hernandez-Milian *et al.* (2011)
Bottlenose dolphin	Wales	Mackerel, seabass, herring, whiting	Pesante *et al.* (2008), Nuuttila *et al.* (2017)
	Wales	Seabass, salmon, conger eel, garfish, sandeel, small sharks	Evans and Hintner (2013)
	Ireland	Whiting, blue whiting, pollock, saithe, haddock, poor-cod	Hernandez-Milian *et al.* (2011)
	Scotland	Cod, saithe, whiting, salmon, haddock	Santos *et al.* (2004)
Minke whale	Scotland	Sandeel, herring, sprat, mackerel, goby, Norway pout/poor cod	Pierce *et al.* (2004)
Grey seal	Wales	Cod, righteye flounders, large-tooth flounders, harbour porpoise	Stringell *et al.* (2015), Nelms *et al.* (2019)
	Wales	Whiting, poor-cod, sole, herring	Evans and Hintner (2013)

12.6.2.131 During construction activities, there is the potential for disturbance to both herring and sandeels, both of which have had potential spawning grounds identified within the Study Area. The spawning grounds of both of these species are highly sensitive to disturbance, however Chapter 10: Fish and Shellfish Ecology concluded that there was no significant predicted impact from construction activities, since the footprint of construction is unlikely to result in a significant change to overall stock abundance of these species.

12.6.2.132 While there may be certain species that comprise the main part of their diet, all marine mammals in this assessment are considered to be generalist feeders and are thus not reliant on a single prey species. As a result, the impact is of negligible magnitude and the marine mammal receptors are assessed as having a low sensitivity to changes in prey abundance and distribution. Therefore, a **negligible** effect is predicted, which is not significant in EIA terms.

Construction phase summary:

12.6.2.133 None of effects during the construction phase identified above is major or moderate adverse (significant in EIA terms). Therefore, no additional mitigation is required to reduce the significance to non-significant in EIA terms, and the significance of residual effects remains as detailed above.

12.6.3 Operational Phase

Barrier effects

12.6.3.1 The presence of the floating WTGs and substructures during the operational phase of the windfarm has the potential to result in barrier effects for marine mammals.

12.6.3.2 Potential barrier effects during the Project's lifespan have been assessed by examining the impact on marine mammals at a number of previously constructed offshore windfarm sites. A number of recent studies have reported the presence of marine mammals within wind farm footprints. For example, at the Horns Rev and Nysted offshore wind farms in Denmark, long-term monitoring showed that both harbour porpoise and harbour seals were sighted regularly within the operational OWFs, and within two years of operation, the populations had returned to levels that were comparable with the wider area (Diederichs *et al.* 2008). Similarly, a monitoring programme at the Egmond aan Zee OWF in the Netherlands reported that significantly more porpoise activity was recorded within the OWF compared to the reference area during the operational phase (Scheidat *et al.* 2011) indicating the presence of the windfarm was not adversely affecting harbour porpoise presence.

12.6.3.3 Other studies at Dutch and Danish OWFs (Lindeboom *et al.* 2011) also suggest that harbour porpoise may be attracted to increased foraging opportunities within operating offshore wind farms. In addition, recent tagging work by Russell *et al.* (2014) found that some tagged harbour and grey seals demonstrated grid-like movement patterns as these animals moved between individual WTGs, strongly suggestive of these structures being used for foraging. Previous reviews have also concluded that operational wind farm noise will have negligible barrier effects (Madsen *et al.* 2006, Teilmann *et al.* 2006a, Teilmann *et al.* 2006b, CEFAS 2010, Brasseur *et al.* 2012).

12.6.3.4 There is no information available on the potential for floating WTG sub-structures to result in barrier effects for marine mammals. However, given the relative spatial scale of devices, the low number of devices at the Project, the water depth and the size of marine mammals, it is expected that marine mammals would be unlikely to perceive the Project substructures as a barrier to movement.

12.6.3.5 Based on results of studies conducted at other offshore windfarm locations, it is not anticipated that the Project will create a barrier to marine mammals and therefore will not prevent their access to or transit through the area. The magnitude of the impact has been assessed as negligible and the sensitivity of receptors also as negligible. Therefore, barrier effects due to the presence of semi-submersible floating platforms/WTGs and substructures are predicted to result in a **negligible** effect, which is not significant in EIA terms.

Entanglement

12.6.3.6 *Sub-sea structures:* The mooring lines and array cables present in the water column during the operation phase of the Project may represent an entanglement risk for marine mammals. Entanglement is defined as the unintentional capture/restraint of marine animals by strong, flexible, anthropogenic materials such as stationary ropes, lines, cables and other mainly linear structures including lines associated with fishing gears (Benjamins *et al.* 2014). Marine mammals, typically large cetaceans, may become entangled within stationary ropes, lines or cables for a number of reasons. For example, a marine mammal may not be able to detect the presence of these sub-structures (visual systems may be compromised due to environmental factors such as low light levels, high turbidity and/or high levels of suspended sediment), they may perceive the sub-structures as a threat or in some cases they may deliberately approach and encounter the sub-structures (Benjamins *et al.* 2014).

12.6.3.7 Typically, smaller cetaceans such as dolphins and porpoises are not as likely to become entangled in subsea structures, with these species being typically more vulnerable to bycatch (Benjamins *et al.* 2014). Larger cetaceans, such as minke whales, are known to become entangled in various subsea structures (Benjamins *et al.* 2014). These known entanglements of larger cetaceans are, typically, in relation to fisheries, with entanglement being the associated mortality for approximately half of all reported minke whale strandings in Scotland (Northridge *et al.* 2010), with creel fisheries identified as the primary cause in most cases. The inability of larger cetaceans such as minke whales to flex their body, results in these animals having limited manoeuvrability to enable them to escape entanglement situations.

12.6.3.8 Minke whales can become entangled in a variety of ways, with evidence of injury and lesions to the mouth and jaw (suggesting entanglement when mouth is open or feeding) as well as entanglement lesions to the tail stock and dorsal fin (Northridge *et al.* 2010). There is evidence in the literature that whales (including sperm, humpback and killer whales) can become entangled in submarine telegraphic cables (Heezen 1957, Wood and Carter 2008), with these entanglement events being associated with loops and suspensions of the cable form on the seabed. Typically, entanglements occur because of lines with loose ends or with lines that have sufficient slack to allow the formation of loops within which an individual can become entangled (Garavelli 2020).

12.6.3.9 There is nothing in the existing literature to suggest that entanglement of marine mammals in catenary or tensioned mooring lines is likely to pose a significant risk. However Garavelli (2020) suggests that the relative spatial scale of devices and their associated mooring lines, the water depth, and the size of marine mammals indicates that the likelihood of encounter is low because the subsea structures (mooring lines and cables) occupy a very small cross section of the water column. It is important to note that, while floating wind farms are relatively new in the offshore wind industry, the oil and gas industry has used offshore floating oil rig platforms for decades. The impact of entanglement with floating oil rigs is considered to be negligible (Morandi *et al.* 2018) and, thus, a similar level of risk can be expected from floating wind structures.

12.6.3.10 *Mooring Lines:* The semi-submersible floating platform will be attached to the seabed using a series of anchored mooring lines. A catenary mooring system will be used, a system that is widely used in the offshore oil and gas industry. This consists of anchors, ground chains, synthetic ropes and other connectors. Clump weights, usually iron and occasionally concrete, will be used to load the line, therefore, reducing the overall length of the mooring lines. There will be between three to five mooring lines in a triangular fashion from each floating platform, to provide a mooring system with low pre-tension requirements. The mooring lines are likely to be made from chain, steel and synthetic rope, using offshore grade materials.

12.6.3.11 Benjamins *et al.* (2014) and Harnois *et al.* (2015) conducted a qualitative risk assessment to understand the risk of entanglement from different mooring configurations under various sea states, using the dynamic analysis software OrcaFlex™. They concluded that all mooring systems examined (including catenary mooring systems) were under too much tension to create a loop that could potentially entangle a whale. Likewise, the engineers on the Project have confirmed that there is "absolutely no risk" of the mooring lines forming a loop as there will always be a minimum tension in the lines. Therefore, there is considered to be no pathway under which a marine mammal could become entangled directly in the mooring lines.

12.6.3.12 *Array Cables:* The WTG units will be connected through a series of array cables. The array cables will have a Lazy Wave formation to allow for dynamic movement without the cable stretching or snapping. The array cables will touchdown on the seabed up to 140 m from the hull of the floating platform. The array cable system will also include the cable hang-off, bend stiffener, buoyancy modules and touchdown point protection, as part of the Lazy Wave configuration.

12.6.3.13 No risk exists for the of the array cables forming any form of loop due to the tension that will be built into the design of the cable. Therefore, there is considered to be no pathway under which a marine mammal could become entangled directly in the array cables.

12.6.3.14 *Export cable:* The offshore array will be connected to the landfall point via a single marine export cable along which electricity will be transported to the grid at the onshore substation. It is expected that most of the export cable will be buried, however up to 16% of the offshore export cable length may be required to be surface laid, which would then be covered by external cable protection such as rock berm. Therefore, it is not expected that any part of the export cable will be exposed and, thus, there is no pathway under which a marine mammal could become entangled directly in the offshore export cable.

12.6.3.15 *Ghost-fishing*; There is a potential risk of indirect entanglement to all marine mammal species if ghost/derelict fishing gear and other marine litter becomes attached to the sub-sea structures of the Project. Since approximately half of all reported minke whale strandings in Scotland (Northridge *et al.* 2010) are reported to be due to entanglement with creel fisheries gear, there is a potential risk of entanglement due to ghost fishing which may be present within the Project array area.

12.6.3.16 A study of cetacean strandings in Irish waters reported 241 strandings between 1990 and 2015, where animals presented signs of possible entanglement or interactions with fishing gear (Lusher *et al.* 2018). Therefore, ghost fishing gear presents a potential risk to marine mammals even in the absence of the Project sub-sea structure.

12.6.3.17 Garavelli (2020) recommends that measures are put in place to routinely monitor mooring systems with ROVs. This would serve to both detect any malfunctions in the mooring lines but also identify the presence of any derelict fishing gear that has attached to the lines or cables. If this monitoring detects the presence of derelict gear on the structures, then it can be removed in order to reduce the entanglement risk to marine mammals.

12.6.3.18 The PDE has identified that ROV inspections of the moorings and sub-structures will be conducted, and that their frequency will depend on findings. This should allow a better understanding of the true entanglement risk and allow removal of any snagged derelict gear/marine litter, should this occur.

Table 12.27 - Summary of entanglement risk

Source	Risk
Mooring lines	Mooring lines will be under tension. No pathway under which a marine mammal could become entangled directly in the mooring lines.
Array cables	Array cables will be under tension. No pathway under which a marine mammal could become entangled directly in the array cables.
Offshore Export cable	Cable will be buried or protected if surface lain. No pathway under which a marine mammal could become entangled directly in the offshore export cable.
Ghost fishing	Potential for entanglement if derelict gear attaches to mooring lines and cables. Considered unlikely and will be monitored during ROV inspections.

12.6.3.19 In the highly unlikely event that a marine mammal does become entangled either directly with the sub-structure or indirectly with snagged derelict gear/marine litter, it has the potential to result in injury or death to the individual and as such the sensitivity of all marine mammals to entanglement is considered to be high. The fact that there is no pathway under which a marine mammal could become entangled directly in the mooring lines, array cables or offshore export cables, means that the magnitude of impact is assessed as negligible.

12.6.3.20 Given that ROV surveys of the moorings and sub-structures will be conducted, it is expected that any snagged derelict gear/marine litter can be identified and removed (noting that the removal of derelict gear/marine litter from the environment would be of beneficial effect) and thus the likelihood of entanglement, and so magnitude of impact is considered to be negligible. Therefore, entanglement is predicted to result in a **minor adverse** effect, which is not significant in EIA terms.

12.6.3.21 The Applicant wishes to note that while it is expected that the likelihood of entanglement in snagged derelict gear/marine litter is considered in this assessment to be negligible, it is acknowledged that there is currently no evidence upon which to base an assessment of the likelihood of this occurring. Therefore, the Applicant will consider the option for monitoring and reporting on this impact pathway as part of the Marine Mammal Monitoring Plan.

12.6.3.22 Should any monitoring suggest that the likelihood of this impact occurring is higher than expected, then contingency measures will be put in place. The exact measures within the contingency plan have yet to be determined, and consultation and agreement with stakeholders will be sought. Measures could, for example, involve more regular monitoring of lines and cables in order to remove any snagged derelict gear/marine litter as quickly as possible, to minimise the chance of indirect entanglement.

Collision with vessels

12.6.3.23 As stated previously, the Project site (array area and offshore export cable corridor) and surrounding areas experience a wide range of existing vessel activity, with the greatest shipping density occurs within the approaches to Milford Haven, with relatively few transits within the array area as compared to across the offshore export cable corridor, particularly closer to shore (see Volume 3, Technical Appendix 16.1: Navigational Risk Assessment, Figure 23 which shows the annualised vessel density for a 10 km buffer around the Project). Therefore, the presence of vessels associated with the Project is not a novel impact pathway for marine mammals in the area.

12.6.3.24 The embedded mitigation of a vessel management plan will ensure that vessel traffic moves along predictable routes and will define how vessels should behave in the presence of marine mammals. During O&M, it is anticipated that there will be two crew transfer vessels on site per day (one per 12 hour period) throughout the operational lifespan (Table 12.12), so this will not result in a significant increase in vessel traffic in the area. These vessels are also anticipated to be stationary or slow moving throughout operations at the Project, for significant periods of time.

12.6.3.25 It is not expected that the level of vessel activity during operations would cause an increase in the risk of mortality from collisions. The adoption of a vessel management plan during operations will minimise the potential for any impact. Therefore, the impact of vessel collisions occurring is of negligible magnitude.

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

12.6.3.27 The magnitude of the impact has been assessed as negligible and the sensitivity of receptors as high. Therefore, collisions from O&M vessels is concluded to result in a **minor adverse** effect, which is not significant in EIA terms.

Disturbance from vessels

12.6.3.28 As stated previously, the greatest existing shipping density occurs within the approaches to Milford Haven, with relatively few transits within the array area as compared to across the cable route, particularly closer to shore (see Volume 3, Technical Appendix 16.1: Navigational Risk Assessment, Figure 23 which shows the annualised vessel density for a 10 km buffer around the Project). Therefore, the presence of vessels associated with the Project is not a novel impact pathway for marine mammals in the area.

12.6.3.29 Vessel noise levels from O&M vessels will result in an increase in non-impulsive, continuous sound in the vicinity of the Project array, typically in the range of 10-100 Hz (although higher frequencies may also be produced) (Sinclair *et al.* 2021), with an estimated source level of 161–168 SEL_{cum} dB re 1 µPa@1m (RMS). It is anticipated there will be two crew transfer vessels on site per day (one per 12 hour period), conducting round trips throughout the operational lifetime, so this will not result in a significant increase in vessel traffic in the area.

12.6.3.30 Heinänen and Skov (2015) suggested that harbour porpoise density was significantly lower in areas with vessel transit rates of greater than 80 per day (within a 5 km^2 area). It is not anticipated that vessel traffic in the Project area will exceed this figure, even considering the addition of Project O&M traffic, which will be less than during the construction phase. Therefore, the impact is expected to be of low magnitude.

12.6.3.31 As previously stated in paragraphs 12.4.8.47, 12.4.8.53 and 12.4.8.54, the sensitivity of all cetacean species to vessel disturbance has been assessed as low and the sensitivity of grey seals has been assessed as negligible.

12.6.3.32 The magnitude of disturbance from vessels has been assessed as low and the sensitivity of receptors as low for cetaceans and negligible for grey seals. Therefore, a **minor adverse** effect is predicted for cetaceans and a **negligible** effect for grey seals, neither of which is significant in EIA terms.

Disturbance at seal haul-outs

12.6.3.33 The presence of vessels close to the coast has the potential to lead to the disturbance of coastal and onshore habitats used by seals as haul-out sites.

12.6.3.34 The main grey seal breeding sites in Wales are located at Ramsey Island, Skomer MCZ, north Pembrokeshire and north Wales (SCOS 2021), with the closest site (Skomer MCZ) being >10 km from the nearest proposed landfall site (West Angle Bay).

12.6.3.35 As stated in the construction section (Section 12.6.2.124 *et seq*.), there is the potential for vessels moving between port and the array area to cause disturbance to grey seal haul-outs, however, it is not expected that any vessels would pass close enough to the haul-out, or be travelling at sufficient speed to result in any disturbance.

12.6.3.36 The impact, should it occur, is predicted to be of local spatial extent, short term duration, intermittent and is reversible, with no potential for survival and reproductive rates to be impacted to the extent that the population trajectory would be altered. The magnitude is therefore considered to be negligible. Furthermore, grey seals have a negligible sensitivity to disturbance from impulsive noise. Therefore, a **negligible** effect is predicted, which is not significant in EIA terms.

Indirect impacts on prey

12.6.3.37 Given that marine mammals are dependent on fish prey, there is the potential for indirect effects on marine mammals as a result of impacts upon fish species or the habitats that support them. The key prey species for each marine mammal receptor are listed in Table 12.26.

12.6.3.38 During O&M activities, there is the potential for loss of existing habitat which currently provides foraging/spawning/nursery habitat for fish species. However, Chapter 10: Fish and Shellfish Ecology concluded that there are no significant impacts to fish species predicted during O&M.

12.6.3.39 While there may be certain species that comprise the main part of their diet, all marine mammals in this assessment are considered to be generalist feeders and are thus not reliant on a single prey species. As a result, the impact is of negligible magnitude and the marine mammal receptors are assessed as having a low sensitivity to changes in prey abundance and distribution. Therefore, changes in prey abundance occurring as a result of construction activities is predicted to result in a **negligible** effect, which is not significant in EIA terms.

Operational phase summary:

12.6.3.40 None of effects identified above is major or moderate adverse (significant in EIA terms). Therefore, no additional mitigation is required to reduce the significance to non-significant in EIA terms, and the significance of residual effects remains as detailed above.

12.6.4 Decommissioning

Disturbance from removal of structures

12.6.4.1 The decommissioning phase will comprise the reversal of the installation process, with platforms and moorings removed from the Project array area and returned to local ports for disassembly and disposal. Cable will be left *in situ* as far as is possible from a technical and environmental perspective.

12.6.4.2 The most appropriate approach to decommissioning will be decided nearer the end of the Project lifespan, to ensure approaches are based on best practice and best available technologies at the time of decommissioning. As the exact methods to be used for decommissioning are to be decided, the impact of disturbance from the removal of structures cannot be accurately determined at this time.

12.6.4.3 However, it is anticipated that with the implementation of embedded mitigation in the form of a Vessel Management Plan, Decommissioning Plan/Program and a MMMP specific to decommissioning activities the significance of these impacts will be reduced. The effects of decommissioning activities are assumed to be of a similar or lesser extent than during piling in the construction phase and therefore will be of **minor adverse** to **negligible** significance, which is not significant in EIA terms

Collision with vessels

12.6.4.4 The embedded mitigation of a vessel management plan will ensure that vessel traffic moves along predictable routes and will define how vessels should behave in the presence of marine mammals. During decommissioning, it is anticipated that there will be a similar number, or fewer, vessels on site than during construction (Table 12.12), so this will not result in a significant increase in vessel traffic in the area. These vessels are also anticipated to be stationary or slow moving throughout operations at the Project, for significant periods of time.

12.6.4.5 It is not expected that the level of vessel activity during decommissioning would cause an increase in the risk of mortality from collisions. The adoption of a vessel management plan during operations will minimise the potential for any impact. Therefore, the risk of vessel collisions occurring is of negligible magnitude.

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

12.6.4.7 The magnitude of the impact has been assessed as negligible and the sensitivity of receptors as high. Therefore, collisions from decommissioning vessels is concluded to result in a **minor adverse** effect**,** which is not significant in EIA terms.

Disturbance from vessels

12.6.4.8 It is anticipated that vessel traffic during the decommissioning phase will be similar, or less, than that during construction and, therefore, will not result in a significant increase in vessel traffic in the area.

12.6.4.9 Heinänen and Skov (2015) suggested that harbour porpoise density was significantly lower in areas with vessel transit rates of greater than 80 per day (within a 5 km^2 area). It is not anticipated that vessel traffic in the Project area (array area and ECC), will exceed this figure, even considering the addition of Project decommissioning traffic, which will be less than during the construction phase. Therefore, the impact is expected to be of Low magnitude.

12.6.4.10 As previously stated in paragraphs 12.4.8.47, 12.4.8.53 and 12.4.8.54, the sensitivity of all cetacean species to vessel disturbance has been assessed as low and the sensitivity of grey seals has been assessed as negligible.

12.6.4.11 The magnitude of the impact has been assessed as low and the sensitivity of receptors as low (for cetacean species) and negligible (for grey seals). Therefore, collisions from decommissioning vessels is concluded to result in a **negligible** and **minor adverse** effect, which is not significant in EIA terms.

Disturbance at seal haul-outs

12.6.4.12 The presence of vessels close to the coast, and additional noise from decommissioning, has the potential to lead to the disturbance of coastal and onshore habitats used by seals as haul-out sites.

12.6.4.13 The main grey seal breeding sites in Wales are located at Ramsey Island, Skomer MCZ, north Pembrokeshire and north Wales (SCOS 2021), with the closest site (Skomer MCZ) being >10 km from the nearest proposed landfall site (West Angle Bay).

12.6.4.14 As stated in the construction section (Section 12.6.2.124 *et seq*.), there is the potential for vessels moving between port and the array area to cause disturbance to grey seal haul-outs, however, it is not expected that any vessels would pass close enough to the haul-out, or be travelling at sufficient speed, to result in any disturbance.

12.6.4.15 The impact during decommissioning is predicted to be similar to, or of a lesser extent, than that experienced during construction. Any impact will be of local spatial extent, short term duration, intermittent and is reversible, with no potential for survival and reproductive rates to be impacted to the extent that the population trajectory would be altered. The magnitude is therefore considered to be negligible. Furthermore, grey seals have a negligible sensitivity to disturbance from impulsive noise. The significance of the effect has, therefore, been assessed as **negligible**, which is not significant in EIA terms.

Indirect impacts on prey

12.6.4.16 Given that marine mammals are dependent on fish prey, there is the potential for indirect effects on marine mammals as a result of impacts upon fish species or the habitats that support them. The key prey species for each marine mammal receptor are listed in Table 12.26.

12.6.4.17 During decommissioning activities, there is the potential for temporary habitat disturbance, however Chapter 10: Fish and Shellfish Ecology concluded that there are no significant impacts to fish species predicted during decommissioning.

12.6.4.18 While there may be certain species that comprise the main part of their diet, all marine mammals in this assessment are considered to be generalist feeders and are thus not reliant on a single prey species. As a result, the impact is of negligible magnitude and the marine mammal receptors are assessed as having a low sensitivity to changes in prey abundance and distribution. Therefore, changes in prey abundance occurring as a result of construction activities is judged to result in a **negligible** effect, which is not significant in EIA terms.

Decommissioning phase summary:

12.6.4.19 None of effects identified above is major or moderate adverse (significant in EIA terms). Therefore, no additional mitigation is required to reduce the significance to non-significant in EIA terms, and the significance of residual effects remains as detailed above.

12.7 Additional Mitigation

12.7.1.1 All impacts assessed for marine mammal receptors during construction, O&M and decommissioning have been assessed as minor or negligible which are non-significant in EIA terms. Therefore, no additional mitigation is required to reduce the significance of the residual effects beyond that proposed in Section 12.4.9.

12.8 Additional Monitoring

12.8.1.1 The following monitoring is proposed to form part of the Environmental Monitoring and Mitigation Plan to be drafted in consultation with NRW prior to the commencement of works:

- Monitoring of loading on the mooring lines from derelict fishing gear and/or marine mammal entanglement for all phases of the Project. This would likely be achieved via load cells being attached to mooring lines and ROV inspections of the moorings and sub-structures; and
- The Applicant would also be keen to provide input/support to any regional-scale strategic studies into marine mammals that may be developed as FLOW projects develop further in the Celtic Sea region.

12.9 Inter-Related Effects

12.9.1.1 Inter-relationships are considered to be the effects of different aspects of the proposed project on the same receptor. These are considered to be:

- *Project lifetime effects:* Assessment of the scope for effects that occur throughout more than one phase of the project (construction, O&M, and decommissioning); to interact to potentially create a more significant effect on a receptor than if just assessed in isolation in these three key project stages (e.g. subsea noise effects from piling, operational WTGs, vessels and decommissioning); and
- *Receptor led effects:* Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor. As an example, all effects on benthic ecology such as direct habitat loss or disturbance, sediment plumes, scour, jack-up vessel use etc., may interact to produce a different, or greater effect on this receptor, than when the effects are considered in isolation. Receptor-led effects might be short-term, temporary or transient effects, or incorporate longer term effects.

12.9.1.2 The assessment of impacts arising from construction, O&M and decommissioning of the Project indicates that impacts on receptors addressed in different aspects of the Project may potentially further contribute to the impacts assessed on marine mammals and *vice versa*. These are primarily from:

- Collision with vessels (Sections 12.6.2.103 *et seq*., 12.6.3.23 *et seq*. and 12.6.4.4 *et seq*.);
- Disturbance from vessels (paragraphs 12.6.2.110 *et seq*., 12.6.3.28 *et seq*. and 12.6.4.8 *et seq*.);

- Disturbance at seal haul-outs (paragraphs 12.6.2.124 *et seq*.,12.6.3.33 *et seq*. and 12.6.4.12 *et seq*.);
- Indirect impacts on prey (paragraphs 12.6.2.130 *et seq*.,12.6.3.37 *et seq*. and 12.6.4.16 *et seq*.); and
- Entanglement and collision (paragraph 12.6.3.6 *et seq*.).

12.9.1.3 The effect of inter-relationships between receptors and vessel collision has been assessed as a **minor adverse** significance. The effect of vessel disturbance has been assessed as **minor adverse** to **negligible** significance. The effect of disturbance at seal haul-outs and on prey species has been assessed as **negligible** significance. Therefore, none of the impacts of inter-relationships is considered significant in EIA terms.

12.9.1.4 Overall, no inter-relationships have been identified where an accumulation of residual impacts on marine mammals and the relationship between those impacts gives rise to a need for additional mitigation, beyond the embedded mitigation already considered.

12.10 Cumulative Effects Assessment

12.10.1.1 A Cumulative Effects Assessment (CEA) has been made, based on existing and proposed developments in the Study Area (Chapter 30: Cumulative Effects). The approach to the CEA is described in Chapter 30: Cumulative Effects. Cumulative effects are defined as those effects on a receptor that may arise when the development is considered together with other reasonably foreseeable projects.

12.10.2 Tiers

12.10.2.1 In assessing the potential cumulative effects for the Project, it is important to recognise that certain projects, predominantly those 'proposed' or identified in development plans, may not actually be taken forward, or fully built out as described within their MDS. There is, therefore, a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals. For example, those projects under construction are likely to contribute to cumulative impacts (providing effect or spatial pathways exist), whereas those proposals not yet approved are less likely to contribute to such an impact, as some may not achieve approval, or may not ultimately be built due to other factors.

12.10.2.2 With this in mind, all projects and plans considered alongside the Project have been allocated into 'tiers' reflecting their current stage within the planning and development process. This allows the cumulative assessment to present several future development scenarios, each with a differing potential for being ultimately built out. This approach also allows appropriate weight to be given to each scenario (tier) when considering the potential cumulative impact. The proposed tier structure is intended to ensure that there is a clear understanding of the level of confidence in the cumulative assessments provided in the Project ES. An explanation of each tier is included in Table 12.28.

12.10.2.3 The proposed tier structure for marine mammals is different from that presented for other receptors. This is due to the need to take into account greater levels of uncertainty in the degree and timing of overlap of activities, which will generate significant levels of underwater noise during the construction phase of projects.

Table 12.28 – Description of tiers of other developments considered for CEA (adapted from PINS Advice Note 17)

Tier	Description
Tier 1	Tier 1 includes all projects currently under construction which were not in place when baseline data were collected. Projects with a legally secure consent that have been awarded a CfD but have not yet been implemented.
Tier 2	Tier 2 includes all projects/plans that have a legally secure consent, but have no CfD; therefore, there is uncertainty about the timeline for construction of these projects. The potential for cumulative construction phase impacts have been considered where there is a reasonable chance of overlap of pile driving with the Project.
Tier 3	Tier 3 projects are projects for which an application has been submitted, but not yet determined. There is therefore information on which to base a quantitative assessment of cumulative impact but there is a degree of uncertainty as to the final approved design of the project and the timeline for construction. Tier 3 offshore wind farm projects have the potential for cumulative construction impacts.
Tier 4	Tier 4 projects are relevant marine infrastructure projects that the regulatory body is expecting to be submitted for determination, and projects for which a draft ES has been submitted, but not yet a full ES. There is, therefore, some information on which to base a quantitative assessment of cumulative impact, but there is a large degree of uncertainty as to the final design of the project and the timeline for construction. Tier 4 offshore wind farm projects have the potential for cumulative construction impacts.
Tier 5	Tier 5 projects are relevant marine infrastructure projects that the regulatory body is expecting to be submitted for determination (e.g. projects listed under the Planning Inspectorate programme of projects). For Tier 5 projects there is a lot of uncertainty and not enough information to allow a robust assessment. However, as a very precautionary approach, the Tier 5 UK offshore wind farm projects, that we are currently aware of, have been included in the CEA.

12.10.3 Screening

12.10.3.1 The plans and projects selected as relevant to the CEA of effects on marine mammals are based on an initial screening exercise undertaken on a long list (Chapter 30: Cumulative Effects Assessment). For offshore wind farms, the website https://www.4coffshore.com/ was used to identify all projects within the Celtic and Greater North Sea MU (which encompasses all the other relevant species MUs). For other offshore developments, The Crown Estate website and Emod.net were used to identify projects.

12.10.3.2 The potential cumulative effects of the Pembrokeshire Demonstration Zone (PDZ) have not been considered at the time of writing due to the lack of detail with which to assess the effects of the proposed project.

12.10.3.3 An EIA Scoping Report was produced and issued to NRW in 2018 for a proposed wave/floating wind project however based on discussions with Celtic Sea Power (the 3rd party agents for the PDZ) and recent public presentations by members of Celtic Sea Power, it is understood the PDZ will be repurposed as an offshore electrical hub. In the absence of an updated EIA Scoping Report and insufficient project information to allow the effects to be reasonably understood and a cumulative assessment undertaken, it has been omitted from this assessment.

12.10.3.4 For those reasons identified above, including the absence of EIA Scoping Reports, the potential cumulative effects of the recently announced Llyr 1, Llyr 2 and Whitecross FLOW projects are also omitted from this cumulative assessment.

12.10.3.5 As set out in PINS Guidance Note 17: Cumulative Effects Assessment, the Project proposed an assessment cut-off date of 1 October 2021 to allow the finalisation of the EIA and HRA assessments, even if project information came forward between the cut-off date and submission. This was agreed with NRW Marine Licensing, noting that in the absence of S.36/Marine Licence guidance the Project was drawing upon the best available advice. It is understood that should sufficient detail of these projects come forward following submission the Project may be requested to provide additional information during the determination period.

12.10.3.6 The offshore plans or projects considered included:

- Marine renewables (wind, wave and tidal);
- Port and harbour developments;
- Marine aggregate extraction and dredging;
- Licensed disposal sites;
- Oil and gas exploration and extraction; and
- Subsea cables and pipelines.

12.10.3.7 A consideration of effect-receptor-pathways, data confidence and temporal and spatial scales has been given, to select projects for a topic-specific short-list. For the potential effects for marine mammals, planned projects were screened into the assessment based on the extent of the relevant marine mammal reference population area (MU).

12.10.3.8 The long-list of projects was screened to remove the following:

- All projects that are located outside of the Celtic and Greater North Sea MU (which encompasses all the other relevant species MUs);
- All projects that are already operational/active, as they are considered to be existing impacts included within the baseline (this includes all shipping ports, shipping routes and oil and gas pipelines);
- All projects where there is no expected temporal overlap with construction of the Project; and
- All projects where the timing of construction activities is unknown.

12.10.3.9 The following effects were scoped out of the CEA:

- Any that are assessed as having a negligible effect significance during the Project assessment:
  - PTS from construction activities for all marine mammal species;
  - Disturbance from UXO;
  - Disturbance from piling for minke whale and grey seal;

- Disturbance from other construction activities for all marine mammal species;
- Barrier effects for all marine mammal species;
- Entanglement/collision for all marine mammal species;
- Collision with vessels for all marine mammal species;
- Impacts on prey for all marine mammal species; and
- Disturbance to seal haul-outs;

- Effects of fishing activities: considered to be existing impacts included within the baseline;
- Effects of shipping: considered to be existing impacts included within the baseline; and
- Effects of disturbance from vessel activity during O&M phases: determined to be relatively small in relation to regional background levels of vessel traffic.

12.10.3.10 Therefore, the CEA for marine mammals covered the following effects:

- Disturbance from underwater noise during construction for common dolphins, bottlenose dolphins and harbour porpoise (assessed as having a non-negligible significance); and
- Disturbance from vessel activities during construction activities for all marine mammal species.

12.10.4 Disturbance from underwater noise during construction

12.10.4.1 Different EIAs have assessed disturbance during construction activities using a variety of thresholds and methods, including effective deterrence ranges, fixed noise thresholds and dose-response curves. This means that the predicted number of animals disturbed is not necessarily comparable between projects. To standardise the CEA approach, the assessment of disturbance from construction activities at offshore development projects assumes the following:

- The Project – Disturbance impact based on maximum numbers presented in this impact assessment (worst case from pile driving);
- Other windfarms: Pinpile - Assume construction related impacts are limited to a 15 km radius around the array area, based on JNCC *et al.* (2020);
- Other windfarms: Monopile - Assume construction related impacts are limited to a 26 km radius around the array area, based on JNCC *et al.* (2020);
- Other windfarms: Floating - assume no pile driving. Assume construction related impacts are limited to a 5 km radius of the array area;
- Other windfarms: Gravity base - assume no pile driving. Assume construction related impacts are limited to a 5 km radius of the array area;
- Wave projects - assume no pile driving. Assume construction related impacts are limited to a 5 km radius of the array area;
- Tidal projects - assume no pile driving. Assume construction related impacts are limited to a 5 km radius of the array area; and
- Interconnector projects - assume no pile driving. Assume construction related impacts are limited to a 5 km radius from a single noise source.

12.10.4.2 The offshore construction timeline at the Project is expected to be:

- Offshore pre-construction surveys: 01 April 2026 to 02 May 2026;
- Semi-submersible floater platform & mooring installation: 01 June 2026 to 30 October 2026; and
- Offshore export and array cable installation: bulk of offshore export cable and array installation activity anticipated May – Sept 2026.

12.10.4.3 The full list of offshore wind farm projects screened into the assessment of disturbance from underwater noise during construction is provided in Table 12.29. This includes all projects that are located within the Celtic and Greater North Sea MU for common dolphins, the Offshore Channel and SW England MU for bottlenose dolphins and the Celtic and Irish Sea MU for harbour porpoise and are scheduled to conduct offshore construction activities before or at the same time as the Project.

Table 12.29 Offshore projects screened into the cumulative impact assessment for common dolphins, bottlenose dolphins and harbour porpoise

Wind Farm	Offshore Construction Starts	Full Commissioning	2021				2022				2023				2024				2025				2026				CD MU	BND MU	HP MU
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4			
Erebus	Q2 2026	Q4 2026																									Y	Y	Y
Princess Elisabeth - Noordhinder Noord - 2023 Tender	01-Jan-25	31-Dec-27																									Y	N	N
Borkum Riffgrund 3	01-Aug-23	31-Dec-25																									Y	N	N
Gode Wind 3	01-Jan-23	01-Jan-24																									Y	N	N
EnBW He Dreiht	01-Apr-24	31-Dec-25																									Y	N	N
N-3.7	01-Jan-25	01-Jan-26																									Y	N	N
N-3.8	01-Jan-25	01-Jan-26																									Y	N	N
N-7.2	01-Jan-26	01-Jan-27																									Y	N	N
Kaskasi	01-Sep-21	01-Oct-22																									Y	N	N
Hesselø - 2021 Tender - Direct Connection to Land	01-Jan-26	01-Jan-27																									Y	N	N
Thor - 2020 Tender	31-Dec-25	31-Dec-27																									Y	N	N
Frederikshavn Offshore Wind Demo	01-Jan-24	01-Sep-24																									Y	N	N
Vesterhav Nord/Syd	01-Jun-22	01-Dec-23																									Y	N	N
Dieppe - Le Tréport	01-Jan-24	01-Jan-25																									Y	Y	N
Fécamp	05-Jul-21	31-Dec-23																									Y	Y	N
Calvados	01-Jan-22	31-Oct-24																									Y	Y	N
Saint-Brieuc	03-May-21	31-Dec-23																									Y	N	N
Dunkerque	01-Jan-26	31-Dec-27																									Y	N	N
Codling (Relevant Project)	01-Sep-24	01-Jan-27																									Y	N	Y
Oriel (Relevant Project)	01-Jan-23	01-Jan-25																									Y	N	Y
Dublin Array (Relevant Project)	01-Jun-25	01-Jan-27																									Y	N	Y
Hollandse Kust Zuid Holland I and II (Tender 2017)	20-Aug-20	01-Jun-23																									Y	N	N
Hollandse Kust Zuid Holland III and IV (Tender 2019)	28-Jun-21	01-Jun-23																									Y	N	N
Hollandse Kust Noord (Tender 2019)	01-Sep-21	31-Dec-23																									Y	N	N
Windpark Fryslân	07-Sep-20	30-Sep-21																									Y	N	N

Wind Farm	Offshore Construction Starts	Full Commissioning	2021				2022				2023				2024				2025				2026				CD MU	BND MU	HP MU
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4			
Hollandse Kust West (Tender 2021) Site VI	01-Mar-22	01-Jan-26																									Y	N	N
Ten noorden van de Waddeneilanden - (Tender 2022)	01-Jan-26	01-Jun-27																									Y	N	N
Hollandse Kust West (Tender 2021) Site VII	01-Jan-24	01-Jan-26																									Y	N	N
Hywind Tampen	01-Feb-22	31-Dec-22																									Y	N	N
TetraSpar Demonstrator - Metcentre	22-May-21	01-Sep-21																									Y	N	N
SeaTwirl S2	01-Jan-22	28-Feb-22																									Y	N	N
Dogger Bank B	01-Apr-23	01-Jan-25																									Y	N	N
Dogger Bank C	01-Jan-24	01-Jan-26																									Y	N	N
Sofia	01-Jan-22	01-Oct-26																									Y	N	N
Hornsea Project Three	01-Jan-23	01-Jan-25																									Y	N	N
Hornsea Project Two	01-Aug-20	01-Jun-22																									Y	N	N
TwinHub	02-Jul-10	01-Jan-26																									Y	Y	Y
East Anglia Hub - ONE North	01-Jan-24	31-Dec-26																									Y	N	N
Triton Knoll	17-Jan-20	01-Jan-22																									Y	N	N
East Anglia Hub - TWO	01-Jan-25	31-Dec-26																									Y	N	N
Moray East	18-May-19	01-Oct-22																									Y	N	N
Seagreen	01-Jul-21	31-Dec-22																									Y	N	N
Rampion 2	01-Jan-26	01-Jan-29																									Y	Y	N
Kincardine - phase 2	19-Jul-20	31-Aug-21																									Y	N	N
Dolphyn Project - pre-commercial	01-Jan-25	01-Jan-25																									Y	N	N
Pentland	01-Apr-26	30-Sep-26																									Y	N	N
Inch Cape	01-Apr-24	01-Jan-25																									Y	N	N
Neart na Gaoithe	13-Aug-20	01-Jan-23																									Y	N	N
Shearwater One	01-Jan-26	01-Jan-29																									Y	N	N
Beech	01-May-23	01-Jan-27																									Y	N	N
Aspen	01-May-23	01-Jan-27																									Y	N	N

Wind Farm	Offshore Construction Starts	Full Commissioning	2021				2022				2023				2024				2025				2026				CD MU	BND MU	HP MU
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4			

ForthWind Offshore Wind Demonstration Project - phase 1	01-Apr-24	01-Oct-24																									Y	N	N
East Anglia Hub - THREE	01-Jan-23	31-Dec-26																									Y	N	N
Norfolk Vanguard	01-Jan-25	15-Apr-27																									Y	N	N
Norfolk Boreas	01-Jan-25	15-Apr-27																									Y	N	N
Moray West	01-Jan-24	01-Dec-26																									Y	N	N
Dogger Bank A	01-Apr-22	31-Dec-23																									Y	N	N
Fair Head	2022	2025																									Y	N	N
Holyhead Deep (Minesto)	2022	2022																									Y	N	Y
Viking link	now	2023																									Y	N	N
Greenlink Interconnector	2024	2024																									Y	Y	Y
META – East Pickard Bay (Bombora)	Q2 2022	Q3 2023																									Y	Y	Y
Atlantic Marine Energy Test Site	2021	2021																									Y	N	Y

12.10.5 Cumulative disturbance from underwater noise

Bottlenose dolphin

12.10.5.1 Almost all of the offshore projects screened into the assessment for bottlenose dolphins (located within the Offshore Channel and SW England MU and constructing before or concurrently with the Project) (Volume 2, Figure 12.2) are planned to conduct offshore construction work prior to the Project offshore construction window and, thus, the predicted impacts do not overlap (Table 12.30). However, since they are planning offshore construction activities to commence after the Project site-specific baseline surveys were completed, they are considered in this impact assessment as their construction activities may alter the existing baseline. This means that the impact across these projects between 2021-2025 would occur irrespective and independent of the Project.

12.10.5.2 As expected, the highest levels of predicted disturbance are from developments that include pile driving within the project envelope (Dieppe - Le Tréport, Calvados and Rampion 2). Prior to the offshore construction activities commence at the Project, the construction of the other developments is expected to have a Negligible to Low magnitude (0.1-1.5% MU impacted) (Table 12.31). As stated in paragraph 12.4.8.25, bottlenose dolphins have been assessed as having a Low sensitivity to disturbance from piling. Therefore, disturbance from the cumulative impact of construction work prior to the construction of the Project is concluded to result in a **negligible** to **minor adverse** effect, which is not significant in EIA terms. Thus, the bottlenose dolphin population is not expected to be altered from the baseline prior to the offshore construction commencing at the Project.

12.10.5.3 The only development expected to be conducting offshore construction activities at the same time as the Project, is Rampion 2 (located in the English Channel). Despite the inclusion of monopiles within the Rampion 2 project envelope, the predicted densities of bottlenose dolphins in that area is relatively low, and thus the predicted disturbance levels on any day of pile driving activity is expected to be lower than that predicted for the Project (Table 12.31).Should both projects conduct pile driving at the same time, then it is anticipated that up to a maximum of 420 bottlenose dolphins could experience behavioural disturbance on any piling day (noting that the Project would only be piling on 18 days).

12.10.5.4 This represents only 3.8% of the MU which is considered to be a low magnitude. It is worth noting here that both assessments (the Project and Rampion 2) used the harbour porpoise dose-response curve as a proxy to assess bottlenose dolphin disturbance, which is expected to largely over-estimate the response expected in bottlenose dolphins. Despite this, the magnitude of impact on the bottlenose dolphin population remains between low in 2026 when both the Project and Rampion 2 are expected to be constructing.

12.10.5.5 As stated in paragraph 12.4.8.25, bottlenose dolphins have been assessed as having a low sensitivity to disturbance from piling (and assumed to be the same or lower for other construction activities).

12.10.5.6 The magnitude of the impact has been assessed as low and the sensitivity of bottlenose dolphin receptors as low. Therefore, disturbance from the cumulative impact of construction work across projects located within the relevant MU both prior to and during the construction of the Project, is concluded to result in a **minor adverse** effect, which is not significant in EIA terms.

Table 12.30 Projects screened into the cumulative impact assessment for bottlenose dolphins (FLOW = Floating Offshore Wind, OWF = Offshore Wind Farm, G = Gravity base foundations, PP = pin-pile foundations, MP = Monopile foundations, T = Tidal and IC = Interconnector)

Project	Type	Tier	Offshore construction
The Project	FLOW	-	Apr-Oct 2026
META – East Pickard Bay (Bombora)	Wave	1 (Consented)	Summer 2022 for 18 months
Dieppe - Le Tréport	OWF PP	1 (Consented)	Throughout 2024
Fécamp	OWF G	1 (Consented)	Jul 2021 – Dec 2023
Calvados (Courseulles-sur-mer)	OWF MP	1 (Consented)	Jan 2022 – Oct 2024
Rampion 2	OWF MP	4 (PEIR[24] submitted)	Jan 2026 – Dec 2028
TwinHub (WaveHub)	FLOW	1 (Consented)	Wide construction window (Jul 2010 – Dec 2025)
Greenlink Interconnector	IC	1 (Consented)	Throughout 2024

[24] Rampion 2 Wind Farm, PEIR, Volume 2, Chapter 11: Marine mammals

Table 12.31 Cumulative effect assessment of disturbance from construction activities for bottlenose dolphins

Project	Tier	2021				2022				2023				2024				2025				2026			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Erebus	-																						**310**	**310**	**310**
Bombora	1						5	5	5	5	5	5													
Dieppe	1													38	38	38	38								
Fécamp	1			21	21	21	21	21	21	21	21	21	21												
Calvados	1					114	114	114	114	114	114	114	114	114	114	114	114								
Rampion 2	2																					110	**110**	**110**	**110**
TwinHub	1	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8				
Greenlink	1													4	4	4	4								
# Impacted		8	8	29	143	148	148	148	148	148	148	148	143	164	164	164	164	8	8	8	8	110	310	310	310
% MU		0.1%	0.1%	0.3%	0.3%	1.3%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.3%	1.5%	1.5%	1.5%	1.5%	0.1%	0.1%	0.1%	0.1%	1.0%	3.8%	3.8%	3.8%
Magnitude		Neg	Neg	Neg	Neg	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Neg	Neg	Neg	Neg	Low	Low	Low	Low

Note: in order to calculate the number of bottlenose dolphins disturbed by each project, a uniform density was assumed within the MU (204,566 km^2 MU, containing 10,947 bottlenose dolphins = uniform density of 0.0535 dolphins/km^2). For Rampion 2 the predicted disturbance values from the PEIR were used.

Common dolphin

12.10.5.7 Almost all of the projects within the common dolphin MU (Celtic and Greater North Seas) have been omitted from the assessment below, due to the fact that almost all of them are located in the North Sea, where common dolphins are not expected to be present in sufficient numbers to include in impact assessments[25]. As such, none of the projects in the North Sea (including the Dogger Bank, East Anglia, Hornsea, Moray Firth and Firth of Forth Projects) scoped common dolphins into their assessments. No assessment was available for the French developments, and as such a decision was made to not include them in the cumulative effects assessment since common dolphins are expected to be present in only very low numbers, if at all, at these sites (the SCANS III density for block C is 0.00 common dolphins). Therefore, these projects were not included in the common dolphin cumulative effects assessment as, while the projects are located within the MU, no common dolphins are expected to be present.

12.10.5.8 Of the remaining five developments included in the final cumulative assessment (Table 12.32) (Volume 2, Figure 12.3), four of them are planned to conduct offshore construction work prior to the Project offshore construction window and, thus, the predicted impacts do not overlap (Table 12.33). However, since they are planning offshore construction activities to commence after the Project site-specific baseline surveys were completed, they are considered in this cumulative impact assessment as their construction activities may alter the existing baseline. This means that the impact across these projects between 2021-2025 would occur irrespective of and independent of the Project. Prior to the offshore construction activities commence at the Project, the construction of the other developments is expected to have a negligible magnitude (0.1-0.5% MU impacted) (Table 12.33). Thus, the common dolphin population is not expected to be altered from the baseline prior to the offshore construction commencing at the Project.

12.10.5.9 The only development expected to be conducting offshore construction activities at the same time as the Project, is Rampion 2 (located in the English Channel). Despite the inclusion of monopiles within the Rampion 2 project envelope, the predicted densities of common dolphins in that area is relatively low, and thus the predicted disturbance levels on any day of pile driving activity is expected to be lower than that predicted for the Project (Table 12.33).Should both projects conduct pile driving at the same time, then it is anticipated that up to a maximum of 2,573 common dolphins could experience behavioural disturbance on any piling day (noting that the Project would only be piling on 18 days).

12.10.5.10 This represents only 2.5% of the MU which is considered to be a low magnitude. It is worth noting here that both assessments (the Project and Rampion 2) used the harbour porpoise dose-response curve as a proxy to assess common dolphin disturbance, which is expected to largely over-estimate the response expected in common dolphins. Despite this, the magnitude of impact on the common dolphin population remains between low in 2026 when both the Project and Rampion 2 are expected to be constructing.

12.10.5.11 As stated in paragraph 12.4.8.19, common dolphins have been assessed as having a low sensitivity to disturbance from piling (and the same has been assumed for other construction related activities).

12.10.5.12 The magnitude of the impact has been assessed as negligible and the sensitivity of common dolphin receptors as low.

[25] SCANS III density estimates for blocks C, L, M, N, O, P, R and S is 0.000 common dolphins/km^2

12.10.5.13 Therefore, disturbance from the cumulative impact of construction work across projects located within the relevant MU both prior to and during the construction of the Project, is concluded to result in a **negligible** effect, which is not significant in EIA terms.

Table 12.32 Projects screened into the cumulative effects assessment for common dolphins (FLOW = Floating Offshore Wind, IC = Interconnector, OWF = Offshore Wind Farm, MP = Monopile foundations)

Project	Type	Tier	Offshore construction
The Project	FLOW	-	Apr-Oct 2026
META – East Pickard Bay (Bombora)	Wave	1 (Consented)	Spring 2021 for 12 months
TwinHub (WaveHub)	FLOW	1 (Consented)	Wide construction window (Jul 2010 – Dec 2025)
Atlantic Marine Energy Test Site (AMETS)	FLOW	1 (Consented)	Commissioning expected by Jan 2022
Greenlink Interconnector	IC	1 (Consented)	Throughout 2024
Rampion 2	OWF MP	4 (PEIR submitted)	Jan 2026 – Dec 2028

Table 12.33 Cumulative effects assessment of disturbance from construction activities for common dolphins (N=Negligible, L=Low)

		2021				2022				2023				2024				2025				2026			
Project	**Tier**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Erebus	-																						**2067**	**2067**	**2067**
Rampion 2	4																					506	**506**	**506**	**506**
Bombora	1						35	35	35	35	35	35													
TwinHub	1	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55				
AMETS	1	57	57	57	57																				
Greenlink	1													29	29	29	29								
# Impacted		112	112	112	112	55	90	90	90	90	90	90	55	84	84	84	84	55	55	55	55	506	2573	2573	2573
% MU		0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.5%	2.5%	2.5%	2.5%
Magnitude		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	L	L	L

Note: to calculate the number of common dolphins disturbed by each project, the density estimate for SCANS III Block D was used (apart from AMETS which used the ObSERVE Stratum 1 density estimate) and Rampion 2 (which used the predicted disturbance values from the PEIR).

Harbour porpoise

12.10.5.14 Many of the offshore projects screened into the assessment for harbour porpoise (located within the Celtic and Irish Seas MU and constructing before or concurrently with the Project) are planned to conduct offshore construction work prior to the Project offshore construction window and, thus, the predicted impacts do not overlap (Table 12.34). However, since they are planning offshore construction activities to commence after the Project site-specific baseline surveys were completed, they are considered in this cumulative effect assessment as their construction activities may alter the existing baseline.

12.10.5.15 This means that the impact across these projects between 2021-2025 would occur irrespective of and independent of the Project. Prior to the offshore construction activities commence at the Project, the construction of the other developments is expected to have a negligible to medium magnitude (0.1-6.8% MU impacted) (Table 12.35). As stated previously, harbour porpoise have been assessed as having a low sensitivity to disturbance from piling (and the same has been assumed for other construction related activities).

12.10.5.16 Therefore, a **minor adverse** effect is predicted, which is not significant in EIA terms. Thus, the harbour porpoise population is not expected to be altered from the baseline prior to the offshore construction commencing at the Project.

12.10.5.17 Of the offshore projects screened into the cumulative effect assessment for harbour porpoise (Volume 2, Figure 12.4), it is the projects that may include pile driving construction work (Codling, Dublin Array and the Project) that have the highest level of predicted disturbance impact (Table 12.35). Should the Project, Codling and Dublin Array all conduct pile diving at the same time, then it is anticipated that up to a maximum of 6,215 porpoise could experience behavioural disturbance on any piling day (noting that the Project would only be piling on 18 days). This represents 9.9% of the MU.

12.10.5.18 A simulation modelling exercise carried out by Booth *et al.* (2017) used the iPCoD framework to predict the long-term consequences of planned offshore wind developments in the eastern North Sea concluded that, even with a total of 15% of the population being predicted to be disturbed over a period of 12 years, there was no evidence for any significant risk to the long-term health of the North Sea harbour porpoise population. Since the level of impact predicted here is less than that assumed in Booth *et al.* (2017), it is not expected that there would be any significant risk to the long-term population health.

12.10.5.19 While this level of impact is predicted to result in temporary changes in behaviour and/or distribution of individuals at a scale that would result in potential reductions to lifetime reproductive success to some individuals, it is not expected to affect the population trajectory over a generational scale, and thus the magnitude is assessed as medium.

12.10.5.20 The magnitude of impact on the harbour porpoise population ranges between negligible and medium (adverse) across all years and projects included in the cumulative assessment.

12.10.5.21 As stated previously, harbour porpoise have been assessed as having a low sensitivity to disturbance from piling (and the same has been assumed for other construction related activities).

12.10.5.22 The magnitude of the impact has been assessed as negligible to medium (adverse) and the sensitivity of harbour porpoise receptors as low. Therefore, disturbance from the cumulative impact of construction work across projects located within the relevant MU both prior to and during the construction of the Project, is concluded to result in a **minor adverse** effect, which is not significant in terms of the EIA regulations.

Table 12.34 Projects screened into the cumulative impact assessment for harbour porpoise (FLOW = Floating Offshore Wind, IC = Interconnector, OWF MP = Offshore wind farm installed using monopile foundations, OWF G = Offshore wind farm installed using gravity base foundations)

Project	Type	Tier	Offshore construction
The Project	FLOW	-	Apr-Oct 2026
META – East Pickard Bay (Bombora)	Wave	1 (Consented)	Spring 2021 for 12 months
TwinHub (WaveHub)	FLOW	1 (Consented)	Wide construction window (Jul 2010 – Dec 2025)
Atlantic Marine Energy Test Site (AMETS)	FLOW	1 (Consented)	Commissioning expected by Jan 2022
Greenlink Interconnector	IC	1 (Consented)	Throughout 2024
Holyhead Deep (Minesto)	Tidal	1 (Consented)	Throughout 2022
Codling	OWF MP	5 (pre-submission)	Sep 2024 – Dec 2026
Oriel	OWF G	5 (pre-submission)	Throughout 2023 and 2024
Dublin Array	OWF MP	5 (pre-submission)	Jun 2025 – Dec 2026

Table 12.35 Cumulative impact assessment of disturbance from construction activities for harbour porpoise (N=Negligible, L=Low, M=Medium)

		2021				2022				2023				2024				2025				2026			
Project	**Tier**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Erebus	-																						**1967**	**1967**	**1967**
Bombora	1						11	11	11	11	11	11													
TwinHub	1	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17				
AMETS	1	27	27	27	27																				
Greenlink	1													9	9	9	9								
Hoyhead Deep	1					37	37	37	37																
Codling	5															2124	2124	2124	2124	2124	2124	2124	2124	2124	2124
Oriel	5									69	69	69	69	69	69	69	69								
Dublin Array	5																		2124	2124	2124	2124	2124	2124	2124
# Impacted		44	44	44	44	54	65	65	65	97	97	97	86	95	95	2219	2219	2141	4265	4265	4265	4248	6215	6215	6215
% MU		0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	3.5%	3.5%	3.4%	6.8%	6.8%	6.8%	6.8%	9.9%	9.9%	9.9%
Magnitude		N	N	N	N	N	N	N	N	N	N	N	N	N	N	L	L	L	M	M	M	M	M	M	M

Note: to calculate the number of harbour porpoise disturbed by each project, the density estimate used were either: SCANS III Block D (0.118 porpoise/km^2), ObSERVE Stratum 1 (0.085 porpoise/km^2) or ObSERVE Stratum 5 (0.883 porpoise/km^2).

12.10.6 Cumulative disturbance from vessels

12.10.6.1 It is extremely difficult to reliably quantify the increased disturbance risk to marine mammals resulting from increased vessel activity on a cumulative basis, given the large degree of temporal and spatial variation in vessel movements between projects and regions, coupled with the spatial and temporal variation in marine mammal movements across the region. This cumulative assessment considers the increased potential for disturbance to marine mammals, due to the potential increase in vessel movements from the Project with other planned or existing projects, plans and activities.

12.10.6.2 Vessel routes to and from offshore wind farms and other projects will use existing vessel routes, where marine mammals will be accustomed to, and potentially habituated to, regular vessel movements and, therefore, the additional risk is confined mainly to construction sites. Vessel movements within development areas are likely to be limited and relatively slow. In addition, most projects are likely to adopt vessel management plans (or follow best codes of conduct) in order to minimise any potential effects on marine mammals.

12.10.6.3 The impact is predicted to be small scale, long-term duration but intermittent. It is expected that any marine mammals that are disturbed as a result of vessel presence will return to the area once the vessel disturbance has ended. It is expected that any increase in vessel movements during the construction, O&M and decommissioning of offshore developments are relatively small in relation to regional background levels of vessel traffic. The magnitude is therefore considered to be low.

12.10.6.4 All marine mammal receptors are deemed to be of low vulnerability given the existing evidence behavioural responses to vessels. The sensitivity of the marine mammal receptors is therefore considered to be negligible to low.

12.10.6.5 Overall, the sensitivity of marine mammals to vessel disturbance has been assessed as low and the magnitude is predicted to be negligible to low. Therefore, a **negligible** to **minor adverse** effect is predicted, which is not significant in EIA terms.

12.11 Transboundary

12.11.1.1 Transboundary effects are defined as those effects upon the receiving environment of other European Economic Area (EEA) states, whether occurring from the Project alone, or cumulatively with other projects in the wider area.

12.11.1.2 There may be behavioural disturbance or displacement of marine mammals from the Project site as a result of underwater noise. Behavioural disturbance resulting from underwater noise during construction and decommissioning could occur over large ranges (tens of kilometres) and, therefore, there is the potential for transboundary effects to occur where subsea noise arising from the Project could extend into waters of other EEA states. The Project is located in close proximity to other states (e.g. Irish waters, English waters) and, therefore, there is the potential for transit of certain species between areas. Any transboundary impacts that do occur as a result of underwater noise at the Project are predicted to be short-term and intermittent, with the recovery of marine mammal populations to affected areas following the completion of construction activities.

12.11.1.3 Disturbance to prey species from loss of fish spawning and nursery habitat and suspended sediments and deposition may also occur. The effects of reduction in prey availability are predicted to be limited in extent to a number of kilometres from the Project and are therefore not predicted to extend into the waters of other EEA states. Therefore, the impact of a reduction in prey ability will not lead to a significant effect.

12.11.1.4 It should be noted that the mobile nature of marine mammals results in the potential for transboundary effects to occur. Whilst each species has been assessed within the relevant MU for the Project, the MUs under which each species has been assessed varies greatly in the area covered, with the MUs for harbour porpoise, bottlenose dolphin and grey seals being relatively localised and the MUs for common dolphin and minke whale covering the Celtic and Greater North Sea area. Furthermore, the respective MUs do not represent closed populations. This means that impacts, whilst localised, could potentially affect other MUs if mixing between the assessed populations occurs. For example, bottlenose dolphins are known to have a large home range (Duckett 2018) and therefore mixing with the Irish Sea MU population is considered possible.

12.11.1.5 The magnitude of the impact has been assessed as low to negligible and the sensitivity of receptors as low to negligible. Therefore, behavioural disturbance leading to transboundary effects is concluded to result in a **minor adverse** effect, which is not significant in EIA terms.

12.12 Summary

12.12.1.1 This chapter has assessed the potential effects on marine mammal receptors arising from the Project.

12.12.1.2 The marine mammal baseline was characterised by a combination of site-specific aerial surveys and literature reviews of existing data from various sources. The marine mammal study area varies depending on the species, considering individual species ecology and behaviour. The study area for marine mammals was therefore defined at two spatial scales: the management unit scale for species specific population units and the site-specific survey areas for an indication of the local densities of each species.

12.12.1.3 A total of four marine mammal species are expected to be present in the area year-round: common dolphins, harbour porpoise, bottlenose dolphins and grey seals, and in addition to this, minke whales are expected to be present in the summer months. The site-specific surveys found common dolphins to be the most abundant marine mammal species in the area, found in high densities across the area and throughout the year. There was very little data on Risso's dolphins in the area, and no density estimate was available for this species, therefore they have been included in the impact assessment qualitatively only.

12.12.1.4 The impacts considered include direct impacts (e.g. disturbance from UXO clearance), as well as indirect impacts (e.g. change in prey species abundance), alongside cumulative impacts (e.g. underwater noise from various offshore energy developments within the species MU). Potential effects considered in this chapter, alongside any mitigation and residual effects are summarised in Table 12.36.

12.12.1.5 Throughout the construction, operation and decommissioning phases of the Project all effects assessed were found to have either negligible, or minor effects on all marine mammal receptors and thus no pathway was considered to be significant in EIA terms.

12.12.1.6 The assessment of cumulative effects from the Project and other developments and activities concluded that any cumulative effects would be of minor significance at the most, and thus not significant in EIA terms.

Table 12.36 – Summary of Effects

Description of Effect	Significance of Potential Effect (assuming standard mitigation implemented)		Additional Mitigation Measure	Significance of Residual Effect	
	Significance	Beneficial/ Adverse		Significance	Beneficial/ Adverse
Construction					
PTS from UXO (deflagration)	Negligible	-	None required beyond embedded mitigation	Negligible	-
Disturbance from UXO (deflagration)	Negligible	-	None required beyond embedded mitigation	Negligible	-
PTS from pile driving	Negligible	-	None required beyond embedded mitigation	Negligible	-
Disturbance from pile driving	Negligible to Minor	Adverse	None required beyond embedded mitigation	Negligible to Minor	Adverse
PTS from other construction activities	Negligible	-	None	Negligible	-
Disturbance from other construction activities	Negligible to Minor	Adverse	None required beyond embedded mitigation	Negligible to Minor	Adverse
Collision with vessels	Minor	Adverse	None required beyond embedded mitigation	Minor	Adverse
Disturbance from vessels	Negligible to Minor	Adverse	None required beyond embedded mitigation	Negligible to Minor	Adverse
Disturbance at seal haul-outs	Negligible	-	None required beyond embedded mitigation	Negligible	-
Indirect impacts on prey	Negligible	-	None	Negligible	-

Description of Effect	Significance of Potential Effect (assuming standard mitigation implemented)		Additional Mitigation Measure	Significance of Residual Effect	
	Significance	Beneficial/ Adverse		Significance	Beneficial/ Adverse
Operation					
Barrier effects	Negligible	-	None	Negligible	-
Entanglement and collision	Minor	Adverse	None required beyond embedded mitigation	Minor	Adverse
Collision with vessels	Minor	Adverse	None required beyond embedded mitigation	Minor	Adverse
Disturbance from vessels	Negligible to Minor	Adverse	None required beyond embedded mitigation	Negligible to Minor	Adverse
Disturbance at seal haul-outs	Negligible	-	None required beyond embedded mitigation	Negligible	-
Indirect impacts on prey	Negligible	-	None	Negligible	-
Decommissioning					
Disturbance from removal of structures	Negligible to Minor	Adverse	None required beyond embedded mitigation	Negligible to Minor	Adverse
Collision with vessels	Minor	Adverse	None required beyond embedded mitigation	Minor	Adverse
Disturbance from vessels	Negligible to Minor	Adverse	None required beyond embedded mitigation	Negligible to Minor	Adverse
Disturbance at seal haul-outs	Negligible	-	None required beyond embedded mitigation	Negligible	-
Indirect impacts on prey	Negligible	-	None	Negligible	-

Table 12.37 – Summary of Cumulative Effects for marine mammals

Receptor	Effect	Cumulative Developments	Significance of Cumulative Effect	
			Significance	Beneficial/Adverse
Bottlenose dolphin	Disturbance from underwater noise	The Project, META – East Pickard Bay (Bombora), Dieppe - Le Tréport, Fécamp, Calvados (Courseulles-sur-mer), TwinHub (WaveHub) and Greenlink Interconnector	Negligible to Minor	Adverse
Common dolphin	Disturbance from underwater noise	The Project, META – East Pickard Bay (Bombora), TwinHub, Atlantic Marine Energy Test Site and Greenlink Interconnector	Negligible to Minor	Adverse
Harbour porpoise	Disturbance from underwater noise	The Project, META – East Pickard Bay (Bombora), TwinHub, Atlantic Marine Energy Test Site, Greenlink Interconnector, Holyhead Deep (Minesto), Codling, Oriel and Dublin Array	Negligible to Minor	Adverse
All species	Disturbance from vessels	All within relevant MU	Minor	Adverse

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