MORGAN OFFSHORE WIND PROJECT: GENERATION ASSETS

Environmental Statement

Volume 2, Chapter 4: Marine mammals

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Glossary

Term	Meaning
Anthropogenic	An activity resulting from or relating to the influence of humans.
Baseline	The status of the environment without the Morgan Generation Assets in place.
Climate change	A change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels.
Collision	The act or process of colliding (crashing) between two moving objects.
Cumulative Effects	The combined effect of the Morgan Generation Assets in combination with the effects from other proposed developments, on the same receptor or resource.
Design Envelope	A description of the range of possible elements and parameters that make up the Morgan Generation Assets options under consideration, as detailed in Volume 1, Chapter 3: Project Description. This envelope is used to define the Morgan Generation Assets for EIA purposes when the exact engineering parameters are not yet known. This is also referred to as the Maximum Design Scenario (MDS) or Rochdale Envelope approach.
Development Consent Order	An order made under the Planning Act 2008, as amended, granting development consent.
Duration (Of Impact)	The time over which an impact occurs. An impact may be described as short, medium or long-term and permanent or temporary.
Dynamic Positioning	Computer-controlled system used to automatically maintain a vessel's heading and position without the use of mooring lines and/or anchors.

Term	Meaning
Effect	The term used to express the consequence of an impact. The significance of effect is determined by correlating magnitude of the impact with the importance, or sensitivity, of the receptor or resource in accordance with defined significance criteria.
Ensonified	Filled with sound.
Environmental Impact Assessment	The process of identifying and assessing the significant effects likely to arise from a project. This requires consideration of the likely changes to the environment, where these arise as a consequence of a project, through comparison with the existing and projected future baseline conditions.
Environmental Statement	The document presenting the results of the Environmental Impact Assessment process.
European Sites	Designated nature conservation sites which include the National Site Network (designated within the UK) and Natura 2000 sites (designated in any European Union country). This includes Sites of Community Importance, Special Areas of Conservation and Special Protection Areas.
Evidence Plan Process	A voluntary consultation process with specialist stakeholders to agree the approach to, and information to support, the EIA and Habitats Regulations Assessment processes for certain topics.
Expert Working Group	A forum for targeted engagement with regulators and interested stakeholders through the Evidence Plan process.
Habitat Regulations	The Conservation of Habitats and Species Regulations 2017 (as amended) and the Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended).
Impact	Change that is caused by an action/proposed development, e.g., land clearing (action) during construction which results in habitat loss (impact).
Inter-related Effects	Inter-related effects arise where an impact acts on a receptor repeatedly over time to produce a potential additive effect or where a number of separate impacts, such as sound and habitat loss, affect a single receptor.
Kurtosis	A measure of sharpness of the peak of a frequency-distribution curve.
Marine Licence	The Marine and Coastal Access Act 2009 requires a marine licence to be obtained for licensable marine activities. Section 149A of the Planning Act 2008 allows an applicant for to apply for ‘deemed marine licences’ in English waters as part of the development consent process.
Maximum Design Scenario	The realistic worst case scenario, selected on a topic-specific and impact specific basis, from a range of potential parameters for the Morgan Generation Assets.
Mitigation Measures	The purpose of such measures is to avoid, prevent, reduce or, if possible, offset significant adverse environmental effects.
Mysticete	Baleen whales, also known as whalebone whales, are a parvorder of carnivorous marine mammals of the infraorder Cetacea which use keratinaceous baleen plates in their mouths to sieve planktonic creatures from the water.
National Policy Statement	The current national policy statements published by the Department of Energy and Climate Change in 2011.
Non-statutory consultee	Organisations that an applicant may choose to consult in relation to a project who are not designated in law but are likely to have an interest in the project.
Planning Inspectorate	The agency responsible for operating the planning process for applications for development consent under the Planning Act 2008.

Term	Meaning
Reversibility	A reversible impact is one where recovery is possible naturally in a relatively short time period, or where mitigation measures can be effective at reversing the impact. An irreversible impact may occur when recovery is not possible within a reasonable timescale, or there is no reasonable chance of action being taken to reverse.
Scoping Opinion	Sets out the Planning Inspectorate's response (on behalf of the Secretary of State) to the Scoping Report prepared by the Applicants. The Scoping Opinion contains the range of issues that the Planning Inspectorate, in consultation with statutory stakeholders, has identified should be considered within the Environmental Impact Assessment process.
Scour Protection	Protective materials to avoid sediment being eroded away from the base of the foundations due to the flow of water.
Sound Exposure Levels	The representation of a sound event if all the energy were compressed into a one second period. This provides a uniform way to make comparisons between sound events of different durations.
Spatial Extent	Geographical area over which the impact may occur.
Statutory Consultee	Organisations that are required to be consulted by an applicant pursuant to section 42 of the Planning Act 2008 in relation to an application for development consent. Not all consultees will be statutory consultees (see non-statutory consultee definition).
Teuthophagous	Feeds on cephalopods.
Transboundary Effects	Effects from a project within one state that affect the environment of another state(s).
Vibrissae	Vibrissae are more generally called whiskers, are a type of stiff, functional hair used by mammals to sense their environment.

Acronyms

Acronym	Description
ADD	Acoustic Deterrent Device
AU	Assessment Unit
BAP	Biodiversity Action Plan
BEIS	Department for Business, Energy and Industrial Strategy
CCW	Countryside Council for Wales
CEA	Cumulative Effects Assessment
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CGNS MU	Celtic and Greater North Seas Management Unit
CIEEM	Chartered Institute of Ecology and Environmental Management
CIS	Celtic and Irish Seas
CIS MU	Celtic and Irish Seas Management Unit
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMACS	Centre for Marine And Coastal Studies
CMS	Conservation of Migratory Species

Acronym	Description
CPT	Cone Penetration Testing
CTV	Crew Transfer Vessel
CV	Coefficient of Variation
DCO	Development Consent Order
DDT	Dichlorodiphenyltrichloroethane
DP	Dynamic Positioning
EDR	Effective Deterrence Range
EIA	Environmental Impact Assessment
EMF	Electromagnetic Fields
EMP	Environmental Management Plan
EPP	Evidence Plan Process
EPS	European Protected Species
EWG	Expert Working Group
FCS	Favourable Conservation Status
GBF	Gravity Base Foundation
GES	Good Environmental Status
GIS	Geographical Information System
GSRP	Grey Seal Reference Population
HF	High Frequency
HRA	Habitats Regulations Assessment
HSRP	Harbour Seal Reference Population
HVAC	High Voltage Alternating Current
IA	Intermediate Assessment
IAMMWG	Inter-Agency Marine Mammal Working Group
IEF	Important Ecological Feature
Isle of Man	Isle of Man
IPCoD	Interim Population Consequences of Disturbance Model
ISAA	Information to Support an Appropriate Assessment
IS	Irish Sea
IS MU	Irish Seas Management Unit
IUCN	International Union for Conservation of Nature
JCP	Joint Cetacean Protocol
JNCC	Joint Nature Conservation Committee
KEC	Framework for Assessing Ecological and Cumulative Effects
LF	Low Frequency

Acronym	Description
MCZ	Marine Conservation Zone
MBES	Multi-Beam Echo-Sounder
MDS	Maximum Design Scenario
MHWS	Mean High Water Springs
MMEA	Manx Marine Environmental Assessment
MMMP	Marine Mammal Mitigation Protocol
MMO	Marine Management Organisation
MMOs	Marine Mammal Observers
MNR	Marine Nature Reserve
MPA	Marine Protected Area
MPCP	Marine Pollution Contingency Plan
MU	Management Units
MWDW	Manx Whale and Dolphin Watch
MWT	Manx Wildlife Trust
NAS	Noise Abatement System
NISA	North Irish Sea Array
NMFS	National Marine Fisheries Service
NMPI	National Marine Plan Interactive
NPPF	National Planning Policy Framework
NPS	National Policy Statements
NPWS	National Parks and Wildlife Service
NRA	Navigational Risk Assessment
NRW	Natural Resources Wales
NS MU	North Sea Management Unit
NSIP	Nationally Significant Infrastructure Project
OC	Organochlorines
OCSE MU	Offshore Channel and Southwest England MU
ORJIP	Offshore Renewables Joint Industry Programme
OSP	Offshore Substation Platform
OSPAR	Convention for the Protection of the Marine Environment of the North East Atlantic
PAM	Passive Acoustic Monitoring
PBDE	Penta-mix brominated diphenyl ether congeners
PCB	Polychlorinated Biphenyl
PCW	Pinnipeds in water
PDV	Phocine Distemper Virus

Acronym	Description
PEIR	Preliminary Environmental Information Report
POP	Persistent Organic Pollutants
PTS	Permanent Threshold Shift
QA	Quality Assurance
RIAA	Report to Inform Appropriate Assessment
RSPB	Royal Society for Protection of Birds
SAC	Special Area of Conservation
SBES	Single Beam Echosounder
SBP	Sub-Bottom Profilers
SCANS	Small Cetacean Abundance in the North Sea
SCOS	Special Committee on Seals
SEA	Strategic Environmental Assessment
SEL	Sound Exposure Level
SEL_{cum}	Cumulative Sound Exposure Level
SNCB	Statutory Nature Conservation Body
SMRU	Sea Mammal Research Unit
SOV	Service Operation Vessels
SPL	Sound Pressure Level
SPA	Special Protection Areas
SPL_{pk}	Peak Sound Pressure Level
SSC	Suspended Sediment Concentrations
SSS	Side Scan Sonar
SSSI	Site of Special Scientific Interest
SWF	Sea Watch Foundation
TBT	Tributyltin
TTS	Temporary Threshold Shift
TWT	The Wildlife Trust
UHRS	Ultra High Resolution Seismic
UK	United Kingdom
US	United States
UXO	Unexploded Ordnance
VHF	Very High Frequency
ZOI	Zone Of Influence

Units

Unit	Description
%	Percentage
Km^2	Square kilometres
μPa	Micro Pascal (10^{-6})
dB	Decibel
Hz	Hertz
kJ	Kilojoule
Km	Kilometres
Kg	Kilogram
KHz	Kilohertz
m	Metre
m/s	Metres per second
MW	Megawatt
Mg	Milligram
Nm	Nautical mile
s	Second

4 Marine Mammals

4.1 Introduction

4.1.1 Overview

4.1.1.1 This chapter of the Environmental Statement presents the assessment of the potential impact of the Morgan Offshore Wind Project: Generation Assets, hereafter referred to as the Morgan Generation Assets, on marine mammals. Specifically, this chapter considers the potential impact of the Morgan Generation Assets seaward of Mean High Water Springs (MHWS) during the construction, operations and maintenance, and decommissioning phases. This Marine mammals chapter has been updated at Examination Deadline 5 to make minor wording changes in Table 4.16 and at paragraph 4.9.3.6. Paragraph numbering has been updated where relevant and all errata addressed as part of the update.

4.1.1.2 The assessment presented is informed by the following technical chapters:

- Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement
- Volume 2, Chapter 7: Shipping and navigation of the Environmental Statement.

4.1.1.3 This chapter also draws upon information contained within Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement. The technical report provides a detailed characterisation of the marine mammal species ecology within the vicinity of the Morgan Generation Assets, the wider Irish Sea and wider Celtic Sea. It is based on existing literature and site-specific surveys and provides information on marine mammal species of ecological importance and conservation value. This chapter is also informed by a technical report developed to understand underwater sound emissions associated with the Morgan Generation Assets, which is included as Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement.

4.1.2 Purpose of chapter

4.1.2.1 The primary purpose of the Environmental Statement is outlined in Volume 1, Chapter 1: Introduction of the Environmental Statement. In summary, the primary purpose of an Environmental Statement is to support the Development Consent Order (DCO) application for Morgan Generation Assets under the Planning Act 2008 (the 2008 Act). The Environmental Impact Assessment (EIA) has been finalised following completion of pre-application consultation and the Environmental Statement will accompany the application to the Secretary of State for Development Consent.

4.1.2.2 In particular, this Environmental Statement chapter:

- Presents the existing environmental baseline established from desk studies, site-specific surveys and consultation
- Identifies any assumptions and limitations encountered in compiling the environmental information
- Presents the potential environmental effects on marine mammals arising from the Morgan Generation Assets, based on the information gathered and the analysis and assessments undertaken

- Highlights any necessary monitoring and/or mitigation measures which could prevent, minimise, reduce or offset the potential environmental effects of the Morgan Generation Assets on marine mammals.

4.2 Legislative and policy context

4.2.1 Legislation

4.2.1.1 The full relevant legislative context for the Morgan Generation Assets has been detailed in Volume 1, Chapter 2: Policy and legislative context of the Environmental Statement, with the legislation outlined below being the most relevant to marine mammals.

Habitats Regulations

4.2.1.2 The Habitats Directive is transposed into UK law by four sets of regulations. In English waters, relevant regulations are the Conservation of Habitats and Species Regulations 2017 and the Conservation of Offshore Marine Habitats and Species Regulations 2017 (the 'Habitats Regulations'). These require the assessment of significant effects on internationally important nature conservation sites where these may arise as a result of a project. For marine mammals these internationally important sites include Special Areas of Conservation (SACs), or candidate SACs. These designated sites have been given consideration in section 4.5.1, with further detail in Volume 6, Annex 4.1: Marine mammal technical report of the Environmental Statement. Before deciding to undertake, or give any consent, permission or other authorisation for, a plan or project which is likely to have a significant effect on a European offshore marine site or a European site (either alone or in combination with other plans or projects), and is not directly connected with or necessary to the management of the site, the relevant competent authority must undertake an appropriate assessment of the implications for the site in view of that site's conservation objectives. If the potential for adverse effects on European site integrity cannot be discounted, the project could only proceed if imperative reasons of over-riding public interest are found to exist and if compensatory measures can be secured.

4.2.1.3 A person is guilty of an offence if they deliberately capture, injure, or kill any wild animal of a European Protected Species (EPS). In English and Welsh inshore waters (within 12 nm of the coast), offences relating to the protection of marine EPS are provided for under the Habitats Regulations[1]..

Marine and Coastal Access Act 2009

4.2.1.4 Parts three and four of the Marine and Coastal Access Act 2009 introduced a new marine planning and licensing system for overseeing the marine environment and a requirement to obtain a marine licence for certain activities and works at sea. Section 149A of the Planning Act 2008 allows applicants for development consent to apply for a 'deemed marine licence' as part of the consenting process.

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[1] The Conservation (Natural Habitats, &c.) Regulations (1994 implement the Habitats Directives in territorial waters out to 12 nautical miles (nm). The Offshore Marine Conservation (Natural Habitats &c.) Regulations 2007 (as amended) (the Offshore Marine Regulations) transpose the provisions of the Habitats Directive in offshore waters, beyond 12 nm.

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

4.2.1.5 The Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) came into force in 1994. The aim of the Agreement is to promote close co-operation amongst Parties with a view to achieving and maintaining a favourable conservation status for small cetaceans.

OSPAR Convention 1992

4.2.1.6 The Convention for the Protection of the Marine Environment of the North-East Atlantic (referred to as the OSPAR Convention) was signed at the ministerial meeting of the Oslo and Paris Commissions in Paris in 1992 and aims to protect the marine environment of the North-East Atlantic. As part of this work, the need for a network of Marine Protected Areas (MPAs) has been identified, and includes SACs with marine components, which is relevant to marine mammals.

Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention, 1979)

4.2.1.7 The principal aims of the Convention are to ensure conservation and protection of wild plant and animal species and their natural habitats (listed in Appendices I and II of the Convention), to increase co-operation between contracting parties, and to regulate the exploitation of migratory species listed in Appendix III.

4.2.1.8 The UK Government ratified the Bern Convention in 1982. The obligations of the Convention are transposed into UK law by means of the Wildlife and Countryside Act (1981 as amended), Nature Conservation (Scotland) Act 2004 (as amended), Wildlife (Northern Ireland) Order 1985, and the Nature Conservation and Amenity Lands (Northern Ireland) Order 1985.

The Convention on the Conservation of Migratory Species of Wild Animals 1979 (the Bonn Convention)

4.2.1.9 The Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention or CMS) was adopted in Bonn, Germany in 1979 and came into force in 1985. Contracting Parties work together to conserve migratory species and their habitats by providing strict protection for endangered migratory species, concluding multilateral Agreements for the conservation and management of migratory species which require or would benefit from international co-operation (listed in Appendix II), and by undertaking co-operative research activities.

The Conservation of Seals Act 1970

4.2.1.10 An Act to provide for the protection and conservation of seals in England and Wales and Scotland and in the adjacent territorial waters. The Conservation of Seals Act 1970 prohibits killing or taking seals. It is an offence to intentionally or recklessly kill, injure or take a seal. As of 1 March 2021, amendments made to the Conservation of Seals Act 1970 by Schedule 9 of the Fisheries Act 2020 come into force. Individual seals can no longer be controlled under the 'netsman's defence' as this defence was removed from the legislation as of 1 March 2021.

4.2.2 Planning policy context

4.2.2.1 The Morgan Generation Assets is located in English offshore waters (beyond 12 nm from the English coast). As set out in Volume 1, Chapter 1: Introduction of the Environmental Statement, as the Morgan Generation Assets is an offshore generating station with a capacity of greater than 100 MW located in English waters, it is a Nationally Significant Infrastructure Project (NSIP) as defined by Section 15(3) of the Planning Act 2008 (as amended) (the 2008 Act). As such, there is a requirement to submit an application for a DCO to the Planning Inspectorate to be decided by the Secretary of State for the Department for Energy Security and Net Zero.

4.2.3 National Policy Statements

4.2.3.1 There are currently six energy National Policy Statements (NPSs), two of which contain policy relevant to offshore wind development and the Morgan Generation Assets, specifically:

- Overarching NPS for Energy (NPS EN-1) which sets out the UK Government's policy for the delivery of major energy infrastructure (Department for Energy Security & Net Zero, 2023a)

4.2.3.2 NPS for Renewable Energy Infrastructure (NPS EN-3) (Department for Energy Security & Net Zero, 2023b).The main policies relevant to marine mammals are in NPS EN-1 and NPS EN-3 and include guidance on what matters are to be considered in the assessment. NPS EN-1 and NPS EN-3 also highlight a number of factors relating to the determination of an application and in relation to mitigation. These are summarised in Table 4.1 below.

Table 4.1: Summary of the NPS EN-1 and NPS EN-3 provisions relevant to marine mammals.

Summary of NPS EN-3 and EN-1 provision	How and where considered in the Environmental Statement
NPS EN-1	
Where the development is subject to EIA the applicant should ensure that the Environmental Statement clearly sets out any effects on internationally, nationally, and locally designated sites of ecological or geological conservation importance (including those outside England), on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity, including irreplaceable habitats. (NPS EN-1 paragraph 5.4.17)	The potential effects on internationally, nationally and locally designated sites for ecological or geological features of conservation importance have been identified and assessed for the Morgan Generation Assets. The Habitats Regulations Assessment (HRA) Stage 1 Screening (Document Reference E1.4) identified direct or indirect effects on sites which could be affected, and those sites have been assessed in the HRA Stage 2 Information to Support Appropriate Assessment (ISAA) (Document Reference E1.1). Important protected areas for marine mammals have been discussed in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement and in section 4.5.1.
The applicant should show how the project has taken advantage of opportunities to conserve and enhance biodiversity and geological conservation interests. (NPS EN-1 paragraph 5.4.19)	Measures that will be adopted as part of the Morgan Generation Assets to conserve marine mammal biodiversity are presented in section 4.8.
The design of Energy NSIP proposals will need to consider the movement of mobile/migratory species such as birds, fish and marine and terrestrial mammals and	The movement of mobile/migratory species such as marine mammals is considered in the assessment across the UK (section 4.9) and more widely across Europe in

Summary of NPS EN-3 and EN-1 provision	How and where considered in the Environmental Statement
their potential to interact with infrastructure. As energy infrastructure could occur anywhere within England and Wales, both inland and onshore and offshore, the potential to affect mobile and migratory species across the UK and more widely across Europe (transboundary effects) requires consideration, depending on the location of development. (NPS EN-1 paragraph 5.4.22)	the cumulative (section 4.11) and transboundary assessment (section 4.12).
Applicants should include appropriate avoidance, mitigation, compensation and enhancement 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 • The timing of construction has been planned to avoid or limit disturbance • 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 • Opportunities will be taken to enhance existing habitats rather than replace them, and where practicable, create new habitats of value within the site landscaping proposals. Where habitat creation is required as mitigation, compensation, or enhancement the location and quality will be of key importance. In this regard habitat creation should be focused on areas where the most ecological and ecosystems benefits can be realised. • mitigations required as a result of legal protection of habitats or species will be complied with. (NPS EN-1 paragraph 5.4.35)	Appropriate avoidance and mitigation measures (primary and tertiary mitigation) relevant for marine mammals which will be adopted as part of the Morgan Generation Assets are detailed in section 4.8. The Maximum Design Scenario (MDS) represents the parameters that make up the realistic worst case scenario (i.e. the maximum project design parameters) and is selected on a topic-by-topic and impact-by-impact basis and assessed in section 4.9. . The Morgan Generation Assets has also prepared an Outline underwater sound management strategy (Document Reference J13) which is secured within the deemed marine licences withing the draft DCO (Document Reference C1). This establishes a process of investigating options to manage underwater sound levels in consultation with the licensing authority and SNCBs and agreeing, prior to construction, which mitigation measures will be implemented to reduce impacts such that there will be no residual significant effect from the Morgan Generation Assets.
NPS EN-3	

Summary of NPS EN-3 and EN-1 provision	How and where considered in the Environmental Statement
Given the scale of offshore wind deployment required to meet 2030 and 2050 ambitions, applicants will need to give close consideration to impacts on MPAs, either alone or in combination, and employ the mitigation hierarchy and if necessary, provide compensation (both individually and in combination with other plans or projects) which may be needed to approve their projects. It is likely that mitigation may include proactive measures to reduce the impact of deployment (e.g. micrositing of offshore transmission routes to avoid vulnerable habitats, alternatives piling or trenching techniques, noise abatement technology, collision avoidance methods, or if necessary, compensation for habitat loss). (NPS EN-3 paragraph 2.8.52 and 2.8.53)	Important marine protected areas, SACs designated for marine mammals, and Marine Nature Reserves (MNRs) in Manx waters are identified in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement and in section 4.5.1 of this chapter. Primary and tertiary mitigation relevant for marine mammals which will be adopted as part of the Morgan Generation Assets are detailed in section 4.8. The Morgan Generation Assets has also prepared an Outline underwater sound management strategy (Document Reference J13). This establishes a process of investigating options to manage underwater sound levels in consultation with the licensing authority and SNCBs and agreeing, prior to construction of those works which would lead to underwater sound impacts, which mitigation measures will be implemented to reduce impacts such that there will be no residual significant effect from the Morgan Generation Assets.
As part of the Offshore Wind Environmental Improvement Package set out in the British Energy Security Strategy, Government committed to establishing Offshore Wind Environmental Standards (OWES; previously referred to as Nature Based Design Standards) to accelerate deployment whilst offering greater protection of the marine environment. OWES aim to support developers to take a more consistent approach to avoiding, reducing, and mitigating the impacts of an offshore wind farms and/or offshore transmission infrastructure. The measures could apply to the design, construction, operation and decommissioning of offshore wind farms and offshore transmission (as defined in EN-5 at section 2.12). Defra will consult on a series of OWES before drafting clear OWES Guidance, which sets out where and how Defra expects each measure to be applied to a development. Once the OWES Guidance is issued, the Secretary of State will expect applicants to have applied the relevant measures to their applications. Applicants should explain how their proposals comply with the guidance or, alternatively, the grounds on which a departure from them is justified. Any reasons for departure from the OWES should be fully detailed within the application documents, with details of any agreements made with statutory consultees. (NPS EN-3 paragraph 2.8.90 to 3.8.92)	The Applicant is aware of the requirements in NPS EN-3 to apply the guidance on environmental standards, once this final OEWS guidance is issued. The Applicant will review the guidance once available and determine how the Morgan Generation Assets complies, and consider the guidance, where, if relevant, the Morgan Generation Assets departs from the Offshore Wind Environmental Standards, providing reasoning for any depature including details of any agreements made with statutory consultees.
Applicants need to consider environmental and biodiversity net gain as set out in Section 4.6 of EN-1 and the Environment Act 2021. Applicants should assess the potential of their proposed development to have net positive effects on marine ecology and biodiversity, as well as negative effects. (NPS EN-3 paragraph 2.8.102 and 2.8.103)	Both potential positive and negative effects for marine mammals have been considered for the Morgan Generation Assets (see section 4.9). These are also considered in the Biodiversity benefit statement (Document Reference J18).

Summary of NPS EN-3 and EN-1 provision	How and where considered in the Environmental Statement
Applicants should consult at an early stage of pre-application with relevant statutory consultees and energy not-for profit organisations/non-governmental organisations, as appropriate, on the assessment methodologies, baseline data collection, and potential avoidance, mitigation and compensation options should be undertaken. In developing proposals applicants must refer to the most recent best practice advice originally provided by Natural England under the Offshore Wind Enabling Action Programme and/or their relevant SNCB. Any relevant data that has been collected as part of post-construction ecological monitoring from existing, operational offshore wind farms should be referred to where appropriate. (NPS EN-3 paragraph 2.8.104 to 2.8.106)	Assessment methodologies and baseline data collection has been consulted on, through the Evidence Plan Process (EPP). Relevant data collected as part of post-construction ecological monitoring from existing operational offshore wind farms has been included where appropriate to inform the baseline (see section 4.5) with further detail given in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement.
Where necessary, assessment of the effects on marine mammals should include details of: • Likely feeding areas and impacts on prey species and prey habitat • Known birthing areas/haul out sites for breeding and pupping • Migration routes • Protected sites • Baseline noise levels • Predicted construction and soft start noise levels in relation to mortality, permanent threshold shift (PTS), temporary threshold shift (TTS) and disturbance • Operational noise • Duration and spatial extent of the impacting activities including cumulative/in-combination effects with other plans or projects • Collision risk • Entanglement risk • Barrier risk. The scope, effort and methods required for marine mammal surveys and impact assessments should be discussed with the relevant Statutory Nature Conservation Body (SNCB). (NPS EN-3 paragraph 2.8.131 and 2.8.132)	The potential for effects on marine mammals has been assessed in section 4.9 and a detailed technical baseline, including likely feeding areas; known birthing areas/haul out sites; known migration or commuting routes has been presented within Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement and in this chapter. Relevant protected areas to the Morgan Generation Assets are discussed in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement and in this chapter (4.5.1). Baseline sound levels; predicted received sound levels in relation to mortality, PTS and TTS and disturbance; soft-start sound levels according to proposed hammer and pile design; and operational sound have been considered within Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement. The duration and spatial extent of potentially disturbing activities, including cumulative effects with other plans or projects is presented in 4.11. An assessment of in-combination effects is presented in the HRA Stage 2 ISAA (Document Reference E1.1). Collision risk has been considered within section 4.9.5. Where relevant, the potential for barrier effects has been considered.

Summary of NPS EN-3 and EN-1 provision	How and where considered in the Environmental Statement
The applicant should discuss any proposed noisy activities with the relevant statutory body and must reference the Joint Nature Conservation Committee (JNCC) and SNCB underwater noise guidance, and any successor of this guidance, in relation to noisy activities (alone and in-combination with other plans or projects) within SACs, SPAs and Ramsar sites, in addition to the JNCC mitigation guidelines to piling, explosive use, and geophysical surveys. NRW has a position statement on assessing noisy activities which should also be referenced where relevant. Where the assessment identifies that noise from construction and Unexploded Ordnance (UXO) clearance may reach noise levels likely to lead to noise thresholds being exceeded (as detailed in the JNCC guidance) or an offence is committed, the applicant will be expected to look at possible alternatives or appropriate mitigation. The applicant should develop a Site Integrity Plan (SIP) or alternative assessments for projects in English and Welsh waters to allow the cumulative impacts of underwater noise to be reviewed closer to the construction date, when there is more certainty in other plans and projects. (NPS EN-3 paragraph 2.8.133 to 2.8.135)	Potential sound as a result of piling activity at the Morgan Generation Assets has been discussed in section 4.9.2. Potential sound as a result of UXO clearance activities has been discussed in section 4.9.3 and potential sound as a result of geophysical surveys has been discussed in section 4.9.6. Appropriate measures adopted as part of the Morgan Generation Assets to reduce the magnitude of impact such that any residual significant effects from the Morgan Generation Assets are reduced to a non-significant levels, along with those specific to construction, operations and maintenance and decommissioning are presented in section 4.8. Furthermore, an Outline underwater sound management strategy (Document Reference J13) has been prepared to investigate options to reduce any potential significant impacts such that there will be no residual significant effects from the project alone, and is secured within the deemed marine licences within the draft DCO. NRW's position statement (NRW, 2023b) has been reviewed and incorporated throughout the assessment.
Monitoring of the surrounding area before and during the piling procedure can be undertaken by various methods including marine mammal observers and passive acoustic monitoring. Active displacement of marine mammals outside potential injury zones can be undertaken using equipment, such as acoustic deterrent devices. Soft start procedures during pile driving may be implemented. This enables marine mammals in the area disturbed by the sound levels to move away from the piling before physical or auditory injury is caused. Where noise impacts cannot be avoided, other mitigation should be considered, including alternative installation methods and noise abatement technology, spatial/temporal restrictions on noisy activities, alternative foundation types. Applicants should undertake a review of up-to-date research and all potential mitigation options presented as part of the application, having consulted the relevant JNCC mitigation guidelines. (NPS EN-3 paragraphs 2.8.237 to 2.8.239)	Measures adopted as part of the Morgan Generation Assets are set out in section 4.8, which include a measure to develop and adhere to a Marine Mammal Mitigation Protocol (MMMP) which will be developed in accordance with the Outline MMMP (Document Reference J17) and in line with the latest research and JNCC mitigation guidelines. Measures required to meet legislative requirements, or adopted standard industry practice are also set out in section 4.8, and include a measure to develop and adhere to an Underwater sound management strategy that includes consideration of Noise Abatement Systems (NAS) as part of mitigation options, which will be developed in accordance with the Outline underwater sound management strategy (Document Reference J13). The Underwater sound management strategy will be made as part of a stepped strategy post consent and following the mitigation hierarchy - avoid, reduce, mitigate.

Summary of NPS EN-3 and EN-1 provision	How and where considered in the Environmental Statement
The Secretary of State 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 reasonably to minimise significant impacts on marine mammals. Unless suitable noise mitigation measures can be imposed by requirements to any development consent the Secretary of State may refuse the application. The conservation status of cetaceans and seals are of relevance and the Secretary of State should be satisfied that cumulative and in-combination impacts on marine mammals have been considered. (NPS EN-3 paragraphs 3.8.312 to 2.8.314)	Morgan Generation Assets project parameters relevant to marine mammals have been set out in Table 4.16 (Maximum design scenario considered for the assessment of potential impacts on marine mammals). Measures adopted as part of the Morgan Generation Assets are set out in section 4.8, which include a measure to develop and adhere to a Marine Mammal Mitigation Protocol (MMMP) which will be developed in accordance with the Outline MMMP (Document Reference J17) and in line with the latest research and JNCC mitigation guidelines. Measures required to meet legislative requirements, or adopted standard industry practice are also set out in section 4.8, and include a measure to develop and adhere to an Underwater sound management strategy that includes consideration of (NAS as part of mitigation options, which will be developed in accordance with the Outline underwater sound management strategy (Document Reference J13). The Underwater sound management strategy will be made as part of a stepped strategy post consent and following the mitigation hierarchy - avoid, reduce, mitigate. An assessment of cumulative effects presented in 4.11 and an assessment of in-combination effects is presented in the HRA Stage 2 ISAA (Document Reference E1.1).

4.2.4 National Planning Policy Framework

4.2.4.1 The Morgan Generation Assets study area includes areas of mainland England. The National Planning Policy Framework (December 2023) (NPPF) provides overarching advice regarding development. The aim of achieving sustainable development is the main theme of the NPPF. Those sections of particular relevance to marine mammals are set out in Table 4.4, below.

Table 4.2: English National Planning Policy Framework relevant to marine mammals.

Summary of NPPF provision.	How and where considered in the Environmental Statement
2. Achieving sustainable development	
Achieving sustainable development means that the planning system has three overarching objectives, which are interdependent and need to be pursued in mutually supportive ways (so that opportunities can be taken to secure net gains across each of the different objectives): **An environmental objective** – to protect and enhance our natural, built and historic environment, including making effective use of land, improving biodiversity, using natural resources prudently, minimising waste and pollution, and mitigating and adapting to climate change, including moving to a low carbon economy. **(English NPPF, 2. Achieving sustainable development paragraph 8)**	Measures that will be adopted as part of the Morgan Generation Assets to conserve marine mammal biodiversity are presented in section 4.8.

Summary of NPPF provision.	How and where considered in the Environmental Statement
15. Conserving and enhancing the natural environment	
Planning policies and decisions should contribute to and enhance the natural and local environment by: d) minimising impacts on and providing net gains for biodiversity, including by establishing coherent ecological networks that are more resilient to current and future pressures. **(English NPPF, 2. Conserving and enhancing the natural environment paragraph 174)** <u>Habitats and biodiversity</u> The following should be given the same protection as habitats sites: a) Potential Special Protection Areas and possible Special Areas of Conservation b) Listed or proposed Ramsar sites c) Sites identified, or required, as compensatory measures for adverse effects on habitats sites, potential Special Protection Areas, possible Special Areas of Conservation, and listed or proposed Ramsar sites. **(English NPPF, 2. Conserving and enhancing the natural environment paragraph 181)** The presumption in favour of sustainable development does not apply where the plan or project is likely to have a significant effect on a habitats site (either alone or in combination with other plans or projects) unless an appropriate assessment has concluded that the plan or project will not adversely affect the integrity of the habitats site. **(English NPPF, 2. Conserving and enhancing the natural environment paragraph 182)**	An assessment of the potential impact on marine mammals has been presented in section 4.9 for the project alone and cumulatively with other plans and projects in section 4.11. Measures to minimise the potential for impacts on marine mammals are set out in section 4.8. Important marine protected areas, SACs designated for marine mammals, and Marine Nature Reserves (MNRs) in Manx waters are identified in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement and in section 4.5.1 of this chapter. An assessment of the potential effects on SACs designated for marine mammals is provided in the HRA Stage 2 ISAA (Document Reference E1.2).

4.2.5 The Marine Strategy Framework Directive

4.2.5.1 The Marine Strategy Framework Directive (MSFD) aims to protect more effectively the marine environment across Europe.

Table 4.3: Summary of the MSFD's high level descriptors of Good Environmental Status (GES) relevant to marine mammals and consideration in the Morgan Generation Assets.

MSFD Descriptor relevant to marine mammals	How and where considered in the Environmental Statement
Descriptor 1: Biological diversity: 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.	The potential effects on biological diversity has been described and considered within the assessment for Morgan Generation Assets both alone (section 4.9) and in the Cumulative Effects Assessment (CEA) (section 4.11). A detailed baseline assessment which describes the distribution and abundance of marine mammal species in the study area has been undertaken in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental

MSFD Descriptor relevant to marine mammals	How and where considered in the Environmental Statement
	Statement, and a summary presented in section 4.5. Appropriate and precautionary densities to take forward to the assessment have been agreed in consultation with stakeholders (Table 4.12).
Descriptor 4: Elements of marine food webs: 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.	The potential effects of prey species (see assessment of impacts on fish prey species in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement) on the abundance and distribution of marine mammal receptors within the regional marine mammal study area has been described and considered within the assessment for Morgan Generation Assets both alone (section 4.9) and in the CEA (section 4.11).
Descriptor 6: Sea floor integrity: Seafloor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.	The potential effects on temporary and long term habitat loss and introduction of new habitat on benthic ecosystems and associated benthic species have been considered within Volume 2, Chapter 2: Benthic subtidal and intertidal ecology and Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement. Subsequently, the potential indirect effects on marine mammals in relation to changes in prey species communities within the Morgan marine mammal study area has been described and considered within the assessment for the Morgan Generation Assets both alone (section 4.9) and in the CEA (section 4.11).
Descriptor 8: Contaminants: Concentrations of contaminants are at levels not giving rise to pollution effects.	The potential effects of contaminants on marine mammal receptors were scoped out as agreed in the Morgan Generation Assets EIA Scoping Report and as agreed with the marine mammal Expert Working Group (EWG) (Table 4.7).
Descriptor 10: Marine litter: Properties and quantities of marine litter do not cause harm to the coastal and marine environment.	An appropriate Offshore Environmental Management Plan (EMP) will be produced and implemented. The Offshore EMP will also outline any procedures implemented during the operations and maintenance phase. A Decommissioning Programme is required under the provisions of the Energy Act 2004. This must be approved by the Secretary of State for the Department for Energy Security and Net Zero before works commence.
Descriptor 11: Energy including underwater noise: Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.	The potential effects of underwater sound from piling of wind turbine foundations, and Offshore Substation Platform (OSP) foundations, from other construction activities (e.g. cable installation) and from vessel sound have been considered within the assessment for the Morgan Generation Assets both alone (section 4.9) and in the CEA (section 4.11). It is noted that the European Union recently adopted thresholds for maximum acceptable levels for impulsive (e.g. piling) and continuous sound (e.g. shipping). The new limits mean, that to be in tolerable status, no more than 20% of a given marine area can be exposed to continuous underwater sound over a year. Similarly, no more than 20% of a marine habitat can be exposed to impulsive sound over a given day, and no more than 10% over a year. The Morgan Generation Assets has committed to an Underwater sound management strategy (with Outline underwater sound management strategy included as part of the

MSFD Descriptor relevant to marine mammals	How and where considered in the Environmental Statement
	application, Document Reference J14) which will consider further mitigation measures to reduce any residual significant effects from the project alone to a non-significant level, on the basis of a refined project design post consent, where more detailed information is available.

4.2.6 North West Inshore and North West Offshore Marine Plans

4.2.6.1 The assessment of potential changes to marine mammals has also been made with consideration to the specific policies set out in the North West Inshore and North West Offshore Marine Plans (MMO, 2021). Key provisions are set out in Table 4.4 along with details as to how these have been addressed within the assessment.

Table 4.4: North West Inshore and North West Offshore Marine Plan policies of relevance to marine mammals.

Policy	Key provisions	How and where considered in the Environmental Statement
NW-MPA-1	Proposals that support the objectives of marine protected areas and the ecological coherence of the marine protected area network will be supported. Proposals that may have adverse impacts on the objectives of marine protected areas must demonstrate that they will, in order of preference: a. avoid b. minimise c. mitigate adverse impacts, with due regard given to statutory advice on an ecologically coherent network.	This chapter presents the spatial scale of potential effects in relation to sites protected for marine mammal features (e.g. SACs, MNRs). A detailed assessment of the spatial overlap with European nature conservation designations has been undertaken as part of the HRA (HRA Stage 2 ISAA (Document Reference E1.1)). Measures have been adopted as part of the Morgan Generation Assets to reduce the spatial scale of potential effects and are described in section 4.8.
NW-BIO-2	NW-BIO-2 requires proposals to manage negative effects which may significantly adversely impact the functioning of healthy, resilient and adaptable marine ecosystems.	The Applicant will implement a range of measures adopted (primary and tertiary) as part of the Morgan Generation Assets to mitigate potential negative effects which are detailed in section 4.9. The Morgan Generation Assets has also committed to an Underwater sound management strategy (with an Outline underwater sound management strategy included as part of the application for consent, Document Reference J13), which, post-consent, will set out the approach to further management measures that may be required to reduce the impact such that there will be no residual significant effect for underwater sound, following a refined project design and more detailed information post consent.

Policy	Key provisions	How and where considered in the Environmental Statement
NW-UWN-2	Proposals that result in the generation of impulsive or non-impulsive noise must demonstrate that they will, in order of preference: a. avoid b. minimise c. mitigate Adverse impacts on highly mobile species so they are no longer significant.	The potential impacts of underwater sound resulting from the construction, operations and maintenance, and decommissioning phases have been considered in the underwater sound impact assessment (section 4.9.2). The Applicant will implement a range of measures adopted (primary and tertiary) as part of the Morgan Generation Assets which will reduce the potential effects of sound, detailed in section 4.8. The Morgan Generation Assets has also committed to an Underwater sound management strategy (with an Outline underwater sound management strategy included as part of the application for consent, Document Reference J13), which post-consent will set out the approach to further management measures that may be required to reduce the impact such that that there will be no residual significant effect from underwater sound from the project alone, following a refined project design and more detailed information post consent.
NW-CE-1	Proposals which may have adverse cumulative effects with other existing, authorised, or reasonably foreseeable proposals must demonstrate that they will avoid, minimise and mitigate.	Potential cumulative effects have been quantified and their significance assessed in section 4.11. A detailed Outline MMMP (Document Reference J17) will be developed post-consent subject to project refinements and will consider mitigation in order to reduce the potential effects for the project alone, which will reduce the contribution to potential cumulative effects. The Morgan Generation Assets has also committed to an Underwater sound management strategy (with an Outline underwater sound management strategy included as part of the application for consent, Document Reference J13), which post-consent will set out the approach to further management measures that may be required to reduce the magnitude of the impact such that that there will be no residual significant effect from underwater sound from the project alone.

4.3 Consultation

4.3.1.1 A summary of the key issues raised during consultation activities undertaken to date specific to marine mammals is presented in Table 4.5 below, together with how these issues have been considered in the production of this Environmental Statement chapter. Further detail is presented within Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement.

4.3.1 Evidence plan

4.3.1.1 The purpose of the Evidence Plan Process (EPP) is to agree the information the Morgan Generation Assets needs to supply to the Secretary of State, as part of a DCO application for Morgan Generation Assets. The Evidence Plan has sought to ensure compliance with the HRA and EIA Regulations. The development and monitoring of the Evidence Plan and its subsequent progress has been undertaken by the Steering Group. The Steering Group comprises the Planning Inspectorate, the Applicant, Natural England, Natural Resources Wales (NRW), JNCC and the Marine Management Organisation (MMO) as the key regulatory and SNCBs. To inform the EIA and HRA process during the pre-application stage of the Morgan Generation Assets, a Marine Mammal Expert Working Group (EWG) was also set up to discuss and agree topic specific issues with the relevant stakeholders. Details on the marine mammal EWG meetings, final meeting minutes, any responses from the stakeholders and technical notes provided to the EWG is presented in the Technical engagement plan Part 1 (Document Reference E4.1).

Table 4.5: Summary of key consultation issues raised during consultation activities undertaken for the Morgan Generation Assets relevant to marine mammals.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
February 2022	**Marine Mammals Expert Working Group 1 –** Natural England, MMO, JNCC, Natural Resources Wales (NRW), The Wildlife Trusts (TWT).	Use of digital aerial survey data requires an assessment of the suitability of analysing data covering 12% of the survey area, such as a power analysis to support approach.	Coverage for Morgan aerial surveys are detailed in Appendix A of Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement. Coverage for the Morgan aerial surveys stands at least 12%, which exceeds some previously consented projects and the 10% minimum coverage suggested by literature (BSH, 2013). Coefficients of variation (CVs) are also provided in this technical report to give measure of precision to support approach, but noted CVs will be higher for marine mammals, due to very low sighting numbers given their life history, so the difference between raw counts would be proportionally greater.
		Evidence of sufficient levels of quality assurance should be provided to resolve any concerns regarding the detection probability or species identification confidence associated with the chosen method (e.g. sample images in range of confidence scenarios and visibility conditions).	In processing of aerial data, marine mammals identified in the images were categorised to the lowest taxonomic level possible. Size of individuals were measured to aid in species-level identification. APEM Ltd undertook the aerial surveys for the Morgan Generation Assets, and full details of the survey methodology, data processing, data analyses, assumptions and limitations have been provided in Appendix A of Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement. APEM Ltd. uses the precautionary principle and only identifies to species level when there is 100% confidence and includes a comprehensive internal Quality Assurance (QA) process (details of which are detailed in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement). APEM only gives definite species sightings where an animal can be identified to species level with high confidence. Where a marine mammal sighting cannot be identified with high confidence to species level, sightings are given in their own non species specific categories (e.g. 'seal species', 'dolphin/porpoise', 'marine mammal').
		Survey feedback - advise caution in applying feedback on the survey design with respect to birds to marine mammals.	Survey design with respect to marine mammals was subsequently discussed with responses provided via the EWG process.
		Regional marine mammal study area – NRW query study area extent.	Study areas used in the assessment (as presented in paragraph 4.4.3) were discussed and agreed with the Marine Mammal EWG as

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
			part of the EWG process. The regional marine mammal study area was defined as the Celtic and Irish seas and was confirmed by the Marine Mammal EWG (following fifth EWG meeting on 3 August 2023).
		Key species must include minke whale, often sighted around the Isle of Man.	A baseline description of minke whale is included in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement, and has been scoped into the assessment in section 4.9.
		Desktop data sources – additional sources considered for applicability.	A detailed literature review was undertaken, and additional data sources or informative documents were sought to inform the baseline characterisation (section 4.5). Additional data was provided by Manx Wildlife Trust (MWT), Manx Whale and Dolphin Watch (MWDW) and for Walney Island following direct correspondence and is included in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement, to inform the baseline for assessment in section 4.9.
May 2022	**Underwater sound technical note** – provided to EWG.	Provided information on potential sources of underwater sound, methods for determining source sound levels, sound propagation modelling methodologies, exposure modelling and thresholds for injury and disturbance and stakeholders provided feedback the information presented. Feedback included: **NRW**: NRW would not recommend applying a dose-response curve developed for harbour porpoise to all cetacean species when carrying out an EIA to assess the number of animals that would be disturbed by piling as can lead to over-estimate. Requested justification of dose-response curve in Russell *et al.* (2016) developed for harbour seal, as a proxy to assess number of grey seals disturbed by piling. **Natural England**:	The same dose response curve for harbour porpoise was assumed to apply to all cetacean Important Ecological Features (IEFs) in this assessment (in the absence of species-specific data for other cetacean species) but note that this is a highly precautionary approach. A dose response curve by Whyte *et al.* (2020) using tracking data from harbour seal was used for the assessment and is explained in detail in paragraph 4.9.1.11 Piling has been modelled both with Acoustic Deterrent Devices (ADDs) (as it is a standard tertiary mitigation measure) and without ADD, and is discussed in the assessment (section 4.9.2). Whilst ADDs are a recognised mitigation measure during piling and UXO clearance, they are not a sound reduction or abatement system. No modelling of NAS is presented in this chapter, but these potential measures will be considered as an option under the Underwater sound management strategy (Document Reference J13) post consent, if required. For the UXO assessment the TTS metric has been applied as a proxy for potential behavioural effects (as the animal are assumed

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
		It would be beneficial to consider modelling piling with NAS in place, to understand the possible reduction in underwater sound (and associated impacts) if such mitigation methods are used. Similarly, sound abatement for UXO clearance where deflagration is not an option should also be considered. A quantitative assessment of the TTS impact ranges and the number of animals within those ranges would expect to be seen. Natural England advise the outputs from Whyte *et al.* (2020) which provides a dose-response curve for seals in relation to decreasing Sound Exposure Levels (SELs) should be considered. Natural England expect to see the underwater sound from operational wind turbines quantified in Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement. Request clarification as to whether consecutive piling (i.e. multiple piles, one after the other) is also within the project design envelope. **JNCC**: highlighted using the dose-response curve based on harbour porpoise only for all cetaceans, given they are a high frequency cetacean species. JNCC recommend further justification for this approach is included and a discussion with the EWG to agree a suitable approach.	to move away from the sound source) and effect ranges have been modelled and applied to the quantitative assessment. Consecutive scenarios have been modelled and assessed and included in section 4.6.
July 2022	**Marine Mammals Expert Working Group 2 –** Natural England, MMO,	Agreement sought on approach to the baseline characterisation with regards to regional marine mammal study area. NRW in agreement that Celtic and Irish Sea (harbour porpoise) MU is an appropriate study area for dolphin and minke whale.	Species-specific Management Units (MU) have been applied as reference populations where relevant. The Celtic and Irish Sea (CIS) MU (the harbour porpoise MU, (IAMMWG, 2023)) was adopted as the regional marine mammal study area (as per agreement through the EWG) and has been used as the maximum extent for screening of cumulative projects for cetaceans.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
	JNCC, NRW, The Wildlife Trust (TWT), Cefas.	Discussion of species to scope in/out of the EIA and HRA. Agreement that white-beaked dolphin can be scoped out.	A baseline description of harbour seal is included in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement, and harbour seal have been scoped into the assessment in section 4.9. White-beaked dolphin were scoped out of the assessment, an approach which was also supported through Scoping Opinion.
July 2022	**Scoping Opinion** The Planning Inspectorate	Agreement on defining the mitigation zone using the dual metric approach of peak sound pressure level (SPL_{pk}) and sound exposure level (SEL_{cum}).	The dual metric approach has been applied to the impact assessment of injury and disturbance from elevated underwater sound from piling (section 4.9).
		The Inspectorate does not agree to scope out impacts to Harbour Seals. Based on the literature review and recent surveys low numbers of Harbour Seals are located within the generation asset area that may be impacted. The Applicant should agree the scope of an assessment for this species with the EWG.	Harbour seal has been scoped into the assessment (section 4.9 and 4.11), and baseline information is presented in section 4.5. The scope of assessment for harbour seal has been agreed with the EWG.
		The regional study area for marine mammals is proposed to be the extent of the Irish Sea. The Inspectorate considers that the relevant Management Unit for each marine mammal receptor identified is the appropriate scale for consideration of the regional impacts for marine mammals.	Marine mammal MUs have been considered as relevant populations against which to assess potential impacts (section 4.9); and the Irish and Celtic seas have been defined as the regional marine mammal study area. The Celtic and Irish Seas MU is defined as the cumulative marine mammal study area in agreement with relevant stakeholders as per the second EWG meeting, with the addition of an extended screening area for grey seal only (OSPAR Region III) (see section 4.4.3).
		The Environmental Statement should describe the Permanent Threshold Shift (PTS), Temporary Threshold Shift (TTS) and disturbance ranges used for all species assessed, as well as the potential for the disturbance impact footprints to overlap with the boundary of offshore designated sites.	PTS, TTS and disturbance ranges are presented for each species for relevant impacts in this chapter (section 4.9). Proximity to designated sites has been considered for relevant impacts (section 4.9) and the potential for overlap of disturbance with designated sites has been considered in the Morgan Generation Assets HRA Stage 2 ISAA (Document Reference E1.1).
		The Environmental Statement should clearly identify all sources of underwater sound and vibration, for all phases of the Proposed Development, and assess the impacts from these activities where significant effects are likely to occur. The Environmental Statement	Sources of underwater sound from piling UXO clearance, vessel use, and other activities including cable trenching, laying and jack up rigs have been modelled and the assessment presented in section 4.9 of in this chapter, including a summary of the methodology and relevant assumptions. The underwater sound modelling methodology and results are presented in full in Volume

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
		should set out the methodology and assumptions for all modelling undertaken.	3, Annex 3.1: Underwater sound technical report of the Environmental Statement.
		The Environmental Statement should demonstrate that the worst-case scenario accounts for concurrent piling activities that are located as far apart from each other as would be possible in the design envelope, and thus result in the greatest potential extent of noise impacts.	Underwater sound modelling accounted for concurrent piling according to the MDS, including parameters for minimum and maximum distances between two concurrent piling events (Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement). The MDS is set out in Table 4.16 and sound impacts are assessed in section 4.9.
		Geophysical surveys are a source of underwater noise and should be assessed in the Environmental Statement where significant effects are likely to occur, both alone and cumulatively with other noise sources.	The impact of geophysical surveys on marine mammals has been assessed for Morgan Generation Assets alone (section 4.9.6), and as part of the cumulative effects assessment (section 4.11).
		The Environmental Statement should assess cumulative impacts on marine mammals where significant effects are likely to occur.	Other impact pathways assessed for Morgan Generation Assets alone are also considered in the cumulative effects assessment in section 4.11. Any assessment of minor significance or above for the Morgan Generation Assets alone has been carried forward the CEA.
	Scoping Opinion JNCC	Morgan regional marine mammal study area – JNCC query study area extent.	Study areas were discussed and agreed with JNCC as part of the EWG and the regional marine mammal study area was defined as the Celtic and Irish Seas for application to both the assessment and the CEA study area.
		Agree that harbour porpoise, minke whale, bottlenose dolphin, common dolphin, Risso's dolphin, and grey seal are scoped into the EIA; and white-beaked dolphin and harbour seal are scoped out.	White-beaked dolphin has been scoped out of the assessment, but harbour seal has been scoped into the assessment, following EWG discussions.
	Scoping Opinion Natural England	Marine Mammal Management Units should be used as the regional study area for the purposes of calculating the reference populations, the screening extent as regards Special Areas of Conservation, and for cumulative impacts spatial screening extent.	Study areas were discussed and agreed with Natural England as part of the EWG and the regional marine mammal study area was defined as the Celtic and Irish Seas.
		Suggests harbour seals cannot yet be excluded from the high-level assessment until there is suitable evidence (i.e. from the results of the complete digital aerial survey campaign) for their exclusion.	Harbour seal has been scoped in as a key species as result of EWG discussi4ns. Baseline description of harbour seal is included in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement and has been included in the assessment in section 4.9 of in this chapter.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
		Advise data derived from the site-specific aerial surveys is considered alongside existing data for the area when selecting the best/most precautionary estimate of marine mammal density to use for the quantitative assessment.	Data from site-specific aerial surveys has been presented along with broadscale published data. Species-specific density estimates derived from site-specific aerial surveys were considered alongside existing data, and the most precautionary and robust density estimates have been carried forward to the assessment (Table 4.12).
		Data source suggestions for inclusion.	All suggested data sources have been included in the baseline (Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement).
		Note that a number of individuals could not be identified to species level. We welcome clarification on how these observations are going to be included in the assessment to ensure that species' density estimates are not underestimated	Individuals identified as 'seal species' were combined with the data on grey seal, whilst those identified as 'cetacean species' were combined data on harbour porpoise. These were the only two species where it was possible to generate density estimates and combining higher taxonomic identifications provided the most precautionary estimate of density for use in the impact assessment (see Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement). The design and application of marine mammal digital aerial surveys, in combination with desktop study for baseline characterisation, were agreed by Natural England, NRW and JNCC following the fifth EWG meeting technical note issued to the marine mammal EWG on 11 September 2023 (presented in the Technical engagement plan Part 1 (Document Reference E4.1)).
July 2022		The Environmental Statement should thoroughly assess the potential for the proposal to affect designated sites. Internationally designated sites (e.g. designated Special Areas of Conservation (SAC) and Special Protection Areas (SPA)) fall within the scope of the Conservation of Habitats and Species Regulations 2017 (as amended). In addition paragraph 181 of the National Planning Policy Framework requires that potential Special Protection Areas, possible Special Areas of Conservation, listed or proposed Ramsar sites, and any site identified as being necessary to compensate for adverse impacts on classified, potential or possible SPAs, SACs and Ramsar sites be	Information in relation to designated sites is set out in the baseline environment section of this Environmental Statement (section 4.5), and any overlap of designated sites with disturbance contours is identified in section 4.9. The full assessment with respect to the conservation objectives of a particular site is provided in the Morgan Generation Assets HRA Stage 2 ISAA (Document Reference E1.1).

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
		treated in the same way as classified sites (NB. sites falling within the scope of regulation 8 of the Conservation of Habitats and Species Regulations 2017 are defined as 'habitats sites' in the NPPF). The Environmental Statement should include a full assessment of the direct and indirect effects of the development on the features of special interest within these sites, and should identify such mitigation measures as may be required in order to avoid, minimise or reduce any adverse significant effects.	
		Natural England do not agree that impacts from operational turbines can be scoped out at this stage. The size of the wind turbines proposed for this project are significantly larger than those that were the subject of the various referenced studies. We advise that the underwater noise modelling includes an assessment of underwater noise emissions from operational wind turbines, using the best available evidence and reasonable assumptions.	Operational sound is assessed in section 4.9.7 and includes an assessment of underwater sound emissions from operational wind turbines (detailed in Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement).
		Carter *et al*. (2020) should be used as a source of telemetry data for seals, which can inform the movements and origins of seals in the study area.	More up to date Carter *et al.* (2022) data is used in the assessment. Species-specific density estimates for grey seal and harbour seal derived from this data informs the environmental baseline (section 4.5), the assessment of potential effects (section 4.9) and CEA (section 4.11). Telemetry data obtained from Sea Mammal Research Unit (SMRU) is also incorporated into Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement to inform movements of seals in the regional marine mammal study area.
	Scoping Opinion ISLE OF MAN Department of Infrastructure	Whilst not identified as European designated sites, the level of protection to habitats and species is on a level with those designated under European Directives, and as such, it is essential that Manx protected sites are included within the preparation of the EIA.	Designated sites have been identified and set out in the baseline environment within section 4.5. This includes relevant Marine Nature Reserves (MNR) in Isle of Man waters.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
		The Territorial Seas Committee (TSC) would request that appropriate consideration is given to the species which are protected under the Wildlife Act, and ensure that there are no detrimental impacts on these species as part of this proposed project. In addition, the same would be requested in respect of the marine protected sites and the manner in which these are designated and managed, including any transboundary impacts arising from the project.	All species of cetaceans and pinnipeds are listed under the Wildlife Act 1981. The assessment of significant effects has considered relevant marine mammals (cetaceans and pinnipeds) in section 4.9. Screening of transboundary effects is presented in Volume 3, Annex 5.2: Transboundary impacts screening of the Environmental Statement and is set out in section 4.12.
November 2022	**Marine Mammals Expert Working Group 3 –** Natural England, MMO, Joint Nature Conservation Committee (JNCC), Natural Resources Wales (NRW), The Wildlife Trust (TWT), Cefas, Isle of Man Government	Discussion on densities and reference populations for marine mammals. Proposed approach set out in EWG03 and pre-meeting note.	Approach to density and reference populations is presented in detail in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement with a summary presented in Table 4.12.
		Approach to assessment presented, covering: • Dose response curves and use of National Marine Fisheries Service (NMFS) (or other) thresholds • Assumptions of the cumulative assessment	Dose response curve derived from Graham *et al.* (2019) applied to other cetacean species due to lack of alternative suitable approach. NMFS thresholds also applied to the assessment (section 4.10). A tiered approach is applied in the cumulative assessment, with modelling carried out across Tier 1 projects to provide a qualitative assessment. Tier 2 projects where quantitative information is available in the public domain has also been included in modelling. Detailed description of the cumulative assessment approach is provided in section 4.10.
		Initial underwater sound modelling outputs for piling presented to the EWG. Highlighted sensitivity of Interim Population Consequences of Disturbance Model (iPCoD) modelling to parameters chosen.	PTS has been carried forward to the assessment in section 4.9.2. The ranges for TTS are presented in the Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement but are not included in the assessment for injury and disturbance for elevated underwater sound during piling. The method for iPCoD modelling used to understand long term population effects is presented in paragraph 4.9.2.13 *et seq*, and a detailed iPCoD report is presented in Appendix B.
		Assessment on grey seal haul outs	A qualitative assessment on the impact of piling activities on grey seals at haul out sites, looking at grey seal movements between established haul outs and the Morgan Generation Assets has been presented in paragraph 4.9.2.100 *et seq.*

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
February 2023	**Marine Mammals Expert Working Group 04** Natural England, MMO, JNCC, NRW, TWT, Cefas, Isle of Man Government	The baseline and approach to assessment for Morgan Generation Assets was presented, including the application of one year only of site-specific surveys for PEIR. It was highlighted that an additional year of data would be available to present in the Environmental Statement. Details covered: • Species densities to be carried forward to the assessment • MUs • Key data sources • Approach to assessment • Approach to iPCoD modelling • Initial underwater sound modelling outputs • Initial CEA outputs • Actions to mode the assessment from PEIR to Environmental Statement.	The baseline approach was agreed for Morgan Generation Assets, in line with that presented in EWG03 (November 2022), above. The EWG were asked to provide advice on the densities and reference populations proposed for harbour porpoise and bottlenose dolphin. The EWG agreed with the proposed approach, noting (in line with that presented for EWG03, November 2022) that density estimates for harbour porpoise and bottlenose dolphin would be updated using the Welsh Marine Mammal Atlas (Evans and Waggitt, 2023). Data from Evans and Waggitt, 2023 has been included in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement and associated densities have been adopted for the Environmental Statement (Table 4.11).
June 2023	**Statutory Consultation (S42)**	MMO, NRW, Natural England and JNCC recommended use of NAS. NRW highlighted the use of noise mitigation strategies/attenuation technology such as bubble curtains, timing of piling and piling methods have not been proposed as potential mitigation methods.	Measures adopted as part of the Morgan Generation Assets are presented in Table 4.17. A commitment to considering NAS as an option as part of the Outline Underwater sound management strategy (Document Reference J13) has been made as part of a stepped strategy, post-consent, following the mitigation hierarchy - avoid, reduce, mitigate. The Applicant has prepared an Outline underwater sound management strategy (Document Reference J13) which is secured in the deemed marine licences within the draft DCO(Document Reference C1). This establishes a process of investigating options (such as NAS) to manage underwater sound levels in consultation with the licensing authority and SNCBs and agreeing, prior to construction, which mitigation measures will be implemented to reduce impacts such that there will be no residual significant effect.
		Natural England noted that the geotechnical activities 'Cone Penetration Testing' (CPT) and 'Vibro-Coring' have the potential to cause PTS injury to marine mammals. Natural England also noted cable trenching	An assessment of injury and disturbance from elevated underwater sound generated from site investigation survey sources is presented in section 4.9.6, and an assessment of injury and disturbance from elevated underwater sound due to vessel use and other (non-piling)

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
		has a large disturbance range (18 km). Suitable mitigation should be considered. Natural England advise that mitigation is applied to reduce the risk of injury when using this equipment.	sound producing activities (including cable trenching) is presented in section 4.9.4. Measures adopted are presented in Table 4.17 and an Outline Underwater sound management strategy (Document Reference J13) will be developed as part of a stepped strategy, post-consent, following the mitigation hierarchy - avoid, reduce, mitigate.
		Natural England did not agree that a 30 minute ADD should be included in the underwater noise modelling to predict impact ranges for the assessment. Natural England advises that the assessment should be based on the underwater noise modelling without ADDs and revise any assessments, including cumulative and HRA, that are based on the predicted ranges with 30 min ADDs	The assessment of injury and disturbance from piling in section 4.9.2 presents the ranges both without ADD and with ADD, the latter providing evidence to demonstrate the potential efficacy of using ADD as a tool in the mitigation strategy.
		NRW did not agree with the Effective Deterrence Range (EDR) approach and disagreed with using dose response curves to assess area disturbed for harbour porpoise. Instead recommended that in addition / in parallel to EDRs, an unweighted noise threshold of 143 dB re 1μPa (or 103 dB re 1μPa VHF-weighted) single strike sound exposure level should be used to represent the minimum fixed noise threshold at which significant disturbance would occur from impulsive noise sources.	An unweighted sound threshold of 143 dB re 1μPa^{2}s (SEL_{ss}) has been applied to represent the minimum fixed sound threshold at which significant disturbance could occur in addition to dose response for the EIA (section 4.9). Quantification of the percentage overlap of this sound threshold, for piling, with relevant SACs has been provided in paragraph 4.9.2.61. The EDR approach has only been used for the purposes of the HRA, considered in the Morgan Generation Assets HRA Stage 2 ISAA (Document Reference E1.1). NRWs position statement (NRW, 2023) has been reviewed and incorporated throughout the assessment.
		NRW did not agree with the approach taken to assume that Mona Offshore Wind Project, Morecambe Offshore Windfarm Generation Assets (hereafter referred to as the Morecambe Generation Assets), Morgan and Morecambe Offshore Wind Farms: Transmission Assets, North Irish Sea Array Offshore Wind Farm and Oriel Offshore Wind farm would not be expected to contribute to the impacts of bottlenose dolphin within the Irish Sea MU.	At the time of publication of the Morgan Generation Assets PEIR, the Morecambe Generation Assets PEIR was not available. The assessment, including iPCoD modelling, has been reviewed on the basis of the latest information at the time and therefore has included additional projects that have since released information into the public domain, including Mona Offshore Wind Project, Morecambe Offshore Windfarm Generation Assets and Morgan and Morecambe Offshore Wind Farms: Transmission Assets (see section 4.11.1).

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
		For harbour porpoise and bottlenose dolphin, Natural England and NRW did not agree with the densities used for PEIR. For harbour porpoise, the site-specific density was substantially lower than more up to date densities. For bottlenose dolphin, Natural England and NRW did not agree with the more complex approach of using dual densities (higher coastal density and lower offshore density). Furthermore they did not recommend that water depth or distance from the coastline alone are used to predict density distributions since other factors need to be taken into consideration. Natural England and NRW recommended the use of the Marine Mammal Atlas (Evans and Waggitt, 2023) ensuring that the most precautionary or the most scientifically robust values are taken forward to the assessment.	The final densities used in the assessment for harbour porpoise, bottlenose dolphin and short-beaked common dolphin have been based on the latest edition of the Welsh Marine Mammal Atlas (Evans and Waggitt, 2023) as agreed with Natural England and other stakeholders via the marine mammals EWG and therefore some densities are different than previously applied for PEIR. Densities have been presented in Table 4.12 (as agreed via the EWG) and the assessment has been updated in section 4.9.
		CEA screening area NRW suggested the use of MUs as the appropriate screening distance was not always followed when screening in projects for the assessment of potential cumulative effects on marine mammals. NRW requested consideration of the whole OSPAR Region III for screening of cumulative projects with respect to grey seal only. NRW and JNCC also suggested the two populations of bottlenose dolphins (Irish Sea MU (IS MU) and Offshore Channel and Southwest England MU (OCSE MU)) will need to be assessed separately due to being part of separate MUs. NRW also recommended for screening in projects for the assessment of injury and disturbance from pre-construction site investigation surveys, all projects that fall within that MU should be screened in (rather than the approach of using the maximum impact ranges).	For the purpose of the cumulative assessment screening of projects was undertaken within the relevant species MUs with the maximum extent delineated by the Celtic and Irish Seas (CIS) MU. With respect to grey seal an extended screening area was applied following specific feedback from the EWG and included projects within OSPAR Region III (see 4.10.1.5). Taking a proportionate approach, only offshore wind projects were screened across this larger cumulative study area. For bottlenose dolphin the approach agreed with the marine mammal EWG was to consider cumulative projects only within the Irish Sea MU and therefore the Offshore Channel and Southwest England MU is no longer included within the cumulative study area for this species. For site-investigation surveys, screening used the species-specific CEA areas (rather than the maximum modelled impact ranges derived from the underwater sound modelling assessment used in PEIR) and used a proportionate number to assume how many surveys will occur at the same time. Justification of approach has been provided in detail in Table 4.52, with a conservative approach

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			which assumed as a maximum design scenario, up to two surveys (in addition to Morgan site-investigation surveys). This approach was agreed with the marine mammal EWG (September 2023 technical note, provided in the technical engagement plan appendices Part 1 (Document Reference E4.1)).
		NRW tentatively agreed that it may be unrealistic to assess injury and disturbance from vessel use by presenting a sum of the impact ranges of all vessels within each offshore windfarm, but highlighted no alternative method has been proposed to gauge the impact and advise that this impact pathway is adequately assessed.	A more detailed approach to assessing vessel sound has been included in section 4.9.4 to give further quantification to the potential impacts. Empirical data has been gathered from field studies to determine realistic impact ranges and a quantification of the number of animals potentially affected based on densities of key species has been provided. In addition, further quantification of the baseline levels of activity (as provided in Volume 2, Chapter 7: Shipping and navigation of the Environmental Statement) has been included to demonstrate the potential elevation in sound above background levels in the Morgan Array Area.
		Barrier effects from piling for grey seal have not been adequately assessed.	Further detail has been provided in section 4.9.2.98 on barrier effects specifically in relation to any potential elevations in underwater sound close to high density areas for grey seal with evidence derived from recent studies on measurable responses of grey seals to underwater sound as per Whyte *et al.* (2020).
		Based on the contours provided for PEIR, concurrent piling of monopiles at a maximum hammer energy of 5,000 kJ at the greatest spatial extent showing contours in 5 dB isopleths, it could be difficult to rule out an adverse effect on the North Anglesey Marine SAC for the MDS of two simultaneous monopiles.	Monopiles have been removed from the Project Design Envelope, and the potential impact of pin piles has been assessed in section 4.9. Further assessment of the potential effects on SACs is provided in the HRA Stage 2 ISAA (Document Reference E1.2).
		NRW recommended that the ratio of the impacted versus unimpacted population over a set period of time (for example the first 6 years, based on the former Favourable Conservation Status (FCS) reporting period), and the full 25-year modelled period are provided.	Results from the iPCoD modelling at both six-year, and 25-year time periods, have been provided within the project alone (section 4.9.2) and the CEA for elevated underwater sound during piling (section 4.11.1), for harbour porpoise, bottlenose dolphin, minke whale and grey seal.
		Isle of Man key responses The Isle of Man government stated they would like to see specific evidence of the consideration of Risso's	In further EWG meetings the Isle of Man Government was content that Risso's dolphin have been adequately included in the assessment (EWG meetings with final meeting minutes and any

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
		dolphins, given their proximity to the development and estimated density and impact on the reference population. Isle of Man also highlighted the SMRU report appendix in the technical report excluded any Isle of Man data.	responses from the stakeholders is provided in the Technical engagement plan appendices Part 1 (Document Reference E4.1)). Specific detail has been included in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement and a further detailed consideration of the Manx populations has been included in the impact assessment in section 4.9. The Carter *et al.* (2022) maps used to derive seal densities in the impact assessment cover the Isle of Man. Furthermore, SMRU confirmed that they do not hold any additional data than that presented in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement, Appendix C. The SMRU data is an additional data source rather than the only data source that has been used in the assessment. Further tracking information was provided in August 2023 by Manx Wildlife Trust (MWT) and has been included in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement.
June 2023	**Marine Mammals Expert Working Group 05**	NRW did not agree with the approach based upon site-investigation surveys outlined for screening cumulative impacts for site investigation surveys for marine mammals.	For site-investigation surveys, screening used the species-specific CEA areas (rather than the maximum modelled impact ranges derived from the underwater sound modelling assessment used in PEIR) and used a proportionate number to assume how many surveys will occur at the same time. Justification of approach has been provided in detail in Table 4.52, with a conservative approach which assumed as an MDS scenario that up to two surveys (in addition). This approach was agreed with the marine mammal EWG (September 2023 technical note).
		Agreement on densities and reference populations NRW recommended the use of densities from the Welsh Marine Mammal Atlas which links 30 years of sightings and effort data with a number of other environmental parameters for bottlenose dolphin and short-beaked common dolphin (rather than Waggitt *et al.* 2020 which was proposed). Agreed to remaining species densities and reference populations provided with minutes for minke whale, Risso's dolphin, grey seal and harbour seal.	The final densities used in the assessment (section 4.9) for bottlenose dolphin and short-beaked common dolphin are from the latest edition of the Welsh Marine Mammal Atlas (Evans and Waggitt, 2023) (Table 4.12) Both the Grey Seal Reference Population (GSRP) and OSPAR Region III region has been presented in the Morgan Generation Assets impact assessment (section 4.9).

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
		NRW agreed that the use of the combined SMU populations in parallel with the OSPAR Region III would be beneficial	
		NRW agreed to scoping out project Erebus for the cumulative assessment, particularly given that their assessment focused on quantifying impacts to the Offshore MU.	For bottlenose dolphin the approach agreed with the marine mammal EWG was to consider cumulative projects only within the Irish Sea MU and therefore the Offshore Channel and Southwest England MU is no longer included within the cumulative study area for this species.
		Natural England and NRW recommended maintaining a sensitivity score of high for all species for PTS, and a magnitude of medium.	Sensitivity has been reviewed for the Environmental Statement, with regards to feedback from all stakeholders and adopting a precautionary approach and as per comments from Natural England, the sensitivity to PTS is considered to be high although noting that this is highly conservative as per Booth and Heinis (2018).
		NRW and Natural England recommended modelling impact ranges without ADDs in parallel.	The assessment in section 4.9.2 presents impact ranges both without ADD and with ADD, the latter providing evidence to demonstrate the potential efficacy of using ADD as a tool in the mitigation strategy.
August 2023	**Marine Mammals Expert Working Group 5:** additional meeting with Isle of Man Government	Specific requests from the Isle of Man Government were covered: • Confirmation content with data sources to be used in assessment • Specific request for further consideration of Risso's dolphin in assessment. Following discussions in EWG05 the Isle of Man Government was content that Risso's dolphin have been adequately included in the assessment • Following suggestion of restricted baseline using SMRU data, Isle of Man Government provided a personal communication to explain connectivity of grey seals around the Isle of Man • Isle of Man confirmed the 400 seal estimate for the Manx population was suitable.	Risso's dolphin have been included in the impact assessment using the same approach and the same detail as other species (section 4.9). Detailed baseline information is presented in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement. Connectivity of grey seals for the marine mammal study area has been presented in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement and is used to inform the impact assessment (section 4.9). The Manx seal population of 400 has been included in the GSRP detailed in section 4.9 and Table 4.12.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
		Further discussion on the movement of dolphins between Cardigan Bay and the east coast of the Isle of Man. Evidence of populations mixing and therefore summer dolphins in Cardigan Bay may be subject to impacts in Manx waters. Following discussions in EWG05 the Isle of Man Government was content that bottlenose dolphin has been adequately included in the assessment.	
September 2023	**Marine Mammals Expert Working Group Technical Note**	**CEA** Refinement of the approach to CEA based on projects within relevant species-specific MUs only, and use of OSPAR Region III as the appropriate screening area for grey seal. NRW agreed that the use of the CIS MU would be a pragmatic screening distance for all cetacean species with large MUs such as minke whale and dolphin species other than bottlenose dolphin. Natural England agreed to GSRP for CEA.	Following EWG05, the Marine Mammals Expert Working Group Technical Note and S42 responses to the PEIR, the CEA assessment (for EIA) has adopted a species-specific approach for screening as discussed in 4.10.1.5 which uses the CIS MU for most cetacean species, the IS MU for bottlenose dolphin (therefore excluding the OCSE MU) and OSPAR Region III for grey seal (rather than the GSRP).
		Design of aerial surveys with respect to marine mammals and use of an appropriate buffer around Morgan Array Area. NRW agreed with approach outlined in technical note. JNCC content with proposed additions to ES and noted baseline characterisation does not rely on the aerial surveys alone.	Further detail about the consistency of coverage of surveys over the survey area (comprising the Morgan Array Area and buffer) during the monthly survey and discussion on a spatial coverage monthly and seasonally has been included in Volume 4, Annex 4.1: Marine mammal technical report.
		Agreement of densities NRW, Natural England and JNCC agreed with densities and reference populations for harbour porpoise, bottlenose dolphin, Risso's dolphin, minke whale, grey seal and harbour seal submitted via email following EWG05. NRW recommended for short-beaked common dolphin the use of densities from the newest version of the	The final densities used in the assessment as agreed with stakeholders via the marine mammals EWG technical note issued in September 2023 are presented in Table 4.12. Densities to take forward to assessment for harbour porpoise, bottlenose dolphin and short-beaked common dolphin have been derived from the Welsh Marine Mammal Atlas (Evans and Waggitt, 2023). Densities for minke whale and Risso's dolphin are derived from SCANS-III. Densities for grey seal and harbour seal are derived from Carter *et al.* (2022).

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
		Welsh Marine Mammal Atlas (Evans and Waggitt, 2023) instead of Waggitt *et al.* (2020). Final agreements on all densities for the Morgan Transmission Assets was presented in technical note and NRW and JNCC agreed with densities, including update to short-beaked common dolphin. Natural England agreed with use of Welsh Marine Mammal Atlas unless new data reveals evidence of greater densities (e.g. Small Cetaceans in European Atlantic waters and the North Sea (SCANS IV); or site-specific surveys).	The latest SCANS-IV data was consulted on with the EWG (post the fifth EWG meeting), and the approach remained as presented in Table 4.12.
		Revised approach to CEA screening area for site investigation surveys and use of a maximum number of SI surveys occurring concurrently was presented. NRW agreed with the proposed approach of two site investigation surveys occurring simultaneously, and the rationale on which The Environmental Statement is based on. Natural England agreed MU approach over impact radius and broadly agreed with two geophysical surveys overlapping Morgan site-survey investigations.	The CEA methodology presented in 4.10.1, has screened in using the species-specific CEA areas for site-investigation surveys rather than using maximum modelled impact ranges.
		Sound modelling clarifications NRW and Natural England supported use of dual metric approach (SPL and SELcum) for impact assessment with the largest range of impact being taken forward for the purpose of mitigation.	Both SPL_{pk} and SEL_{cum} have been presented in the impact assessment with the metric predicting the largest range of impact taken forward for the purposes of mitigation and considered in the adoption of appropriate measures to reduce injury to marine mammals.
		Approach to presenting both with and without ADD and to base the conclusions of the assessment on the impacts which take into account any measures adopted, including the use of ADDs. NRW agreed with the proposed approach. Natural England advised assessment should be based on the underwater noise modelling without ADDs.	ADDs are included as part of standard industry tertiary measures (Table 4.17) and therefore the assessment has considered the implementation of an indicative 30 minute ADD deployment duration as well as the predicted ranges without the use of an ADD.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
		Use of the area-based approach for HRA based on EDR and 143 dB re 1 μPa²s SEL_{ss} threshold for harbour porpoise only. For all other marine mammal species considered in HRA the NMFS level-B harassment threshold of 160 dB SPL_{rms} will be applied for piling alongside the relevant EDR (NMFS, 2005). **NRW, Natural England, JNCC agreed with the proposed approach. NRW recommend the use of the dose-response approach alone to assess behavioural disturbance from piling sound in the EIA.**	In this chapter, a dose-response approach has been used alongside the threshold of 143 dB re 1 μPa²s SEL_{ss}. EDRs have not been used in the EIA. For HRA, an unweighted sound threshold value of 143 dB re 1 μPa²s SEL_{ss} (or VHF-weighted 103 dB re 1μPa SPL (root mean square (rms))) has been used to represent the minimum fixed generalised response threshold at which significant disturbance could in occur for harbour porpoise, in addition to the Effective Deterrence Range (EDR) approach. Dose-response has not been applied to the area-based assessment. For all other species the NMFS (2005) threshold of 160 dB re 1 μPa SPL_{rms} has been used.
		iPCoD • Presenting the 6-year time step in the modelling period for iPCoD modelling, alongside 25 years • At PEIR, only the spatial design scenario was presented but for the Environmental Statement the temporal MDS as well as spatial MDS will be presented • NRW advised that applying projects screened in for the Grey Seal Reference Population (GSRP) to the larger OSPAR Region III reference population would effectively be diluting the impact. • NRW, Natural England and JNCC agreed with approach related to iPCoD modelling.	• Both a six year time period and the full 25 year modelled period are provided within the project alone (section 4.9.1) and the CEA impact assessments for elevated underwater sound from piling (section 4.11.2), for harbour porpoise, bottlenose dolphin, minke whale and grey seal • Both the spatial MDS and temporal design scenario has been modelled (Appendix B) and presented in the cumulative impact assessment (section 4.11.2). The CEA has also modelled Tier 1 projects screened in using the OSPAR Region III grey seal population (see Appendix B for detail).
December 2023	**Marine Mammals Expert Working Group 6**	**Presented updated Morgan assessment** Changes from PEIR to Environmental Statement: • Removal of monopiles from project design. • Separation distances between concurrent piling. • Additional information on haul out connectivity for grey seals has been included, utilising SMRU telemetry data for the four SMUs covering the Irish Sea.	The MDS (Table 4.17) summarises the scenarios used for the assessment, and the impact of pin piles are assessed in section 4.9. Commitments to separation distances are given in the Outline MMMP (Document Reference J17). Information on haul out connectivity for grey seals has been included in section 4.9.2in the assessment of underwater sound from piling (paragraphs 4.9.2.100 to 4.9.2.104).

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
		• Impacts assessment uses the combination of four seal management units as the Grey Seal Reference Population (GSRP) alongside OSPAR Region III. • OSPAR Region III has been used as extended screening area for grey seal for offshore wind projects only to allow a proportionate approach to assessment. List of cumulative projects has been updated and the marine mammal assessments have been updated with any changes to information available. White Cross Offshore Wind Farm now included in the CEA assessment in Tier 1. Presented key results of injury and disturbance from piling and UXO. Discussed hierarchy approach to UXO.	Relevant study areas are described in section 4.4.3for use in the project alone assessment (section 4.9) and the cumulative assessment (section 4.11). The projects used in the cumulative assessments are given in section 4.10.2 (and detailed in Table 4.50).
		Presented the **Underwater sound management strategy** which focuses on the impacts of underwater sound for marine mammals and fish. The Underwater sound management strategy will set out potential mitigation options which could be employed if there are residual concerns about the cumulative impacts of underwater sound following refined project design.	The Outline underwater sound management strategy (Document Reference J13) includes potential further mitigation options, should the measures in the MMMP (Document Reference J17) not reduce impacts, such that there will be no residual significant effect from the project alone. The Underwater sound management strategy is discussed in Table 4.17 and discussed in the relevant sections throughout the assessment (piling and UXO).
		Presented updates to HRA approach and screening areas: • OSPAR Region III been considered to identify any additional sites with grey seal as a qualifying feature, which may have connectivity with the Morgan Generation Assets. Telemetry data used to screen out additional sites that did not show connectivity. • Approach to the assessment of disturbance resulting from piling for harbour porpoise in the ISAA now presents both EDRs (15 km for pin piles) and area-based threshold approach (using 143 1 μPa^2s SEL_{ss}). For all other species, the NMFS	Further HRA assessment of the potential effects on SACs is provided in the HRA Stage 2 ISAA (Document Reference E1.1).

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
		level-B harassment threshold of 160 dB SPL_{rms} will be applied for piling alongside the relevant EDR (NMFS, 2005).	

4.4 Baseline methodology

4.4.1 Relevant guidance

4.4.1.1 Several guidance documents have been considered for marine mammals to aid baseline characterisation. These include the use of Inter-Agency Marine Mammal Working Group (IAMMWG) (IAMMWG, 2021) defined Management Units (MU) for seven common cetacean species in UK waters. Abundance estimates were calculated for these MUs for each species within their respective MUs using the most recent data available at the time. Formal advice is given by Special Committee on Seals (SCOS) (SCOS, 2022), under the Conservation of Seals Act 1970 and the Marine (Scotland) Act 2010, the Natural Environment Research Council (NERC) which has a duty to provide scientific advice to government on matters related to the management of seal populations.

4.4.1.2 The identification of designated sites for marine mammals is a key feature of this chapter (discussed in detail in section 4.5.1 and 0).

4.4.2 Scope of the assessment

4.4.2.1 The scope of this Environmental Statement has been developed in consultation with relevant statutory and non-statutory consultees as detailed in section 4.3. This consultation process involved the scoping opinion, a number of regular EWGs and the statutory Section 42 consultation period. The consultation added detail to the range of potential impacts which could affect marine mammal receptors, taking into account local and national views about adequate coverage of important species within the marine mammal study area.

4.4.2.2 Considering the scoping and consultation process Table 4.6 summarises the impacts considered as part of this assessment.

Table 4.6: Potential impacts considered within this assessment.

Activity	Potential impacts scoped into the assessment
Construction phase	
Piling of wind turbine foundations and OSP foundations	Injury and disturbance from elevated underwater sound during piling.
UXO clearance prior to commencement of construction	Injury and disturbance to marine mammals from elevated underwater sound during UXO clearance.
Vessel traffic (e.g. vessels associated with sand wave clearance, installation vessel, construction vessel, rock placement vessel and cable installation vessels, boulder clearance, jack-up rig, tug/anchor handlers, guard vessels, survey vessel and support vessels crew transfer vessel, scour/cable protection/seabed preparation/installation vessels) and other sound-producing activities (cable trenching, cable laying, jack-up rig, drilled piling)	Injury and disturbance from elevated underwater sound due to vessel use and other (non-piling) sound producing activities.
	Increased likelihood of injury due to collision with vessels.
Site-investigation surveys – geophysical and geotechnical surveys	Injury and disturbance from elevated underwater sound generated from site investigation survey sources.
Potential effects on fish assemblages	Changes in fish and shellfish communities affecting prey availability.

Activity	Potential impacts scoped into the assessment
Operation and maintenance	
Wind turbine operation	Underwater sound from wind turbine operation.
Potential effects on fish assemblages	Changes in fish and shellfish communities affecting prey availability.
Vessel traffic associated with operations and maintenance (e.g. CTVs, jack-up vessels, cable repair vessels, service operations vessels (SOV), excavator/backhoe dredger).	Injury and disturbance from vessel use and other (non-piling) sound producing activities.
Decommissioning	
Vessels used for a range of decommissioning activities such as removal of foundations. Sound from vessels assumed to be as per vessel activity described for construction phase above.	Injury and disturbance from vessel use and other (non-piling) sound producing activities.
Potential effects on fish assemblages	Changes in fish and shellfish communities affecting prey availability.

4.4.2.3 Effects which are not considered likely to be significant have been scoped out of the assessment. A summary of the effects scoped out, together with justification for scoping them out and whether the approach has been agreed with key stakeholders through either scoping or consultation, is presented in Table 4.7.

Table 4.7: Impacts scoped out of the assessment for marine mammals.

Potential impact	Justification
Accidental pollution during all phases.	The impact of pollution including accidental spills and contaminant releases associated with the construction and decommissioning of infrastructure and use of supply/service/decommissioning vessels may lead to direct mortality of marine mammals or a reduction in prey availability, either of which may affect species' survival rates. With implementation of an Offshore EMP (including Marine Pollution Contingency Plan (MPCP) secured by deemed marine licence conditions under the DCO (see Draft DCO (Document Reference C1))) and based on evidence from other offshore wind farm consent applications (for example Awel y Môr Offshore Wind Farm Environmental Statement (2022)) it is considered that a significant impact within the equivalent extent of a wind farm's array plus buffer area is very unlikely to occur, and a major incident that may impact any species at a population level is considered very unlikely. It was predicted that any impact would be of local spatial extent, short-term duration, intermittent and medium reversibility within the context of the regional populations and therefore not significant in EIA terms. This is considered to be equally applicable to the Morgan Generation Assets for which construction will be comparable in scale and operation within the same environment, whilst implementing an appropriate pollution prevention plan. Consultees (The Planning Inspectorate and Natural England) agreed to scope out this impact for all stages of the Morgan Generation Assets via the Morgan Generation Assets EIA Scoping Opinion (Document Reference J8).
Increased suspended sediment concentrations (SSC) and associated sediment deposition during all phases.	Disturbance to water quality as a result of construction and decommissioning operations can have both direct and indirect potential impacts on marine mammals. Potential direct impacts include the impairment of visibility and therefore foraging ability of marine mammals, which might be expected to reduce foraging success. Marine mammals are well known to forage in tidal areas where water conditions are turbid and visibility conditions poor. For example, harbour porpoise and harbour seal in the UK have been

Potential impact	Justification
	documented foraging in areas with high tidal flows (e.g. Pierpoint, 2008; Marubini *et al*., 2009; Hastie *et al*., 2016); therefore, low light levels, turbid waters and suspended sediments are unlikely to negatively impact marine mammal foraging success. When the visual sensory systems of marine mammals are compromised, they are able to sense the environment in other ways, for example, seals can detect water movements and hydrodynamic trails with their mystacial vibrissae; while odontocetes primarily use echolocation to navigate and find food in darkness. Whilst elevated levels of SSC arising during construction of Morgan Generation Assets may decrease light availability in the water column and produce turbid conditions, the maximum impact range is expected to be localised with sediments rapidly dissipating over one tidal excursion. In addition, there is likely to be large natural variability in the SSC within the Morgan marine mammal study area due the proximity to Liverpool Bay, so marine mammals living here are considered likely to be tolerant of any small-scale increases, such as those associated with the construction activities. In summary, the Zone of Influence (ZoI) of increased SSC will be small, particularly in the context of the wider available habitat, and the duration of potential impacts will be short and dissipate rapidly (e.g. one tidal excursion). Therefore, marine mammal receptors in the Morgan marine mammal study area are not considered to be sensitive to increases in SSC as they are likely to be adapted to high natural variation in sediment levels. Therefore, it is proposed that this impact is scoped out of the EIA. Consultees agreed to scope out this impact for all stages of the Morgan Generation Assets EIA Scoping Opinion (Document Reference J8).
Impact of Electromagnetic Fields (EMF) (from surface lain or buried cables) during the operations and maintenance phase.	Based on the data available to date, there is no evidence of EMF related to marine renewable devices having any impact (either positive or negative) on marine mammals (Copping, 2018). There is no evidence that seals can detect or respond to EMF, however, some species of cetaceans may be able to detect variations in magnetic fields (Normandeau *et al*., 2011). To date, two species have been shown to respond to EMF. The Guiana dolphin *Sotalia guianensis* has been shown to possess an electroreceptive system, which uses the vibrissal crypts on its rostrum to detect electrical stimuli similar to those generated by small to medium sized fish and shows behavioural effects (attraction and perception) (Czech-Damal *et al*. (2012)). Bottlenose dolphin has also recently been shown to detect the presence of electrical stimuli, with four dolphins demonstrating electroreceptive behaviours (Hüttner *et al*., 2021), but further studies are needed to determine impacts of EMF on cetaceans and behavioural responses. It has not been shown in any other species of marine mammal to date. Consultees agreed to scope out this impact during marine mammals via the Morgan Generation Assets EIA Scoping Opinion (Planning Inspectorate, 2022).

4.4.3 Study area

4.4.3.1 For the purposes of the marine mammal characterisation, two appropriate marine mammal study areas were defined:

- Morgan marine mammal study area: this area is defined as the area encompassing the Morgan Array Area plus a buffer of approximately 10 to 13.3 km (Figure 4.1), which is based upon the Morgan Aerial Survey Area. Following the Preliminary Environmental Information Report (PEIR), the size of the array project boundary has been reduced, so whilst the buffer extent remains the same as for PEIR, the area of the buffer has increased around the redefined Morgan Array Area (previously a 10 km buffer).

- Regional marine mammal study area: marine mammals are highly mobile and may range over large distances and therefore, to provide a wider context, the desktop review considered the marine mammal ecology, distribution and density/abundance within the Irish Sea and wider Celtic Sea.

4.4.3.2 The regional marine mammal study area boundaries were discussed during the EWG meetings, with a summary provided in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement and in Table 4.5. in this chapter. In accordance with advice received during consultation, potential population level effects were informed by species MUs (Figure 4.2 and Figure 4.3). For grey seal and harbour seal the approach taken was to include those MUs whereby connectivity was demonstrated as presented in the seal telemetry report (Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement). This meant that a number of different MUs from English, Welsh, Scottish, Isle of Man and Irish waters (where connectivity with the Morgan Generation Assets boundary was demonstrated) were combined to represent a GSRP and a Harbour Seal Reference Population (HSRP). Further, for grey seal, The Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR) Region III 'interim' MU (hereafter referred to as the 'OSPAR Region III reference population') was also included to provide additional context as requested by NRW during the EWG process. The spatial extent of the species MUs is presented in Figure 4.2 and Figure 4.3 and further information on the reference populations (and combined reference populations for seal species) provided in section 4.5.2.

4.4.3.3 For the purpose of the cumulative assessment screening of projects was undertaken within the relevant species MUs with the maximum extent delineated by the CIS MU (as agreed with consultees; section 4.3). This was to ensure a proportionate approach was taken, such that the screening focussed on the region within which receptor-impact pathways are considered likely to occur. Potential cumulative effects from the Morgan Generation Assets are considered unlikely to occur with projects over the entire extent of the Celtic and Greater North Seas (CGNS) MU. With respect to grey seal, however, an extended screening area was applied following specific feedback from NRW and included projects within OSPAR Region III.

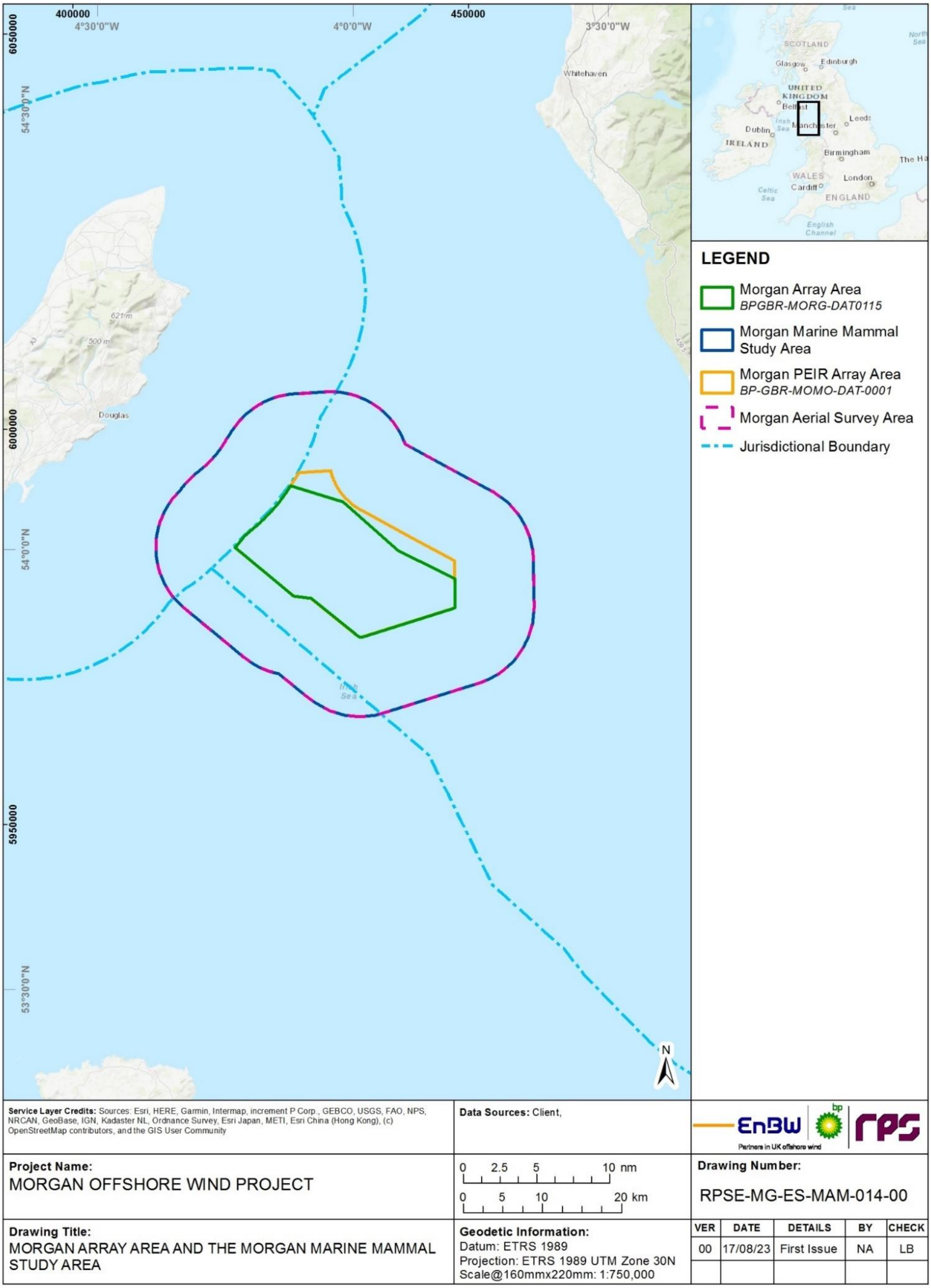


Figure 4.1: Morgan Array Area and Morgan marine mammal study area.

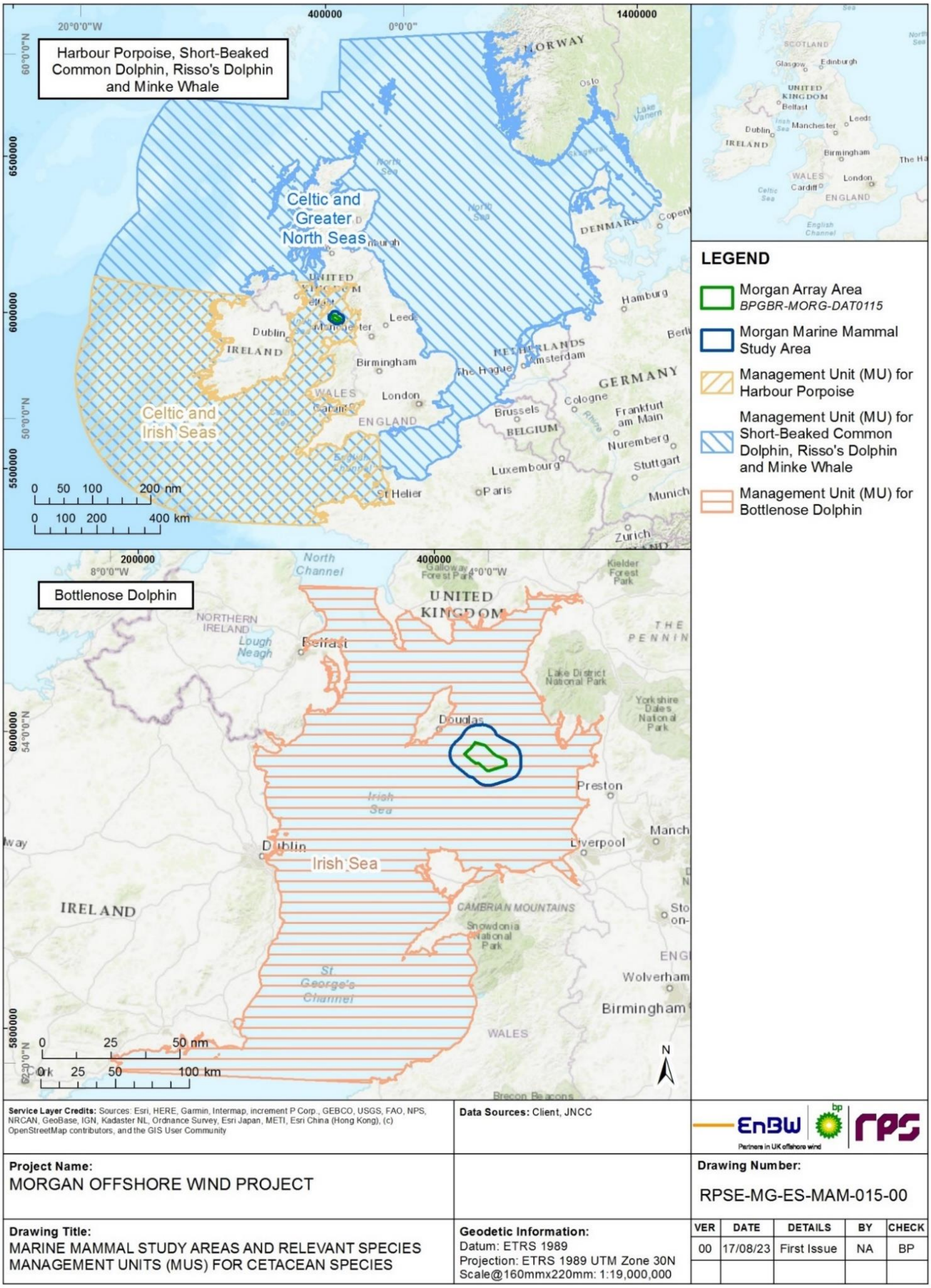
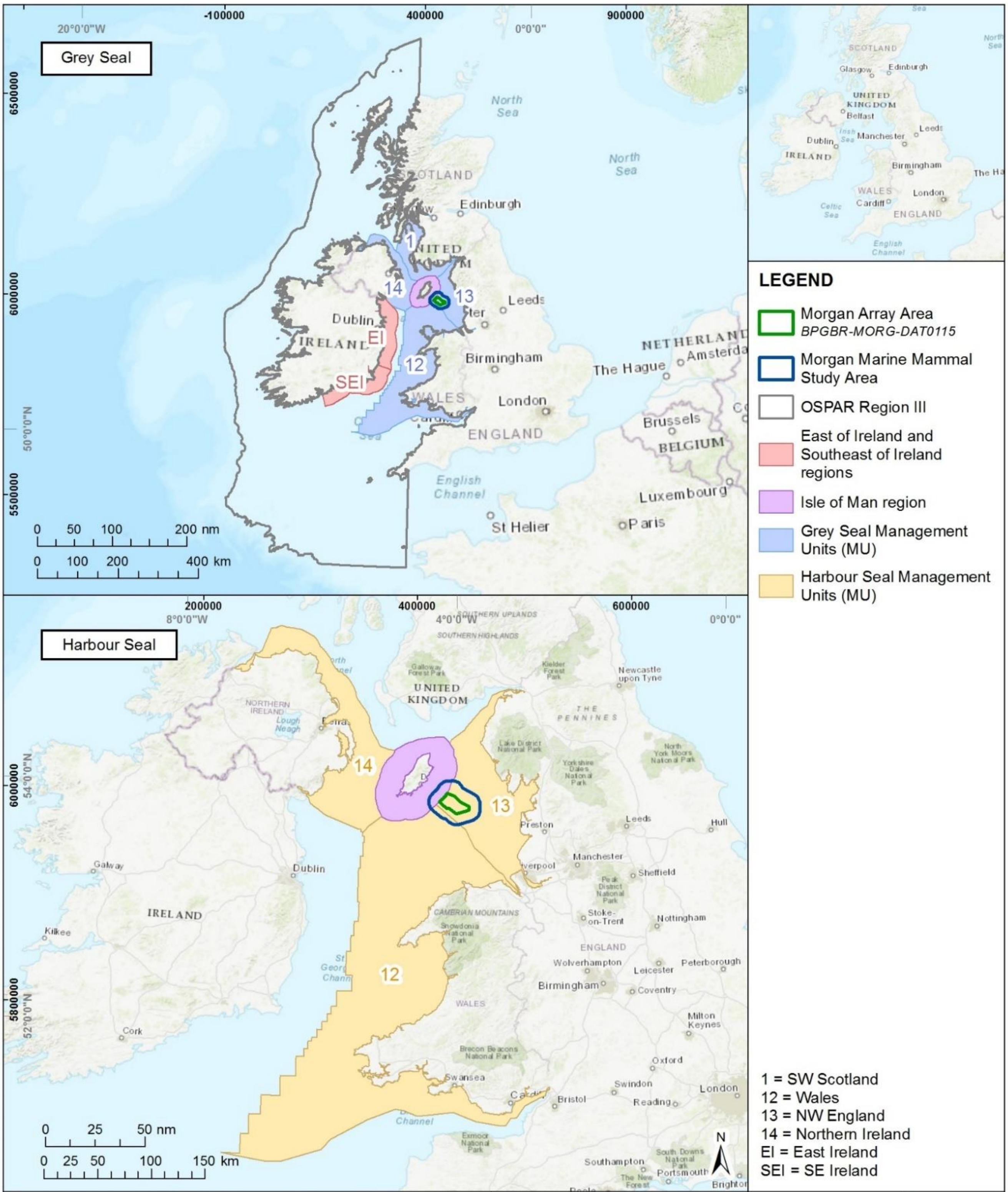


Figure 4.2: Marine mammal study areas and relevant species MUs for cetacean species.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community	**Data Sources:** Client, JNCC, SCOS, NPWS	EnBW bp Partners in UK offshore wind rps
Project Name: MORGAN OFFSHORE WIND PROJECT		**Drawing Number:** RPSE-MG-ES-MAM-016-00
Drawing Title: MARINE MAMMAL STUDY AREAS AND RELEVANT SPECIES MANAGEMENT UNITS (MUS) FOR PINNIPED SPECIES	**Geodetic Information:** Datum: ETRS 1989; Projection: ETRS 1989 UTM Zone 30N; Scale@160mmx220mm: 1:16,000,000	

VER	DATE	DETAILS	BY	CHECK
00	17/08/23	First Issue	NA	BP

Figure 4.3: Marine mammal study areas and relevant species MUs for pinniped species.

4.4.4 Desktop study

4.4.4.1 Information on marine mammals within the regional marine mammal study area was collected through a detailed desktop review of existing studies and datasets. These are summarised at Table 4.8 below.

Table 4.8: Summary of key desktop reports.

Title	Source	Year	Author
Anglesey based surveys	Various sources	2002 to 2018	Shucksmith *et al*. (2009); Jacobs (2018); Veneruso and Evans (2012); Pesante *et al*. (2008); Duckett (2018); Evans *et al*. (2015)
Atlas of the Marine Mammals of Wales (2012)	Countryside Council for Wales (CCW)	1990 to 2009	Baines and Evans (2012)
Awel y Môr Offshore Wind Farm surveys	APEM Ltd.	2019 to 2021	Sinclair *et al*. (2021)
Mona Offshore Wind Project	Mona Offshore Wind Project	March 2020 to February 2022	Mona Offshore Wind Ltd. (2023)
Density surface modelling from SCANS-III surveys	SCANS	2016	Lacey *et al*. (2022)
Distribution maps of cetacean and seabird populations in the northeast Atlantic (2020)	Bangor University	1980 to 2018	Waggitt *et al.* (2020)
Estimates of cetacean abundance in European Atlantic waters from the Small Cetaceans in European Atlantic waters and the North Sea (SCANS) aerial and shipboard surveys	SCANS	1994; 2005; 2016; 2022	Hammond *et al*. (2002); Hammond *et al*. (2017); Hammond *et al*. (2021); Gilles *et al.* (2023)
Gwynt y Môr Offshore Wind Farm baseline	Centre for Marine and Coastal Studies (CMACS)	2003 to 2005	CMACS Ltd. (2011; 2013); Goddard *et al*. (2017); Goddard *et al*. (2018); Goulding *et al*. (2019)
Habitat-based predictions of at-sea distribution for grey and harbour seal in the British Isles	Report to Department for Business, Energy and Industrial Strategy (BEIS)	1996 to 2015	Carter *et al*. (2020; 2022)
JNCC Report 544: Harbour Porpoise Density	JNCC	1994 2011	Heinänen and Skov (2015)
Joint Cetacean Protocol (JCP) Phase I, III Analysis	JCP	1994 to 2010	Paxton and Thomas (2010); Paxton *et al*. (2016)
Manx Marine Environmental Assessment	Isle of Man Government	2018	Howe (2018a); Howe (2018b)
Manx Whale and Dolphin Watch (MWDW) surveys • Opportunistic and effort-based sighting data	MWDW	2006 to 2022	Data from MWDW Manley (2021, 2020, 2019); Clark *et al.* (2019, 2017); Felce and Adams (2016); Felce, 2015; Adams (2017)

Title	Source	Year	Author
Manx Wildlife Trust (MWT) surveys: • Seal pup surveys on Calf of Man • Opportunistic land sightings • Seal haul-out survey data • Calf of Man Seal survey reports 2017 to 2021	MWT	• 2017 to 2021 • 2016 to 2022 • 2017 • 2017 to 2021	MWT
Modelled Distribution and Abundance of Cetaceans and Seabirds in Wales and Surrounding Waters (2023) (Welsh Marine Mammal Atlas)	NRW	1990 to 2020	Evans and Waggitt (2023)
Mona Offshore Wind Project site-specific aerial digital surveys	Mona Offshore Wind Ltd.	2020 to 2023	Mona Offshore Wind Ltd. (2023)
Morecambe Generation Assets Marine Mammal Information and Survey data (this includes HiDef aerial digital site surveys)	Morecambe Offshore Windfarm, Ltd.	Aerial surveys from March 2021 to February 2022	Morecambe Offshore Windfarm, Ltd (2023)
ObSERVE surveys	National Parks and Wildlife Service (NPWS)	2015 to 2017	Rogan *et al.* (2018)
Rhiannon Wind Farm aerial and boat-based surveys	Celtic Array Ltd.	2010 to 2013	Celtic Array Ltd. (2014)
Seal Telemetry Data	SMRU	2004 to 2018	Wright and Sinclair (2022)
Special Committee on Seals (SCOS) Reports	SMRU	1990 to 2020	SMRU
Strategic Environmental Assessment 6	SMRU	2005	Hammond *et al*. (2005)
Updated abundance estimates for cetacean Management Units in UK waters	JNCC	2021	IAMMWG (2021)
Walney Nature Reserve survey data	Cumbria Wildlife Trust	1981 to 2023	Data from Cumbria Wildlife Trust

4.4.5 Identification of designated sites

4.4.5.1 All designated sites within the regional marine mammal study area and qualifying interest features that could be affected by the construction, operations and maintenance, and decommissioning phases of the Morgan Generation Assets were identified using the three-step process described below:

- Step 1: All designated sites of international, national and local importance within the regional marine mammal study area were identified using a number of sources. These sources included JNCC, SCOS, National Marine Plan Interactive (NMPI) and European Nature Information System (EUNIS) websites
- Step 2: Information was compiled on the relevant marine mammal features for each of these sites as follows:
  - The known occurrence of species within the regional marine mammal study area was based on relevant desktop information (section 4.5) and site-specific

surveys presented within Appendix A of Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement)

- Step 3: Using the above information and expert judgement, sites were included for further consideration if:
  - A designated site directly overlaps with the Morgan Generation Assets
  - Sites and associated features were located within the potential ZoI for impacts associated with the Morgan Generation Assets (e.g. potential injury and/or disturbance ranges of underwater sound as a result of piling activities during construction (section 4.9.2))
  - Marine mammal features of a designated site were either recorded as present during historic surveys or recent Morgan aerial digital surveys within the Morgan Aerial Survey Area, or identified during the desktop study as having the potential to occur within the Morgan marine mammal study area.

4.4.6 Site specific surveys

4.4.6.1 To inform the Environmental Statement, site-specific surveys were undertaken, as agreed with the marine mammal EWG (see Table 4.5 for further details). A summary of the surveys undertaken to inform the marine mammal impact assessment is outlined in Table 4.9 below.

Table 4.9: Summary of site-specific survey data.

Title	Extent of survey	Overview of survey	Survey contractor	Date	Reference to further information
Aerial Digital Surveys - Morgan	Morgan Array Area plus 10 to 13.3 km buffer	Aerial digital survey	APEM Ltd.	April 2021 to March 2023	Aerial survey data analysis in Appendix A of Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement.

4.5 Baseline environment

4.5.1.1 The Morgan Generation Assets lies within the east Irish Sea, an important area for marine mammals, with 24 species of cetacean and two species of pinniped having been sighted here to date. Seven marine mammal species are known to occur regularly in the regional marine mammal study area: harbour porpoise, bottlenose dolphin, short-beaked common dolphin, Risso’s dolphin, minke whale, grey seal and harbour seal. Other cetacean species are occasional or rare visitors.

4.5.1.2 The distribution of marine mammals in the Irish Sea is patchy; cetaceans are highly mobile, and their occurrence is unpredictable. Harbour porpoise occurs throughout entire Irish Sea, whilst short-beaked common dolphin and Risso’s dolphin are largely restricted the south of the Irish Sea. Sightings of bottlenose dolphin are highest in the Cardigan Bay SAC.

4.5.1.3 Grey seal extensively uses areas of the south Irish Sea, the north of St George's Channel, and Liverpool Bay. Several sites in Wales (such as the Marloes Peninsula and north Pembrokeshire coast and islands off west coast of Pembrokeshire and the Llŷn Peninsula), southwest England (especially Lundy and the Scilly Isles) Northern Ireland (e.g. Strangford Lough) the Republic of Ireland (e.g. the Saltee Islands and Lambay Island) and Liverpool Bay (Solway Firth) support important haul-out sites and genetic studies suggest that individuals here may form a distinct population from those found off west Scotland (SCOS, 2022). Telemetry studies have demonstrated adults and pups travel between Pembrokeshire Marine SAC, Llŷn Peninsula and the Sarnau SAC and the Saltee Islands SAC (Ireland) (SCOS, 2014).

4.5.1.4 Harbour seals are concentrated along the northeast coast of Ireland, east coast of Northern Ireland and the Firth of Clyde. In Northern Ireland most harbour seal haul-outs are located in the southeast of the country, with most individuals being counted at Carlingford Lough, Murlough SAC and Rathlin Island (Duck and Morris, 2019), but also counted in aerial surveys in the Maidens SAC, Strangford Lough SAC and Murlough SAC.

4.5.1.5 A summary of the marine mammal baseline characterisation within the Morgan marine mammal study area, in the context of the regional marine mammal study area, is presented in Table 4.10 and in detail in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement.

Table 4.10: Summary of marine mammals baseline ecology.

Species	Baseline Summary	Conservation importance
Harbour porpoise *Phocoena phocoena*	Widespread in cold and temperate northwest European shelf waters, and abundant throughout the Irish Sea. Harbour porpoise is a common inshore species found in high densities in the Irish Sea. The highest relative abundances are found in the west half of the central Irish Sea (Wall *et al*., 2013). High predicted relative densities in both winter and summer in the Irish Sea (Waggitt *et al.,* 2020). Data from the Morgan Generation Assets found that harbour porpoise was recorded in all months of the year across the 24-month Morgan aerial digital survey period. Broad scale historical data collating heterogenous datasets from 1990 to 2009 confirms regular widespread sightings of harbour porpoise across the Irish Sea study area (Baines and Evans, 2012). SCANS-III data estimated densities of 0.239 animals per km^2 (CV = 0.282) in block E and 0.086 animals per km^2 (CV = 0.383) in block F (Hammond *et al.,* 2021). SCANS-IV block CS-E (Gilles *et al*., 2023) estimated a density of 0.5153 animals per km^2 (CV = 0.250), noting that these blocks cover a large part of the Irish Sea and therefore high densities are influenced by overlap with SACs designated for harbour porpoise. Heinänen and Skov (2015) divide the year into two bio-seasons based upon bimodal patterns of distribution: summer (April to September) and winter (October to March). In this study (which modelled predicted densities between 1997 and 2009) predicted densities reached >3.0 km^2 in the western region of the Irish Sea (between Anglesey and the Isle of Man in summer 2003, and north of the Isle of Man in winter 1997). Persistent high density areas were identified in these areas, with lower densities towards the Morgan Generation Assets. Design based estimates from the Morgan Aerial Survey Area gave 0.219 animals per km^2 in the summer bio-season, and 0.159 animals per km^2 in the winter bio-season (when adjusted for availability bias). As agreed with the EWG, the density taken forward to assessment is the density for the Morgan marine mammal study area (0.262 animals per km^2) derived from the Welsh Marine Mammal Atlas (Evans and Waggitt, 2023) as a precautionary but proportionate density for the area (Table 4.12). The Welsh Marine Mammal Atlas uses 30 years of data from 1990 to 2020 from dedicated aerial and vessel surveys (including SCANS surveys) across Wales and the surrounding waters to produce modelled density distribution maps at a 2.5 km^2 resolution. The study is designed to quantify broad level habitat preferences and seasonality of species within regions of interest (such as the Morgan marine mammal study area.) This allows a robust representation of densities at a fine scale within the Irish Sea, rather than broad-scale densities derived from a single survey season conducted over a short timescale, such as the SCANS IV surveys. Harbour porpoise is a qualifying interest of a number of SACs and MNRs (Isle of Man) within the regional marine mammal study area (Table 4.11).	Annex II species protected under the European Council directive on the conservation of natural habitats and of wild fauna and flora (92/43/EEC) (Habitats Directive) within a European Marine Site, European Protected Species (EPS), OSPAR protected species, International Union for Conservation of Nature (IUCN) Red List Least Concern, Wildlife Act 1990 (Isle of Man).
Bottlenose dolphin *Tursiops truncatus*	Near-global distribution, widely distributed in the North Atlantic and occurs year-round throughout the Irish Sea near-shore. There is evidence of large home ranges for bottlenose dolphin, but in the Irish sea their distribution is largely coastal (Quick *et al.*, 2014), with resident populations in Cardigan Bay and off the coast of Co. Wexford. Seasonal differences in dispersion have been noted (e.g. dolphins in summer occurring mainly in small	Annex II species protected under the Habitats Directive within a European Marine Site, EPS, IUCN Red List Least

Species	Baseline Summary	Conservation importance
	groups near the coast, centred upon Cardigan Bay, dispersing more widely and generally northwards, where they may form very large groups in winter). Data from the Morgan Generation Assets found that nine bottlenose dolphin were sighted across the 24-month Morgan aerial digital survey period. All of these sightings were in June 2021. Site specific digital aerial surveys did not record sufficient numbers of bottlenose dolphin in the area to carry out model-based density analyses. Using lower uniform densities for this area (such as those in SCANS-III or SCANS-IV) is unsuitable for this species as it does not take consideration of their specific habitat preferences. SCANS-III surveys in 2016 estimated a density of 0.008 animals per km^2 (CV = 0.573) in block E, with no animals sighted within block FSC. The survey period was limited to 35 days in summer, so densities may vary in other months of the year, and in Manx waters, bottlenose dolphin do show a very clear temporal pattern, with 73% of sightings being reported between October and March (Howe, 2018). There is suggestion of temporal movement between Manx waters for winter habitat and Cardigan Bay for calving (Howe, 2018; Pesante and Evans, 2008), as well as movement between UK and Irish waters (Robinson *et al.*, 2012). As agreed with the EWG, the density (0.0012 animals per km^2) taken forward to assessment is a single density from the Welsh Marine Mammal Atlas (Evans and Waggitt, 2023) for the Morgan marine mammal study area. The Welsh Marine Mammal Atlas focuses on the specific inshore ecotype found in the Irish Sea, providing a precautionary but proportionate density for the area; and allows a robust representation of densities at a fine scale within the Irish Sea (rather than broad-scale densities derived from a single survey season conducted over a short timescale, such as the SCANS IV surveys) (Table 4.12). Bottlenose dolphin is a qualifying interest of a number of SACs and three MNRs (Isle of Man) within the regional marine mammal study area (Table 4.11).	Concern, Wildlife Act 1990 (Isle of Man).
Risso's dolphin *Grampus griseus*	Worldwide distribution, and in northwest Europe appears to be a continental shelf species. Clusters regularly seen in the Irish Sea, with a relatively localised distribution, forming a wide band running southwest-northeast that encompasses west Pembrokeshire, the west end of the Llŷn Peninsula and Anglesey in Wales, the southeast coast of Ireland in the west, and waters around the Isle of Man in the north (Evans *et al.*, 2003). The Morgan Generation Assets lies within Block F for the SCANS-III surveys and although no Risso's dolphin were sighted within this block in 2016 they were recorded in the adjacent Block E with an estimated density at 0.0313 animals per km^2 (CV = 0.686). Recent SCANS-IV data did not report any Risso's dolphin in block CS-E but reported a density of 0.0022 animals per km^2 (CV = 1.012) in adjacent block CS-D (Gilles *et al.,* 2023). As agreed with the EWG, the SCANS-III density for block E (0.0313 animals per km^2) is applied to the Morgan marine mammal study area in the assessment (Table 4.12). Whilst SCANS IV data is the later survey, the densities presented in SCANS IV are lower than equivalent densities from SCANS III and therefore to apply these would result in less conservative estimates of impact, where density values are applied.	Annex II species protected under the Habitats Directive within a European Marine Site, EPS, IUCN Red List Least Concern, Wildlife Act 1990 (Isle of Man).

Species	Baseline Summary	Conservation importance
	In recent years, predicted distribution maps of Risso's dolphin at monthly scales by Waggitt *et al.* (2020) demonstrated Risso's dolphin densities to be lower in the Irish Sea from November to May, with increased densities in summer months between June to September. No Risso's dolphin were recorded during the Morgan aerial digital survey. Risso's dolphin is a feature of interest for four MNRs in the Isle of Man (Table 4.11).	
Short-beaked common dolphin *Delphinus delphis*	This is the most numerous offshore cetacean species in the temperate northeast Atlantic. Widespread and abundant, centred upon the Celtic Deep at the south end of the Irish Sea, where water depths range from 50 to 150 m. High-density area extends eastwards towards the coast and islands of west Pembrokeshire. Elsewhere in the Irish Sea, the species occurs at low densities mainly offshore, in a central band that extends northwards towards the Isle of Man. Data from the Morgan Generation Assets found that short-beaked common dolphin were sighted in three months (Jully 2022; September 2022; and October 2022) across the 24-month Morgan aerial digital survey period. Site specific digital aerial surveys did not record sufficient numbers of short-beaked common dolphin in in the area to carry out model-based density analyses. SCANS-III is a key baseline dataset, and the Morgan Generation Assets lies within Block F for the SCANS-III surveys in 2016, but no short-beaked common dolphin were sighted within that block or the adjacent Block E. Predicted density values using SCANS-III data showed common dolphin densities were low (0.00 to 0.07 animals per km^2) in the Irish sea but increased towards the Celtic Sea (BEIS, 2022). The SCANS-II density estimate for Block O (corresponding to SCANS-III blocks E and F combined) was 0.018 animals per km^2 (CV = 0.780). Recent SCANS-IV data did not report any short-beaked common dolphin in block CS-E (in which the Morgan Generation Assets) but reported a density of 0.0272 animals per km^2 (CV = 0.814) in adjacent block CS D (Gilles *et al*., 2023). As agreed with the EWG, the density taken forward to impact assessment is from the most recent Welsh Marine Mammal Atlas data (0.000288 animals per km^2) specific to the Irish Sea region (Evans and Waggitt, 2023) for the Morgan marine mammal study area, as this was considered to be the most representative density for the region, rather than older SCANS II data or broad scale block estimates from an adjacent SCANS-IV block (CS-D) (Gilles *et al.,* 2023) (Table 4.12).	Annex II species protected under the Habitats Directive within a European Marine Site, EPS, IUCN Red List Least Concern, Wildlife Act 1990 (Isle of Man).
Minke whale *Balaenoptera acutorostrata*	Minke whale inhabits all major oceans of the world and are most abundant on the continental shelf, in relatively cool waters. Around the UK, minke whales are widely distributed and present year-round, and in the Irish Sea, they mainly occur in the south and west of the area (Hammond *et al.*, 2005), and are present from late April to early August (Wall, 2013). This is confirmed by a high degree of seasonality in Manx waters, with presence between June and November, and a clear spatial aspect to the distribution of Minke whale sightings in Manx waters, where the majority of summer sightings are on the west coast of the island, and most autumn sightings made on the east coast (Howe, 2018).	Annex II species protected under the Habitats Directive within a European Marine Site, EPS, IUCN Red List Least Concern, Wildlife Act 1990 (Isle of Man).

Species	Baseline Summary	Conservation importance
	No minke whale were recorded during the Morgan aerial digital survey, and no sightings were made within SCANS-III Block F, but estimated densities of 0.0173 animals per km^2 (CV = 0.618) were reported in Block E. SCANS-III data were also used to model density surfaces for minke whale in 2016, with high predicted densities around the Isle of Man (0.027 – 0.036 animals per km^2) and moderate densities across the entire Irish Sea (0.012 – 0.02 animals per km^2) (BEIS, 2022). Recent SCANS IV data reported densities of 0.0088 animals per km^2 (CV = 1.145) in block CS-E and 0.0137 animals per km^2 (CV = 0.632) in block CS-D (Gilles *et al*., 2023). JCP III (Paxton *et al.,* 2016) density surface modelling gave UK-wide mean densities of 0.022 animals per km^2, with areas of persistent high relative density around the Isle of Man (0.100 animals per km^2 in summer 2010). As agreed with the EWG, the SCANS-III Block E density of 0.0173 animals per km^2 is applied to the Morgan marine mammal study area in the impact assessment (Table 4.12). Whilst SCANS IV data is the later survey, the densities presented in SCANS IV are lower than equivalent densities from SCANS III and therefore to apply these would result in less conservative estimates of impact, where density values are applied Minke whale is a feature of interest for one MNR in the Isle of Man (Table 4.11).	
Grey seal *Halichoerus grypus*	Approximately 38% of the world's grey seal population occurs in the UK (SCOS, 2014), where numbers have increased steadily over the past 60 years, in part due to its favourable conservation status. The main grey seal population centre in the UK is at the Scottish colonies, which account for approximately 77% of the UK estimated population. The Irish Sea is also an important centre of grey seal abundance, being used by animals tagged at haul-out sites in the Southwest Scotland, Northwest England and Wales MUs. Data from the Morgan Generation Assets found that grey seal were sighted in 12 months of the 24-month Morgan aerial digital survey period, with October and November being the only months in which animals were not sighted. Mean absolute design-based density estimates (i.e. density adjusted for availability bias) across the whole survey period was 0.099 animals per km^2, with a mean absolute density of 0.130 animals per km^2 during the pupping season (August to November) and 0.071 animals per km^2 during the non-pupping season (December to July). UK-wide at-sea distribution for grey seals by Carter *et al.*, (2022) demonstrated areas of high use around Liverpool Bay, the east coast of Ireland and to the northwest of the Isle of Man. Finer scale seasonal movements were also identified, with seals transitioning between sites within the Irish Sea, but not leaving Wales (Carter *et al*, 2020). Average grey seal density for the Morgan Array Area plus buffer was estimated at 0.0412 animals per km^2 (Carter *et al*., 2022) and is taken forward to the impact assessment for all potential impacts except piling, which uses Carter *et al.* grid cells to quantify number of animals impacted (Table 4.12). SMRU-tagged grey seals also showed presence throughout the regional marine mammal study area, with highest density of tracks in the Northwest England and Wales MUs (Wright and Sinclair, 2022). A detailed	Annex II species protected under Habitats Directive within a European Marine Site, IUCN Red List Least Concern, Wildlife Act 1990 (Isle of Man).

Species	Baseline Summary	Conservation importance
	overview of grey seal abundance is provided in the Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement is based upon visual counts at haul-out sites (Table 4.12). Grey seal is a qualifying interest of several SACs and three MNRs (Isle of Man) within the regional marine mammal study area (Table 4.11). Designated haul-out sites located in the Southwest Scotland MU are: Little Scares (SW-006); Solway Firth Outer Sandbank (SW-007); Sanda and Sheep Island (SW-001); Sound of Pladda Skerries (SW-002) and Lady Isle (SW-005).	
Harbour seal *Phoca vitulina*	Harbour seals are widely distributed, inhabiting temperate and subpolar seas throughout the Northern Hemisphere. The UK and Ireland represents an important population centre for both species, with approximately 36% of the pup production for Eastern Atlantic subspecies of harbour seals (SCOS, 2020). Carter *et al.* (2022) suggested large centres of harbour seal abundance in Shetland, The Wash (in Southeast England) and West Scotland, with high density at-sea areas adjacent to those hotspots. The main harbour seal haul-outs are located in the north region of the marine mammal study area, in the Southwest Scotland MU, and he nearest designated haul out sites for harbour seals in the vicinity of the Morgan Array Area are Manx MNRs (Calf and Wart Bank, Langness, Ramsey and West Coast), and Murlough SAC, Strangford Lough SAC and The Maidens SAC. Harbour seal presence in the vicinity of the Morgan marine mammal study areas is low (Carter *et al.*, 2022), with mean at-sea usage estimated (via telemetry studies) at a density of 0.00005 animals per km^2. Data from the Morgan Generation Assets found that no harbour seals were observed for the entire 24-month Morgan aerial digital survey period (Table 4.12). Harbour seal is a qualifying interest of several SACs and three MNRs (Isle of Man) within the regional marine mammal study area (Table 4.11). Designated haul-out sites located in the Southwest Scotland MU are: Sanda and Sheep Island (SW-001); Yellow Rock (SW-004); Sound of Pladda Skerries (SW-002); Rubha nan Sgarbh (SW-003); and Lady Isle (SW-005).	Annex II species protected under Habitats Directive within a European Marine Site, IUCN Red List Least Concern, Wildlife Act 1990 (Isle of Man).

4.5.1 Designated sites

4.5.1.1 A number of marine mammal species are listed in Annex II of the Habitats Directive (Council Directive 92/43/EEC) as species whose conservation requires the designation of SACs. In the UK Annex II marine mammal species for which SACs are designated include harbour porpoise, grey seal, harbour seal and bottlenose dolphin. Designated sites identified for the marine mammal chapter are described below in Table 4.11.

4.5.1.2 All cetacean species listed under Annex IV of the Habitats Directive are EPS. Cetacean EPS are afforded strict protection wherever they occur within a Member State's territory, both inside and outside designated protected areas.

4.5.1.3 In the UK, a number of international conventions afford specific protection to marine mammals as follows:

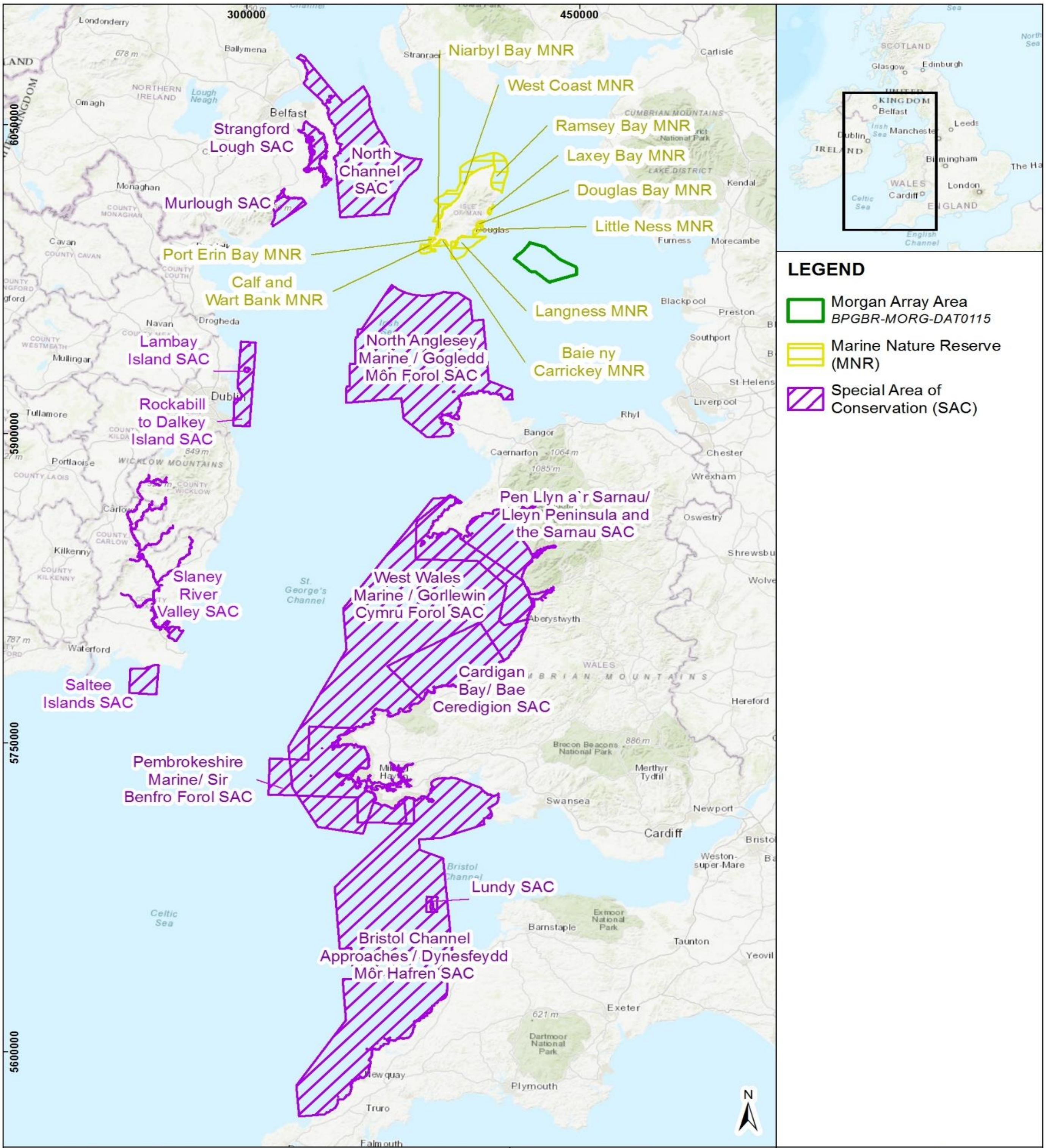
- All species of marine mammals are listed under Appendix I and II of the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animals (CMS))
- The Bern Convention (Conservation of European Wildlife and Natural Habitats) affords protection to all species of cetacean under Appendix II (strictly protected fauna) and to grey seal and harbour seal under Appendix III (protected fauna species)
- All species of cetacean are listed under Appendix II of the Convention on the International Trade in Endangered Species of Flora and Fauna (CITES)
- OSPAR protects marine mammals under Annex V, including the prevention and control of adverse impacts from human activities, such as anthropogenic sound.

4.5.1.4 In the UK, all species of marine mammal are protected under the Wildlife and Countryside Act 1981 and are also protected in Manx waters by the Isle of Man Wildlife Act 1990.

Table 4.11: Designated sites and relevant qualifying interests for the marine mammal chapter.

Designated Site	Distance to the Morgan Array Area (km) (marine route)	Features
Langness MNR	16.7	• Harbour seal *Phoca vitulina* • Grey seal *Halichoerus grypus* • Harbour porpoise *Phocoena phocoena* • Risso's dolphin *Grampus griseus*
Little Ness MNR	20.4	• Harbour porpoise *Phocoena phocoena* • Bottlenose dolphin *Tursiops truncatus* • Minke whale *Balaenoptera acutorostrata* • Risso's dolphin *Grampus griseus*
Douglas Bay MNR	22.2	• Bottlenose dolphin *Tursiops truncatus* • Risso's dolphin Grampus griseus

Designated Site	Distance to the Morgan Array Area (km) (marine route)	Features
Laxey Bay MNR	22.4	• Harbour porpoise *Phocoena phocoena* • Minke whale *Balaenoptera acutorostrata* • Bottlenose dolphin *Tursiops truncatus*
Ramsey Bay MNR	27.3	• Harbour seal *Phoca vitulina* • Grey seal *Halichoerus grypus*
North Anglesey Marine/Gogledd Môn Forol SAC	28.2	• Harbour porpoise *Phocoena phocoena*
Baie Ny Carrickey MNR	30.2	• Risso's dolphin Grampus griseus • Harbour porpoise *Phocoena phocoena* • Bottlenose dolphin *Tursiops truncatus*
Calf and Wart Bank MNR	35.8	• Risso's dolphin *Grampus griseus* • Harbour porpoise *Phocoena phocoena*
Port Erin Bay MNR	40.1	• Harbour porpoise *Phocoena phocoena*
West Coast MNR	41.6	• Harbour porpoise *Phocoena phocoena* • Harbour seal *Phoca vitulina* • Grey seal *Halichoerus grypus*
Niarbyl MNR	44.7	• Harbour porpoise *Phocoena phocoena* • Grey seal *Halichoerus grypus*
North Channel SAC	62.6	• Harbour porpoise *Phocoena phocoena*
Strangford Lough SAC	93.8	• Harbour seal *Phoca vitulina*
Murlough SAC	98.4	• Harbour seal *Phoca vitulina*
Pen Llŷn a`r Sarnau/Llŷn Peninsula and the Sarnau SAC	122.0	• Bottlenose dolphin *Tursiops truncatus* • Grey seal *Halichoerus grypus*
West Wales Marine/Gorllewin Cymru Forol SAC	123.3	• Harbour porpoise *Phocoena phocoena*
Rockabill to Dalkey Island SAC	123.4	• Harbour porpoise *Phocoena phocoena*
Lambay Island SAC	130.4	• Harbour seal *Phoca vitulina* • Grey seal *Halichoerus grypus*
Cardigan Bay/Bae Ceredigion SAC	190.4	• Bottlenose dolphin *Tursiops truncatus* • Grey seal *Halichoerus grypus*
Slaney River Valley SAC	211.53	• Harbour seal *Phoca vitulina*
Pembrokeshire Marine/Sir Benfro Forol SAC	215.24	• Grey seal *Halichoerus grypus*
Saltee Islands SAC	237.94	• Grey seal *Halichoerus grypus*
Bristol Channel Approaches /Dynesfeydd Môr Hafren SAC	281.11	• Harbour porpoise *Phocoena phocoena*
Lundy SAC	320.28	• Grey seal *Halichoerus grypus*



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Data Sources: Client, JNCC, NPWS

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 5 10 20 30 40 nm
0 10 20 40 60 80 km

Drawing Number:
RPSE-MG-ES-MAM-E001-00

Drawing Title:
DESIGNATED SITES WITHIN THE MARINE MAMMAL STUDY AREA.

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:3,000,000

VER	DATE	DETAILS	BY	CHECK
00	07/11/23	First Issue	MJ	LB

Figure 4.4: Designated sites within the regional marine mammal study area.

4.5.2 Important ecological features

4.5.2.1 IEFs are those marine mammal receptors that have the potential to be affected by the Morgan Generation Assets. The importance of ecological features is dependent upon their biodiversity, social, and economic value within a geographic framework of appropriate reference (CIEEM, 2018). Marine mammal IEFs have been identified based on biodiversity importance, recognised through international or national legislation, conservation status/plans and on assessment of value according to the functional role of the species within the context of the regional marine mammal study area. Relevant legislation/conservation plans for marine mammals would include, for example: Annex II species under the Habitats Directive; Annex IV(a) of the Habitats Directive as European Protected Species (EPS); species listed as threatened and/or declining by OSPAR; International Union for Conservation of Nature (IUCN) Red List species; and UK Biodiversity Action Plan (BAP) priority species either alone or under a grouped action plan.

4.5.2.2 Table 4.12 presents the value/importance that has been assigned to each ecological feature and a summary of the densities and the relevant MU populations carried forward to the assessment. Densities presented below have been agreed in advance with consultees via the marine mammal EWG (Table 4.5). For most cetaceans the densities applied to the assessment were taken from the most recent Welsh Marine Mammal Atlas (Evans and Waggitt, 2023). The exceptions were Risso's dolphin and minke whale where the densities agreed were the precautionary values from the SCANS-III surveys (Hammond et al., 2021). For pinnipeds, offshore densities are given for average and inshore densities are used for maximum, both taken from Carter et al. (2022) maps. Further detail on the baseline and the densities and reference populations taken forward to assessment is given in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement. All marine mammals with the potential to be affected by the Morgan Generation Assets are protected under some form of international legislation and/or are important from a conservation perspective in an international/national context (section 4.5.1) and therefore the 'importance' of all marine mammal IEFs was determined to be International.

Table 4.12: Marine mammal IEFs, densities, MU populations and their importance within the regional marine mammal study area.

[1] Density derived from Evans and Waggitt (2023) for the Morgan marine mammal study area.

[2] SCANS-III (Hammond *et al.,* 2021) for adjacent block E (none observed for block F).

[3] Carter *et al.* (2022) values – average densities calculated to per km² from 25 km² cells for the Morgan marine mammal study area.

[4] All population estimates include the Isle of Man unless population estimate given separately.

[5] Based upon counts in SCOS (2020) and Morris and Duck (2019) with updated scalar of 0.215 from SCOS (2021) for grey seal.

[6] From Howe (2018b).

[7] Population estimates per SMU from SCOS (2021).

[8] The minimum estimate (nmin) is used as a precautionary estimate rather than the mean estimate (n).

Species	Density (animals per km²)	Management Unit (MU)	Reference population MU[4]	Importance
Harbour porpoise *Phocoena phocoena*	0.262[1]	Celtic and Irish Sea	62,517	International
Bottlenose dolphin *Tursiops truncatus*	0.0012[1]	Irish Sea	293	International

Species	Density (animals per km²)	Management Unit (MU)	Reference population MU[4]	Importance
Short-beaked common dolphin *Delphinus delphis*	0.00029[1]	Celtic and Greater North Seas	102,656	International
Risso's dolphin *Grampus griseus*	0.0313[2]	Celtic and Greater North Seas	12,262	International
Minke whale *Balaenoptera acutorostrata*	0.0173[2]	Celtic and Greater North Seas	20,118	International
Grey seal *Halichoerus grypus*	0.0412[3]	12 Wales 13 NW England 14 Northern Ireland 1 SW Scotland Isle of Man estimate East of Ireland Southeast of Ireland ('Grey Seal Reference Population' (GSRP))	3,579[5] 994[5] 2,008[5] 2,056[5] 400[6] 1,662[5] 2,211[5] GSRP = 12,910	International
		OSPAR Region III reference population[8]	60,780	
Harbour seal *Phoca vitulina*	0.00005[3]	12 Wales 13 NW England 14 Northern Ireland Isle of Man ('Harbour Seal Reference Population' (HSRP))	13[7] 6[7] 1,405[7] No estimate available HSRP = 1,424	International

4.5.3 Future baseline scenario

4.5.3.1 The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 requires that 'an outline of the likely evolution thereof without implementation of the development 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 Environmental Statement. In the event that Morgan Generation Assets does not come forward, an assessment of the future baseline conditions has been carried out and is described within this section.

4.5.3.2 The baseline environment is not static and will exhibit some degree of natural change over time, even if the Morgan Generation Assets does not come forward, due to naturally occurring cycles and processes and additionally any potential changes resulting from climate change and anthropogenic activity. Therefore, when undertaking impact assessments, it is necessary to place any potential impacts within the context of the envelope of change that might occur over the timescale of the Morgan Generation Assets.

4.5.3.3 Marine mammals are known to be impacted by various anthropogenic activities, including offshore developments, but also fisheries, anthropogenic sound and transportation. Avila *et al*. (2018) reported that between 1991 and 2016, globally almost all species of marine mammals (98%) were documented to be affected by at least one threat. Catch of marine mammals in active fishing gear (bycatch) was the most common threat category for odontocetes and mysticetes, followed by pollution (solid waste), commercial hunting and boat-collisions. Ghost-net entanglements, solid and liquid wastes, and infections were reported to be the main threats for pinnipeds.

4.5.3.4 In addition to anthropogenic impacts, marine mammals are also vulnerable to indirect impacts, including climate change which can result in increasing sea temperatures.

4.5.3.5 Shifts in spatial distribution is one of the most common responses to temperature changes by marine mammals and has the potential to modify the ranges of certain species. Furthermore, changes in water temperatures are likely to alter the life cycles of marine mammal prey species and may result in predator-prey mismatch, where there is a discrepancy between the abundances of prey species and those of marine mammals, affecting migratory marine mammal species and species displaying some site fidelity. Additionally, climate change could affect survival rates of marine mammals by affecting reproductive success, increasing the stress of the animal and fostering the development of pathogens (Albouy *et al.,* 2020).

4.5.3.6 Given that anthropogenic pressures are now exacerbated by climatic changes, it is challenging to predict future trajectories of marine mammal populations in the absence of the Morgan Generation Assets. In terms of data, monitoring is not in place at the relevant temporal or spatial scales in order to assess the baseline dynamics of some marine mammal populations, especially for minke whale and Risso's dolphin. Therefore, a summary of current and future pressures and where data is available, information about population dynamics is presented below.

Harbour porpoise

4.5.3.7 Harbour porpoise are severely vulnerable to incidental entanglements in fishing gear, known as bycatch (Moan *et al.,* 2020). Harbour porpoise are most likely to die shortly after entanglement, as they cannot drag fishing gear to the surface to breathe, and this mortality can have large population-level effects, causing negative population trajectories of harbour porpoises (IMR/NAMMCO, 2019). The Celtic and Irish Seas assessment units (AUs, as defined in IMR/NAMMCO, 2019) have a higher bycatch level than other AUs, with bycatches constituting 852 animals or 2.42% of the abundance estimated for the AU (Moan *et al.*¸ 2020). The Celtic Sea region has known concern for harbour porpoise bycatch (Andersens, 2013). A study by Brown *et al. (*2015) on potential risk to cetaceans from static fishing gears demonstrated gillnets were considered to have high potential for capturing harbour porpoise and were likely to result in fatality from an interaction.

4.5.3.8 Prey availability also influences harbour porpoise abundance. Given that harbour porpoise has a high metabolic rate (Rojano-Doñate *et al*., 2018) and therefore has to feed regularly, it is thought to be highly dependent on year-round proximity to food sources and harbour porpoise distribution and condition is considered likely to reflect the availability and energy density of prey (Santos and Pierce, 2003). Therefore, any changes in the abundance and density of harbour porpoise prey species may have the potential to affect harbour porpoises foraging in an area.

4.5.3.9 Harbour porpoise has high parasitic exposure, with post-mortem examinations regularly revealing heavy parasitic worm burdens (Bull *et al.,* 2006). A causal immunotoxic relationship between Polychlorinated Biphenyl (PCB) exposure and infectious disease mortality has also been highlighted (Murphy *et al.,* 2015), with total

PCB levels were significantly higher in the infectious disease group compared to the physical trauma group in a study by Jepson *et al.* (2005), thus suggesting anthropogenic contaminants are having adverse effects on harbour porpoise. In a toxicology database from harbour porpoise stranded and incidentally caught between 1990 and 2011 (Jepson 2005, Deaville & Jepson 2011, Law *et al*., 2012), it was shown that stable and often high levels of PCBs exist in harbour porpoise, but declining levels of organochlorine pesticides (e.g. Dichlorodiphenyltrichloroethane (DDT) and dieldrin) (Law *et al*., 2012) and penta-mix brominated diphenyl ether congeners (PBDEs) (Law *et al*. 2010), and only trace levels of butyltins (including Tributyltin (TBT)) (Law *et al*. 2012b). These Persistent Organic Pollutants (POPs) may have impacts on reproduction, as during pregnancy lipid-soluble contaminants, such as Organochlorines (OCs), may be transferred from the mother to the foetus (in particular the firstborn calf) (Murphy *et al*., 2013).

4.5.3.10 The impact of climate change on harbour porpoise remains poorly understood (Evans and Bjørge, 2013), with existing research limited and uneven in distribution. Impacts of climate change on marine mammals in general have included geographical range shifts (Kaschner *et al*., 2011; Lambert *et al*., 2011; Hazen *et al*., 2013; Ramp *et al*., 2015; Nøttestad *et al*., 2015; Vikingsson *et al*., 2015; Silber *et al*., 2017), food web changes (Ramp *et al*., 2015; Nøttestad *et al*., 2015; Vikingsson *et al*., 2015), and increased susceptibility to disease and contaminants (Hall and Frame, 2010; Twiner *et al*., 2011; Fire and Van Dolah, 2012; Jensen *et al*., 2015; Haüssermann *et al*., 2017; Mazzariol *et al*., 2018).

4.5.3.11 Data from SCANS II, SCANS III and SCANS IV suggested that the abundance of harbour porpoise in the North Sea (NS) MU is stable (IAMMWG, 2015; IAMMWG, 2021, Gilles *et al.* 2023). Comparison of the impact of climate change on the species range and distribution in van Weelden *et al.* (2021) suggested a northward shift and expansion of harbour porpoise range, similar to MacLeod *et al.* (2009), but no increase in maximum latitude – which may lead range contraction and present a risk for North-west European populations with their preference for sub-polar to temperate water temperature preference. There has been an increase in strandings of harbour porpoise (and short-beaked common dolphin) in northwest Scotland (Haelters *et al.* 2011, Leeney *et al. 2008,* MacLeod *et al.* 2005), and decrease in cold-temperate water species (northern bottlenose whale *Hyperoodon ampullatus,* long-finned pilot whales *Globicephala melas*, Sowerby's beaked whales *Mesoplodon bidens* and white-beaked dolphins *Lagenorhynchus albirostris*) suggesting a shift in habitat in the region, favouring warm-water species over cold-water species.

4.5.3.12 Climate change may also affect prey distribution, having implications for predators such as harbour porpoise (as discussed in section 4.5.3.8). Warming sea temperatures are predicted to cause changes in prey abundance and distribution, and enhanced stratification forcing earlier occurrence of the spring phytoplankton bloom and potential cascading effects through the food chain (Evans and Bjørge, 2013). The impacts of climate change on marine predator-prey distributions in Sadykova *et al.* (2020) predicted a large future distribution shift in sandeel and porpoise habitat overlap (164 km) but a small shift (16 km) in overlap between herring *Clupea harengus* and porpoise.

4.5.3.13 The results of the most recent UK assessment of favourable conservation status show that the current range of harbour porpoises covers all of the UK's continental shelf and there appears to have been no change in range since 1994 (Paxton *et al*., 2016; JNCC, 2019a). The future trend in the range of this species has therefore been assessed as overall stable (good). Due to insufficient data the future trend in the population and consequently future prospects of harbour porpoise was assessed as unknown (JNCC, 2019a). Due to the establishment of SACs for this species in UK waters, the future prospects for the supporting habitat was assessed as good. The report on conservation status assessment for the species concluded that, assuming that conservation measures are maintained, and further measures are taken should other pressures emerge (or existing pressures change) then the future prospects for harbour porpoise in UK waters should remain favourable (JNCC, 2019a).

Bottlenose dolphin

4.5.3.14 Abundance estimates of bottlenose dolphin in the Irish Sea (IS) MU have declined in recent years (IAM MWG, 2021), with 379 animals in the MU in 2015 based upon Evans (2012), and 293 in 2021 based upon Hammond *et al.* (2021) and Rogan *et al.* (2018) estimates. Bottlenose dolphin have been monitored annually in Cardigan Bay since 2001 and increased in abundance until a peak in 2007 to 2008, but have generally declined since then, with numbers now are similar to those in 2001 (Lohrengel *et al*., 2018).

4.5.3.15 The impacts of climate change for cetaceans are described in section 4.5.3.10. For the Irish Sea, Evans and Waggitt (2020) suggested no obvious trends in bottlenose dolphins since 2005 (Hammond *et al*., 2013, 2017).

4.5.3.16 Evans and Waggitt (2020) highlighted both the frequency and severity of toxic algal blooms are also predicted to increase as a result of nutrient enrichment (via increased rainfall and freshwater runoff) and increased temperature (via climate change) and salinity, and mass die-offs due to fatal poisonings have been reported in bottlenose dolphins (Fire *et al*., 2007, 2008).

4.5.3.17 The results of the most recent UK assessment of favourable conservation status shown that the future trend in the range of bottlenose dolphin is, overall, stable (good) (JNCC, 2019b). However, although the pressures impacting bottlenose dolphin population and available habitat are not thought to be increasing and there are no threats identified which are likely to impact in the next 12 years, due to insufficient data to establish current trends for this species, the future trend and consequently the future prospects for the population and habitat parameters are unknown (JNCC, 2019b). Therefore, the overall assessment of future prospects and conservation status for bottlenose dolphin is unknown (JNCC, 2019b).

Short-beaked common dolphin

4.5.3.18 In the Irish Sea and Celtic Sea, there appears to be no obvious trends in status for common dolphin (Baines and Evans, 2012). In other areas such as the North Sea off northeast Scotland, Orkney and Shetland, common dolphin are more regularly observed, even in winter (Sea Watch Foundation, unpublished data in Evans and Waggitt 2020; Macleod *et al.* 2005). This may reflect the expanding range of fish species like anchovy and sardine that are warmer water species.

4.5.3.19 Climate change may impact these predator-prey dynamics, alongside other impacts of a warming climate. Short-beaked common dolphin are wide ranging with a capacity for range expansion (Murphy *et al.,* 2013) typically warmer water species and appear to be extending their shelf sea range further north off west Britain and around the northern North Sea (Evans *et al*., 2003; MacLeod *et al*., 2005). Short-beaked common dolphin show a positive relationship with increasing temperature (Evans and Waggitt, 2020), and thus warming waters may lead to a shift in the range of short-beaked common dolphin (MacLeod *et al*., 2005).

4.5.3.20 Other pressures on common dolphin includes fisheries interactions, pollutants, sound pollution and habitat disturbance. In ICES sub-division VII, which encompasses the Celtic Sea, the English Channel and the Irish Sea, 410 to 610 common dolphins were killed in pelagic trawl and static net fisheries between 2005 and 2006 (Northridge *et al*., 2007)) and whilst these levels of bycatch were not of major conservation concern, when combined with gill or tangle nets impacts may be greater. Common dolphins have been observed taking fish from the cod end and foraging on discarded fish (Svane, 2005), inside sea bass trawls in the English Channel (Northridge *et al*. 2004), and off the southwest coast of Ireland they have been observed targeting horse mackerel in the vicinity of pelagic trawl nets (Couperus *et al*., 1997).

4.5.3.21 Common dolphin, as with all marine mammals, are susceptible to POPs which may bio magnify (higher levels occur higher up the food chain) and bioaccumulate (increased concentration with age). As discussed in 4.5.3.9, trends in POPs in harbour porpoise are likely to be found in common dolphins around the UK (Murphy *et al.*, 2013). Potential impacts of POPs on female short-beaked common dolphin were investigated from strandings in the North East Atlantic from 2001 to 2003, found the threshold reported to have adverse health effects (17 mg kg^{-1}) was frequently exceeded in common dolphins (40%), and was driven primarily by individual feeding history (Pierce *et al*., 2008). Subsequent studies found existence of non-reproductive female short-beaked common dolphins stranding on the southwest coast of the UK due to high contaminant burdens (Murphy *et al*., 2010) and may have implications for future population trajectories.

4.5.3.22 The results of the most recent UK assessment of favourable conservation status shown that the future trend in the range of short-beaked common dolphin was overall stable (good) (JNCC, 2019c). However, although the pressures impacting short-beaked common dolphin population and available habitat are not thought to be increasing and there are no threats identified which are likely to impact in the next 12 years, due to insufficient data to establish a current trend for this species, the future trend and consequently the future prospects for the population and habitat parameters are unknown (JNCC, 2019c). Therefore, the overall assessment of future prospects and conservation status for bottlenose dolphin is unknown (JNCC, 2019c).

Risso's dolphin

4.5.3.23 In the Irish Sea and Celtic Sea, there appears to be no obvious trends in status for Risso's dolphin (Baines and Evans, 2012). There has been an increase in abundance of squid in recent years in areas around the UK (Western Approaches, Channel, North Sea) which may lead to an increased presence of squid predators such a Risso's dolphin (Evans and Bjørge, 2013). As a predominantly teuthophagous (feeding on cephalopods) species that feeds in continental slope waters, the Risso's dolphin may be less vulnerable to the threat of overfishing as the main cephalopod species are not commercially important and most fishing occurs in shelf waters and targets bony fishes. There remains the risk that fisheries will target lower in the food web if populations of higher trophic level species are depleted (Pauly *et al*., 1998; Sala *et al*., 2004; Pauly and Palomares, 2005) which could reduce prey populations or disrupt food webs.

4.5.3.24 Known threats to Risso's dolphin includes bycatch (e.g. pelagic drift nets), sound disturbance and ingestion of plastic debris (Bearzi *et al.,* 2011). Small numbers of Risso's dolphin have been observed entangled in pelagic drift gillnets, pelagic longlines, purse seines and pelagic pair trawls (Carretta *et al*., 2008; Waring *et al*., 2009), with high mortality for gillnets. Whilst studies of sound disturbance on Risso's dolphin is limited, there are some studies that demonstrate resting behaviour of Risso's dolphin was disrupted by whale watching boats in the Azores (Visser *et al*., 2006).

4.5.3.25 In terms of climate change, there is little good quality information on the impact on Risso's dolphin with the impact at a population level unknown (Bearzi *et al*., 2011). There is some evidence of fluctuations in community structure and species composition likely driven by climate change, for example short-finned pilot whales were replaced by Risso's dolphin in an area of south California coinciding with El Nino events (Shane, 1994, 1995 and during El Niño 1997 to 1998 and La Niña 1999 events species such as Risso's dolphin that were virtually absent at the surface became more conspicuous (Benson *et al*., 2002). As mentioned in 4.5.3.21, Risso's dolphin are also susceptible to POPs and PCBs.

4.5.3.26 The results of the most recent UK assessment of favourable conservation status shown that the future trend in the range of Risso's dolphin is overall stable (good) (JNCC, 2019d). As the current conservation status for range is favourable for this species, the future prospects are considered good (JNCC, 2019d). Therefore, the overall assessment of future prospects and conservation status for Risso's dolphin is unknown; this is due to there being insufficient data to establish current trends for these parameters (JNCC, 2019d).

Minke whale

4.5.3.27 No obvious status changes have been observed in minke whale in the Irish Sea since 2005 (Evans and Waggitt, 2020, Baines and Evans, 2012), but there may have been increases in relative abundance since the 1980s (Evans *et al*., 2003; Paxton and Thomas, 2010). Minke whales are regularly observed in the Irish Sea and Celtic Sea, but foraging behaviour is less well known. Volkenandt *et al*. (2015) found minke whales were dominantly observed in areas with herring and sprat *sprattus sprattus*, and less in areas with mackerel *Scomber scombrus*. Healy *et al.* (2007) also found a significant relationship between the presence of baleen whales with herring and sprat in the Celtic Sea, and the species had preference for small schooling pelagic fish (similar to studies on minke whale stomach contents by Pierce *et al*. (2004) in Scotland).

4.5.3.28 Howe *et al.* (2018) also highlighted minke whale appear to target two herring stocks in the Irish Sea, the Mourne stock and Manx stock, with minke appearing to mirror the Irish Sea herring in Manx waters. These prey species may be impacted by climate change and have knock-on effects on minke whale foraging. The results of analysis of minke whale stomach contents in Icelandic waters suggested minke whale may adapt their diet under changed environments (Víkingsson *et al*., 2013). The study showed a decrease in the proportion of sandeel and cold water species in the diet and an increase in gadoids and herring, which may reflect responses of minke whale to a changed environment, possibly driven by climate change. Studies also suggest that minke whales are likely to shift their distribution as a response to the decrease in the abundance of the preferred prey species (Víkingsson *et al.*, 2015).

4.5.3.29 Major threats affecting minke whale in UK waters include direct and indirect interactions with fisheries. Entanglement is the primary source of anthropogenic mortality of minke in the northwest Atlantic (Van der Hoop *et al*., 2013). Gillnets and longlines and pots have high potential to entangle minke whale (Brown *et al.,* 2015), but not necessarily lethal encounters. Other impacts include boat strikes, exposure to anthropogenic sound, ingestion of contaminants and debris and the loss or degradation of critical habitat (Gill *et al*., 2000; Robinson and MacLeod 2009, Robinson *et al*., 2009). Data from SCANS II, SCANS III and SCANS IV suggested that the abundance of minke whale in the CGNS MU is stable (IAM MWG, 2015; IAM MWG, 2021).

4.5.3.30 The results of the most recent UK assessment of favourable conservation status shown that there is no evidence to suggest that minke whale range has changed since last report on conservation status in 2013 and therefore it has been assessed as, overall, stable (good) (JNCC, 2019e). The OSPAR Intermediate Assessment (IA) suggest that minke whale abundance in the Greater North Sea is stable (OSPAR IA, 2017; JNCC, 2019e). However, although the pressures impacting minke whale population and available habitat are not thought to be increasing and there are no threats identified which are likely to impact in the next 12 years, due to insufficient data to establish current trends for this species, the future trend and consequently the future prospects for the population and habitat parameters are unknown (JNCC, 2019e). Therefore, the overall assessment of future prospects and conservation status for minke whale is unknown (JNCC, 2019e).

Grey seal

4.5.3.31 UK grey seal numbers are currently stable or increasing throughout their monitored range (SCOS, 2021), suggesting that their population status is not under threat. The overall UK pup production increased by <1.5% per annum between 2016 and 2019, but growth was mainly limited to North Sea colonies. There has been evidence of increased haul-out counts of grey seal within all MUs in the regional marine mammal study area (Wright and Sinclair, 2022), but this could be due to an increase in species reporting (SCOS, 2021). The only sizeable breeding colony in Wales that is monitored annually is on Skomer Island, where following a period of little population growth (1993 to 2011), pup production has increased by an average of 10% per annum between 2011 and 2015 (Bull *et al*., 2017).

4.5.3.32 Pinnipeds are vulnerable to impacts of climate change (Evans and Waggitt, 2022). SMRU explored potential habitat shifts of grey seal and harbour seal in two scenarios of climate change (from IPCC, 2014) in the North Atlantic. Overall compression of core habitat, with slight loss of habitat in the north and extensive habitat loss in the south edges of distribution was observed for grey seal in the low warming scenario whilst in the high warming scenario, there was a northward shift in core habitat. Furthermore, pinnipeds such as grey seal that haul-out or breed on low lying coastal areas are vulnerable to sea level rise and increased storm surges. This could become an issue in particular for seals in the south North Sea (Evans and Bjørge, 2013; Zicos *et al*., 2018).

4.5.3.33 Warming sea temperatures may also lead to increase in pathogen exposure or spread of novel infectious diseases (Evans and Waggitt, 2020). Climate change has the potential to increase pathogen development and survival rates, disease transmission, and host susceptibility (Harvel *et al*., 2002), whilst higher temperatures may stress organisms, increasing their susceptibility to some diseases (Lafferty *et al*., 2004). Furthermore, species such as seals that occupy near shore regions near human settlements and have a semi-aquatic lifestyle will likely be at increased risk of pathogen exposure or risk to both marine and terrestrial pathogens (Cohen *et al*., 2018, Kroese *et al*., 2018, Keroack *et al*. 2018, Lehnert *et al*., 2017, Sanderson *et al*. 2020, Jensen *et al*., 2010).

4.5.3.34 Impacts on the food chain may also occur due to climate change and reduce food availability. It has also been suggested that some potential effects of pollutants (e.g. disruption of the immune, reproductive or endocrine systems) could also be exacerbated by nutritional stress brought on by reduced food availability due to climate change (Jepson *et al*., 2005). Potential additive effects of pollutants on predators who are already under stress from habitat changes (e.g. climate change) and prey availability are poorly understood, but there are suggestions that warming temperatures will alter pathways and concentrations of pollutants (Mazzariol *et al*., 2018).

4.5.3.35 The results of the most recent UK assessment of favourable conservation status shown that the future trend in the range of grey seal is, overall, stable (good) (JNCC, 2019f). Modelling of population size at the beginning of each breeding season between 1984 and 2017 demonstrated an increasing trend and although the rate of increase has declined, the abundance estimate is above historic estimates (JNCC, 2019f). As the current conservation status for range and population is favourable for this species, the future prospects for both parameters are considered good (JNCC, 2019f). The future trend of grey seal habitat has been assessed as overall stable (good) (JNCC, 2019f).

Harbour seal

4.5.3.36 UK harbour seal numbers have increased since the late 2000s and is close to the late 1990s level prior to the 2002 Phocine Distemper Virus (PDV) epizootic (SCOS, 2021) but population dynamics vary significantly between regions. Populations in west Scotland are either stable or increasing, with the Southwest Scotland MU (which is located in the regional marine mammal study area) increasing since the 1990s. The main harbour seal haul-out locations are concentrated in the north region of the regional marine mammal study area, in the Southwest Scotland MU, with no information on the location of harbour seal hauled-out in the Wales and Northwest England MUs (Wright and Sinclair, 2022). Most harbour seal haul-out locations in Northern Ireland are located in the southeast of the country, with most harbour seal being counted at Carlingford Lough, Murlough SAC and Rathlin Island. Population estimates have increased since 2011 to 2015 survey periods (SCOS, 2021), but remain lower than 2000 to 2006 and 2007 to 2009 estimates. Colonies on the east coast appear to have experienced more dramatic declines (Wilson *et al*., 2019).

4.5.3.37 Threats to harbour seal includes competition with grey seal, predation from killer whales and exposure to toxins from harmful algal blooms (Blanchet *et al*., 2021, Wilson *et al*., 2019, Jones *et al*., 2017, Jensen *et al.,* 2015). Harbour seal in declining colonies have been shown to be significantly more exposed to harmful algal toxin (e.g. domoic acid and saxitoxins) and may be contributing to observed declines (Jensen *et al.,* 2015). Harbour seal are also under threat from bycatch, but seal predation and fishing gear damage is not monitored, and until recently seal shooting was still licenced when interacting with fishing equipment (under the 'netsman's defence'). However, in March 2021, amendments made to the Conservation of Seals Act 1970 (which is applicable in England, Wales and Scotland) by Schedule 9 of the Fisheries Act 2020 came into force and individual seals can no longer be killed intentionally or recklessly.

4.5.3.38 Harbour seal are expected to be impacted by climate change, including range changes and changes in haul-out patterns, which are influenced by water and air temperature due to thermoregulation being energetically costly (Simpkins *et al.* 2003). Changes in prey communities can also impact predator foraging patterns and diet composition, and whilst harbour seal have been shown to switch to alternative preys when required, these may come at a fitness cost, such as when harbour seal switched from herring to gadoids and showed signs of fish-induced anaemia (Thompson *et al.,* 1997). As generalist top predators with a flexible and broad diet, harbour seal can shift between several trophic niches if needed to cope with the physical environment. However, shifts in pathogen ranges and survival due to warmer air and water (Fujii *et al*., 2006) may affect harbour seal populations by increasing risk of epidemic outbreaks. Past epizootic viral diseases have caused mass mortality of harbour seals in Europe, with 60% of the North Sea harbour seal died during an outbreak of PDV followed by subsequent outbreak in 2002 (Härkönen *et al.,* 2006, Stokholm *et al*., 2019). Several pinniped-related parasites have begun to expand their range mainly northwards under the influence of environmental parameters (Jensen *et al*. 2009, Gibson *et al*., 2011). As discussed in section 4.5.3.33, those species that occupy both terrestrial and marine habitats may risk more exposure to pathogens.

4.5.3.39 The results of the most recent UK assessment of favourable conservation status show that future trend in the range of harbour seal is, overall, stable (good) (JNCC, 2019g). Although the UK population of harbour seal has increased since 2000, the long-term trend indicates that the UK population is still below population levels documented in the late 1990s and declines were recorded at many sites, including the east of Scotland. Therefore, the current UK harbour seal population estimate has been considered as unfavourable-inadequate. Given that there is not predicted to be any increase in management which would outweigh threats to the species, future prospects of harbour seal population in the UK were assessed as poor (JNCC, 2019g). Although the pressures impacting harbour seal habitats are not thought to be increasing, and there are no threats identified which are likely to impact in the next 12 years, due to insufficient data to establish a current trend for this species, the future trend and consequently the future prospects for the habitat parameter are unknown (JNCC, 2019g).

4.5.4 Data limitations

4.5.4.1 The marine mammal impact assessment was developed on the basis of the best available information at the time of writing. Baseline data used to underpin the assessment was drawn from broadscale sources and site-specific surveys which are subject to temporal and spatial variability and so are likely influence marine mammal distribution and abundance. A summary of the limitations and uncertainties associated with the data is detailed in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement.

4.5.4.2 The approach to the assessments of underwater sound on marine mammals was undertaken using an evidence-based approach based on a comprehensive review of the literature, including empirical data derived from field studies at other offshore wind farms. This makes the assumption that such data is applicable in a different region with a different environmental context. In addition, there is an assumption that responses may be similar across different species.

4.5.4.3 Whilst these data limitations and assumptions could lead to some level of uncertainty, this is overcome by adopting a precautionary approach at each stage of the assessment by adopting a precautionary approach at each stage of the assessment (see paragraph 4.9.1.37).

4.6 Impact assessment methodology

4.6.1 Overview

4.6.1.1 The marine mammals impact assessment has followed the methodology out in Volume 1, Chapter 5: EIA methodology of the Environmental Statement. Specific to the marine mammals impact assessment, the following guidance documents have also been considered:

- Guidance for Ecological Impact Assessment in the UK and Ireland. Terrestrial, Freshwater, Coastal and Marine (Chartered Institute of Ecology and Environmental Management (CIEEM), 2018) - these guidelines combine the Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater and Coastal, 2nd edition (2016) and the Guidelines for Ecological Impact Assessment in Britain and Ireland: Marine and Coastal (2010)
- Statutory Nature Conservation Agency Protocol for Minimising the Risk of Injury to Marine Mammals from Piling Noise (JNCC 2010a)
- JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys JNCC (2017)
- JNCC guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC, 2010b)
- Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects (Judd, 2012).

4.6.1.2 In addition, the marine mammals impact assessment has considered the legislative framework as defined by:

- The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (as amended)
- Marine and Coastal Access Act 2009
- The Planning Act 2008 (as amended) (relevant to the DCO application).

4.6.1.3 Full descriptions of relevant legislation are presented in Volume 1, Chapter 2: Policy and legislative context of the Environmental Statement.

4.6.2 Impact assessment criteria

4.6.2.1 The assessment of significance relies on understanding the impacts arising from proposed activities and the effect that those impacts will have on ecological receptors. These are aligned to Chartered Institute of Ecology and Environmental Management (CIEEM) Guidelines (CIEEM, 2018), and the following definitions are used for impact and effect throughout:

- ‘Impact’ – actions resulting in changes to an ecological feature. For example, elevated underwater sound from piling
- ‘Effect’ – outcome to an ecological feature from an impact. For example, the onset of auditory injury.

4.6.2.2 The criteria for determining the significance of potential effects follows a two-stage process that involves defining the magnitude of the potential impacts and the sensitivity of the receptors. This section describes the criteria applied in this chapter to assign values to the magnitude of potential impacts and the sensitivity of the receptors. The terms used to define magnitude and sensitivity are based on those which are described in further detail in Volume 1, Chapter 5: EIA methodology of the Environmental Statement.

4.6.2.3 Magnitude of impact quantifies the amount of change arising from an activity that could lead to alteration in the environment (e.g. piling could lead to an elevation in underwater sound) and the associated outcome or effect on sensitive ecological receptors. The assessment describes the spatial extent over which potential impacts and potential effects could occur arising from a particular activity within the relevant geographic frame of reference (e.g. area of effect and associated number of animals in a MU population affected), how long animals are exposed to an activity that could cause an effect in the context of the life-history of a species (i.e. the duration), the frequency of the exposure that could lead to a change (i.e. continuous or intermittent) and whether or not the resultant change in either the receiving environment or features exposed is reversible. The criteria for defining magnitude in this chapter are outlined in Table 4.13 below and provides guidance to assessing magnitude for all impacts. This is not a wholly prescriptive approach, as the assessment of magnitude is based upon expert judgement taking into account other factors such as the species life history, the wider population context and movement within the area to aid with defining magnitude.

Table 4.13: Definition of terms relating to the magnitude of an impact.

Magnitude of Impact	Definition
High	The magnitude of the impact would lead to large scale effects on the behaviour and distribution of the marine mammal IEF, with sufficient severity to affect the long-term viability of the population over a generational scale. (Adverse).
	Long-term, large-scale increases in the population trajectory over a generational scale. (Beneficial).
Medium	The magnitude of the impact would lead to temporary changes in behaviour and/or distribution of individuals at a scale that would result in potential reductions to reproductive success during an animal's lifetime to some individuals, although not enough to significantly affect the population trajectory over a generational scale; and/or the impact would lead to permanent effects on individuals that may influence individual survival but not at a level that would alter population trajectory over a generational scale. (Adverse).
	Benefit to the habitat influencing foraging efficiency resulting in increased reproductive potential and increased population health and size. (Beneficial).
Low	The magnitude of the impact would result in some measurable change in attributes, quality or vulnerability (e.g. a threshold shift in hearing), or minor loss, or detrimental alteration to, one (maybe more) key characteristics, features or elements of the species at an individual level (e.g. interruption of feeding or breeding) but is unlikely to be measurable at a population level. (Adverse).
	Minor benefit to, or addition of, one (maybe more) key characteristics, features or elements; some beneficial impact on attribute (e.g. enhance foraging opportunities) but is unlikely to be measurable at a population level, or a reduced risk of negative impact occurring. (Beneficial).
Negligible	The magnitude of the impact would result in a very minor, temporary loss or detrimental alteration to one or more characteristics, features or elements of the species at an individual level which would not affect the population. (Adverse).
	Very minor benefit to, or positive addition of one or more characteristics, features or elements of the species at an individual level but which would not benefit the species at a population level. (Beneficial).

4.6.2.4 The criteria for defining sensitivity in this chapter are outlined in Table 4.14 below. The sensitivity of marine mammal IEFs has been defined by an assessment of the ability of a receptor to adapt to a given impact, its resilience to that impact and its ability to recover back to pre-impact conditions.

4.6.2.5 Resilience is the ability to withstand a perturbation or disturbance by resisting damage. Recoverability is the ability of the same species to return to a state close to that which existed before the activity or event which caused change. It is dependent on the ability of the individuals to recover following cessation of the activity that causes the impact.

4.6.2.6 Information on these aspects of sensitivity of the marine mammal IEFs to given impacts has been informed by the best available evidence from scientific research on marine mammals (studies on captive animals as well as observations from field studies). In particular, evidence from field studies of marine mammals during the construction and operation of offshore wind farms (and analogous activities such oil and gas surveys) has been used to inform this impact assessment. The review of tolerance and recoverability of marine mammal IEFs has been combined to provide an overall evaluation of the sensitivity of a receptor to an impact as outlined in Table 4.14.

Table 4.14: Definition of terms relating to the sensitivity of the receptor.

Sensitivity of the Receptor	Description
Very High	No ability to adapt behaviour so that survival and reproduction may be affected. No resilience; effect is very likely to cause a change in both reproduction and survival of individuals. No ability for the animal to recover from the effect. A receptor is of very high sensitivity where adverse effects on multiple key ecological functions (e.g. feeding, breeding, nursing) could occur with no resilience and no potential for recovery such that reproduction and survival of individuals would be affected.
High	Limited ability to adapt behaviour so that survival and reproduction may be affected. Limited resilience; effect may cause a change in both reproduction and survival of individuals. Limited ability for the animal to recover from the effect. A receptor is of high sensitivity where adverse effects on multiple key ecological functions (e.g. feeding, breeding, nursing) could occur with limited resilience and limited potential for recovery such that reproduction or survival of individuals could be affected.
Medium	Ability to adapt behaviour so that reproduction may be affected but survival rates not likely to be affected. Some resilience; effect unlikely to cause a change in both reproduction and survival rates. Ability for the animal to recover from the effect. A receptor is of medium sensitivity where adverse effects on one or more key ecological functions (e.g. feeding, breeding, nursing) could be sustained beyond the duration of the impact (some resilience to the effect) but not at a level that would affect individual survival although reproductive success may be affected until the individual has recovered (ability to recover).
Low	Receptor is able to adapt behaviour so that survival and reproduction are not affected. Receptor is able to tolerate the effect without any impact on reproduction and survival rates. Receptor is able to return to previous behavioural states/activities once the impact has ceased. Low sensitivity is such that adverse effects on ecological functions (e.g. feeding, breeding, nursing) are likely to be very short term and would not affect reproductive success or individual survival.
Negligible	Very little or no effect on the behaviour of the receptor.

4.6.2.7 The significance of the effect upon marine mammals is determined by correlating the magnitude of the impact and the sensitivity of the receptor. The particular method employed for this assessment is presented in Table 4.15. Where a range of significance of effect is presented in Table 4.15, the final assessment for each effect is based upon expert judgement. As per Guidelines for Ecological Impact Assessment in the UK and Ireland (CIEEM, 2018), significant effects are considered with regard to impacts on the structure and function of defined sites, habitats or ecosystems and the conservation status of habitats and species (including extent, abundance and distribution), where for a species "*the conservation status is determined by the sum of influences acting on the species concerned that may affect its abundance and distribution within a given geographical area*" (CIEEM, 2018). Assessment of potential significant effects provided in section 4.1 is quantified with reference to appropriate geographic scales (e.g. species-specific MUs).

4.6.2.8 In some cases the matrix suggests a range for the significance of effect (i.e. the range is given as minor to moderate) (Table 4.15). In such cases the final significance is based upon the expert's professional judgement as to which outcome delineates the most likely effect, with an explanation as to why this is the case.

4.6.2.9 For the purposes of this assessment, any potential effects with a significance level of minor or less have been concluded to be not significant in terms of The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017. A level of effect of moderate or more will be considered significant in terms of the EIA Regulations.

Table 4.15: Matrix used for the assessment of the significance of the effect.

Sensitivity of Receptor	Magnitude of Impact			
	Negligible	**Low**	**Medium**	**High**
Negligible	Negligible	Negligible or Minor	Negligible or Minor	Minor
Low	Negligible or Minor	Negligible or Minor	Minor	Minor or Moderate
Medium	Negligible or Minor	Minor	Moderate	Moderate or Major
High	Minor	Minor or Moderate	Moderate or Major	Major
Very High	Minor	Moderate or Major	Major	Major

4.6.3 Designated sites

4.6.3.1 Where National Site Network sites (i.e. internationally designated sites) are considered, this chapter summarises the assessments made on the interest features of internationally designated sites as described within section 4.5.1 of this chapter (with the assessment on the site itself deferred to the HRA Stage 2 ISAA (Document Reference E1.1)). With respect to nationally and locally designated sites, where these sites fall within the boundaries of an internationally designated site (e.g. Site of Special Scientific Interest (SSSIs) which have not been assessed within the HRA Stage 2 ISAA (Document Reference E1.1)) only the international site has been taken forward for assessment. This is because potential effects on the integrity and conservation status of the nationally designated site are assumed to be inherent within the assessment of the internationally designated site (i.e. a separate assessment for the national site is not undertaken).

4.6.3.2 The HRA Stage 2 ISAA (Document Reference E1.1) has been prepared in accordance with Advice Note Ten: Habitats Regulations Assessment Relevant to Nationally Significant Infrastructure Projects (The Planning Inspectorate, 2022).

4.7 Key parameters for assessment

4.7.1 Maximum design scenario

4.7.1.1 The MDS identified in Table 4.16 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. These scenarios have been selected from the Project Design Envelope (PDE) provided Volume 1, Chapter 3: Project description of the Environmental Statement. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the Project Design Envelope (e.g. different infrastructure layout), to that assessed here be taken forward in the final design scheme.

Table 4.16: Maximum design scenario considered for the assessment of potential impacts on marine mammals.

[a] C=construction, O=operations and maintenance, D=decommissioning.

Potential impact	Phase[a] C	O	D	Maximum design scenario	Justification
Injury and disturbance from underwater sound generated from piling	✓	×	×	**Construction phase:** **Maximum temporal scenario:** Single piling at up to 78 locations comprising: up to 64 wind turbines (four-legged jacket foundations); up to four OSPs (four-legged jacket foundations); and up to 10 Gravity Base Foundations (GBFs) (which require strengthening pin piles). Total of up to 114 days of piling (up to 64 days for wind turbines, up to 38 days for GBFs and up to 12 days for OSP foundations) estimated as follows: • **wind turbines**: – Installation of up to 64 four-legged jacket foundations (with one driven pin pile per leg) = a total of up to 256 pin piles – Each pin pile with a diameter of 3.8 m installed by impact piling – Maximum hammer energy of 4,400 kJ for up to 16 locations and 3,000 kJ for up to 48 locations – Average duration of up to 4.5 hours piling per pin pile, with a maximum of one foundation (four pin piles) per day = cumulative total of up to 64 days (64 foundations x four legs x one pin pile per leg x 4.5 hours duration per pin pile = up to 1,152 hours) • **GBFs** – Installation of up to 32 GBFs, up to 10 of which could require piling for ground strengthening. A total of up to 15 pin piles per GBF each with maximum 4 m diameter, leading to a total of up to 150 driven pin piles. – Maximum hammer energy of 3,000 kJ (for up to 10 GBFs that require piling). – Average duration of up to 4 hours per pin pile, leading to a maximum cumulative total of up to 600 hours of piling (10 GBFs x 15 pin piles x 4 hours duration per pin pile = up to 600 hours) over 38 days (limited by 4 pin piles per day)	The **maximum temporal scenario** was assessed on the greatest number of days on which piling could occur based on the number of pin piles that could be installed within a 24-hour period (four per day). Of the total of up to 96 WTG locations there would be a maximum of up to 64 jackets and the remaining 32 would be gravity bases, of which up to 10 may require piling to strengthen the foundations. Consecutive piling is assumed over a maximum period of 24 hours. For the **maximum spatial scenario** the largest hammer energy and maximum spacing between concurrent piling events would lead to the largest spatial extent of ensonification at any one time. The Applicant has committed to not using the maximum hammer energy (4,400 kJ) at two concurrent locations and therefore only a 3,000 kJ + 3,000 kJ scenario has been modelled. Minimum spacing between **concurrent piling** represents the **highest risk of injury** to marine mammals as sound from adjacent foundations could combine to produce a greater radius of effect compared to a single piling event. Maximum spacing between concurrent piling represents the highest risk of potential behavioural effects to marine mammals as a larger area would be ensonified at any one time.

Potential impact	Phase[a] C	O	D	Maximum design scenario	Justification
				• **OSPs** – Installation of up to four OSPs with four-legged jacket foundations, with three pin piles per leg = 12 pin piles per OSP = a total of up to 48 driven pin piles) – Each pin pile with a diameter of 3.5 m installed by impact piling – Maximum hammer energy of up to 4,400 kJ – Average duration of up to 4.5 hours piling per pin pile with a cumulative total of up to 216 hours; installation of OSPs over a maximum of 12 days (limited by four pin piles per day). **Maximum spatial scenario:** Concurrent piling at a maximum energy of 3,000 kJ with two vessels, at a minimum separation distance of 1.4 km and a maximum separation distance of 15 km. Only concurrent piling at a maximum hammer energy of 3,000 kJ (i.e. no concurrent piling where a 4,400 kJ hammer is required). Concurrent piling will only occur at wind turbine jacket foundations; GBFs and OSP foundations will be installed using a single vessel. Total piling phase (foundation installation) of up to two years within a four-year construction programme.	
Injury and disturbance from elevated underwater sound generated from site investigation survey sources	✓	×	×	**Construction phase** Geophysical site investigation activities include: • Multi Beam Echosounder (MBES): 200 to 500 kHz; 180 to 240 dB re 1 µPa re 1 m (SPL_{rms}) • Sidescan Sonar (SSS): 200 to 700 kHz; 216 to 228 dB re 1µPa re 1 m (SPL_{rms}) • Single Beam Echosounder (SBES): 20 to 400 kHz; 180 to 240 dB re 1 µPa re 1 m (SPL_{rms}) • Sub-Bottom Profilers (SBP): – Chirp: 0.2 to 14 kHz; 200 to 240 dB re 1 µPa re 1 m (SPL_{rms}) – Pinger: 2 to 7 kHz; 200 to 235 dB re 1 µPa re 1 m (SPL_{rms})	Range of geophysical and geotechnical activities likely to be undertaken using equipment typically employed for these types of surveys. Parameters chosen resulted in the greatest range of impact (e.g. highest source, fastest pulse rate, longest pulse duration) and as such were those that would lead to the greatest spatial extent for potential injury or disturbance.

Potential impact	Phase[a] C	O	D	Maximum design scenario	Justification
				• Sparker (as an example of Ultra High Resolution Seismic (UHRS)): 0.05 to 4 kHz; 219 dB re 1 μPa re 1 m (SPL_{pk}); 182 dB re 1 μPa^{2}s SEL; 170 to 200 dB re 1 μPa re 1 m (SPL_{rms}) Geotechnical site investigation activities include: • Borehole drilling • CPTs • Vibrocoring. Pre-construction site investigation surveys will involve the use of several geophysical/geotechnical survey vessels and take place over a period of up to eight months.	
Injury and disturbance from underwater sound generated from unexploded ordnance (UXO) detonation	✓	×	×	**Construction phase** • Clearance of up to 13 UXO within the Morgan Array Area • A range of UXO sizes assessed from 25 kg up to 907 kg (absolute maximum) with 130 kg the most likely (common) maximum. • For high order detonation donor charges of 1.2 kg (most common) and 3.5 kg (single barracuda blast charge). • Up to 0.5 kg net explosive quantity (NEQ) clearance shot for neutralisation of residual explosive material at each location. • Clearance during daylight hours only. MDS is for high order clearance but assessment also considered: • Low order clearance charge size of 0.08 kg • Low yield clearance configurations of 0.75 kg charges (up to four x 0.75 kg).	Estimated maximum number and maximum size of UXOs encountered in the Morgan Array Area. Due to uncertainties in size of UXOs the assessment presents a range of UXO sizes assessed (from 25 kg up to an absolute maximum of 907 kg), highlighting 130 kg is the most likely (common) size. Most common (1.2 kg) and maximum donor charges assessed for high order detonation. Assumption of a clearance shot of up to 0.5 kg at all locations although noting that this may not always be required. For the assessment of low order/low yield clearance, charges are based on the maximum required to initiate clearance event.
Injury and disturbance from vessel use and other (non-piling) sound producing activities	✓	✓	✓	**Construction phase** **Vessels** • Up to a total of 69 construction vessels on site at any one time (22 main installation and support vessels, eight tug/anchor handlers, seven cable lay installation and support vessels, one guard vessel, six survey vessels, eight seabed preparation vessels, 12 Crew	The maximum design scenario considers the maximum number of vessels on site at any one time and greatest number of round trips during each phase of the Morgan Generation Assets. This represents the broadest range of vessel types and therefore sound signatures within the marine environment to affect marine mammal receptors.

Potential impact	Phase[a]			Maximum design scenario	Justification
	C	O	D		
				Transfer Vessels (CTVs), three scour protection installation vessels and two cable protection installation vessels) • Up to a total of 1,929 installation vessel movements (return trips) during construction (521 main installation and support vessels, 74 tug/anchor handlers, 56 cable lay installation and support vessels, 50 guard vessel, 31 survey vessels, 19 seabed preparation vessels, 1,135 CTVs, 41 scour protection installation vessels and two cable protection installation vessels) **Other activities:** • Up to 100% of overall pin piles are anticipated to require drilling (up to 64, four-legged wind turbine jacket foundations with a diameter of 3.8 m and four x four-legged OSP jacket foundations with a diameter of 3.5 m), up to two concurrent drilling vessels • Burial of up to 390 km of inter-array cables and 60 km of interconnector cables via ploughing, trenching and jetting; protection of up to 39 km of inter-array cables and 12 km of interconnector cables via rock dump and mattressing. Maximum offshore construction duration of up to four years. **Operations and maintenance phase** • Up to a total of 16 operations and maintenance vessels on site at any one time (five CTVs/workboats, three jack-up vessels, three cable repair vessels, four Service Operation Vessels (SOV) or similar and one excavator/backhoe dredger) • Up to a total of 719 operations and maintenance vessel movements (return trips) each year (608 CTVs/workboats, 25 jack-up vessels, 6 cable repair vessels, 78 SOVs or similar and two excavators/backhoe dredgers) • Operational lifetime of up to 35 years. **Decommissioning phase** • Vessels used for a range of decommissioning activities such as removal of foundations (e.g. using cutting tools) • Sound from vessels assumed to be as per vessel activity described for construction phase above.	The maximum design scenario considers the maximum durations for which activities could be conducted.

Potential impact	Phase[a]			Maximum design scenario	Justification
	C	O	D		
Injury and disturbance from underwater sound generated from wind turbine operation	×	✓	×	**Operations and maintenance phase** Up to 64 foundations at the largest wind turbine size.	The maximum design scenario considers the largest size of potential wind turbines for the Morgan Generation Assets as wind turbine size is the main factor influencing the sound from operational wind farms and this represents the potential for highest underwater sound levels.
Injury due to increased risk of collision with vessels	✓	✓	✓	**Construction phase** As described for vessel disturbance above. **Operations and maintenance phase** As described for vessel disturbance above. **Decommissioning phase** As described for vessel disturbance above.	The maximum design scenario considers the maximum number of vessels on site at any one time and largest numbers of round trips during each phase of the Morgan Generation Assets. This represents the broadest range of vessel types and movements, and therefore greatest potential for collision risk.
Effects on marine mammals due to changes in prey availability	✓	✓	✓	**Construction phase** As described in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement for: • Temporary habitat loss/disturbance • Long term habitat loss • Increased SSC and associated sediment deposition • Disturbance/remobilisation of sediment-bound contaminants • Underwater sound during the construction phase impacting fish and shellfish receptors. **Operations and maintenance phase** As described in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement for: • Temporary habitat loss/disturbance • Long term habitat loss • Increased SSC and associated sediment deposition • Disturbance/remobilisation of sediment-bound contaminants	As described in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement.

Potential impact	Phase[a]			Maximum design scenario	Justification
	C	O	D		
				• EMF from subsea electrical cabling • Colonisation of hard structures. **Decommissioning phase** As described in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement for: • Temporary habitat loss/disturbance • Long term habitat loss • Increased SSC and associated sediment deposition • Disturbance/remobilisation of sediment-bound contaminants.	

4.8 Measures adopted as part of the Morgan Generation Assets

4.8.1.1 For the purposes of the EIA process, the term 'measures adopted as part of the project' is used to include the following measures (adapted from Institute of Environmental Management and Assessment (IEMA), 2016):

- Measures included as part of the project design. These include modifications to the location or design envelope of the Morgan Generation Asset which are integrated into the application for consent. These measures are secured through the consent itself throughout the description of the development and the parameters secured in the DCO and/or marine licence (referred to as primary mitigation in IEMA, 2016)
- Measures required to meet legislative requirements, or actions that are standard practice used to manage commonly occurring environmental effects and are secured through the DCO requirements and/or marine licence (referred to as tertiary mitigation in IEMA, 2016).

4.8.1.2 A number of measures (primary and tertiary) will be adopted as part of the Morgan Generation Assets to reduce the potential for impacts on marine mammals. These are outlined in Table 4.17 below. As there is a secured commitment to implementing these measures, they are considered inherently part of the design of the Morgan Generation Assets and have therefore been considered in the assessment presented in section 4.8 below (i.e. the determination of magnitude and therefore significance assumes implementation of these measures).

4.8.1.3 Where significant effects have been identified, further mitigation measures (referred to as secondary mitigation in IEMA 2016) have been identified to reduce the significance of effect to acceptable levels following the initial assessment. These are measures that could further prevent, reduce and, where possible, offset any adverse effects on the environment. These measures are set out in Table 4.17 below.

4.8.1.4 The Morgan Generation Assets design has changed from the PEIR to the Environmental Statement, including a reduction in the number of wind turbines from 107 to 96. The number of wind turbines has been reduced by approximately 10% subsequently reducing the number of foundations that require piling. Monopile foundations (as presented in the PEIR) have also been removed from the Project Design Envelope, and pin piles only have been considered in the Environmental Statement. As such, the maximum hammer of 5,500 kJ (presented in the PEIR for monopiles) has not been taken forward to the Environmental Statement. A proportion of hammer energy is converted into waterborne acoustic energy going into the water column. A proportion of hammer energy is converted into waterborne acoustic energy going into the water column and the resultant sound levels received by marine mammals are influenced by a number of factors, including hammer energy and duration of piling. The removal of monopile foundations and the maximum hammer energy of 5,500 kJ from the design envelope has reduced the range at which instantaneous auditory injury could occur to all marine mammal species from peak received sound pressure levels (SPL_{pk}). The removal of monopile foundations and the associated maximum hammer energy of 5,500 kJ from the design envelope has reduced the range at which cumulative (SEL_{cum}) auditory injury could occur for Very High Frequency (VHF) cetacean species (e.g. harbour porpoise), High Frequency (HF) cetacean species (e.g. bottlenose dolphin, short-beaked common dolphin, Risso’s dolphin) and pinniped species (e.g. grey seal, harbour seal). For Low Frequency (LF) species (e.g. minke whale) the removal of monopiles, and associated increase in piling duration has resulted in a slight increase in the range at which received SEL_{cum} could occur.

Table 4.17: Measures adopted as part of the Morgan Generation Assets.

Measures adopted as part of the Morgan Generation Assets	Justification	How the measure will be secured
Primary measures: Measures included as part of the project design		
Development of and adherence to a Marine Mammal Mitigation Protocol (MMMP) which will be developed in accordance with the Outline MMMP (Document Reference J17) that requires implementation of an initiation stage of a piling soft start and ramp-up.	This measure will minimise the likelihood of injury from elevated underwater sound to marine mammal and fish species in the immediate vicinity of piling operations, allowing individuals to move away from the area before sound levels reach a level at which injury may occur. Compliance with these guidelines will, in most cases, reduce the likelihood of injury to marine mammals to negligible levels.	MMMP secured in the deemed marine licences within the draft DCO (Document Reference C1).
Development and adherence to a MMMP (to be developed in accordance with the Outline MMMP (Document Reference J17)) which sets a maximum separation limit of 15 km for concurrent piling.	Commitments made around maximum separation during concurrent piling will minimise the likelihood of disturbance to marine mammal and fish species in the immediate vicinity of piling operations, by limiting the ensonified area during concurrent piling. Where piling occurs concurrently a maximum separation distance of 15 km is used to limit received sound levels by reducing the area of overlapping sound emission from each of the piling activities.	MMMP secured in the deemed marine licences within the draft DCO (Document Reference C1).
Development and adherence to a MMMP (to be developed in accordance with the Outline MMMP (Document Reference J17)) which sets a minimum separation limit of 1.4 km for concurrent piling.	Commitments made around minimum separation during concurrent piling will minimise the likelihood of injury to marine mammal and fish species in the immediate vicinity of piling operations, by limiting the spatial overlap of areas of ensonification during concurrent piling. Where piling occurs concurrently, a minimum separation distance of 1.4 km is used to minimise the potential for additive effects due to direct overlap of concurrent piling.	MMMP secured in the deemed marine licences within the draft DCO (Document Reference C1).
Development and adherence to a MMMP (to be developed in accordance with the Outline MMMP (Document Reference J17)) which sets the limit on maximum hammer energy used during concurrent piling at 3,000 kJ and during the single event piling at 4,400 kJ.	Commitments made around concurrent piling will minimise the likelihood of injury to marine mammal and fish species in the immediate vicinity of piling operations, by reducing the ensonified area during concurrent piling.	MMMP secured in the deemed marine licences within the draft DCO (Document Reference C1).

Measures adopted as part of the Morgan Generation Assets	Justification	How the measure will be secured
Development and adherence to a MMMP (to be developed in accordance with the Outline MMMP (Document Reference J17) that requires implementation of a mitigation hierarchy with regard to UXO clearance that follows: • Avoid UXO • Clear UXO with low order techniques • Clear UXO with high order techniques. Low order techniques or avoidance of confirmed UXO are not always possible and are dependent upon the individual situations surrounding each UXO. Inclusion of low order techniques has been considered as a clearance option. Where detonation of UXO using low order techniques occurs this is considered to be primary mitigation noting, however, that it is not possible to fully commit to this measure at this stage. A more detailed assessment of mitigation will be undertaken post-consent as further information becomes available to inform the Outline MMMP (Document Reference J17) included in the Outline UWSMS (Document Reference J13).	Low order techniques generate less underwater sound than high order techniques and therefore present a lower risk to sound-sensitive receptors such as marine mammals during UXO clearance. Noting the position statement from statutory authorities on UXO clearance (DEFRA, 2021), the option to clear UXOs with low order techniques has been considered as a potential primary mitigation measure as part of this assessment. Note, however, that low order techniques are not always possible and are dependent upon the individual situations surrounding each UXO and its individual condition state. Given that it is possible that high order detonation may be used, the Outline MMMP (Document Reference J17) includes mitigation to reduce the likelihood of injury from UXO clearance. Please see below. The Outline underwater sound management strategy (Document Reference J13) includes potential further mitigation options, should the measures in the MMMP (Document Reference J17) not reduce impacts, such that there will be no residual significant effect from the project alone. Please see below.	MMMP secured in the deemed marine licences within the draft DCO (Document Reference C1).
Tertiary measures: Measures required to meet legislative requirements, or adopted standard industry practice		
Development of and adherence to an Outline MMMP (Document Reference J17), as an annex to the Outline Underwater sound management strategy (Document Reference J13) will be submitted alongside the Environmental Statement. The Outline MMMP will present appropriate mitigation for activities that could potentially lead to injurious effects on marine mammals including: piling, UXO clearance and some types of geophysical activities. The Outline MMMP will be developed on the basis of the most recent published statutory guidance and in consultation with key stakeholders. <u>Piling</u>: for the purpose of developing the MMMP (Document Reference J17), an annex to the underwater sound management strategy (Document Reference J13), a mitigation zone will be defined based on the maximum predicted injury range from the	The implementation of an approved MMMP (Document Reference J17) will mitigate for the risk of physical or permanent auditory injury to marine mammals within a pre-defined 'mitigation zone' for each activity. The mitigation zone is determined considering the largest injury zone across all species for each relevant activity. The use of an approved Outline MMMP minimises the potential for collision risk, or potential injury to, marine mammals and other marine megafauna (e.g. basking shark and sea turtles). The Outline MMMP (Document Reference J17) includes visual and acoustic monitoring as a minimum over the defined mitigation zones to ensure animals are clear before the activity commences. Additional measures to deter animals	MMMP secured in the deemed marine licences within the draft DCO (Document Reference C1).

Measures adopted as part of the Morgan Generation Assets	Justification	How the measure will be secured
dual metric sound modelling for the maximum spatial scenario (pin piles) and across all marine mammal species. The Outline MMMP sets out the measures to apply in advance of and during piling activity including the use of: • Marine Mammal Observers (MMOb) • Passive Acoustic Monitoring (PAM) • Acoustic Deterrent Devices (ADD) Therefore following the latest JNCC guidance (JNCC, 2010a). UXO clearance: Measures including visual and acoustic monitoring, the use of an ADD and soft start charges will be applied to deter animals from the mitigation zone as defined by sound modelling for the largest possible UXO following the latest JNCC guidance (JNCC, 2010b). Geophysical surveys Mitigation for injury during high resolution geophysical surveys using a sub-surface sensor from a conventional vessel will involve the use of MMOs and PAM to ensure that the risk of injury over the defined mitigation zone is reduced in line with JNCC guidance (JNCC, 2017). Soft start is not possible for SBP equipment but will be applied for other high resolution surveys where possible. Note also, some multi-beam surveys in shallow waters (<200 m) are not subject to the Development of and adherence requirements of mitigation.	from injury risk zones may be applied in some instances (e.g. ADDs or soft start charges). The MMMP will be developed on the basis of the most recent published statutory guidance and in consultation with key stakeholders.	
Development of and adherence to an Underwater sound management strategy that includes consideration of Noise Abatement Systems (NAS) as part of mitigation options, which will be developed in accordance with the Outline underwater sound management strategy (Document Reference J13), will be made as part of a stepped strategy post consent and following the mitigation hierarchy - avoid, reduce, mitigate.	To mitigate for the likelihood of physical or permanent auditory injury to marine mammals.	Underwater Sound Management Strategy secured in the deemed marine licences within the draft DCO (Document Reference C1).
Development of and adherence to an Offshore Environmental Management Plan (EMP) with measures to minimise disturbance	To minimise the potential for collision risk, or potential injury to, marine mammals and megafauna.	The measures to minimise disturbance to marine mammals and rafting birds from transiting vessels (Document

Measures adopted as part of the Morgan Generation Assets	Justification	How the measure will be secured
to marine mammals and rafting birds from transiting vessels, requiring them to: • Not deliberately approach marine mammals as a minimum • Avoid abrupt changes in course or speed should marine mammals approach the vessel to bow-ride, where appropriate and possible taking into account all technical considerations. The Offshore EMP will include a commitment that the site induction processes will incorporate the principles of the Wildlife Safe (WiSe) Scheme to ensure that key personnel are aware of the need to follow the WiSe Code of Conduct. The WiSe Scheme (https://www.wisescheme.org/), which is a UK national training scheme for minimising disturbance to marine life, key measures from the scheme will reduce the disturbance of vessel transits on marine mammals and rafting birds visible at the water surface, or as otherwise agreed with the Statutory Nature Conservation Bodies (SNCBs).		Reference J15) will be included within the Offshore EMP which is secured in the deemed marine licences within the draft DCO (Document Reference C1).
Development of, and adherence to an Offshore EMP that will include a MPCP which will include planning for accidental spills, address all potential contaminant releases and include key emergency details.	To ensure that the potential for release of pollutants during construction, operations and maintenance, and decommissioning phases are minimised. These will likely include designated areas for refuelling where spillages can be easily contained, storage of chemicals in secure designated areas in line with appropriate regulations and guidelines, double skinning of pipes and takes containing hazardous substances, and storage of these substances in impenetrable bunds. The MPCP will ensure that in the unlikely event that a pollution event occurs, that plans are in place to respond quickly and effectively to ensure any spillage is minimised and potential effects on the environment are ideally avoided or minimised. Implementation of these measures will ensure that accidental release of contaminants from vessels will be avoided or minimised, thus providing protection for marine life across all phases of the Morgan Generation Assets.	Offshore EMP secured in the deemed marine licences within the draft DCO (Document Reference C1).

Measures adopted as part of the Morgan Generation Assets	Justification	How the measure will be secured
Development of, and adherence to, a Decommissioning Plan in accordance with the Energy Act 2004 A Decommissioning Programme is required under the provisions of the Energy Act 2004 and this must be approved by the Secretary of State before works commence.	The aim of this plan is to adhere to the existing UK legislation and guidance. Overall, this will ensure the legacy of the Morgan Generation Assets will result in the minimum amount of long-term disturbance to the environment. While this measure has been committed to as part of the Morgan Generation Assets, the MDS for the decommissioning phase has been considered in each of the impact assessments presented in section 4.9.	Legal obligation of the Energy Act 2004 and secured within the draft DCO (Document Reference C1).

4.9 Assessment of significant effects

4.9.1.1 The potential impacts of the construction, operations and maintenance, and decommissioning phases of the Morgan Generation Assets were assessed on marine mammals. The potential impacts arising from the construction, operations and maintenance and decommissioning phases of the Morgan Generation Assets are listed in Table 4.16, along with the MDS against which each impact has been assessed.

4.9.1.2 A description of the potential effect on marine mammal receptors caused by each identified impact is given below.

4.9.1 Underwater sound and marine mammals

4.9.1.1 Marine mammals, in particular cetaceans, are capable of generating and detecting sound (Au *et al.,* 1974; Bailey *et al*., 2010). They are dependent on sound for many aspects of their lives (i.e. prey identification; predator avoidance; communication and navigation). Increases in anthropogenic sound may consequently lead to a potential effect within the marine environment (Parsons *et al*., 2008; Bailey *et al*., 2010), and potential effects on marine mammals.

4.9.1.2 Four zones of influence have been described by Richardson *et al*. (1995), and these vary with the distance from the source, including: audibility (sound is detected); masking (interfere with detection of sounds and communication); responsiveness (behavioural or physiological response) and injury/hearing loss (tissue damage in the ear). This assessment considers the zones of injury (auditory) and disturbance (i.e. responsiveness). There is insufficient scientific evidence to properly evaluate masking and no relevant threshold criteria to enable a quantitative assessment. The relevant thresholds for onset of potential effects, and the evidence base from which they are derived, are given below.

Injury

4.9.1.3 Auditory injury in marine mammals, which is often described in terms of a hearing threshold shift, can either be temporary (TTS), where an animal's auditory system can recover or permanent (PTS), where there is no hearing recovery in the animal. The 'onset' of TTS is deemed to be where there is a temporary elevation in the hearing threshold by 6 dB and is "*the minimum threshold shift clearly larger than any day to day or session to session variation in a subject's normal hearing ability*", and which "*is typically the minimum amount of threshold shift that can be differentiated in most experimental conditions*" (Southall *et al*., 2007). Since it is considered unethical to conduct experiments measuring PTS in animals, the onset of PTS was extrapolated from early studies on TTS growth rates in chinchillas (Henderson and Hamernick, 1986) and is conservatively considered to occur where there is 40 dB of TTS (Southall *et al*., 2007). Whether such shifts in hearing would lead to loss of fitness will depend on several factors including the frequency range of the shift and the duty cycle of impulsive sounds. For example, if a shift occurs within a frequency band that lays outside of the main hearing sensitivity of the receiving animal there may be a 'notch' in this band, but potentially no effect on the animal's ability to survive. Further discussion on the sensitivity of marine mammals to hearing shifts is provided later in this assessment.

4.9.1.4 Potential auditory injury is assessed in terms of PTS given the irreversible nature of the effect, unlike TTS which is temporary and reversible. Animals (particularly highly mobile species) exposed to sound levels that could induce TTS are likely to respond by moving away from ("fleeing") the ensonified area and therefore avoiding potential injury. It is considered there is a behavioural response (disturbance) that overlaps with potential TTS ranges. Since derived thresholds for the onset of TTS are based on the smallest measurable shift in hearing, TTS thresholds are likely to be very precautionary and could result in overestimates of TTS ranges.

4.9.1.5 In addition, the assumptions and limitations of underwater sound modelling (e.g. equal energy rule, reduced sound levels near the surface, conservative swim speeds, and use of impulsive sound thresholds at large ranges; see paragraph 4.9.1.39) also lead to an overestimation of ranges. Notably, Hastie *et al*. (2019) found that during pile driving there were range dependent changes in signal characteristics with received sound losing its impulsive characteristics at ranges of several kilometres, especially beyond 10 km. As such, TTS is not considered a useful predictor of the potential effects of underwater sound on marine mammals where ranges exceed more than c. 10 km and therefore, where this is the case (i.e. piling and UXO clearance), TTS is not included in the assessment of significance for injury. To support this reasoning a synthesis of the use of impulsive sound thresholds at large ranges is presented Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement. Ranges for TTS were, however, modelled for completeness for all potential sound-related impacts and are presented in Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement.

4.9.1.6 For marine mammals, injury thresholds are based on both peak sound pressure levels (SPL_{pk}) (i.e. un-weighted) and marine mammal hearing-weighted cumulative sound exposure level (SEL_{cum}) as per the latest guidance (Southall *et al.*, 2019) (Table 4.18). The marine mammal hearing-weighted categories are based on the frequency characteristics (bandwidth and sound level) for each group within which acoustic signals can be perceived and therefore assumed to have potential auditory effects (Table 4.18).

4.9.1.7 To calculate distances using the SEL_{cum} metric the sound modelling assessment made a simplistic assumption that an animal would be exposed over the duration of the piling activity and that there would be no breaks in activity during this time. It was assumed that an animal would swim away from the sound source at the onset of activity at a constant rate and subsequently, conservative species-specific swim speeds were incorporated into the model summarised in

4.9.1.8 Table 4.19, (further detail is presented in Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement).

Table 4.18: Criteria for assessing injury to marine mammals from impulsive and non-impulsive sound based on different hearing groups.

Hearing Group	Species	Parameter	Impulsive	Non-impulsive
Low Frequency (LF) cetaceans	Baleen whales	SPL_{pk}, unweighted	219	-
		SEL_{cum}, LF weighted	183	199
High Frequency (HF) cetaceans	Dolphins, toothed whales and beaked whales	SPL_{pk}, unweighted	230	-
		SEL_{cum}, HF weighted	185	198
Very High Frequency (VHF) cetaceans	True porpoises, sperm whales and some oceanic dolphins	SPL_{pk}, unweighted	202	-
		SEL_{cum}, VHF weighted	155	173

Hearing Group	Species	Parameter	Impulsive	Non-impulsive
Pinnipeds in water (PCW)	True seals	SPL_{pk}, unweighted	218	-
		SEL_{cum}, PCW weighted	185	201

Table 4.19: Assessment swim speeds of marine mammals that are likely to occur within the Irish Sea for the purpose of exposure modelling for the Morgan Generation Assets.

Species	Hearing group	Swim speed (m/s)	Source reference
Harbour porpoise	VHF	1.5	Otani *et al.* (2000)
Bottlenose dolphin	HF	1.52	Bailey *et al.* (2010)
Short-beaked common dolphin			
Risso's dolphin			
Minke whale	LF	2.3	Boisseau *et al.* (2021)
Grey seal	PCW	1.8	Thompson *et al.* (2015)
Harbour seal			

Disturbance

4.9.1.9 Beyond the zone of injury, sound levels are such that auditory or physical injury is less likely to occur but can result in disturbance to marine mammal behaviour. A marine mammal's response to disturbance will depend on the individual and the context; previous experience and acclimatisation will affect whether an individual exhibits an aversive response to sound, particularly in an area with high sound levels related to human activities. The United States (US) NMFS (NMFS, 2005) define strong disturbance in all marine mammals as Level B harassment and for impulsive sound suggests a threshold of 160 dB re 1 μ Pa SPL (root mean square (rms)). This threshold meets the criteria defined by JNCC (2010a) as a 'non-trivial' (i.e. significant) disturbance and is equivalent to the Southall *et al*. (2007) severity score of five or more on the behavioural response scale. Beyond this threshold the behavioural responses are likely to become less severe (e.g. minor changes in speed, direction and/or dive profile, modification of vocal behaviour and minor changes in respiratory rate (Southall *et al*., 2007)). The NMFS (2005) guidelines suggest a precautionary level of 140 dB re 1 μPa (SPL_{rms}) to indicate the onset of low-level marine mammal disturbance effects for all mammal groups for impulsive sound (NMFS, 2005), although this is not considered likely to lead to a 'significant' disturbance response. This NMFS (2005) guidance is based on thresholds above which strong or mild disturbance could occur and has been widely applied to UK offshore wind farm assessments. However, there have been further studies using empirical evidence from data gathered in the field which demonstrate a proportional disturbance response of animals corresponding to decreasing levels of received sound moving further away from the source.

4.9.1.10 Therefore, both proportional response and evidence-based threshold approaches have been applied to the assessment and these are discussed in more detail below.

Proportional response ('dose-response')

4.9.1.11 Empirical evidence from monitoring at offshore wind farms during construction suggests that pile driving is unlikely to lead to 100% avoidance of all individuals exposed, and that there will be a proportional decrease in avoidance at greater distances from the pile driving source (Brandt *et al*., 2011). This was demonstrated at Horns Rev Offshore Wind Farm, where 100% avoidance occurred in harbour porpoises at up to 4.8 km from the piles, whilst at greater distances (10 km plus) the proportion of animals displaced reduced to <50% (Brandt *et al*., 2011). Similarly, Graham *et al*. (2019) used empirical evidence collected during piling at the Beatrice Offshore Wind Farm (Moray Firth, Scotland) to demonstrate that the probability of occurrence of harbour porpoise (measured as porpoise positive minutes) increased exponentially moving further away from the sound source. Importantly, Graham *et al*. (2019) demonstrated that the response of harbour porpoise to piling diminished over the piling phase such that, for a given received sound level or at a given distance from the source, there were more detections of animals at the last piling location compared to the first piling location (Figure 4.5). Therefore 'dose response' curves can be more representative of actual animal response in the field compared to an approach of assuming that all animals within a given area respond in the same way.

4.9.1.12 Similarly, a telemetry study undertaken by Russell *et al*. (2016) investigating the behaviour of tagged harbour seal during pile driving at the Lincs Offshore Wind Farm in the Wash found that there was a proportional response at different received sound levels. Dividing the study area into a 5 km x 5 km grid, the authors modelled SEL_{ss} levels and matched these to corresponding densities of harbour seal in the same grids during non-piling versus piling periods to show change in usage. The study found that there was a significant decrease in usage (abundance) during piling at predicted received SEL levels of between 142 dB and 151 dB re 1 µPa^{2}s. (SEL_{ss})

4.9.1.13 More recently, a study by Whyte *et al.* (2020) used tracking data from 24 harbour seal to estimate the potential effects of pile driving sounds on seals. Predicted cumulative sound exposure levels (SEL_{cum}) experienced by each seal were compared to different auditory weighting functions and thresholds for TTS and PTS. The study used predictions of seal density during pile driving made by Russell *et al*. (2016) compared to distance from the wind farm and predicted single-strike sound exposure levels (SEL_{ss}) by multiple approaches. Predicted seal density significantly decreased within 25 km or SEL_{ss} (averaged across depths and pile installations) above 145 dB re 1 µPa^{2}s. Predictions of seal density, and changes in seal density, during piling was given in Table V in Whyte *et al*. (2020), averaged across all water depths and piling events.

Application to assessment

4.9.1.14 A dose response curve derived from this study (Figure 4.6) was therefore applied to the seal assessment to determine the number of animals that may potentially respond behaviourally to received sound levels during piling. Unweighted sound exposure level single strike (SEL_{ss}) contours were plotted in 5 dB isopleths in decreasing increments from 180 to 120 dB re 1 µPa^{2}s using the highest modelled received sound level. Other studies have shown similar avoidance reactions for both grey seal and harbour seal to the same sound source (e.g. Gotz and Janik, 2010; Aarts *et al.,* 2017), and therefore provides justification that harbour seal dose response curves could be used as a proxy for grey seal.

4.9.1.15 To adopt the most precautionary approach, the dose response contours were plotted in Geographical Information System (GIS) for all modelled locations. For each species the location taken forward for assessment was that which resulted in the greatest number of animals affected, thereby representing the maximum adverse scenario. For cetaceans (where an average density was used to estimate the number of animals) this was represented by the location with the largest modelled contour, whilst for seals (where the number was derived from the at-sea density map (Carter *et al.,* 2022)) it was the modelled contour that coincided with higher density areas. The areas within each 5 dB isopleth were calculated from the spatial GIS map and a proportional expected response, derived from the dose response curve for each isopleth area, was used to calculate the number of animals potentially disturbed. The number of animals predicted to respond was based on species-specific densities as agreed with statutory consultees (Table 4.5). These numbers were subsequently summed across all isopleths to estimate the total number of animals disturbed during piling.

4.9.1.16 For harbour porpoise the dose-response curve was applied from the first location modelled as shown by Graham *et al*. (2017) where the probability of response approaches zero at c. 120 dB re 1 µPa^{2}s SEL_{ss}. In the absence of species-specific data for other cetacean species the same dose response curve was assumed to apply to all cetacean IEFs in this assessment (Figure 4.5) and represents a precautionary approach to assessment as other cetacean species are likely to be less sensitive than harbour porpoise to behavioural disturbance as noted in the literature (e.g. Tougaard *et al*., 2021).

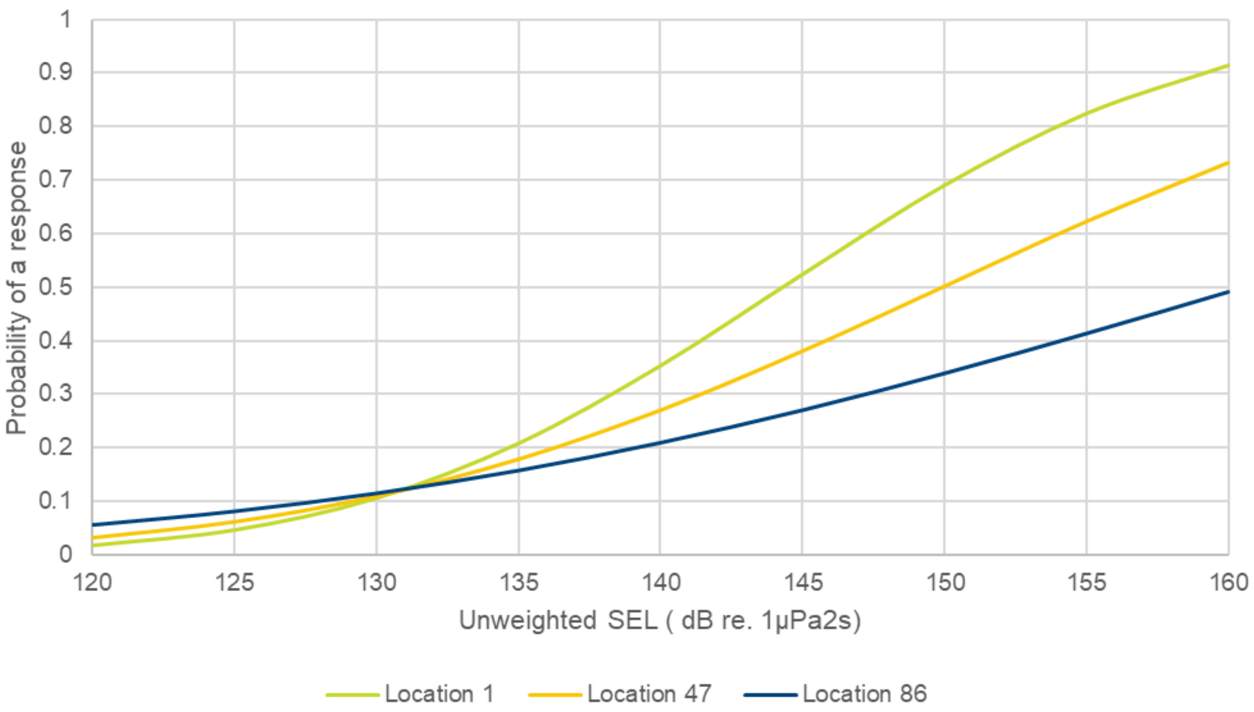

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Figure 4.5: The probability of a harbour porpoise response (24 hr) in relation to the partial contribution of unweighted received single-pulse SEL for the first location piled (green line), the middle location (yellow line) and the final location piled (blue line). Reproduced from Graham *et al*. (2019).

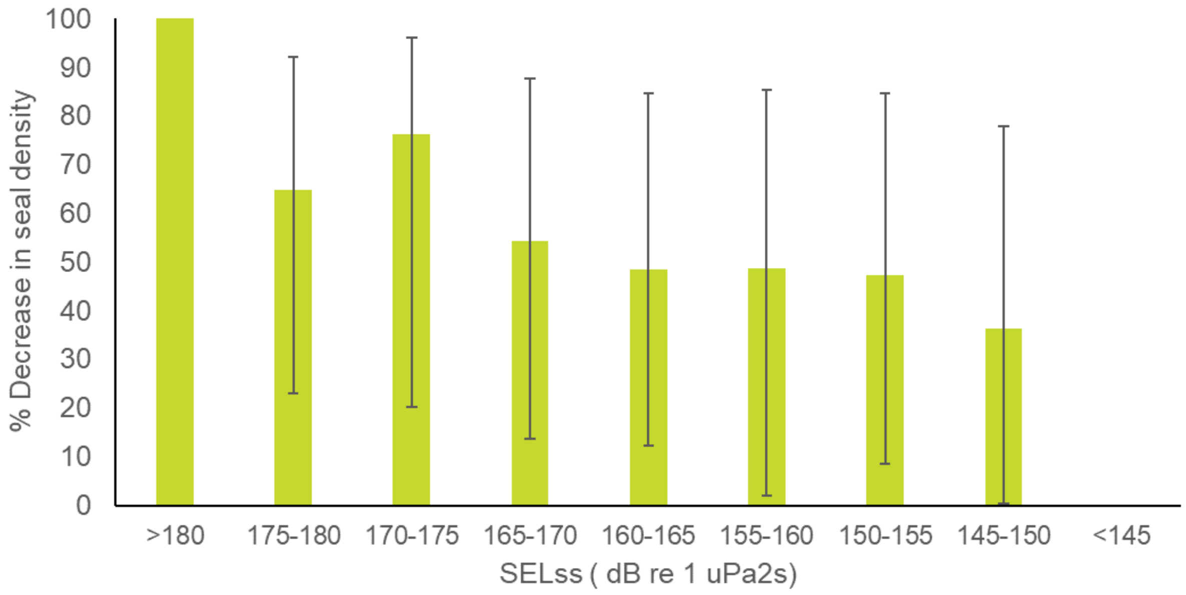


Figure 4.6: Predicted decrease in seal density as a function of estimated sound exposure level, error bars show 95% CI (from Whyte *et al.,* 2020).

4.9.1.17 For harbour seal and grey seal the most appropriate dose response curve was derived from the Whyte *et al*. (2020) study which has been recently applied to Awel y Môr Offshore Wind Farm, after consultation with NE and other SNCBs. It has been assumed that all seals are displaced at sound exposure levels above 180 dB re 1 μPa^{2}s (SEL_{ss}). This is a conservative assumption since there was no data presented in the study at this level. Furthermore, it is important to note that the percentage decrease in response to 170 < 175 and 175 < 180 dB re 1 μPa^{2}s (SEL_{ss}) are slightly anomalous due to the small number of spatial cells included in the analyses for these categories (n = 2 and 3 respectively). The harbour seal curve has been applied to grey seal disturbance also, as no corresponding data for grey seal is available, and it is considered to be an appropriate proxy for grey seal given both species are within the same hearing group (PCW).

4.9.1.18 Dose response is an available approach to understanding the potential behavioural effects from piling and has been applied at other UK offshore wind farms (for example Awel y Môr (RWE, 2022), Seagreen (Seagreen Wind Energy Ltd, 2012) and Hornsea Project Three (Orsted, 2018). The application of a dose response curve allows for more realistic assumptions about animal response varying with sound exposure (which is supported by a growing number of studies e.g. Thompson *et al.* 2013, Graham *et al*. 2017; Graham *et al*. 2019; Russell and Hastie 2017; Whyte *et al.* 2020). Dose response approaches are derived from site-specific studies, and account for the probability of behavioural response to varying sound levels, allowing for a more representative assessment of realistic animal responses (compared to a fixed threshold for example). As discussed in paragraph 4.9.1.16, data on dose response in other cetaceans (e.g. bottlenose dolphin, short-beaked common dolphin, Risso's dolphin and minke whale) is lacking, and therefore limits the reliability of this method for the different hearing ranges and sensitivities between species. However, given harbour porpoise is VHF and likely to be more sensitive to underwater sound than other key species, applying a dose response curve from a more sensitive species to a less sensitive species provides a precautionary approach to assessment (likely to result in overestimates of disturbance).

4.9.1.19 There is, however, a caveat to the application of dose response curves developed from a single specific scenario (i.e. with project-specific piling metric) in a single geographic region (with characterising substrate and bathymetry) and applied more widely across projects with different piling characteristics and in different geographic locations. Distance from an impulsive sound source is a strong predictor of a behavioural response Sound propagation can result in changes in waveform, whereby waveform elongates with distance (which reflects the current understanding of the transition from impulsive to continuous sound). Higher frequencies of the sound are attenuated more due to molecular absorption, whilst very low frequencies cannot propagate in shallow water. Therefore characteristics of the sound far from the source are very different to the characteristics of the sound at source, and therefore likely to affect how a marine mammal perceives and reacts to sound (rather than just using sound level alone).

4.9.1.20 The harbour porpoise dose response curve was derived from measurements taken at the Beatrice Offshore Wind Farm and was based on piling at much smaller hammer energies (average of ~1,000 kJ; Beatrice Offshore Wind Farm, 2018) with modelled effect ranges (to 120 dB re 1 µPa^{2}s SEL_{ss}) not exceeding 60 km. In contrast, the maximum hammer energies modelled for Morgan Generation Assets were 3,000 kJ and 4,400 kJ. The greatest modelled effect ranges (to 120 dB re 1 µPa^{2}s SEL_{ss}) was approximately 225 km for both hammer energies. Additionally, the distance at which a 50% response was measured for the Beatrice Offshore Wind Farm (144.3 dB re 1 µPa^{2}s unweighted SEL_{ss} in the 24-hour period after piling) was 7.4 km at the first location piled (Graham *et al*., 2019) whilst for Morgan Generation Assets the 50% response corresponded to ranges of 17 to 26 km (depending on the transect).

4.9.1.21 Therefore, whilst the assessment applies the dose response as the best available estimate of proportional responses, it is considered to be highly conservative due to the propagation distances predicted for the Morgan Generation Assets which for a given sound level will not be equivalent in characteristics to those found at the Beatrice Offshore Wind Farm. This is because the frequency content (as well as impulsivity, i.e. time based characteristics) will have a bearing on the response. At these much larger ranges the original impulse has dispersed to such an extent that the different frequencies of sound all arrive at different times and the pulse is spread out and is more akin to continuous sound. Thus most of the sound within the peak hearing sensitivity of harbour porpoise will have dissipated, leaving primarily low frequency sound which they are less sensitive to, and may not even be able to hear.

4.9.1.22 To provide further context in respect of dose response over large ranges the dose response quantitative assessment was presented in a risk-based framework. A staged approach was used to derive the number of disturbed animals.

4.9.1.23 First, the probability of response was calculated for SEL_{ss} using the formula:

$$\boldsymbol{P_{resp}(SEL_{ss}) = \frac{1}{1 + e^{-(a+B\times SEL_{ss})}}}$$

where $a = -21.3947$ and $B = 0.1482$ for harbour porpoise;

and $a = -43.5$ and $B = 0.3$ for grey seal.

4.9.1.24 This formula for probability of disturbance is taken from the Framework for Assessing Ecological and Cumulative Effects (Kader Ecologie en Cumulatie (KEC) 4.0) (Heinis *et al.* 2022) and is based upon dose response relationship (rather than discrete thresholds as in previous KECs), allowing differences in the probability of disturbance of animals that are close to piling location compared to those further away to be accounted for. For harbour porpoise, this dose response relationship is based upon piling activities in Netherlands, Germany and Scotland (Geelhoed *et al.* 2018; Brandt *et al.* 2018; Graham *et al.* 2019) and for seals is based upon Kastelein *et al.* (2011), Russell *et al.* (2016), Whyte *et al.* (2020) and Aarts *et al.* (2018) (and assumes from these studies responses of grey seals and harbour seals are comparable). The formula in paragraph 4.9.1.22 is used to calculate a probability of disturbance map to give an 'effective disturbance area', and then the probability of disturbance can be multiplied by the marine mammal density for each cell to give number of animals disturbed in that cell. For harbour porpoise for example, a mean density from the Welsh Marine Atlas was used (0.262 animals per km^2) and for grey seals, densities per cell were taken from the Carter *et al.* (2022) maps. The probability of response maps demonstrate that the likelihood of disturbance on marine mammals reduces considerably as distance from the pile increases.

Fixed threshold approach

4.9.1.25 The US NMFS (NMFS, 2005) define strong disturbance in all marine mammals as Level B harassment and for impulsive sound suggests a threshold of 160 dB re 1 μPa (SPL_{rms}). This threshold meets the criteria defined by JNCC (2010a) as a 'non-trivial' (i.e. significant) disturbance and is equivalent to the Southall *et al*. (2007) severity score of five or more on the behavioural response scale. Beyond this threshold the behavioural responses are likely to become less severe (e.g. minor changes in speed, direction and/or dive profile, modification of vocal behaviour and minor changes in respiratory rate (Southall *et al*. 2007)). The NMFS guidelines suggest a precautionary level of 140 dB re 1 μPa (SPL_{rms}) to indicate the onset of low-level marine mammal disturbance effects for all mammal groups for impulsive sound (NMFS, 2005), although this is not considered likely to lead to a 'significant' disturbance response.

4.9.1.26 For non-impulsive sound sources (such as underwater sound from vessels, sonar, drilling, borehole etc) NMFS provides a precautionary threshold of 120 dB re 1 μPa (SPL_{rms}) for disturbance, with no distinction made between 'strong' and 'mild' in this case (NMFS, 2005).

Application to assessment

4.9.1.27 An unweighted sound threshold value of 143 dB re 1 μPa^2s SEL_{ss} (Brandt *et al.,* 2018; Heinis *et al.,* 2019) for harbour porpoise only was also recommended in NRW's position statement on assessing behavioural disturbance of harbour porpoise from underwater sound (NRW, 2023). In particular, the fixed sound threshold is relevant to the HRA as an area-based approach and in this respect is similar to the Natural England and JNCC guidance on the use of Effective Deterrent Ranges (EDR) which have also been applied to the HRA (HRA Stage 2 ISAA (Document Reference E1.2) in reference to harbour porpoise SACs only.

4.9.1.28 The unweighted sound value threshold of 143 dB re 1 μPa^2s SEL_{ss} is the modelled average of six different studies of full-scale pile driving operations and thereby represents a large amount of empirical data (Tougaard *et al.,* 2021) (Table 4.20). Brandt *et al.* (2018) performed a combined statistical analysis of passive acoustic monitoring data of harbour porpoise from construction of seven different offshore wind farms in the German Bight. Acoustic recordings of the pile driving sound was utilised alongside porpoise monitoring to derive a threshold for porpoise reactions to the sound from pile driving. Declines were found at sound levels exceeding an unweighted single pulse SEL of 143 dB re 1 μPa^2s and up to 17 km from piling. This means that harbour porpoise may react with avoidance only when exposure exceeds a threshold value of 143 dB re 1 μPa^2s (SEL_{ss}) (Brandt *et al.,* 2018) (or a weighted threshold for VHF of 103 dB re 1 μPa calculated as root mean squared level over 125 milliseconds (Tougaard *et al.,* 2021)).

Table 4.20: Summary of VHF-weighted thresholds for behavioural responses to sound from pile driving derived from six different studies (adapted from Tougaard, 2021).

[1]Note that the difference between a VHF-weighted SPL_{rms} and an unweighted SEL_{ss} is approximately 40 dB.

Threshold[1]	Study	Description
100 to 115 dB re 1 µPa	Dähne *et al.* (2013)	Based on reaction distance between 10-25 km at Alpha Ventus offshore wind farm
95 to 101 dB re 1 µPa	Kastelein *et al.* (2013)	Playback of underwater sound from pile driving in captivity
95 dB re 1 µPa	Tougaard *et al.* (2015)	Generalised threshold based on data from pile driving and ADDs
103 dB re 1 µPa	Brandt *et al.* (2018)	Modelled threshold based on six offshore wind farms in the German Bight
110 dB re 1 µPa	Graham *et al.* (2019)	Audiogram-weighted threshold from pile driving at Beatrice Offshore Wind Farm
< 100 dB re 1 µPa	Kastelein *et al.* (2021)	Playback of low-pass filtered underwater sound from pile driving in captivity

4.9.1.29 The results above and derived threshold presented by Tougaard (2021) was reported for harbour porpoise and there are limited studies to support the derivation of similar thresholds for other marine mammal species. For minke whale, for example, based on limited evidence from sonar studies (Kvadsheim *et al.,* 2017, Sivle *et al.,* 2015, Tougaard *et al.,* 2021) evidence suggests that response thresholds are higher than for harbour porpoise (by 40-50 dB re 1 µPa (SPL_{pk})) suggesting lower sensitivity to underwater sound. However, given that minke whales are thought to have better hearing at lower frequencies the reaction distances may be similar (Tougaard *et al.,* 2021). This is also the case for seal species, where a higher threshold combined with greater sensitivity at low frequencies may lead to similar response distances to harbour porpoise (Tougaard *et al.,* 2021). Given the paucity of information for species other than harbour porpoise, the NMFS (2005) threshold was considered to be more appropriate (with the emphasis on the 160 dB re 1 µPa SPL_{rms} strong disturbance threshold) and was agreed with the marine mammal EWG.

Summary of criteria for assessing behavioural disturbance

4.9.1.30 This assessment adopted the dose-response approach for assessing disturbance to marine mammal species from piling and follows the published advice from NRW (NRW, 2023). In their S42 response, NRW also advised the application of a fixed sound threshold value to inform area-based assessments as required for the HRA as per their guidance (NRW, 2023). Thus, the unweighted 143 dB re 1 µPa^{2}s (SEL_{ss}) threshold has been presented alongside the dose-response approach in this EIA to be carried forward to the HRA, as agreed with the EWG. For all other marine mammal species, fixed unweighted thresholds of 140 dB re 1 µPa (SPL_{rms}) and 160 dB re 1 µPa (SPL_{rms}) (NMFS, 2005) have been presented alongside the dose-response approach, as agreed with the EWG (Table 4.21).

4.9.1.31 For underwater sound sources other than piling the assessment adopted the NMFS (2005) published guidance on impulsive and non-impulsive sound sources (Table 4.21). In the absence of published thresholds on potential behavioural effects of underwater sound arising from UXO clearance, the assessment adopted the use of the TTS threshold as a proxy for a disturbance as this is considered to correspond to an animal moving away or 'fleeing' (i.e. behaviourally displaced) (Table 4.21). Further detail is provided under each impact header in the following sections.

Table 4.21: Summary of criteria used in assessment of behavioural disturbance for different marine mammal species.

Sound source	Species	Approach	Source
Pile driving (impulsive)	Harbour porpoise	Dose-response (harbour porpoise) Unweighted threshold 143 dB re 1 µPa^{2}s SEL_{ss}	Graham *et al.* (2019) Tougaard *et al.* (2021)
Pile driving (impulsive)	Minke whale, bottlenose dolphin, Risso's dolphin, short-beaked common dolphin.	Dose-response (harbour porpoise) Unweighted threshold 160 dB re 1 µPa (SPL_{rms}) (strong disturbance) Unweighted threshold of 140 dB re 1 µPa (SPL_{rms}) (mild disturbance)	Graham *et al.* (2019) NMFS (2005)
Pile driving (impulsive)	Grey seal, harbour seal	Dose-response (harbour seal) Unweighted threshold 160 dB re 1 µPa (SPL_{rms}) (strong disturbance) Unweighted threshold of 140 dB re 1 µPa (SPL_{rms}) (mild disturbance)	Whyte *et al.* (2020) NMFS (2005)
UXO (impulsive)	All marine mammal species	Unweighted SPL_{pk} and hearing weighted SEL_{cum} for TTS as a proxy for disturbance ('fleeing' response).	Southall *et al.* (2019)
Vessel sound (non-impulsive)	All marine mammal species	Unweighted threshold of 120 dB re 1 µPa (SPL_{rms})	NMFS (2005)
Site-investigation surveys (impulsive)	All marine mammal species	Unweighted threshold of 160 dB re 1 µPa (SPL_{rms}) (strong disturbance) Unweighted threshold of 140 dB re 1 µPa (SPL_{rms}) (mild disturbance)	NMFS (2005)
Site-investigation surveys (non-impulsive)	All marine mammal species	Unweighted threshold of 120 dB re 1 µPa (SPL_{rms})	NMFS (2005)

Importance of context

4.9.1.32 By applying these criteria the magnitude of effect can be quantified with respect to the spatial extent of disturbance, and subsequently the number of animals potentially disturbed based on available density information. There is, however, a note of caution associated with this approach. Southall *et al*. (2021) highlights that the challenges for developing a comprehensive set of empirically derived criteria for such a diverse group of animals are significant. Extensive data gaps have been identified (e.g. measurements of the potential effects of elevated sound on baleen whales) which means that extrapolation from other species has been necessary. Sounds that disturb one species may, however, be irrelevant or inaudible to other species since there are broad differences in hearing across the frequency spectrum for different marine mammal hearing groups. Variance in responses even within a species are well documented to be context and sound-type specific (Ellison *et al*., 2012). In addition, the potential interacting and additive effects of multiple stressors (e.g. reduction in prey, sound and disturbance, contamination, etc.) is likely to influence the severity of responses (Lacy *et al*., 2017).

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

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

4.9.1.34 Even where studies have been able to assign responses to these categories based on acute exposure there is still limited understanding of how longer term (chronic) exposure could translate into potential population-level effects. The potential for behavioural disturbance to lead to population consequences has been considered for this assessment using the iPCoD approach and is described in detail below (paragraphs 4.9.2.13 to 4.9.2.17).To explore potential population-level effects, Southall *et al*. (2021) reported observations from long term whale watching studies and suggested that there were differences in the ability of marine mammals to compensate for long term disturbance which related to their breeding strategy. For example, mysticetes are 'capital breeders' - accumulating energy in their feeding grounds and transferring this to calves in their breeding ground, whilst other species such as harbour porpoise, bottlenose dolphin and harbour seal are 'income breeders' – they balance the costs of pregnancy and lactation by increased food intake, rather than depending on fat stores. Reproductive strategy can impact the energetic consequences of disturbance, and cause variation in an individual's vulnerability to disturbance based on both its reproductive strategy and stage (Harwood *et al*., 2020). Furthermore, their ability to compensate for chronic exposure to sound will also depend on a range of ecological factors.

4.9.1.35 Such factors include the relative importance of the disturbed area and prey availability within their wider home range, the distance to and quality of other suitable sites, the relative risk of predation or competition in other areas, individual exposure history, and the presence of concurrent disturbances in other areas of their range (Gill *et al.,* 2001). Animals may be able to compensate for short-term disturbances by feeding in other areas, for example, which would reduce the likelihood of longer-term population consequences. Booth (2020) highlighted that foraging behaviour (intensity) and diet (largely target prey size) in harbour porpoise informs vulnerability to disturbance, and if animals can find suitable high energy-density prey they may be capable of recovering from some lost foraging opportunities due to disturbance. Christiansen and Lusseau (2015) studied the effect of whale watching on minke whale in Faxafoi Bay, Iceland and found no significant long-term effects on vital rates, although years with low sandeel density led to increased exposure to whale watching as whales were forced to move into disturbed areas to forage. Odontocetes, however, may be more vulnerable to whale watching compared to mysticetes due to their more localised, and often, coastal home ranges. Bejder *et al*. (2006) documented a decrease in local abundance of bottlenose dolphin which was associated with an increase in whale watching in a tourist area compared to a control area. If, however, there is no suitable habitat nearby animals may be forced to remain in an area despite the disturbance, regardless of whether or not it could affect survival or reproductive success (Gill *et al.*, 2001).

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

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

- Conservative assumptions in the marine mammal baseline (e.g. use of seasonal density peaks for harbour porpoise and grey seal, offshore and inshore densities for pinniped species)
- Conservative assumptions in the MDS for the project parameters (Table 4.16)
- Conservative assumptions in the underwater sound modelling (see summary below) (Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement).

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

Conservatism in the underwater sound modelling approach

4.9.1.39 A number of conservative assumptions were adopted in the underwater sound model that resulted in a precautionary assessment (Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement). These are summarised here:

- The modelling assumed that the maximum hammer energy would be reached and maintained at all locations, whereas this is unlikely to be the case based on examples from other offshore wind farms, e.g. Beatrice Offshore Wind Farm, where the mean actual hammer energy averages were considerably lower than the maximum assessed in the Environmental Statement and only six out of 86 asset locations reached maximum hammer energy (Beatrice, 2018)
- The soft start procedure simulated does not allow for short pauses in piling (e.g. for realignment) and therefore the modelled SEL_{cum} is likely to be an overestimate since, in reality, these pauses will reduce the sound exposure that animals experience whilst moving away
- The modelling assessment assumed that animals swim directly away from the sound source at constant and conservative average speeds based on published values. Whilst this buffers the uncertainty with respect to the directionality of their movement, nonetheless it may lead to overestimates of the potential range of effect as animals are likely to exceed these speeds. For

example, Otani *et al.* (2000) note that horizontal speed for harbour porpoise can be significantly faster than vertical speed and cite a maximum speed of 4.3 m/s. Similarly, Leatherwood *et al.* (1988) reported harbour porpoise swim speeds of approximately 6.2 m/s. For minke whale speeds of up to 4.2 m/s have been reported during acoustic deterrent exposure experiments on free ranging animals (McGarry *et al.*, 2017)

- The use of the SEL_{cum} metric is described as an equal energy rule where exposures of equal energy are assumed to produce the same sound-induced threshold shift regardless of how the energy is distributed over time. This means that for intermittent sound, such as piling, the equal-energy rule overestimates the effects since the quiet periods between sound exposures will allow some recovery of hearing compared to continuous sound
- Modelling of concurrent piling assumes piling will occur at exactly the same time and strike piles simultaneously, whereas in reality this is highly unlikely and could lead to overestimates in the injury and/or disturbance ranges
- Modelling of consecutive piling over 24 hours assumes no pause between piling events moving from one pile to the next which is considered to be highly precautionary and likely to lead to overestimates as, in practice, there would be a period of time (hours) between each piling event as the equipment is moved to a different location (i.e. MDS is for just one foundation per 24 hours allowing for a pause in piling between foundations)
- Due to a combination of factors (e.g. dispersion of the waveform, multiple reflections from sea surface and seafloor, and molecular absorption of high frequency energy), impulsive sounds are likely to transition into non-impulsive sounds at distance from the sound source with empirical evidence suggesting such shifts in impulsivity could occur markedly within 10 km from the sound source (Hastie *et al.,* 2019) (Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement). Since the precise range at which this transition occurs is unknown (not least because the transition also depends on the response of the marine mammals' ear) sound models still adopt the impulsive thresholds at all ranges and this is likely to lead to an overly precautionary estimate of injury ranges at larger distances (tens of kilometres) from the sound source. The transition cross-over point from impulsive to non-impulsive sound is discussed in detail in paragraphs 1.5.7.1 to 1.5.7.4 of Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement), and defining this transition range is an active area of research and scientific debate, with a number of other potential methods being investigated (see paragraph 1.5.7.3 of Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement).

4.9.1.40 These assumptions highlight that both PTS and TTS onset ranges predicted using the SEL_{cum} threshold are likely to be very conservative, and for TTS in particular may lead to overestimates in ranges and therefore should be interpreted with caution.

4.9.2 Injury and disturbance from elevated underwater sound during piling

4.9.2.1 During the construction phase sound emissions from the piling of foundations may lead to auditory injury and disturbance of marine mammals. The MDS is represented by two scenarios (temporal and spatial) and is summarised in Table 4.16.

Summary of piling scenarios

4.9.2.2 Pile driving during the construction phase of the Morgan Generation Assets has the potential to result in elevated levels of underwater sound that are detectable by marine mammals above background levels and could result in auditory injury and/or potential behavioural effects in marine mammal IEFs. A detailed underwater sound modelling assessment was carried out to investigate the potential for such effects to occur, using the latest assessment criteria (Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement).

4.9.2.3 For piling, with respect to the SPL_{pk} metric, the soft start initiation is the most relevant period, as this is when animals may potentially experience injury from underwater sound emitted by the initial strike of the hammer, after which point it is assumed that they will move away from the sound source. However, SPL_{pk} at full hammer energy was also modelled to provide additional context (particularly given the limitations of the assessment for SEL_{cum}; see paragraph 4.9.1.40).

4.9.2.4 The SEL_{cum} metric was modelled over a single installation sequence for pin piles. Following consultation, the SEL_{cum} metric was also applied to a scenario of consecutive piling of single piles over 24 hours (i.e. assuming piles are installed with no break in between and is therefore considered to be highly precautionary).

4.9.2.5 The scenarios modelled were based on the absolute maximum hammer energies (of 4,400 kJ or 3,000 kJ, see Table 4.16), for the longest possible duration, noting that piling is unlikely to reach and maintain the absolute maximum hammer energy at all locations (Table 4.16). The piling campaign was developed with the lowest achievable hammer energy, slow initiation phase, followed by a soft start and ramp up to reduce the potential likelihood of auditory injury (see Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement).

4.9.2.6 The assessment of potential effects on marine mammals from piling considered a maximum spatial and maximum temporal scenario for pin pile foundations (Table 4.16). Maximum spatial scenarios assume concurrent piling of pin piles (leading to the largest area of effect at any one time) whilst maximum temporal scenarios are for single piling (leading to the greatest number of days of piling).

4.9.2.7 For the concurrent piling scenarios, two separate assumptions were identified to determine the MDS, as follows:

- Minimum separation distance of 1.4 km (the minimum distance between foundations) as a maximum adverse scenario for potential injury. This minimum separation distance is used to minimise the potential for additive effects due to direct overlap of concurrent piling
- Separation distance of up to 15 km as a maximum adverse scenario for potential disturbance. This maximum separation distance is used to reduce the area of overlapping sound emission from each of the piling activities.

4.9.2.8 Underwater sound modelling was undertaken for:

- Concurrent piling at 3,000 kJ for two wind turbine jacket foundations only (noting that the Applicant has committed to reducing potential spatial effects by not piling concurrently where a 4,400 kJ hammer may be required, secured within the Outline MMMP (Document Reference J17).

4.9.2.9 Locations selected for the concurrent scenarios were different depending on species since the assessment adopted a precautionary approach selecting those locations which were likely to overlap with sensitive areas for a given species (e.g. areas of high density). As detailed in Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement, these modelling points are as follows:

- Northern boundary of the Morgan Array Area to capture grey seals at Calf of Man (and herring spawning off east coast of Isle of Man)
- Western boundary of the Morgan Array Area to assess potential impacts on the North Anglesey Marine harbour porpoise SAC to the southwest (as well as herring spawning off the east coast of Isle of Man and grey seals at the Calf of Man)
- Eastern boundary of the Morgan Array Area to allow for assessment of potential impact on the seals at Hilbre Point.

4.9.2.10 Concurrent piling locations for each of those three locations were then selected based upon a 15 km separation distance (representative of the maximum adverse scenario in terms of separation distance and bathymetry) (further details given in Volume 3, Annex 3.1: Underwater Sound technical report of the Environmental Statement). As described previously modelling of cumulative exposure assumed installation of single piles (by each vessel) with breaks between installation, as well as consecutive piling over 24 hours assuming no break in piling (although noting the latter is highly precautionary, and practically unlikely).

4.9.2.11 For the maximum temporal scenario the assessment focussed on the longest duration of piling and the greatest number of days over which piling could occur. The longest duration of piling for wind turbine foundations or OSP foundations is up to 4.5 hours per pile and for gravity base foundations is up to 4 hours per pile. Piling would occur over a maximum of 114 days using a single vessel (up to 64 days for wind turbine foundations, up to 12 days for OSP foundations and up to 38 days for GBFs; see Table 4.16 for associated assumptions).

4.9.2.12 A summary of the scenarios assessed is provided in the Table 4.22.

Table 4.22: Summary of piling scenarios assessed for marine mammals at wind turbine and the OSP foundations for single piling and concurrent piling (duration of consecutive piling over 24hrs also modelled for single piling).

[1]Only where hammer energy is 3,000 kJ and for wind turbine jacket foundations (not GBFs)

Structure	Number of piled locations	Number of legs	Piles per leg	Number of piles (up to)	Max.hammer energy (kJ)	Max. piles per day	Number of vessels	Max. piling days
Maximum temporal scenario (no concurrent piling)								
Wind turbine (jacket foundation)	48	4	1	192	3,000	4	1	48
Wind turbine (jacket foundation)	16	4	1	64	4,400	4	1	16
OSP (jacket foundation)	4	4	3	48	4,400	4	1	12
Wind turbine (GBF)	10	1	15	150	3,000	4	1	38
Total	**78**	**-**	**-**	**454**	**-**	**-**	**-**	**114**

Structure	Number of piled locations	Number of legs	Piles per leg	Number of piles (up to)	Max.hammer energy (kJ)	Max. piles per day	Number of vessels	Max. piling days
Maximum spatial scenario (partial concurrent piling at subset of wind turbine foundations[1])								
Wind turbine (jacket foundation)	48	4	1	192	3,000	4	2	24
Wind turbine (jacket foundation)	16	4	1	64	4,400	4	1	16
OSP (jacket foundation)	4	4	3	48	4,400	4	1	12
Wind turbine (GBF)	10	1	15	150	3,000	4	1	38
Total	**78**	**-**	**-**	**454**	**-**	**-**	**-**	**90**

Summary of interim population consequences of disturbance (iPCoD) modelling

4.9.2.13 To understand the potential for long-term population level effects on marine mammal species resulting from piling activities only at the Morgan Generation Assets population modelling using the iPCoD model was undertaken.

4.9.2.14 There is limited understanding of how behavioural disturbance and auditory injury affect survival and reproduction in individual marine mammals and consequently how this translates into potential effects at the population level. The iPCoD model was developed using a process of expert elicitation to determine how physiological and behavioural changes affect individual vital rates (i.e. the components of individual fitness that affect the probability of survival, production of offspring, growth rate and offspring survival).

4.9.2.15 Expert elicitation is a widely accepted process in conservation science whereby the opinions of many experts are combined when there is an urgent need for decisions to be made but a lack of empirical data with which to inform them. In the case of iPCoD, the marine mammal experts were asked for their opinion on how changes in hearing resulting from PTS and behavioural disturbance (equivalent to a score of 5* or higher on the 'behavioural severity scale' described by Southall *et al*. (2007)) associated with offshore renewable energy developments affect calf and juvenile survival and the probability of giving birth (Harwood *et al*., 2014). Experts were asked to estimate values for two parameters which determine the shape of the relationships between the number of days of disturbance experienced by an individual and its vital rates, thus providing parameter values for functions that form part of the iPCoD models (Harwood *et al*., 2014). The relationship between disturbance and survival/reproduction assumes that individual animals would have a limited ability to alter their activity budget to compensate for a reduction in e.g. time spent feeding (Houston *et al*., 2012; King *et al*., 2015). The individual's ability to provision/care for young, evade predation or resist disease would likely be affected, and it is expected that any potential effects would be reflected in changes to vital rates. It is important to note, however, that this relationship is highly simplified (Harwood *et al*., 2014), and an individual's response to disturbance will depend on factors including the context of the disturbance, the individual's existing condition and its exposure history (Ellison *et al*., 2012). The iPCoD framework applies simulated changes in vital rates to infer the number of animals that may be affected by disturbance as a means to iteratively project the size of the population.

4.9.2.16 The iPCoD model simulates the mean population difference over time for an impacted versus an unimpacted population to provide comparison of the type of changes that could occur resulting from natural environmental variation, demographic stochasticity and human-induced disturbance. It can be assumed that disturbance occurs only on the day (24 hours) that piling takes place (Graham *et al*., 2019; Brandt *et al*., 2011). However, residual disturbance has conservatively been set at one day, meaning that the model assumes that disturbance occurs on the day of piling and persists for a period of 24 hours after piling has ceased (Appendix B). The results are summarised in relation to the forecasted population size over time with forecasts made at certain timepoints (e.g. two, six, 13, 19 and 25 years) after piling commences. In addition, the model calculates the median ratio of the unimpacted to the impacted population size at these timepoints[2]. A caveat of the iPCoD framework, however, is that the models do not account for density dependence and therefore the forecasts may be unrealistic as they assume that vital rates in the population will not alter as a result of density-dependent factors (e.g. competition).

4.9.2.17 Whilst there are many limitations to expert elicitation-based iPCoD modelling, this approach was requested by statutory consultees as part of the offshore EIA Scoping process as it represents the best available approach for the species considered in this assessment at this time (Table 4.5). Alternative approaches to assessing the iPCoD include (i) matrix models, which allow for an assessment of a population, with and without disturbance (e.g. Caswell *et al*., 2001) and (ii) data-driven, state-dependent behavioural approaches in lieu of expert elicitation (e.g. McHuron *et al.,* 2017). Nonetheless, uncertainties in the iPCoD framework have been offset as far as possible by adopting a precautionary approach at all stages of the assessment from the maximum design parameters in the project envelope, conservatism in the underwater sound model and adoption of precautionary estimates to represent the densities of key species. Thus, the results from the iPCoD modelling undertaken for the Morgan Generation Assets is considered to be inherently cautious and should be interpreted as such.

4.9.2.18 Population modelling using iPCoD was carried out for the following species (agreed through the EWG meetings, Table 4.5) due to the potential number of animals affected relative to the relevant MU populations:

- Harbour porpoise
- Bottlenose dolphin
- Minke whale
- Grey seal.

4.9.2.19 The population models were developed using the relevant reference populations (Table 4.12) and using published demographic parameters (as agreed with the EWG) (see Appendix B). For bottlenose dolphin, population modelling in support of the

[2] If the median of the ratio of impacted to unimpacted population size equals one, this represents a situation where the median impacted population size is no different to the median unimpacted population size. If the median of the ratio of impacted to unimpacted population size is less than one, this represents a situation where the median impacted population size is smaller than the median unimpacted population size.

project alone impact assessment incorporated two fertility rates to build conservatism into the simulations and to capture a range of population trajectories. These were based upon consultation with NRW (NRW *pers. comm*. 21 October 2022) and estimates developed by Arso Civil *et al*. (2017), and the fertility rates were set at 0.30 and 0.22, respectively. Carrying this forward to the CEA, the population modelling incorporated only the lower fertility rate of 0.22 as the more precautionary approach.

4.9.2.20 For grey seal, where two reference populations have been defined and assessed in this EIA (the 'GSRP' and the OSPAR Region III reference population, Table 4.12), only the most precautionary reference population was assessed within the iPCoD model. Thus, for both the project alone and the CEA the GSRP was defined as the more conservative reference population. Whilst it is acknowledged that this covers a smaller area compared to OSPAR Region III, there were no additional projects in OSPAR Region III that were not captured by the GSRP area, for which quantitative information was available (i.e. Tier 1 or Tier 2 projects; see section 4.10.1). The iPCoD models considered a maximum of six projects for the GSRP (with a population of n=12,910), all of which (and no more) would have been considered under modelling scenarios for the OSPAR Region III reference population (with a population of n=60,780). This highlights that the assessment against the larger OSPAR Region III reference population would dilute the population-level effects. Full details of approach to population modelling are presented in Appendix B.

4.9.2.21 Harbour seal was not included due to the very small number of animals potentially behaviourally disturbed and therefore very low likelihood of a population level effect occurring for this species.

4.9.2.22 The expert elicitation required to inform the transfer functions that are integral to the iPCoD modelling process has not yet considered short-beaked common dolphin or Risso's dolphin. As a consequence, the iPCoD framework does not currently facilitate population modelling for these two species, and they have therefore not been included.

Construction phase

Magnitude of impact

Auditory Injury

4.9.2.23 The maximum spatial effect was predicted for pin piles with a hammer energy of 4,400 kJ. At hammer initiation (first strike) instantaneous injury leading to PTS, based on SPL_{pk}, could occur out to a maximum range of 130 m across all species, with the maximum range predicted for harbour porpoise (Table 4.23). Using the same metric the maximum range of injury was predicted at 652 m at full hammer (although this assumes animals do not move away at the start of piling, which is unlikely).

4.9.2.24 Potential spatial effects were smaller (for the full hammer energy only) for the 3,000 kJ pin piles with a maximum range across all species of 515 m for full hammer energy and the same range of 130 m for instantaneous injury (at hammer initiation) (Table 4.23).

4.9.2.25 Considering cumulative exposure using the SEL_{cum} metric the risk of PTS was predicted to occur out to a maximum range of 5,720 m, as predicted for minke whale assuming single piling at a hammer energy of 4,400 kJ (Table 4.24). Modelling of consecutive piling predicted a slightly larger injury range (5,840 m) although noting that this is considered unrealistic as it assumes no breaks in piling (e.g. breaks between piles or moving from one piling location to another).

4.9.2.26 The maximum temporal effect was predicted as the longest duration of piling. Whilst the effect of PTS is considered to result in permanent injury to animals, the risk of animals being exposed to sound levels leading to auditory injury would occur during piling only. As shown in Table 4.22 piling will be intermittent over a two-year piling phase and will occur up to a maximum of 114 days.

4.9.2.27 Tertiary mitigation in the form of an Outline MMMP (Document Reference J13) (as an annex of the Underwater sound management strategy (Document Reference J17), (discussed in paragraphs 4.9.2.169 and 4.9.2.170) will be implemented to reduce the likelihood of PTS. Such mitigation will include deployment of an ADD as recommended in the JNCC guidelines (2010a). The efficacy of ADD as a mitigation tool was subsequently undertaken as part of this assessment with respect to both SPL_{pk} and SEL_{cum} ranges applying a 30-minute deployment time prior to hammer initiation (see paragraph 4.9.2.29 *et seq*). The exact duration of ADD activation will, however, be discussed and agreed with consultees post-consent and in respect of any refinements in the Project Design Envelope that may be available at a later stage and included within the Outline MMMP (Document Reference J17).

4.9.2.28 The assessment of magnitude with respect to auditory injury is presented below (paragraph 4.9.2.35) on a species-specific basis, where the maximum adverse scenario is identified for each species.

Table 4.23: Summary of SPL_{pk} PTS injury ranges and areas of effect for marine mammal hearing groups for single pin pile installation (N/E = threshold not exceeded).

Hearing group	Threshold (unweighted SPL_{pk})	Hammer energy level	3,000 kJ maximum hammer energy		4,400 kJ maximum hammer energy	
			Range of effect (m)	Area of effect (km^2)	Range of effect (m)	Area of effect (km^2)
VHF	202 dB re 1 µPa	Initiation (first strike)	130	0.053	130	0.053
		Full energy (maximum)	515	0.833	652	1.335
HF	230 dB re 1 µPa	Initiation (first strike)	N/E	N/E	N/E	N/E
		Full energy (maximum)	31	0.003	39	0.004
LF	219 dB re 1 µPa	Initiation (first strike)	23	0.001	23	0.001
		Full energy (maximum)	93	0.027	118	0.043
PCW	218 dB re 1 µPa	Initiation (first strike)	26	0.002	26	0.002
		Full energy (maximum)	103	0.033	130	0.053

Table 4.24: Summary of SEL_{cum} PTS injury ranges and areas of effect for marine mammals for pin pile installation (4,400 kJ and 3,000 kJ) (N/E = threshold not exceeded).

Species	Threshold (SEL_{cum} weighted)	Scenario	Hammer energy	Range of effect (m)	Area of effect (km^2)
Harbour porpoise (VHF)	PTS - 155 dB re 1 µPa²s	Single	4,400 kJ	N/E	N/E
			3,000 kJ	N/E	N/E
		Concurrent	3,000 kJ + 3,000 kJ	N/E	N/E
		Consecutive	4,400 kJ	N/E	N/E
			3,000 kJ	N/E	N/E
Bottlenose dolphin, Short-beaked common dolphin, Risso's dolphin (HF)	PTS - 185 dB re 1 µPa²s	Single	4,400 kJ	N/E	N/E
			3,000 kJ	N/E	N/E
		Concurrent	3,000 kJ + 3,000 kJ	N/E	N/E
		Consecutive	4,400 kJ	N/E	N/E
			3,000 kJ	N/E	N/E
Minke whale (LF)	PTS - 183 dB re 1 µPa²s	Single	4,400 kJ	5,720	102.79
			3,000 kJ	3,050	29.22
		Concurrent	3,000 kJ + 3,000 kJ	4,290	57.82
		Consecutive	4,400 kJ	5,840	107.15
			3,000 kJ	3,130	30.78
Grey seal, harbour seal (PCW)	PTS - 185 dB re 1 µPa²s	Single	4,400 kJ	N/E	N/E
			3,000 kJ	N/E	N/E
		Concurrent	3,000 kJ + 3,000 kJ	N/E	N/E
		Consecutive	4,400 kJ	N/E	N/E
			3,000 kJ	N/E	N/E

MMMP (Tertiary mitigation)

4.9.2.29 Due to the potential injury ranges predicted for marine mammals, mitigation will be required in the form of an ADD to deter animals from the area of impact. The type of ADD and approach to mitigation (including activation time and procedure) is included in the Outline MMMP (Document Reference J17) (as an annex of the Outline underwater sound management strategy, Document Reference J13) and will be discussed and agreed with relevant stakeholders.

4.9.2.30 ADDs have commonly been used in marine mammal mitigation at UK offshore wind farms to deter animals from potential injury zones prior to the start of piling. The JNCC (2010a) draft guidance for piling mitigation recommends their use, particularly in respect of periods of low visibility or at night to allow 24-hour working. With a number of research projects on ADDs commissioned via the Offshore Renewables Joint Industry Programme (ORJIP), the use of ADDs for mitigation at offshore wind farms has gained momentum. For the Beatrice Offshore Wind Farm, the use of ADDs was accepted by the regulators (Marine Scotland) as the only mitigation tool applied pre-piling as it was thought to be more effective at reducing the potential for injury to marine mammals compared to actions informed by standard monitoring measures (MMObs) and PAM) which, as mentioned previously, has limitations with respect to effective detection over distance (Parsons *et al*., 2009; Wright and Cosentino, 2015).

4.9.2.31 There are various ADDs available with different sound source characteristics (see McGarry *et al*., 2020) and a suitable device will be selected based on the key species requiring mitigation for the Morgan Generation Assets. The selected device will typically be deployed from the piling vessel and activated for a pre-determined duration to allow animals sufficient time to move away from the sound source whilst also minimising the additional sound introduced into the marine environment.

4.9.2.32 Sound modelling was carried out to determine the potential efficacy of using an ADD to deter marine mammals from the injury zone for a selected duration of 30 minutes (see Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement).

4.9.2.33 Assuming conservative swim speeds, it was demonstrated that activation of an ADD for 30 minutes would deter all species beyond the maximum injury zone predicted using SPL_{pk} at hammer initiation (and full hammer energy) for both the 4,400 kJ and 3,000 kJ hammer energy (Table 4.25). This corroborates findings of other studies that reported that ADDs deter different marine mammal species over several hundreds of metres or indeed several kilometres from the source (reviewed in McGarry *et al*., 2020).

Table 4.25: Summary of peak pressure (SPL_{pk}) injury ranges at hammer initiation and maximum hammer energy (in parentheses) for marine mammals due to single piling of pin piles at 4,400 kJ and 3,000 kJ hammer energy, showing whether the individual can move beyond the injury range during the 30 minutes of ADD activation.

Species	Threshold (SPL_{pk})	Injury range (3,000 kJ) (m)	Injury range (4,400 kJ) (m)	Swim Speed (m/s)	Swim distance (m)	Move beyond injury range
Minke whale	219 dB re 1 µPa	23 (93)	23 (118)	2.3	4,140	Yes
Bottlenose dolphin, Risso's dolphin, short-beaked common dolphin	230 dB re 1 µPa	N/E (31)	N/E (39)	1.52	2,736	Yes
Harbour porpoise	202 dB re 1 µPa	130 (515)	130 (652)	1.5	2,700	Yes
Grey seal, harbour seal	218 dB re 1 µPa	26 (103)	26 (130)	1.8	3,240	Yes

4.9.2.34 For all species except minke whale, use of an ADD for 30 minutes prior to commencement of piling of pin piles reduces the likelihood of PTS occurring as sound levels are predicted not to be greater than the relevant threshold values, during single, concurrent and consecutive piling for all species (Table 4.26). The exception was minke whale where there was a small residual risk of injury to animals based on the

SEL_{cum} metric only (Table 4.27), as distances at which sound levels are predicted to remain above the relevant threshold values is reduced compared to not using an ADD.

Table 4.26: Injury ranges (SEL_{cum}) for marine mammals due to single, concurrent (3,000 kJ and 3,000 kJ) and consecutive piling (24 hours) of pin piles with and without 30 minutes of ADD (N/E = threshold not exceeded).

Species	PTS Threshold (SEL_{cum} weighted)	Scenario	Hammer energy	Without ADD	With ADD
Minke whale (LF)	183 dB re 1 µPa²s	Single	4,400 kJ	5,720	1,585
			3,000 kJ	3,050	N/E
		Concurrent	3,000 kJ + 3,000 kJ	4,290	310
		Consecutive	4,400 kJ	5,840	1,705
			3,000 kJ	3,130	N/E
All other marine mammal species	VHF - 155 dB re 1 µPa²s HF - 185 dB re 1 µPa²s PCW - 185 dB re 1 µPa²s	Single	4,400 kJ	N/E	N/E
			3,000 kJ	N/E	N/E
		Concurrent	3,000 kJ + 3,000 kJ	N/E	N/E
		Consecutive	4,400 kJ	N/E	N/E
			3,000 kJ	N/E	N/E

Table 4.27: Potential number of animals predicted to be injured (PTS) using weighted SEL_{cum} metric as a result of different piling scenarios.

Species	Scenario	Hammer energy	Without ADD		With ADD	
			Number of animals	% of reference population	Number of animals	% of reference population
Minke whale (LF)	Single	4,400 kJ	2	0.009	<1	0.0007
		3,000 kJ	< 1	0.003	0	N/A
	Concurrent	3,000 kJ + 3,000 kJ	2	0.005	<1	0.00003
	Consecutive	4,400 kJ	2	0.009	<1	0.0008
		3,000 kJ	< 1	0.003	0	N/A
All other marine mammal species	Single	4,400 kJ	0	N/A	0	N/A
		3,000 kJ	0	N/A	0	N/A
	Concurrent	3,000 kJ + 3,000 kJ	0	N/A	0	N/A
	Consecutive	4,400 kJ	0	N/A	0	N/A
		3,000 kJ	0	N/A	0	N/A

Harbour porpoise

4.9.2.35 For harbour porpoise, with primary and tertiary mitigation applied, no animals are predicted to be affected by peak pressure (SPL_{pk}) as they are anticipated to move away at first strike, beyond the zone of injury (see Table 4.25). Similarly, cumulative exposure (SEL_{cum}) would not result in injury to any individuals (Table 4.26).

4.9.2.36 Even without the use of an ADD the modelling suggested that there would be no risk of injury from cumulative exposure (SEL_{cum}), however peak pressure leading to injury could be experienced out to 130 m (at hammer initiation) and 652 m (at full hammer).

4.9.2.37 The injury range is predicted to be localised to within the Morgan Array Area and therefore there is no potential for spatial overlap with the North Anglesey Marine/Gogledd Môn Forol SAC, the closest site designated for harbour porpoise, which is located at a distance of ~23 km (Table 4.11).

4.9.2.38 Harbour porpoise typically live between 12 and 24 years and give birth once a year (Fisher and Harrison, 1970). The duration of piling is up to 114 days, within a two-year piling programme (as defined in Table 4.22), and therefore could potentially overlap with a maximum of two breeding cycles. The duration of the effect in the context of the life cycle of harbour porpoise is classified as medium term, as the risk (albeit very small) is meaningful in the context of the lifespan of this species.

4.9.2.39 The impact (elevated underwater sound during piling) is predicted to be of local spatial extent with respect to the ranges over which PTS could occur, medium term duration, intermittent and, although the impact itself is reversible (i.e. the elevation in underwater sound only occurs during piling), the effect of PTS is permanent. It is predicted that the impact will affect the receptor directly. Without mitigation PTS could affect a small number of animals leading to measurable changes at an individual level but this is unlikely to affect the wider population. Since injury is assumed to be fully mitigated via primary and tertiary mitigation, in the context of the associated assumptions described above, there is considered to be no residual risk of injury; the magnitude is therefore considered to be **negligible**.

Dolphin species

4.9.2.40 For bottlenose dolphin, short-beaked common dolphin and Risso's dolphin, with primary and tertiary mitigation applied, no animals are predicted to be affected by peak pressure (SPL_{pk}) as they are anticipated to move away first strike (see Table 4.25). Similarly, cumulative exposure (SEL_{cum}) would not result in injury to any individuals (Table 4.27).

4.9.2.41 Even without the use of an ADD the modelling suggested that there would be no risk of injury from cumulative exposure (SEL_{cum}), however peak pressure leading to injury would be experienced out to 39 m (at full hammer energy) (the threshold was not exceeded at first strike hammer energy) (Table 4.25).

4.9.2.42 The impact (elevated underwater sound during piling) is predicted to be of local spatial extent with respect to the ranges over which PTS could occur, medium term duration, intermittent and, although the impact itself is reversible (i.e. the elevation in underwater sound only occurs during piling), the effect of PTS is permanent. It is predicted that the impact will affect the receptor directly. Since injury will be fully mitigated via primary and tertiary mitigation there would be no residual risk of injury; the magnitude is therefore considered to be **negligible**.

Minke whale

4.9.2.43 For minke whale, with primary and tertiary mitigation applied, and based on the largest predicted range of 5,840 m (i.e. using the SEL_{cum} metric for consecutive piling at 4,400 kJ), the maximum number of individuals that could be potentially injured calculated using the density value of 0.0173 animals per km^2 (Table 4.12) is no more than one animal (Table 4.27). No animals are predicted to be affected by peak pressure (SPL_{pk}) as they are anticipated to move away first strike (see Table 4.25). The injury range is therefore localised to within the Morgan Array Area and there are no designated sites for minke whale in the vicinity.

4.9.2.44 Without the use of an ADD, modelling demonstrated up to two animals may be at risk of injury using the SEL_{cum} metric for consecutive piling at 4,400 kJ (Table 4.27). Using the SPL_{pk} metric, instantaneous injury would be experienced out to 23 m at first strike hammer energy (118 m at full hammer energy) (Table 4.25).

4.9.2.45 Minke whale typically live up to 60 years and the gestation period is believed to be around ten months. Females may give birth to a calf every one to two years and calves are weaned over five to 10 months, thus the two-year duration of the piling phase could potentially overlap with key breeding/nursing cycles. For an individual female, the risk (albeit small) could interrupt at least one key breeding period with additional risk to mother calf pairs during nursing. This is meaningful in the context of the lifetime of an individual and therefore is classed as medium term.

4.9.2.46 The impact (elevated underwater sound during piling) is predicted to be of local spatial extent with respect to the ranges over which PTS could occur, medium term duration, intermittent and, although the impact itself is reversible (i.e. the elevation in underwater sound only occurs during piling), the effect of PTS is permanent. It is predicted that the impact will affect the receptor directly. PTS could affect a small number of animals leading to measurable changes at an individual level, but this is unlikely to affect the wider population. The residual number of animals predicted to experience PTS were carried forward to the iPCoD modelling assessment alongside disturbance to understand the implications at a population level and the model demonstrated that there would be no long-term effect (see paragraph 4.9.2.92). The magnitude is therefore considered to be **low**.

Pinnipeds

4.9.2.47 For both grey seal and harbour, with primary and tertiary mitigation applied, no animals are predicted to be affected by peak pressure (SPL_{pk}) as they are anticipated to move away first strike (see Table 4.25). Similarly, cumulative exposure (SEL_{cum}) would not result in injury to any individuals (Table 4.27).

4.9.2.48 Even without the use of an ADD the modelling suggested that there would be no risk of injury from cumulative exposure (SEL_{cum}), however peak pressure (SPL_{pk}) leading to injury could be experienced out to 26 m (at first strike) and 130 m (at full hammer) (Table 4.25).

4.9.2.49 Both species of seal typically live between 20 to 30 years with gestation lasting between ten to 11 months (SCOS, 2015; SCOS, 2018), thus the duration of piling (albeit intermittent) could potentially overlap with up to two breeding cycles. Considering the above, the duration of the effect in the context of life cycle of harbour seal and grey seal is classified as medium term.

4.9.2.50 The impact (elevated underwater sound during piling) is predicted to be of local spatial extent, medium term duration, intermittent and although the impact itself is reversible (i.e. the elevation in underwater sound only occurs during piling), the effect of PTS is permanent. It is predicted that the impact will affect the receptor directly. Since injury will be fully mitigated via primary and tertiary mitigation there is no residual risk of injury but taking a precautionary approach the magnitude is therefore considered to be **negligible**.

Behavioural Disturbance

4.9.2.51 Modelled disturbance impact ranges are predicted to extend across the northern part of the Irish Sea. However, he extent of the contours are likely to be an overestimate as the approach assumes that the sound from piling maintains its impulsive characteristics at large distances, which is considered unlikely to be the case. It is noted that there is no agreed approach to modelling the cross-over point from impulsive to continuous sound and this is an ongoing active area of research (see paragraphs 4.9.1.5 and 4.9.1.39, and paragraphs 1.5.5.26 to 1.5.5.29 of Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement for detailed discussion). For this reason, the quantitative assessment should be interpreted with caution and subject to the caveats highlighted by Southall *et al.* (2021) with respect to environmental context (paragraph 4.9.1.32), as assuming impulsive characteristics by comparing predicted sound levels for the whole contour range with impulsive related thresholds is likely to overestimate predicted impact distances..

4.9.2.52 As discussed in paragraphs 4.9.1.16 and 4.9.1.17 dose response curves are obtained from animal reactions in field observations whereby animals react to the underwater sound they receive at their location. The limitations of applying a dose response curve developed for harbour porpoise responses to piling at lower hammer energies and in a different region have been highlighted above and suggest this approach is likely to be very precautionary given the difference in predicted ranges (paragraph 4.9.1.19). In addition, the application of the harbour porpoise dose response curve (in the absence of species-specific data for other cetacean species) (paragraph 4.9.1.16) represents a precautionary approach to the assessment for HF and LF cetaceans. As stated in paragraph 4.9.1.29, for minke whale, for example, based on limited evidence from sonar studies (Kvadsheim *et al.,* 2017; Sivle *et al.,* 2015; Tougaard *et al.,* 2021) evidence suggests that response thresholds are higher than for harbour porpoise (by 40-50 dB re 1 µPa (SPL_{pk})) suggesting lower sensitivity to underwater sound, noting again that given that minke whale are thought to have better hearing at lower frequencies, and sound energy of pile driving is highest in the low frequency range, the reaction distances may be similar (Tougaard *et al.,* 2021)

4.9.2.53 With all the above in mind, the estimated numbers of animals predicted to experience potential disturbance as a result of different piling scenarios is presented in Table 4.28. To provide additional context and allow an area-based assessment (for HRA purposes) the quantitative effect on marine mammal species has also been presented for relevant fixed thresholds (Table 4.21).

4.9.2.54 The estimated numbers of animals potentially disturbed are based on the maximum adverse piling scenario which describe the maximum potential effect for each species. This has been defined with reference to either the extent of the effect, or spatial overlap with abundance hotspots (e.g. areas near the coast). For harbour porpoise, bottlenose dolphin, short-beaked common dolphin, Risso's dolphin and minke whale a quantitative assessment of the number of animals predicted to experience disturbance was undertaken by multiplying the density values (Table 4.12) with the areas within each 5 dB isopleth and correcting the value using the relevant proportional response from Graham *et al.* (2019) for the unweighted SEL_{ss} level (Figure 4.5).

4.9.2.55 For grey seal and harbour seal the quantitative assessment was undertaken by overlaying the unweighted SEL_{ss} contours on at-sea usage density maps produced by Carter *et al*. (2022). The number of animals in each 5 km x 5 km grid cell was summed for each isopleth and corrected using the proportional response as per Whyte *et al*. (2020) (Figure 4.6).

Table 4.28: Potential number of animals predicted to be disturbed within weighted SEL_{ss} sound contours (dose-response approach) as a result of different piling scenarios. Modelling location with the greatest number of animals impacted is presented.

Species	Scenario		Number of animals	% reference population (MU)	Reference population
Harbour porpoise	Single	4,400 kJ	858	1.37	CIS MU
	Single	3,000 kJ	713	1.14	
	Concurrent	3,000 kJ + 3,000 kJ	1,007	1.61	
Bottlenose dolphin	Single	4,400 kJ	4	1.34	IS MU
	Single	3,000 kJ	4	1.11	
	Concurrent	3,000 kJ + 3,000 kJ	5	1.57	
Short-beaked common dolphin	Single	4,400 kJ	2	0.0019	CGNS MU
	Single	3,000 kJ	2	0.0016	
	Concurrent	3,000 kJ + 3,000 kJ	3	0.0022	
Risso's dolphin	Single	4,400 kJ	103	0.84	
	Single	3,000 kJ	86	0.69	
	Concurrent	3,000 kJ + 3,000 kJ	121	0.98	
Minke whale	Single	4,400 kJ	57	0.28	
	Single	3,000 kJ	48	0.23	
	Concurrent	3,000 kJ + 3,000 kJ	67	0.33	
Grey seal	Single	4,400 kJ	54	0.41/0.09	GSRP/OSPAR Region III reference population
	Single	3,000 kJ	41	0.31/0.07	
	Concurrent	3,000 kJ + 3,000 kJ	61	0.47/0.10	
Harbour seal	Single	4,400 kJ	<1	0.0071	HSRP
	Single	3,000 kJ	<1	0.0049	
	Concurrent	3,000 kJ + 3,000 kJ	<1	0.0062	

Harbour porpoise

4.9.2.56 The most conservative estimate of disturbance (using dose-response) led to up to 1,007 animals (based on density from Evans and Waggitt, 2023) predicted to experience potential disturbance from concurrent piling of pin piles (at the Western location) (Table 4.28, Figure 4.8). This equates to 1.61% of the Celtic and Irish Seas (CIS) MU population.

4.9.2.57 The probability of response map presented in the Figure 4.9 illustrates the likelihood of disturbance to harbour porpoise reduces as distance from the piling source increases, based upon the dose response function (see paragraphs 4.9.1.11 to 4.9.1.24 for detail). At the highest sound level around the piles there is the greatest probability of response from animals but this decreases with distance from the piling source towards coastal areas to a much lower probability of response.

4.9.2.58 The estimated numbers of individuals potentially impacted are based on conservative densities and on the assumption that the maximum hammer energies are reached at all piling locations. Although the distribution of harbour porpoise across the Morgan marine mammal study area was found to be uneven (see Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement for further detail), it was assumed that the density of 0.262 animals per km^2 (Table 4.10) is uniformly distributed within all sound contours to provide a precautionary assessment. This density is also higher than those obtained from the Morgan site-specific digital aerial surveys.

4.9.2.59 As described in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement, there are 14 SACs and 10 MNRs within the regional marine mammal study area (Table 4.11, Figure 4.4). Underwater sound modelling for dose-response mapped sound level contours out to as low as 120 dB re 1µPa^{2}s (SEL_{ss}) which extend over large distances. There is therefore potential for overlap of these sound level contours with the closest site designated for harbour porpoise, North Anglesey Marine/Gogledd Môn Forol SAC (located 28.2 km from the Morgan Array Area) as well as Langness MNR, Little Ness MNR, Laxey Bay MNR, Baie Ny Carrickey MNR, West Coast MNR and Rockabill to Dalkey Island SAC, also designated for harbour porpoise.

4.9.2.60 Lying outside the disturbance contours, Calf and Wart Bank MNR, Port Erin Bay MNR, Niarbyl MNR, North Channel SAC, West Wales Marine/Gorllewin Cymru Forol SAC and Bristol Channel Approaches/Dynesfeydd Môr Hafren SAC, also designated for harbour porpoise. Whilst not directly within the region of disturbance mapped, given that harbour porpoise can travel over large distances, there is a possibility that individuals from these designated populations may be occasionally present within the mapped disturbance contours.

4.9.2.61 Using the area-based approach single strike sound exposure level (SEL_{ss}) (paragraph 4.9.1.25) for the unweighted sound threshold of 143 dB re 1 µPa^{2}s disturbance contours were presented for single piling at 3,000 kJ, 4,400 kJ and concurrent piling at 3,000 kJ plus 3,000 kJ and at each location (Figure 4.10, Figure 4.11 and Figure 4.12). This approach, which focuses more on a measurable disturbance response within a known threshold, showed that contours extended to North Anglesey Marine/Gogledd Môn Forol SAC which is designated for harbour porpoise. Due to proximity to the SAC, single piling with a hammer energy of 4,400 kJ at the west location was the only scenario that resulted in an overlap (0.002% overlap). The area-based 143 dB re 1 µPa^{2}s (SEL_{ss}) contours did not extend as far as Isle of Man waters and therefore there was no overlap with MNRs designated for harbour porpoise (Langness, Little Ness, Laxey Bay, Bale Ny Carrickey, Calf and Wart Bank, Port Erin, Niarbyl and West Coast) suggesting that a measurable disturbance would not occur within these protected sites around the Isle of Man.

4.9.2.62 The different approaches described above suggest that close to the piling the disturbance response is likely to be measurable and the probability of such a response is high; individuals could change their baseline behaviour or in some cases actively avoid disturbed areas. At greater distances from the piling source behavioural response are likely to decrease with some individuals (proportional to the distance from the source) tolerating the increase in elevated underwater sound. At ranges beyond the received level of 143 dB re 1 μPa^{2}s (SEL_{ss}) the disturbance is likely to be 'mild' with less likelihood of active avoidance.

4.9.2.63 Piling within a two-year piling phase (albeit with intermittent piling) could coincide with key breeding periods of harbour porpoise and is considered to be meaningful in the context of the lifespan of this species (paragraph 4.9.2.38). As discussed during the third marine mammal EWG consultation (Table 4.5), population modelling was carried out to explore the potential of disturbance during piling to affect the population trajectory over time (which has been suggested to exhibit a declining trend of approximately 4% per annum (IAMMWG, 2021)) and to provide additional certainty in the predictions of the assessment of potential effects. Results of the iPCoD modelling for harbour porpoise against the CIS MU showed that the median ratio of the impacted population to the unimpacted population at both 6 and 25 years was 1.0000 for the maximum temporal scenario, and 1.0000 at 6 years and 25 years for the maximum spatial scenario, which means there is no significant difference between the population trajectories for an unimpacted population and impacted population (Appendix B). Small changes in the impacted population size over time are similar to those predicted for an unimpacted population, as can be seen in Figure 4.7. Here, the maximum temporal scenarios have been presented as the simulated effect on population size (35 animals fewer in the impacted scenario than the unimpacted scenario, equivalent to approximately 0.06% of the CIS MU population estimate) is marginally greater than the maximum spatial scenario (22 animals fewer in the impacted scenario than the unimpacted scenario, equivalent to approximately 0.035% of the CIS MU population estimate).

4.9.2.64 The impact (elevated underwater sound during piling) is predicted to be of regional spatial extent, medium term duration, intermittent and high reversibility (the impact itself occurs only during piling). Similarly, the effect of behavioural disturbance is reversible as receptors are expected to recover within hours/days. It is predicted that the impact will affect the receptor directly. A small proportion (up to 1.61%) of the CIS MU could be affected during piling over the medium term. The results of the iPCoD modelling suggest that over the duration of the impact and up to 25 years after the start of piling the impacted population may be up to 35 individuals smaller than the unimpacted population, corresponding to approximately 0.06% of the MU. In the context of a population that is predicted to decline (IAMMWG, 2021) it is considered that there would be no potential long-term effects on the harbour porpoise population resulting from elevated underwater sound arising during piling. The magnitude is therefore considered to be **low**.

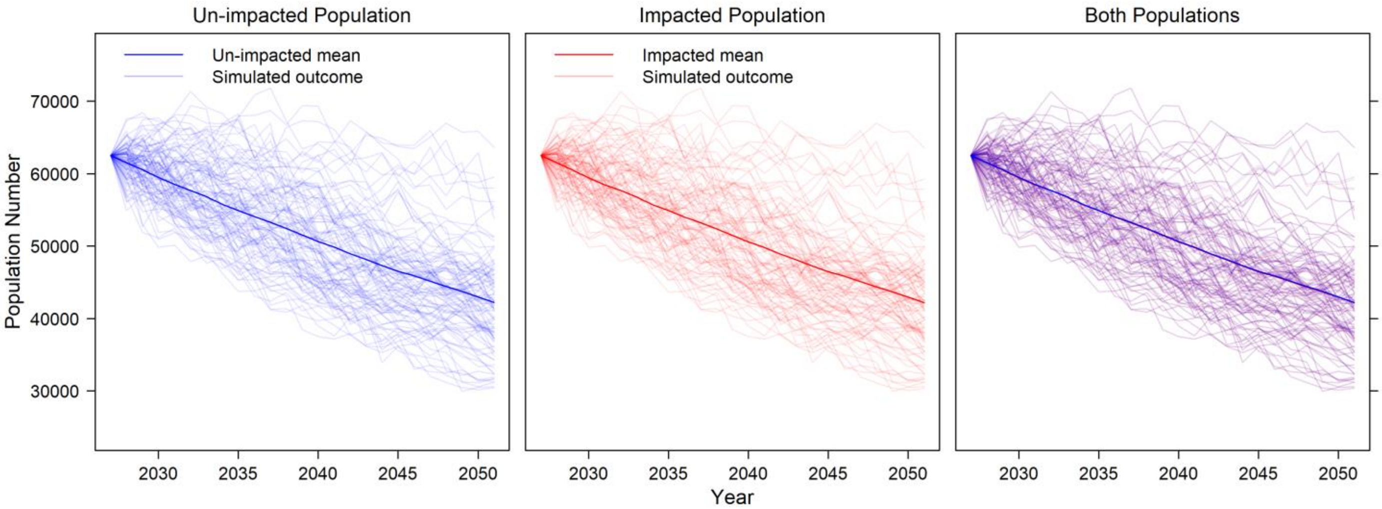


Figure 4.7: Simulated harbour porpoise population sizes for both the baseline (unimpacted) and the impacted populations under the maximum temporal scenario.

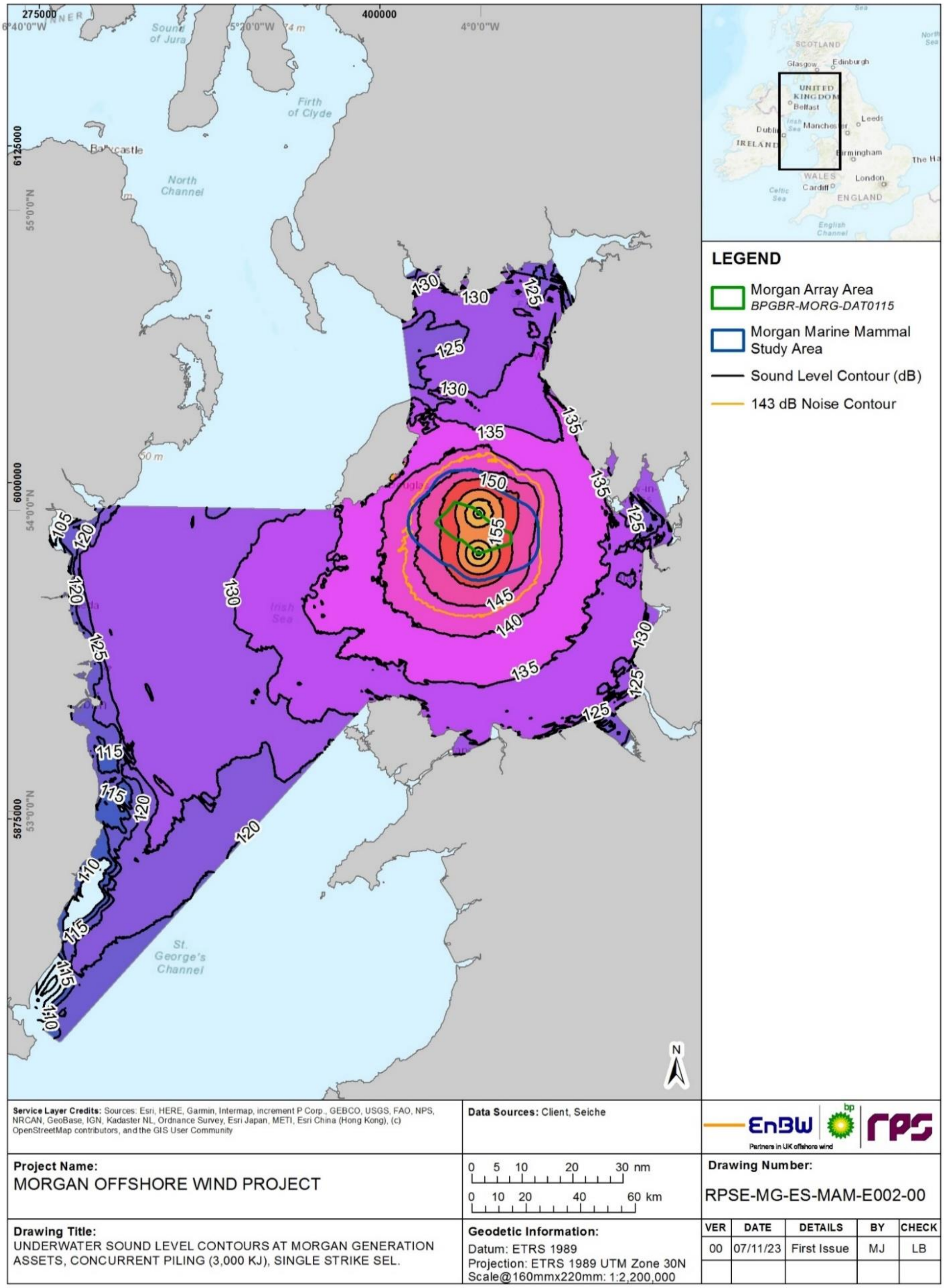


Figure 4.8: Concurrent piling of pin piles at a maximum hammer energy of 3,000 kJ and 3,000 kJ at the greatest spatial extent (with 15 km maximum separation distance) showing SELss contours in 5 dB isopleths (for north modelled location).

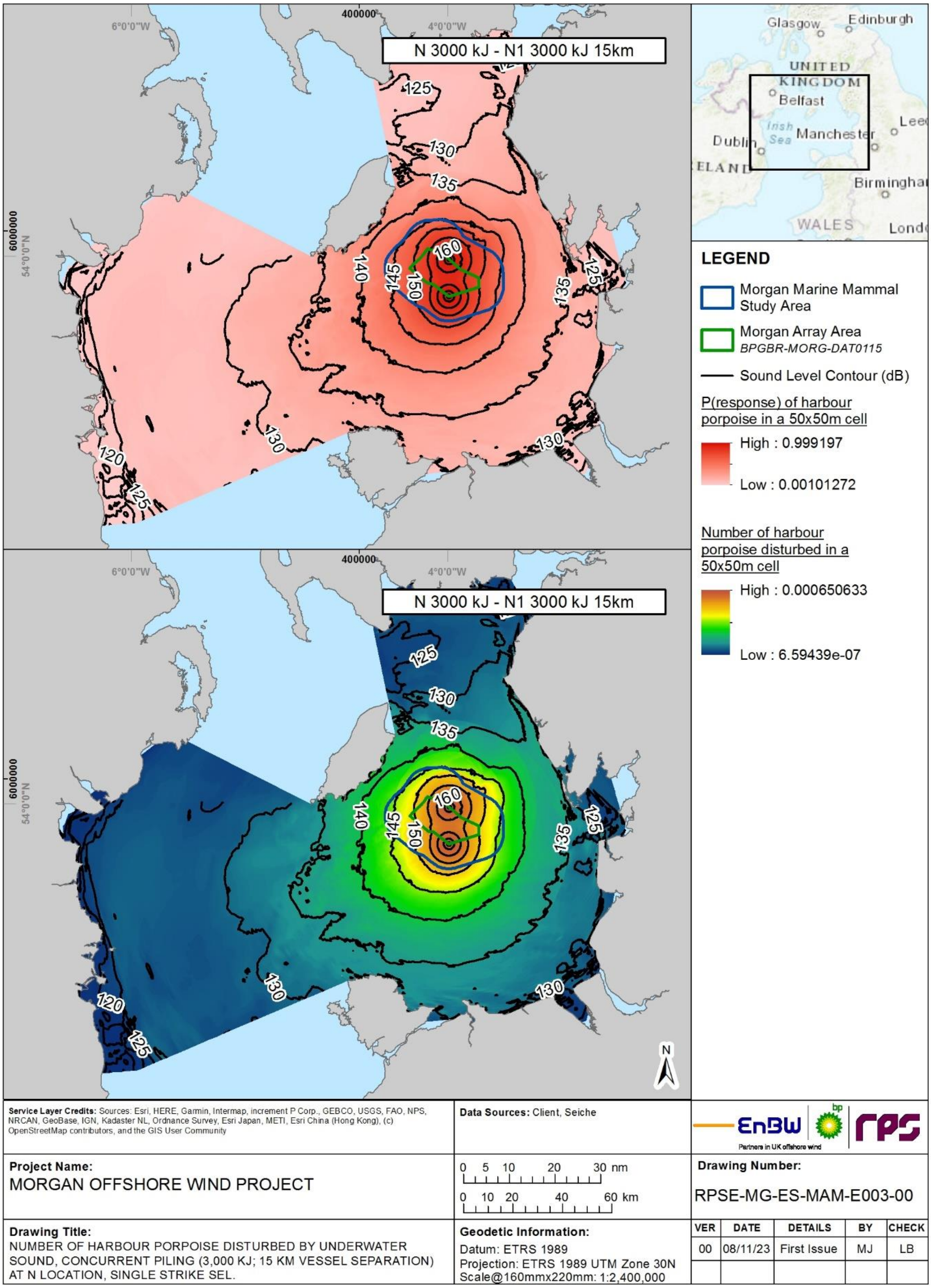


Figure 4.9: Probability of response mapping for harbour porpoise. Top panel presents the probability of response ((P(response)) which shows the percentage of disturbed harbour porpoise per grid cell. Bottom panel demonstrates number of harbour porpoise disturbed per cell.

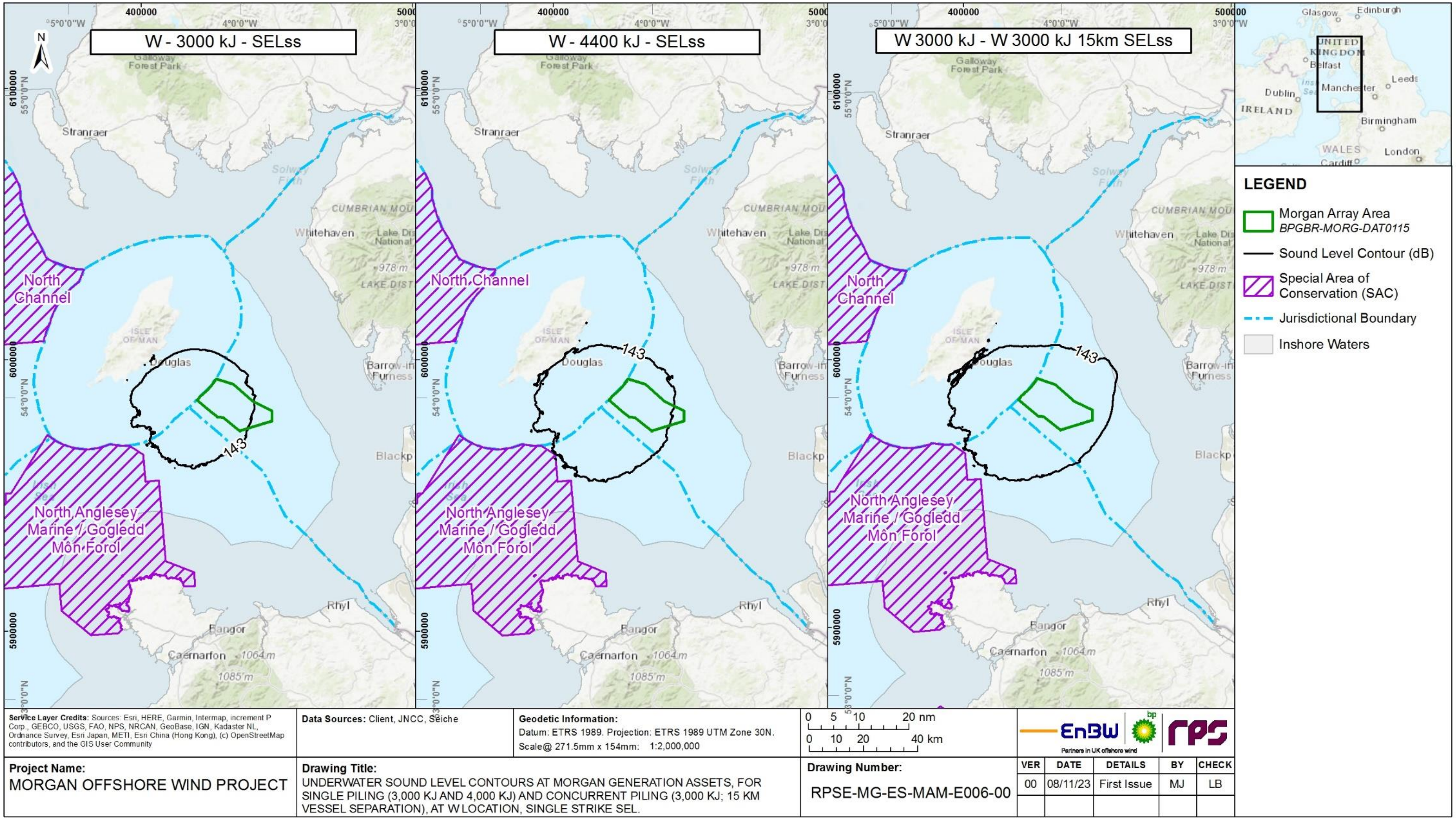


Figure 4.10: Threshold of 143 dB re 1 µPa²s single strike sound exposure level (SEL$_{ss}$) for single and concurrent piling scenarios and the closest SACs designated for harbour porpoise (at west modelled location).

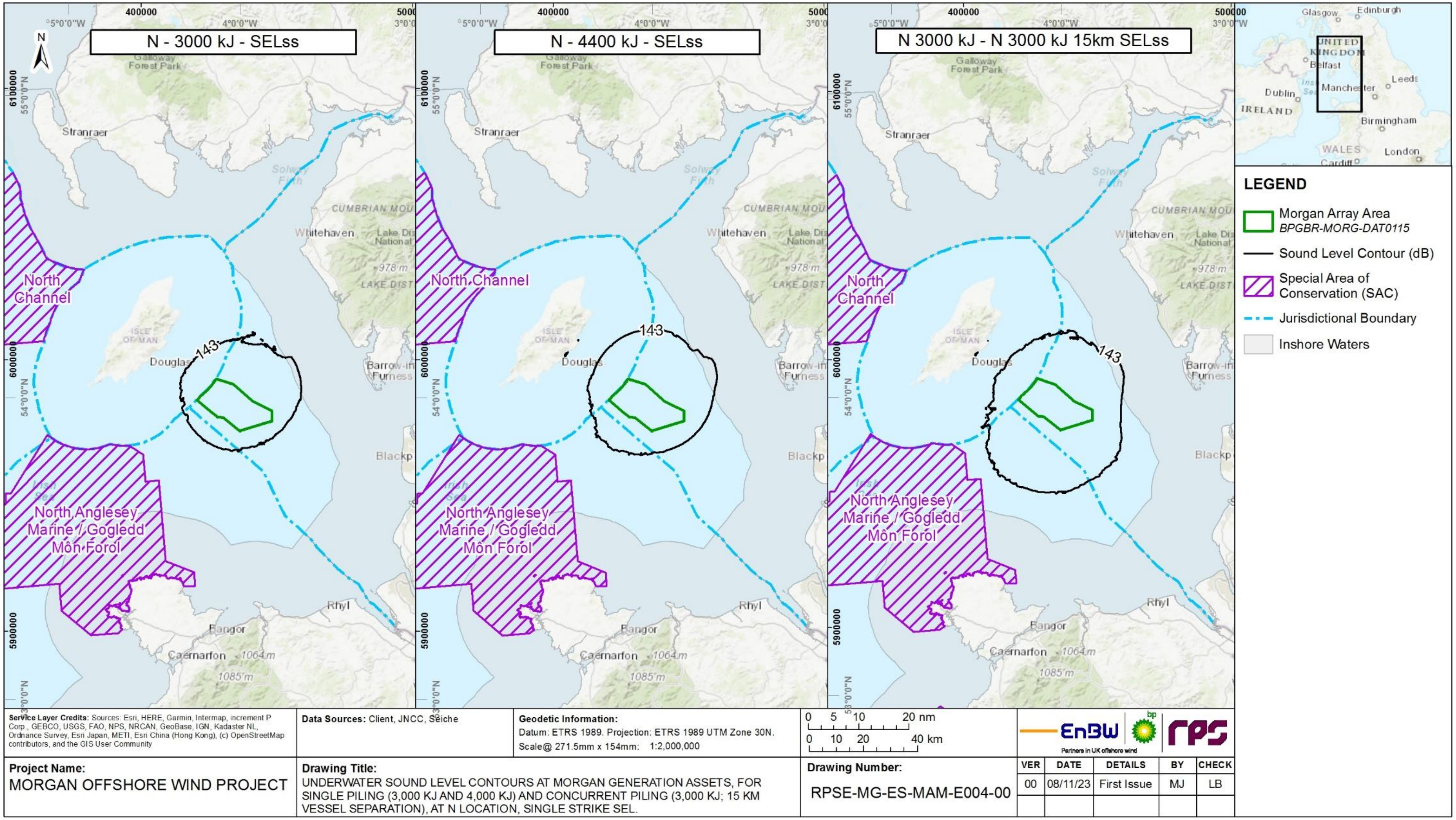


Figure 4.11: Threshold of 143 dB re 1 µPa^{2}s single strike sound exposure level (SEL_{ss}) for single and concurrent piling scenarios and the closest SACs designated for harbour porpoise (at northern modelled location).

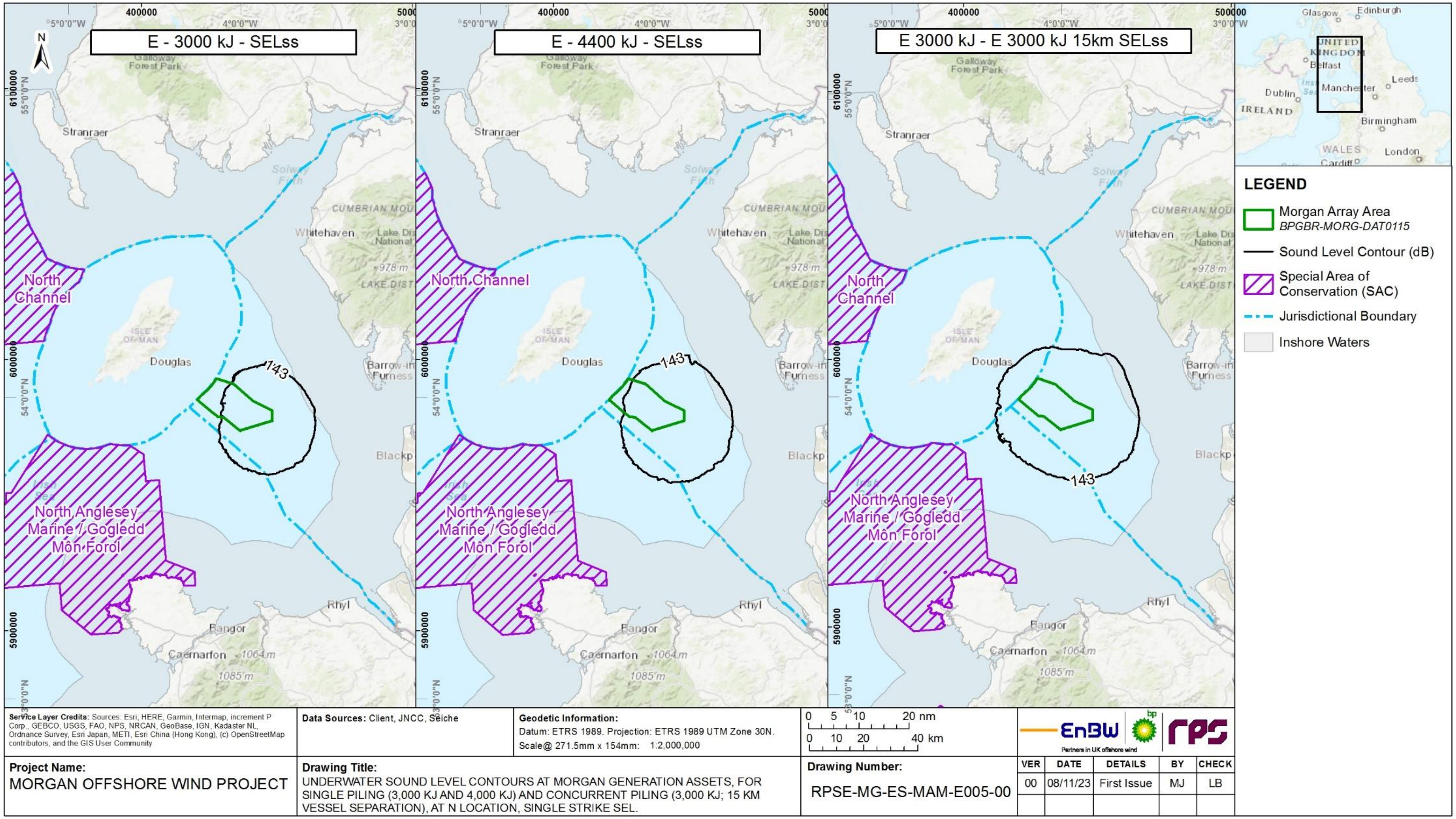


Figure 4.12: Threshold of 143 dB re 1 µPa²s single strike sound exposure level (SELss) for single and concurrent piling scenarios and the closest SACs designated for harbour porpoise (at eastern modelled location).

Bottlenose dolphin

4.9.2.65 The most conservative estimate of disturbance (using dose-response) led to up to five animals predicted to experience potential disturbance from concurrent piling at a maximum hammer energy of 3,000 kJ (Figure 4.8, Table 4.28). This equates to 1.57% of the Irish Sea (IS) MU population.

4.9.2.66 This estimate is a conservative estimate using a single density derived from the Morgan marine mammal study area from the Welsh Marine Mammal Atlas (Evans and Waggitt, 2023) across the Irish Sea and assumes a uniform distribution throughout the area. The density (0.0012 animals per km^2) is applied across the sound level contours, which includes the waters around the Isle of Man (Figure 4.8).

4.9.2.67 As discussed in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement, there is evidence of bottlenose dolphin moving between Cardigan Bay and Manx waters. These animals are part of the same population moving seasonally between the two areas (Lohrengel *et al.,* 2018), and therefore are treated as one population with high connectivity across the marine mammal study area for assessment. In the Irish Sea bottlenose dolphin distribution is largely coastal (Oudejans *et al.*, 2015; Paxton *et al.,* 2016). An inshore ecotype is therefore considered, located within a 6 km region from the coastline (Feingold and Evans, 2014), which lies ~31 km from the nearest boundary of the Morgan Array Area. At this distance the received level from piling will have lost much of the impulsive characteristics (paragraph 4.9.1.6 and 4.9.1.39). However, the outermost sound level contours reach this coastal area and therefore areas of mild disturbance may overlap with the key inshore distribution of inshore ecotype bottlenose dolphin in the IS MU (Figure 4.8).

4.9.2.68 As described in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement, there are 14 SACs and 10 MNRs within the regional marine mammal study area (Table 4.11). Little Ness MNR is the closest MNR (designated for bottlenose dolphin) to the Morgan Array Area and there is potential for overlap of sound disturbance contours with this designated site. Further away, with no potential for overlap of sound disturbance contours, is the Pen Llŷn a`r Sarnau/Llŷn Peninsula and the Sarnau SAC and the Cardigan Bay/Bae Ceredigion SAC, both designated for bottlenose dolphin. The Cardigan Bay population has been estimated to consist of around 125 individuals (JNCC, 2022), with inshore areas being used for both feeding and reproduction and given that bottlenose dolphin can travel over large distances, there is a possibility that individuals from these SAC populations may be occasionally present within the disturbance contours.

4.9.2.69 Application of the NMFS (2005) area-based threshold of 160 dB re 1 μPa SPL_{rms} (strong disturbance) indicated no overlap of disturbance contours with any SAC or MNR designated for bottlenose dolphin in the Morgan marine mammal study area. There was, however, an overlap with the Isle of Man MNRs designated for bottlenose dolphin (Little Ness, Douglas Bay, Laxey Bay, Bale Ny Carrickey) for the larger contour predicted for the 140 dB re 1 μPa SPL_{rms} (mild disturbance) threshold although noting that this would be unlikely to displace animals from the area and would suggest mild disruption of behaviour (Figure 4.13). Therefore, there would not be anticipated to be strong disturbance of individuals within protected sites although individuals originating from these sites could range as far as the ensonified areas. Further assessment of the potential effects on SACs is provided in the HRA Stage 2 ISAA (Document Reference E1.1).

Barrier effects

4.9.2.70 Since the outer dose-response contours reach areas occupied by the coastal bottlenose dolphin population, the potential for barrier effects, e.g. restricting animals from moving along the coast, must also be considered for both single and concurrent piling scenarios. Received sound levels within the coastal region (~6 km buffer from the coastline) are predicted to reach maximum SEL_{ss} levels of 135 dB re 1 $\mu Pa^2 s$ (including along the coast of the Isle of Man) (Figure 4.8). This is equivalent to 145 dB re 1 µPa SPL_{rms} and below the NMFS (2005) threshold for strong disturbance (=160 dB re 1 µPa SPL_{rms}) and therefore likely to elicit less severe disturbance reactions. The modelled contours for the NMFS area-based threshold of 160 dB re 1 µPa SPL_{rms} are illustrated in Figure 4.13 and show that strong disturbance would not occur in coastal habitats. The area-based modelled contours for mild disturbance (140 dB re 1 µPa SPL_{rms}) do, however, extend further and could overlap coastal habitats. According to the behavioural response severity matrix suggested by Southall *et al*. (2021) such low level disturbance (scoring between 0 to 3 on a 0 to 9 scale) could lead to mild disruptions of normal behaviours, but prolonged or sustained behavioural effects, including displacement are unlikely to occur. Further discussion on the sensitivity of bottlenose dolphin is provided in paragraph 4.9.2.121 but for the purposes of assessing magnitude, it is considered that animals are unlikely to be excluded from the coastal areas given the low level disturbance and therefore unlikely to lead to barrier effects.

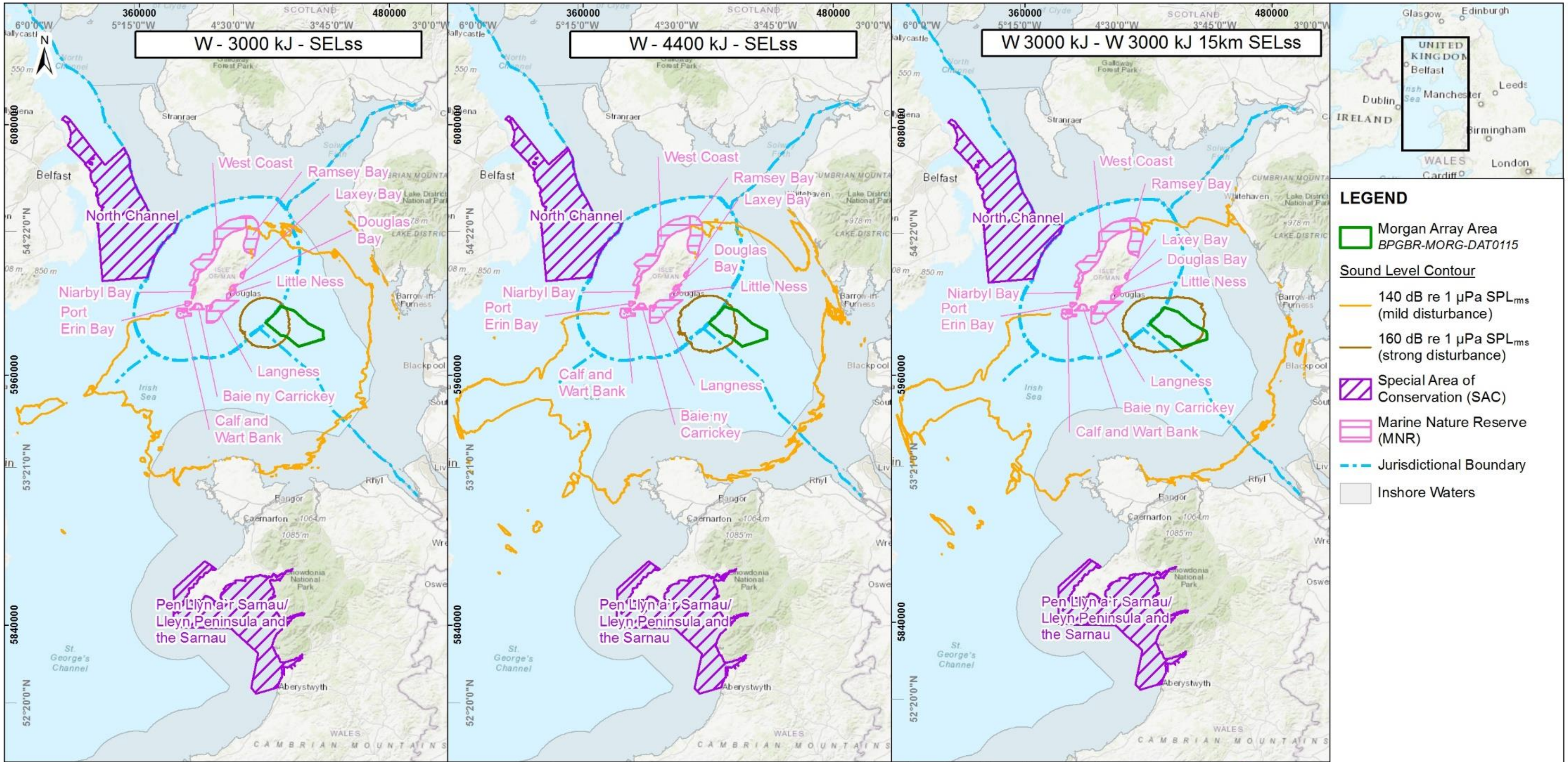
4.9.2.71 Bottlenose dolphin typically live between 20 and 30 years and females reproduce every three to six years. Gestation takes 12 months followed by calves suckling for 18 to 24 months, thus the two-year duration of the piling phase could potentially overlap with key breeding/nursing cycles (although noting that piling would occur intermittently over this period). For an individual female, the risk (albeit very small) could interrupt at least one key breeding period with additional risk to mother-calf pairs during nursing. This is considered to be meaningful in the context of the lifetime of an individual and therefore is classed as medium-term. The magnitude of the impact could also result in a small but measurable alteration to the distribution of marine mammals during piling only and may affect the fecundity of some individuals over the medium term.

4.9.2.72 Population modelling was carried out to explore the potential of disturbance during piling to affect the population trajectory over time and provide additional certainty in the predictions of the assessment of potential effects. Results of the iPCoD modelling for bottlenose dolphin against the MU population showed that the difference between the impacted and unimpacted populations after 25 years was a maximum of one animal (approximately 0.341% of the IS MU population estimate) for both the maximum temporal and maximum spatial scenarios, for both fertility rates. This difference, of one animal, was the maximum difference between the impacted and unimpacted populations throughout the 25 year simulation, for both the maximum temporal and maximum spatial scenarios, for both fertility rates.

4.9.2.73 The median ratio of the impacted population to the unimpacted population was 1.0000 at both six years and 25 years for both the maximum temporal and maximum spatial scenarios (Appendix B) for both fertility rates (0.22 and 0.30). However, mean ratios were marginally lower, at 0.9981 at 6 years and 0.9980 at 25 years for the maximum temporal scenario, and for the maximum spatial scenario mean ratios were 0.9986 at 6 years and 0.9988 at 25 years (based on a fertility rate of 0.22). The corresponding ratios for the models parameterised with a fertility rate of 0.30 were 0.9981 at six years and 0.9982 at 25 years for the maximum temporal scenario, and 0.9981 at both 6 and 25 years for the maximum spatial scenario.

4.9.2.74 Small differences (i.e. one animal) in the population size over time between the impacted and unimpacted population (a maximum of one individual for any scenario) fall within the natural variance of the population, and would not be expected to change the population trajectory as can be seen in Figure 4.14 and Figure 4.15. Therefore, given the scale of differences between impacted and unimpacted populations (i.e. one animal is 0.341% of the IS MU population estimate), it was considered that there is no potential for a long-term effect on this species from elevated underwater sound arising during piling. It is important to highlight that whilst any model is sensitive to input parameters (as evidenced in Appendix B), the parameters (recommended by NRW through the EPP) used in the iPCoD model represent a conservative assessment of population changes.

4.9.2.75 The impact (elevated underwater sound during piling) is predicted to be of regional spatial extent, medium-term duration, intermittent and high reversibility (the impact itself occurs only during piling). Similarly, the effect of behavioural disturbance is reversible as receptors are expected to recover within hours/days. It is predicted that the impact will affect the receptor directly. Whilst 1.57% of the IS MU could be affected during piling the results of the iPCoD modelling suggest that over the duration of the impact and up to 25 years after the start of piling there would be no long-term potential population effects on the bottlenose dolphin population. The impact could result in some measurable changes to individuals that are disturbed (i.e. interruption of feeding or breeding and/or displacement to alternative areas), however, there would be no population-level consequences of disturbance. The magnitude is therefore considered to be **low**.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community	Data Sources: Client, JNCC, Seiche	Geodetic Information: Datum: ETRS 1989. Projection: ETRS 1989 UTM Zone 30N. Scale@ 271.5mm x 154mm: 1:2,800,000	0 5 10 20 30 40 nm; 0 10 20 40 60 80 km
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Figure 4.13: Thresholds of 160 dB re 1 µPa SPL$_{rms}$ (strong disturbance) and 140 dB re 1 µPa SPL$_{rms}$ (mild disturbance) for single and concurrent piling scenarios (at west modelled location, the area with maximum extent of ensonification at these thresholds) and the closest SACs for bottlenose dolphin.

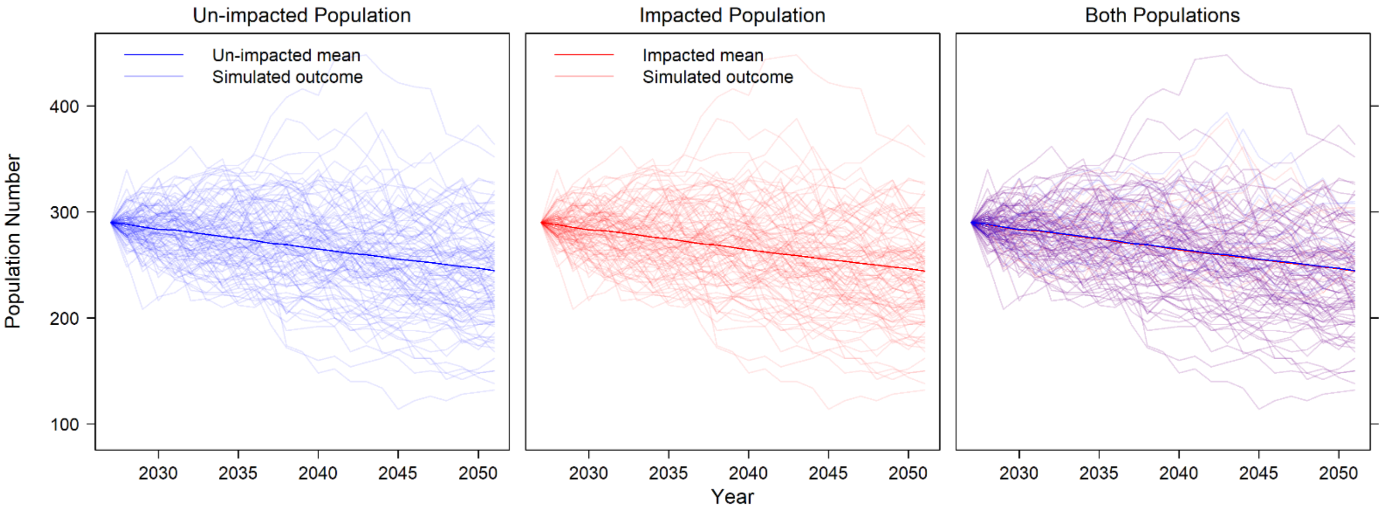


Figure 4.14: Simulated bottlenose dolphin population sizes for both the baseline (unimpacted) and the impacted populations under the maximum temporal scenario, with a fertility rate of 0.22.

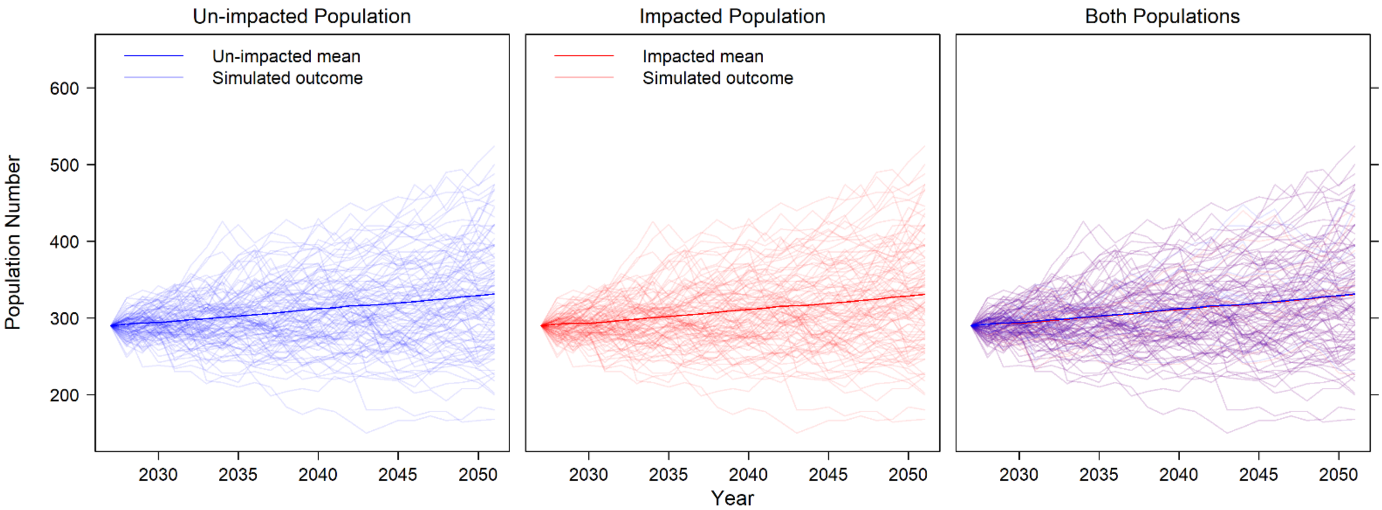


Figure 4.15: Simulated bottlenose dolphin population sizes for both the baseline (unimpacted) and the impacted populations under the maximum temporal scenario, with a fertility rate of 0.30.

Short-beaked common dolphin

4.9.2.76 For short-beaked common dolphin, the most conservative estimate of disturbance (using dose-response) led to up to three animals predicted to experience potential disturbance from concurrent piling of pin piles (Figure 4.8) at a maximum hammer energy of 3,000 kJ. This equates to 0.002% of the CGNS MU population.

4.9.2.77 The maximum numbers presented in Table 4.28 are based on a density (0.000288 animals per km^2) from the Welsh Marine Mammal Atlas (Evans and Waggitt, 2023) for the Morgan marine mammal study area. There were no densities of short-beaked common dolphin reported for SCANS-III surveys for the blocks overlapping the Morgan marine mammal study area and no individuals were recorded in the two years of Morgan site-specific digital aerial surveys.

4.9.2.78 The extents of predicted disturbance based on the area-based thresholds (strong and mild disturbance) are illustrated in Figure 4.13 for the west piling location. No sites are designated for short-beaked common dolphin.

4.9.2.79 Short-beaked common dolphin has a gestation period of 10 to 11 months, weaned at around 19 months old, and then the mother generally has a resting period of approximately 4 months before her next pregnancy. Calving intervals are therefore generally a minimum of two to three years. For an individual female, the risk (albeit very small) could interrupt at least one key breeding period with additional risk to mother-calf pairs during nursing. This is considered to be meaningful in the context the lifetime of an individual and therefore is classed as medium-term.

4.9.2.80 The use of iPCoD was discussed during the third EWG (November 2022) (Table 4.5) and since iPCoD does not facilitate modelling for short-beaked common dolphin no population modelling was carried out for this species.

4.9.2.81 The impact (elevated underwater sound during piling) is predicted to be of regional spatial extent, medium term duration, intermittent and high reversibility (the impact itself occurs only during piling). Similarly, the effect of behavioural disturbance is reversible as receptors are expected to recover within hours/days. It is predicted that the impact will affect the receptor directly. A small proportion (up to 0.002%) of the CGNS MU population) could be affected during piling over the medium term. The area of effect is however very small in relation to the extensive distribution of the population for this species (CGNS MU) and there is predicted to be no population consequences of the impact. The magnitude is therefore considered to be **negligible**.

Risso's dolphin

4.9.2.82 For Risso's dolphin, the most conservative estimate of disturbance (using dose-response) led to up to 121 animals predicted to experience potential disturbance from concurrent piling of pin piles at a maximum hammer energy of 3,000 kJ and 3,000 kJ (Figure 4.8). This equates to 0.98% of the CGNS MU population.

4.9.2.83 The maximum numbers presented in Table 4.28 are considered to be conservative as the estimate assumed uniform distribution throughout the area, and is derived from SCANS-III densities (0.0313 animals per km^2) for block E, which lies to the south of the Morgan Array Area (since there were no reported densities for block F, which overlaps with the Morgan marine mammal study area). No Risso's dolphin were recorded during the 24 months of site-specific aerial surveys in the Morgan Aerial Survey Area (more detail can be found in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement). Therefore, the number of Risso's dolphin that may be disturbed as a result of all piling scenarios should be interpreted with caution as these animals are likely to be present in lower densities.

4.9.2.84 The extents of disturbance based on the area-based thresholds (strong and mild disturbance) are illustrated in Figure 4.13 for the west piling location. The sound level contour for strong disturbance (160 dB re 1 µPa SPL_{rms}) did not extend as far as the MNRs designated for Risso's dolphin around Isle of Man waters (Langness, Little Ness, Douglas Bay, Bale Ny Carrickey, Calf and Wart Bank) although there was an overlap with the predicted extent for mild disturbance (140 dB re 1 µPa SPL_{rms}).

4.9.2.85 Risso's dolphin have a gestation period of 13 to 14 months, giving birth to a single calf. Weaning is between 12 and 18 months, with intervals between calves averaging at 2.4 years. Therefore, the two-year duration of the piling phase could potentially overlap with at least one breeding cycle for an individual female. This is considered to be meaningful in the context the lifetime of an individual and therefore is classed as medium term.

4.9.2.86 Since iPCoD does not facilitate modelling for Risso's dolphin, no population modelling was carried out for this species. However, sound level contours of 135 dB re 1 µPa^{2}s SEL_{ss} (= 145 dB re 1 µPa SPL_{rms}, mild disturbance) have the potential to overlap with the Risso's dolphin Isle of Man population around the south of the Island (Figure 4.8). Based on a density estimate of 0.0313 animals per km^2 up to 18 Risso's dolphin have the potential to be disturbed at this sound level (0.08% of the MU). Around the Isle of Man, Risso's dolphin are likely to be present in summer months thus may experience some temporary displacement if piling is carried out during this season.

4.9.2.87 The impact (elevated underwater sound during piling) is predicted to be of regional spatial extent, medium-term duration, intermittent and high reversibility (the impact itself occurs only during piling). Similarly, the effect of behavioural disturbance is reversible as receptors are expected to recover within hours/days. It is predicted that the impact will affect the receptor directly. A small proportion (up to 0.98%) of the CGNS MU population) could be affected during piling over the medium term. The area of effect is however small in relation to the extensive distribution of the population for this species (CGNS MU) and there is predicted to be no population consequences of the potential impact. The magnitude is therefore considered to be **low**.

Minke whale

4.9.2.88 Based on the SCANS-III block E minke whale density estimate (0.0173 animals per km), up to 67 animals have the potential to be disturbed as a result of concurrent piling (Figure 4.8) at a maximum hammer energy of 3,000 kJ and 3,000 kJ, which equates to 0.33% of the CGNS MU.

4.9.2.89 The maximum numbers presented in Table 4.28 were considered to be conservative as these are based on the SCANS-III block E densities (carried out during summer months) and assume uniform distribution. Minke whale exhibit a temporal distribution in the Irish Sea, present from late April to early August. There is also a high degree of seasonality to Manx waters, as detailed in the Manx Marine Environmental Statement, with presence between June and November (Howe, 2018). Howe (2018) also noted a clear spatial aspect to the distribution of Minke whale sightings in Manx waters, with the majority of summer sightings on the west coast of the island, whereas in the autumn most sightings are on the east coast. As mentioned, two herring stocks in the Irish Sea (the Mourne Stock and the Manx Stock) may drive this pattern, with the Manx herring stock spawning off the east coast of the island in September to October (Bowers 1969), and Mourne stock are found together off the west coast of the island (Bowers 1980). Therefore, density values, and subsequently predicted numbers to be disturbed for minke whale will be overly conservative for piling activities should they occur during winter months.

4.9.2.90 As described in more detail in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement, no minke whale were recorded during the 24 months of site-specific aerial surveys in the Morgan Aerial Survey Area. Therefore, the number of minke whale that may be disturbed as a result of all piling scenarios should be interpreted with caution as these animals are likely to be present in lower densities.

4.9.2.91 The extent of the area-based thresholds (strong and mild disturbance) are illustrated in Figure 4.13 for the west piling location. No sites are designated for minke whale, as discussed in section 4.5.1.

4.9.2.92 Piling within a two-year piling phase (albeit with intermittent piling) could coincide with key breeding periods of minke whale and is considered to be meaningful in the context of the lifespan of this species (paragraph 4.9.2.45). Population modelling was carried out to explore the potential of disturbance during piling to affect the population trajectory over time and provide additional certainty in the predictions of the assessment of potential effects. Results of the iPCoD modelling for minke whale against the CGNS MU showed that the median ratio of the impacted population to the unimpacted population at six years was 0.9998 and at 25 years was 0.9995 for the maximum temporal scenario and 0.9991 at six years and 0.9985 at 25 years for the maximum spatial scenario (Appendix B). Small differences in the population size over time between the impacted and unimpacted population (up to 38 individuals over 25 years in the maximum spatial scenario) fall within the natural variance of the population and would not be expected to elicit a change in the population trajectory, as can be seen in Figure 4.16.

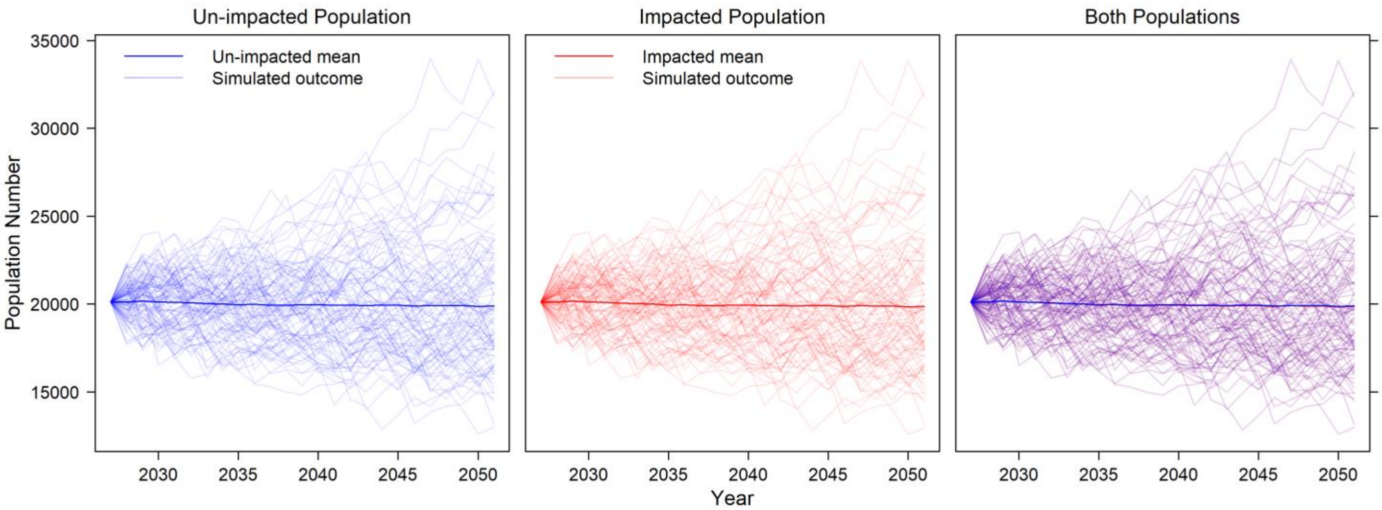


Figure 4.16: Simulated minke whale population sizes for both the baseline (unimpacted) and the impacted populations under the maximum temporal scenario.

4.9.2.93 The impact (elevated underwater sound during piling) is predicted to be of regional spatial extent, medium-term duration, intermittent and high reversibility (the impact itself occurs only during piling). Similarly, the effect of behavioural disturbance is reversible as receptors are expected to recover within hours/days. It is predicted that the impact will affect the receptor directly. A small proportion (up to 0.33%) of the CGNS MU could be affected during piling and the results of the iPCoD modelling suggest that over the duration of the impact, up to 6 years and 25 years after the start of piling there would be a small difference in the size of the impacted population, relative to the unimpacted population. The impacted population was predicted to be up to 25 individuals smaller after six years (corresponding to approximately 0.124% of the CGNS MU population estimate) and up to 38 individuals smaller (corresponding to approximately 0.189% of the CGNS MU population estimate) after 25 years. This is expected to result in no potential long-term effects on the minke whale population. Whilst the impact could result in some measurable changes to individuals that are disturbed (i.e. interruption of feeding or breeding) there would be no population-level consequences of disturbance. The magnitude is therefore considered to be **low**.

Grey seal

4.9.2.94 For grey seal, the most conservative estimate of disturbance (using dose-response) led to up to 61 animals (Carter *et al.*, 2022 densities) predicted to experience potential disturbance from concurrent piling of pin piles at a maximum hammer energy of 3,000 kJ and 3,000 kJ (at the west location, see Figure 4.17). This equates to 0.47% of the GSRP (as described in Table 4.10) or 0.10% of the OSPAR Region III reference population. Telemetry studies (presented in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement) demonstrate that grey seal move extensively across the Irish Sea with connectivity between key haul outs and the Morgan marine mammal study area. Therefore, population estimates for all relevant management units have been summed to give one reference population against which to assess potential disturbance. In addition, further to consultation at the third marine mammal EWG (Table 4.5) the number of animals disturbed was assessed with reference to the OSPAR Region III reference population.

4.9.2.95 The probability of response map presented in Figure 4.18 illustrates the likelihood of disturbance to grey seal reduces as distance from the piling source increases, based upon the dose response function (see paragraphs 4.9.1.30 to 4.9.1.37 for detail). At the highest sound level around the piles there is the greatest probability of response from animals but this decreases with distance from the piling source towards the coastal areas to a much lower probability of response.

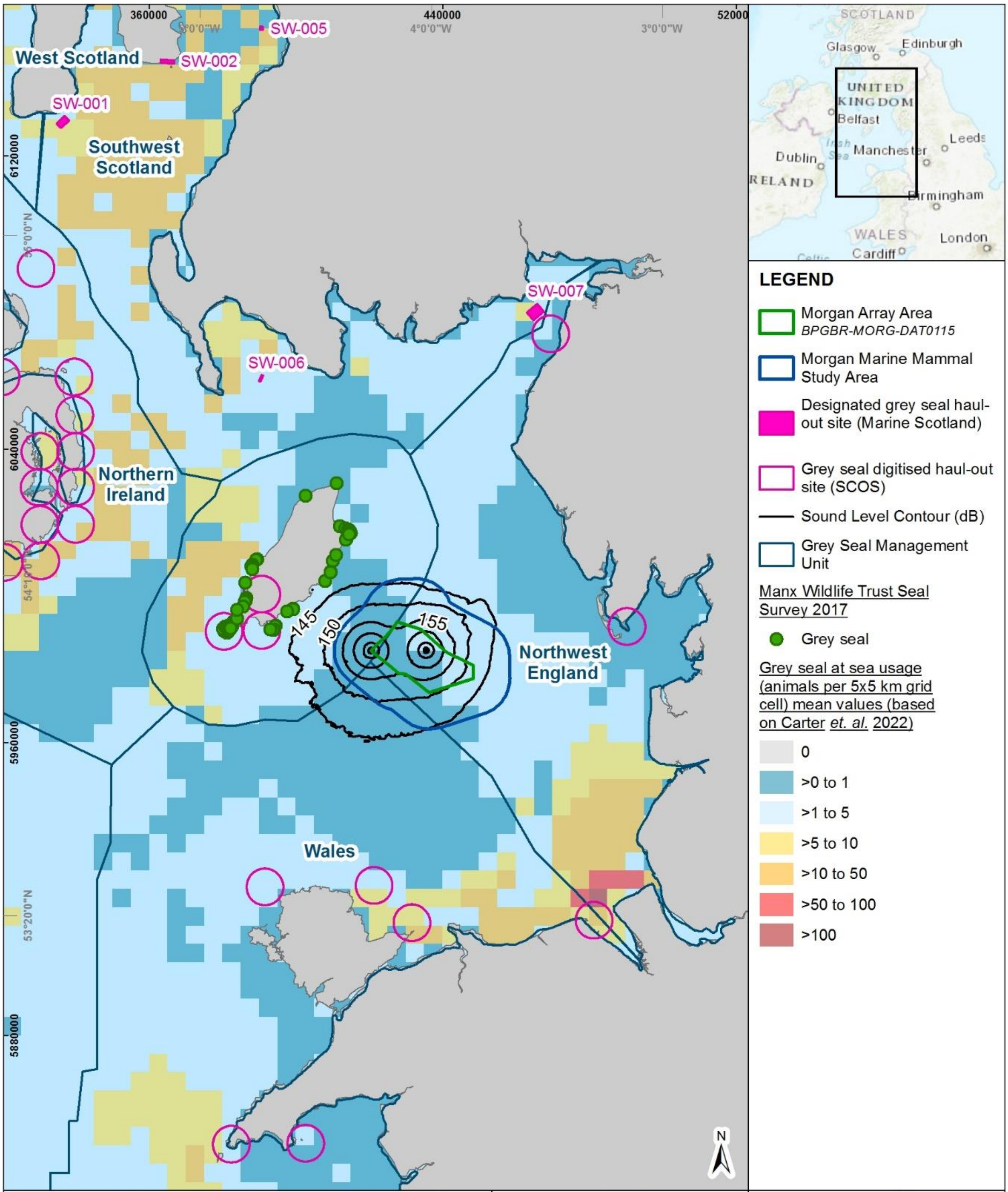
4.9.2.96 As identified in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement, ten sites designated for the protection of grey seal are located within the regional marine mammal study area (see section 4.5.1) (Pen Llŷn a`r Sarnau/Llŷn Peninsula and the Sarnau SAC, Lambay Island SAC, Cardigan Bay/Bae Ceredigion SAC, Pembrokeshire Marine/Sir Benfro Forol SAC, Saltee Islands SAC, Lundy SAC, Langness MNR, Ramsey Bay MNR, Niarbyl MNR, and West Coast MNR). Telemetry tracks presented in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement demonstrated high levels of connectivity between designated sites and therefore there is potential that some animals within the impacted area may be associated with SACs designated for grey seal.

4.9.2.97 Similarly, applying the area-based unweighted sound threshold of 160 dB re 1 μPa SPL_{rms} (strong disturbance) predicted no overlap with any SAC or MNR designated for grey seal in the regional marine mammal study area. There is, however, an overlap with one Isle of Man MNR designated for grey seal (Langness MNR) for the larger contour predicted for the 140 dB re 1 μPa SPL_{rms} (mild disturbance) threshold although noting that received sound levels would only likely elicit mild disruptions in behaviour, rather than resulting in displacement (Figure 4.13). Therefore, whilst individuals originating from protected sites could range as far as the ensonified areas there is not anticipated to be strong disturbance response of those individuals. Further assessment of the potential effects on SACs is provided in the HRA Stage 2 ISAA (Document Reference E1.1).

Barrier effects

4.9.2.98 The potential for barrier effects (i.e. the ability to move between key areas such as haul-out sites and foraging areas offshore) was considered for both concurrent and single piling scenarios. The level at which a measurable response is predicted to occur in seal species is at a maximum received sound level of 145 dB re 1 $\mu Pa^2 s$ SEL_{ss} (= 155 dB re 1 μPa SPL_{rms}) (Whyte *et al.,* 2020). Animals exposed to lower sound levels in the outer disturbance contours are likely to experience mild disruptions of normal behaviours but prolonged or sustained behavioural effects, including displacement, are unlikely to occur (Southall *et al*., 2021). The contours presented in Figure 4.17 at the west location (the location closest to areas of high grey seal density and therefore most likely overlap in area of ensonification) show those for a measurable response for seal species (Whyte *et al.,* 2020), and these contours do not reach the high density areas in the Dee Estuary.

4.9.2.99 With respect to the above, it was considered that grey seal close to the coast could experience very mild disturbance but that this would be unlikely to lead to barrier effects, (i.e. preventing animals from using the foraging grounds in waters along the coast) as animals are unlikely to be excluded from the coastal areas. Furthermore, grey seal has a large foraging range (up 448 km reported in Carter *et al*., 2022) and could therefore move to alternative foraging grounds during piling. Note, however, that animals would be likely to avoid offshore areas where received levels during piling exceed thresholds for strong disturbance. In addition, there may be an energetic cost associated with longer foraging trips and alternative habitat may be sub-optimal in terms of abundance of key prey species.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, JNCC, St Andrews University, Seiche, SCOS, Marine Scotland, Manx Wildlife Trust

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 5 10 20 nm
0 10 20 40 km

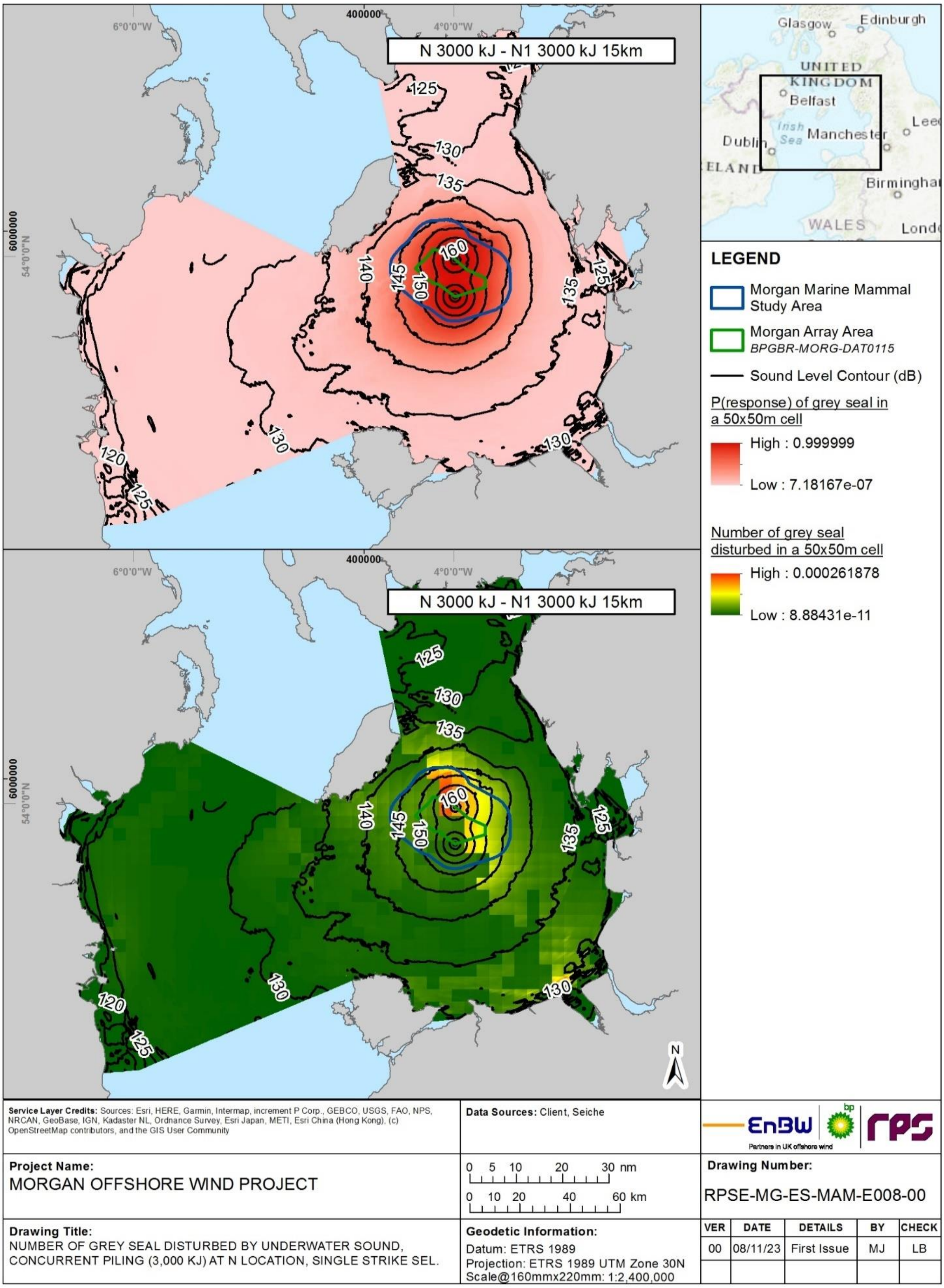
Drawing Number:
RPSE-MG-ES-MAM-E007-00

Drawing Title:
GREY SEAL AT-SEA USAGE (CARTER ET AL., 2022) AND UNWEIGHTED SELSS SOUND LEVEL CONTOURS FOR CONCURRENT PILING (3,000 KJ; 15 KM VESSEL SEPARATION) AT W LOCATION.

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:1,750,000

VER	DATE	DETAILS	BY	CHECK
00	08/11/23	First Issue	MJ	LB

Figure 4.17: Morgan Generation Assets and grey seal at-sea usage (Carter *et al*., 2022) overlaid with unweighted SEL_{ss} contours due to concurrent impact piling of wind turbine pin pile foundations at maximum hammer energy (3,000 and 3000 kJ with 15 km vessel separation) at the west location).



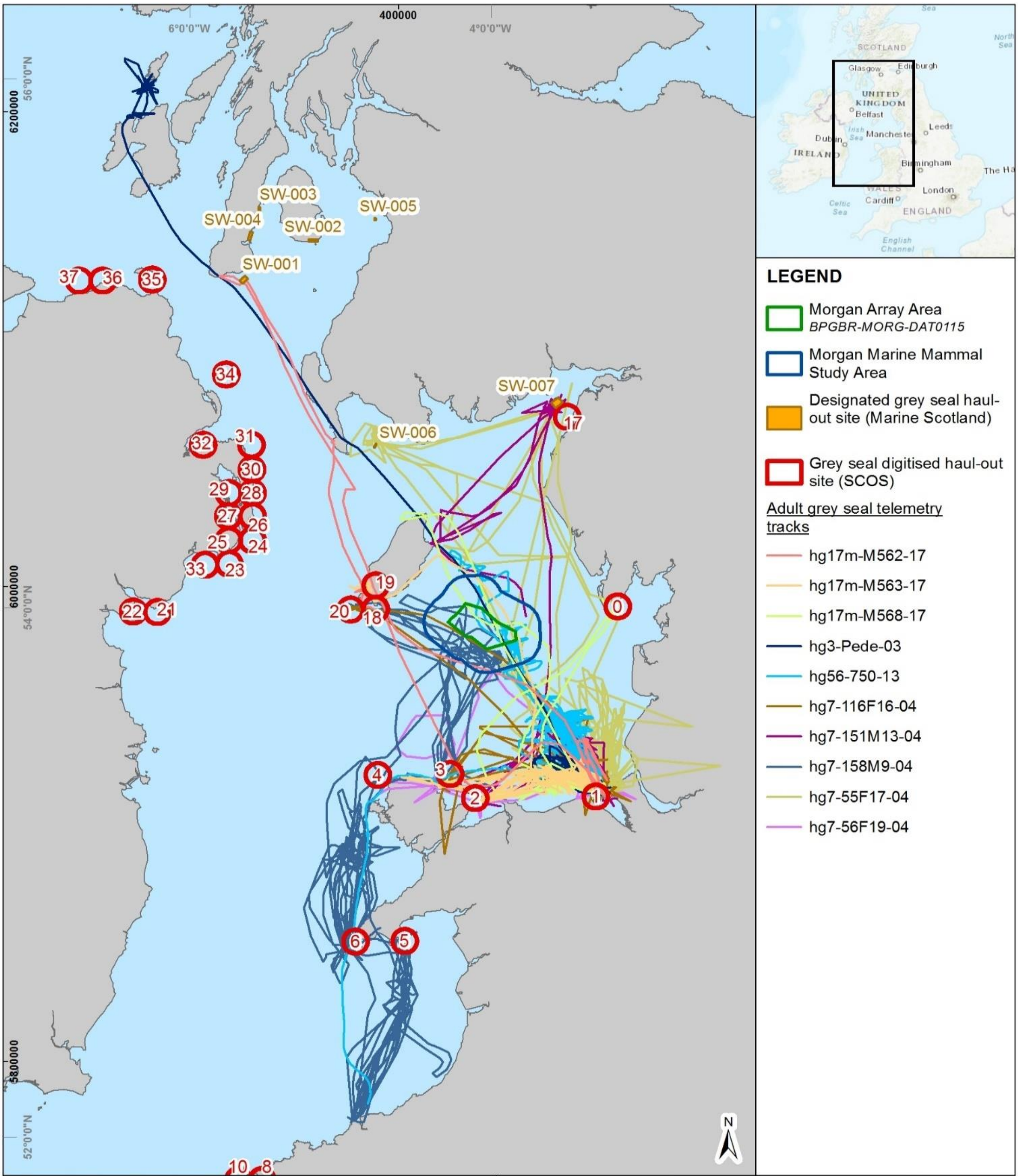
d

Figure 4.18: Probability of response mapping for grey seal. Top panel presents the probability of response (P(response)) which shows the percentage of grey seal disturbed per grid cell. Bottom panel demonstrates number of grey seal disturbed per cell using Carter *et al.* (2022) densities.

Impact on grey seal haul-out sites

4.9.2.100 To assess the impact on grey seal haul out sites, connectivity of grey seal tracks from haul-out sites to the Morgan marine mammal study area was considered. Telemetry data for adult and pup grey seals (provided in Appendix B in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement) showed those seals that entered a 5 km buffer of a haul-out site (SCOS, 2021). Carter *et al.* (2022) aggregated counts from haul out sites to 5 km grid cells known as 'haul-out cells', and a 5 km buffer was applied (noting that Hornsea 4 (Orsted, 2021) applied a 1 km buffer around haul out sites and therefore the 5 km approach is precautionary in comparison). Results of connectivity are presented in Figure 4.19 for adult grey seals and Figure 4.20 for pups.

4.9.2.101 The assessment showed that there is a high level of connectivity between the Morgan marine mammal study area and haul-out sites within the Irish Sea for adult seals (Figure 4.19). Of the adult grey seals that entered the Morgan marine mammal study area, one adult grey seal visited seven haul-out sites across the Irish Sea area, and on average adult grey seals visited 3.9 haul-out sites within the four seal MUs that cover the Irish Sea. One grey seal pup (hg27-04-09) visited three haul-out sites in close proximity to the Morgan marine mammal study area, whilst one pup (hg29-11-10) visited six haul-out sites at greater distances from the Morgan marine mammal study area (Figure 4.20).



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, SMRU, SCOS, Marine Scotland

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 5 10 20 30 nm
0 10 20 40 60 km

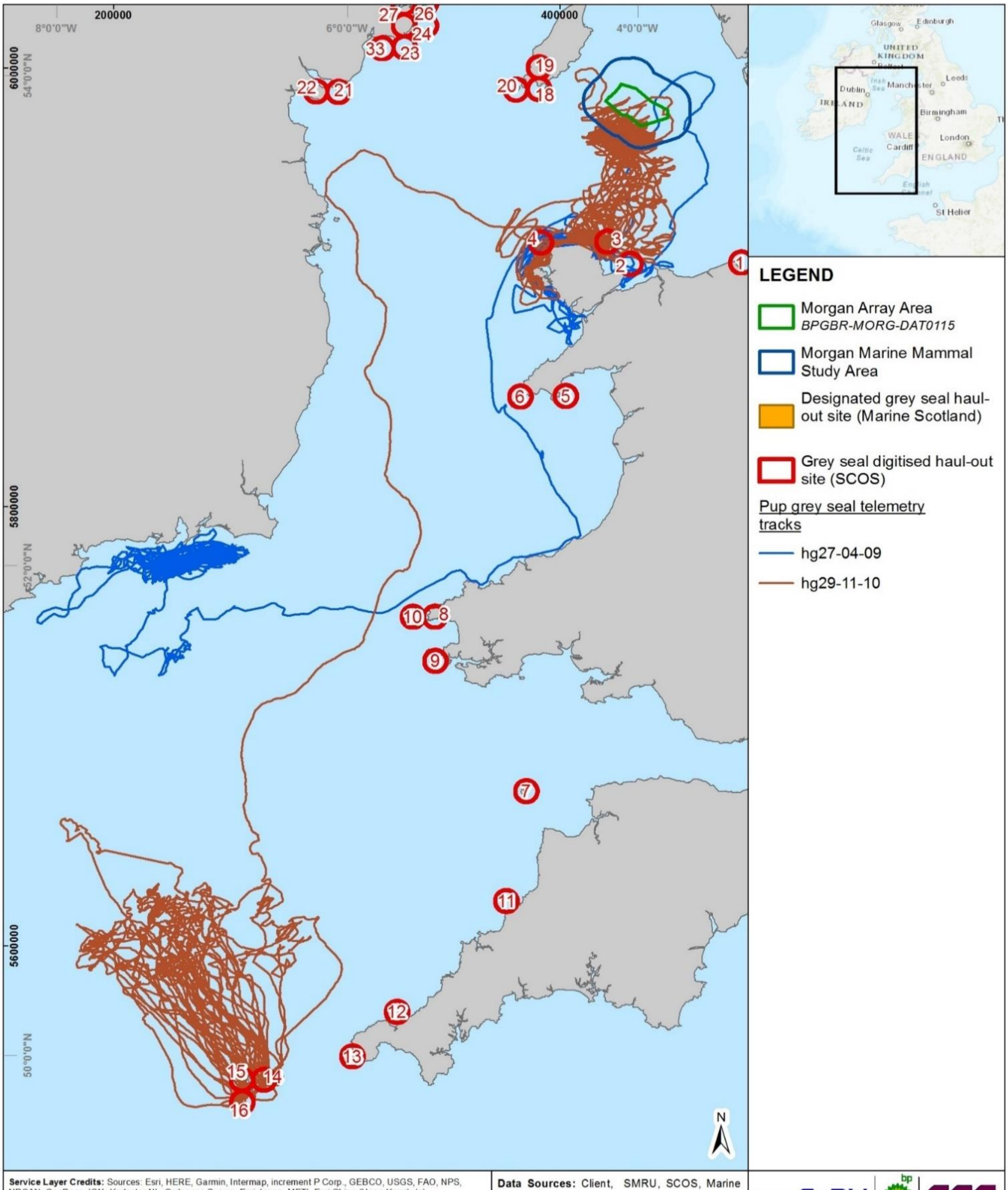
Drawing Number:
RPSE-MG-ES-MAM-E009-01

Drawing Title:
GREY SEAL HAUL-OUT SITES AND ADULT GREY SEAL TELEMETRY TRACKS THAT CROSS THE MORGAN MARINE MAMMAL STUDY AREA.

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:2,668,092

VER	DATE	DETAILS	BY	CHECK
00	08/11/23	First Issue	MJ	LB
01	29/11/23	Revision	NA	LB

Figure 4.19: Adult grey seal tracks that transverse the Morgan marine mammal study area and haul-out sites (SMRU; digitised from SCOS, 2021).



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, SMRU, SCOS, Marine Scotland

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 5 10 20 30 40 nm
0 10 20 40 60 80 km

Drawing Number:
RPSE-MG-ES-MAM-E010-01

Drawing Title:
GREY SEAL HAUL-OUT SITES AND PUP GREY SEAL TELEMETRY TRACKS THAT CROSS THE MORGAN MARINE MAMMAL STUDY AREA.

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:2,874,547

VER	DATE	DETAILS	BY	CHECK
00	08/11/23	First Issue	MJ	LB
01	29/11/23	Revision	NA	LB

Figure 4.20: Pup grey seal tracks that transverse the Morgan marine mammal study area and haul-out sites (SMRU; digitised from SCOS, 2021).

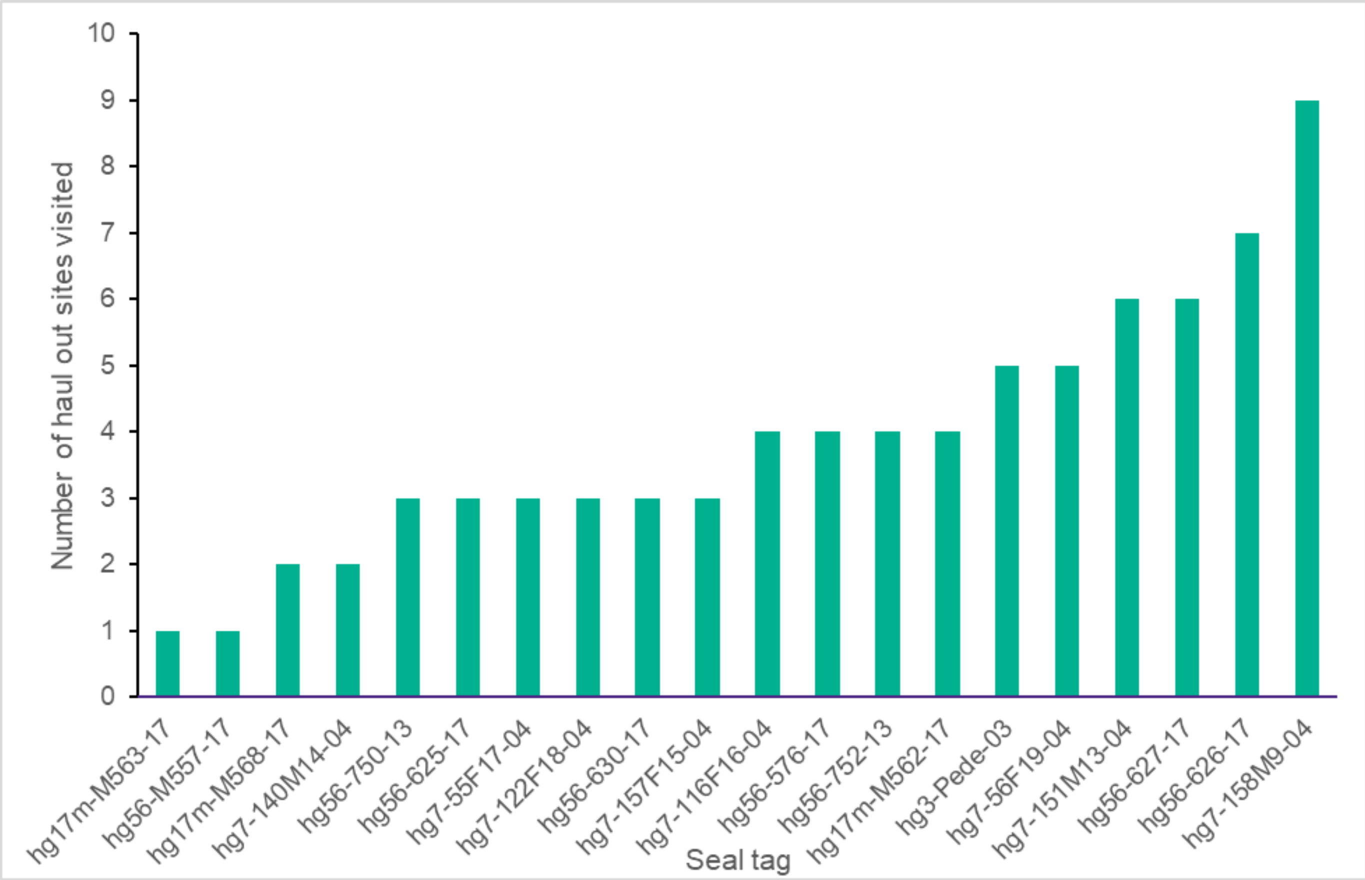


Figure 4.21: Number of haul-out sites visited by each grey seal that entered the Morgan marine mammal study area.

4.9.2.102 In terms of SACs, adult grey seal telemetry data showed that a total of 36 animals (from 44 adult grey seals tagged between 2004 and 2018) occurred within a 100 km buffer (defined based on average foraging range of species) of the Morgan Generation Assets, 19 of which showed connectivity to the surrounding SACs. Of these, 17 grey seals showed connectivity with Pen Llŷn a'r Sarnau/Llŷn Peninsula and the Sarnau SAC (47.2%), eight showed connectivity with Pembrokeshire Marine/Sir Benfro Forol SAC (22.2%), eight showed connectivity with Cardigan Bay SAC (22.2%), three showed connectivity with Saltee Islands SAC (8.3%) and one seal showed connectivity with The Maidens SAC (2.8%). These totals are derived from the SMRU data presented in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement (Appendix B).

4.9.2.103 It can therefore be concluded that there is a high level of connectivity between the Morgan Generation Assets and three SACs in the Wales MU (Pen Llŷn a'r Sarnau/Llŷn Peninsula and the Sarnau SAC and the Pembrokeshire Marine/Sir Benfro Forol SAC and the Cardigan Bay SAC) but comparatively lower levels of connectivity with SACs at greater distances from the Morgan Generation Assets (Saltee Islands SAC and Isles of Scilly Complex SAC).

4.9.2.104 Telemetry data showed that 13 grey seal pups (from a 17 total of grey seal pups tagged between 2009 and 2010) occurred within a 100 km buffer of the Morgan Generation Assets, 11 of which showed connectivity to surrounding SACs. Of these, 10 seals showed connectivity with Pen Llŷn a'r Sarnau/ Llŷn Peninsula and the Sarnau SAC (76.9%), six with Pembrokeshire Marine/Sir Benfro Forol SAC (46.2%), 3 with Cardigan Bay SAC (23.1%), 3 with Saltee Islands SAC (Ireland) (23.1%) and 2 with

Isles of Scilly Complex SAC (15.4%). As in paragraph 4.9.2.103, there is a high level of connectivity between the Morgan marine mammal study area and SACs within the Wales MU and further afield.

4.9.2.105 Grey seal typically live between 20 to 30 years with gestation lasting between 10 to 11 months (SCOS, 2015; SCOS, 2018), thus the duration of piling (albeit intermittent) could potentially overlap with up to two breeding cycles. Considering the above, the duration of the effect in the context of the life cycle of grey seal is classified as medium term.

4.9.2.106 Population modelling was carried out to explore the potential for disturbance during piling to affect the population trajectory over time and provide additional certainty in the predictions of the impact assessment. Results of the iPCoD modelling for grey seal showed that the median ratio of the impacted population to the unimpacted population (assessed against the GSRP) at 6 and 25 years was 1.0000 for both the maximum temporal and maximum spatial scenarios (Appendix B). Moreover, simulated grey seal population sizes for both baseline (unimpacted) and impacted populations showed no difference (Figure 4.22). Therefore, it was considered that there is no potential for long-term effects on this species.

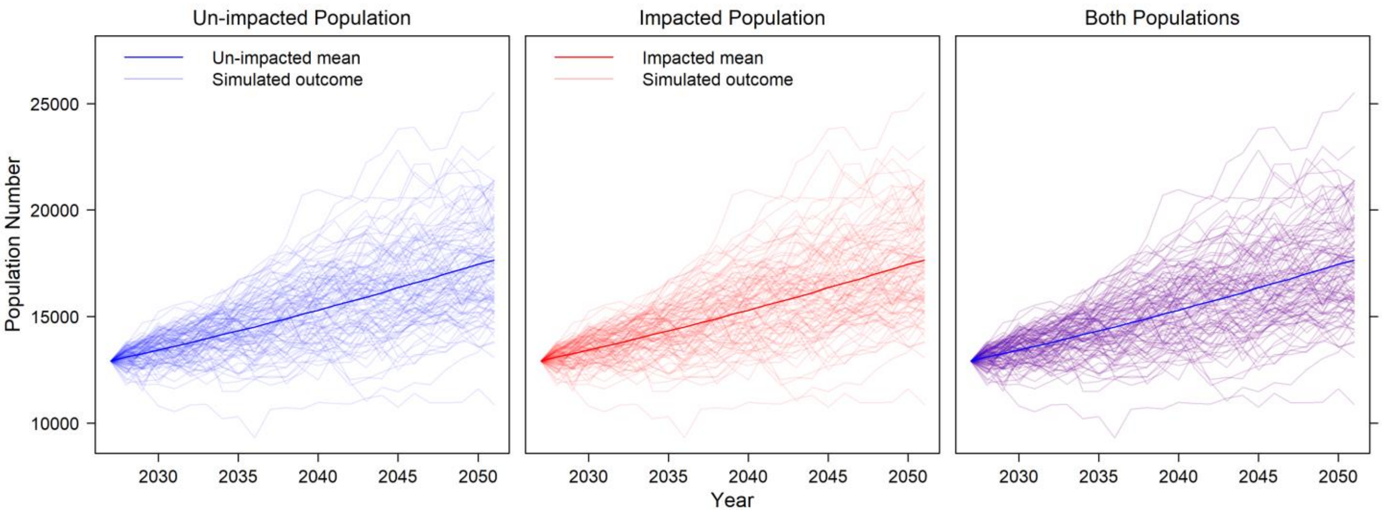


Figure 4.22: Simulated grey seal population sizes for both the baseline (unimpacted) and the impacted populations under the maximum temporal scenario.

4.9.2.107 The impact (elevated underwater sound during piling) is predicted to be of regional spatial extent, medium-term duration, intermittent and high reversibility (the impact itself occurs only during piling). Similarly, the effect of behavioural disturbance is reversible as receptors are expected to recover within hours/days. It is predicted that the impact will affect the receptor directly. A small proportion (up to 0.47% of the GSRP, or 0.10% of OSPAR Region III reference population) would be affected during piling and the results of the iPCoD modelling suggest that over the duration of the impact and up to 25 years after the start of piling there would be no long-term effects on the grey seal population. Whilst the impact could result in some measurable changes to individuals that are disturbed (i.e. interruption of feeding or breeding) there would be no population-level consequences of disturbance. The magnitude is therefore considered to be **low**.

Harbour seal

4.9.2.108 For harbour seal, the most conservative estimate of disturbance (using dose-response) led to up to one animal (Carter *et al.*, 2022 densities) predicted to experience potential disturbance from concurrent piling of pin piles at a maximum hammer energy of 3,000 kJ. This equates to 0.006% of the HSRP (Wales, NW England, Northern Ireland SMUs) (Table 4.12). Telemetry studies (presented in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement) demonstrate that harbour seal traverse all three SMUs and therefore population estimates for the three SMUs have been summed to give one reference population for which to assess potential disturbance against.

4.9.2.109 As identified in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement, seven sites designated for harbour seal are located within the regional marine mammal study area (Langness MNR, Ramsey Bay MNR, West Coast MNR, Strangford Lough SAC, Murlough SAC, Lambay Island SAC and Slaney River Valley SAC) (section 4.5.1). The area-based 143 dB re 1 µPa^{2}s (SEL_{ss}) contours did not extend as far as Isle of Man waters and therefore there was no overlap with MNRs designated for harbour seal. There is potential overlap of sound contours with Langness MNR, Ramsey Bay MNR, Strangford Lough SAC, Murlough SAC, Lambay Island SAC and Slaney River Valley SAC. Telemetry tracks presented in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement demonstrated some connectivity both between designated sites, and between the Morgan Generation Assets and designated sites. There is therefore potential that some harbour seal within the impacted area may be associated with other sites designated for harbour seal. It must be noted that harbour seal have a smaller maximum foraging range (273 km) than grey seal and therefore levels of connectivity between SACs are less than for grey seal which forage over greater distances (448 km) (Carter *et al.,* 2022).

4.9.2.110 Similarly, the area-based unweighted sound threshold of 160 dB re 1 µPa SPL_{rms} (strong disturbance) is not predicted to overlap with any SAC or MNR designated for harbour seal in the regional marine mammal study area. There was, however, an overlap with two of the Isle of Man MNRs designated for harbour seal (Langness MNR and Ramsey Bay MNR) for the 140 dB re 1 µPa SPL_{rms} (mild disturbance) threshold, noting that this would be unlikely to displace animals from the area as received sound levels would elicit only mild disruptions in behaviour (Figure 4.13). Strong disturbance of individuals within protected sites is therefore not anticipated to occur, although individuals originating from protected sites could range as far as the ensonified areas. Further assessment of the potential effects on SACs is provided in the HRA Stage 2 ISAA (Document Reference E1.1).

Barrier effects

4.9.2.111 The potential for barrier effects (i.e. the ability to move between key areas such as haul-out sites and offshore foraging areas) is considered for both concurrent and single piling scenarios. The level at which a measurable response is predicted to occur in seals is at a minimum received sound level of 145 dB re 1 µPa^{2}s SEL_{ss} (Whyte *et al.*, 2020). Sound level contours which overlap coastal areas, and therefore potential haul-out sites are up to a maximum of 135 dB re 1 µPa^{2}s SEL_{ss}. Animals exposed to lower sound levels in the outer disturbance contours are likely to experience mild disruptions to normal behaviours but prolonged or sustained behavioural effects, including displacement, are unlikely to occur (Southall *et al*., 2021). As described in paragraph 4.9.2.110, the area-based unweighted sound threshold for mild disturbance

(140 dB re 1 µPa SPL_{rms}) could overlap with coastal areas, resulting in mild disruptions to normal behaviours. However, prolonged or sustained behavioural effects, including displacement, are unlikely to occur. The area-based unweighted sound threshold for strong disturbance (160 dB re 1 µPa SPL_{rms}) is not predicted to overlap coastal areas or high density areas for harbour seal

4.9.2.112 It is considered that very small numbers of harbour seal (i.e. no more than one animal at any one time) close to the coast could experience mild disturbance but that this is unlikely to lead to barrier effects, (i.e. preventing animals from using the foraging grounds in waters along the coast) as animals are unlikely to be excluded from coastal areas. Furthermore, as mentioned in paragraph 4.9.2.59, animals can travel to other areas to feed during piling, although harbour seal tend to forage within 50 km of the coast and therefore may be restricted in the area of available habitat. However, whilst animals would likely avoid offshore areas where received sound levels during piling exceed thresholds for strong disturbance, there may be an energetic cost associated with longer foraging trips, and alternative habitat (and associated key prey species abundance) may be sub-optimal.

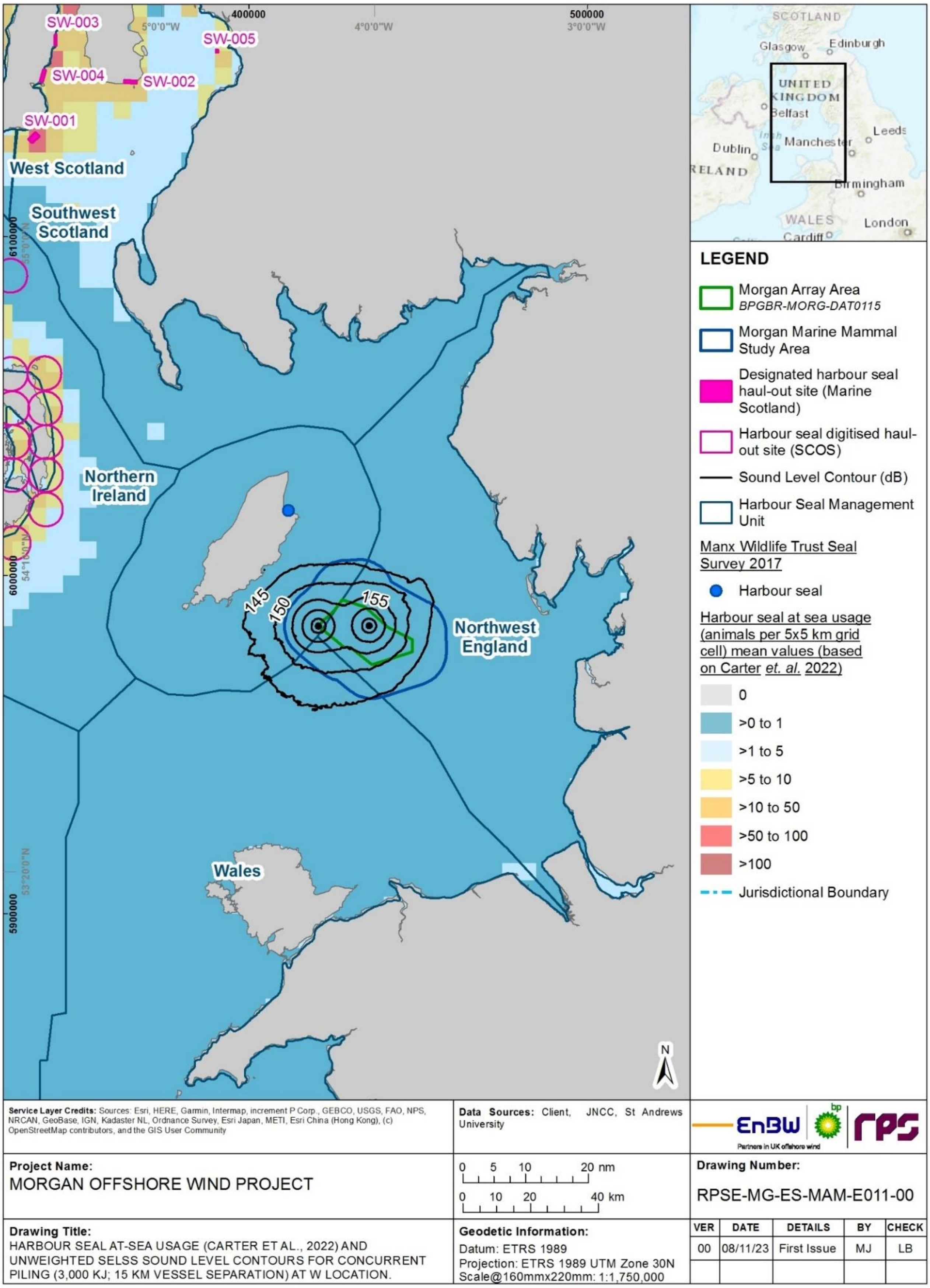


Figure 4.23: Harbour seal at-sea usage (Carter *et al*., 2022) overlaid with unweighted SEL_{ss} (dB) contours from Morgan Generation Assets due to concurrent impact piling of wind turbine pin piles at maximum hammer energy (3,000 and 3,000 kJ) at the west modelled location.

4.9.2.113 Harbour seal typically live between 20 to 30 years with gestation lasting between ten to 11 months (SCOS, 2015; SCOS, 2018), thus the duration of piling (albeit intermittent) could potentially overlap with up to two breeding cycles. Considering the above, the duration of the effect in the context of life cycle of harbour seal is classified as medium term. The magnitude of the impact could also result in a very small effect on the distribution of harbour seal during piling only and may affect the fecundity of very small numbers in the context of the reference population (up to 0.01% of the combined total of HSRP at any one time) over the medium term. Due to the very small numbers and small proportion of the population affected the magnitude of the impact is unlikely to lead to a population-level effect and this species was not carried forward for further assessment within the iPCoD model framework.

4.9.2.114 The impact (elevated underwater sound during piling) is predicted to be of regional spatial extent, medium-term duration, intermittent and high reversibility (the impact itself occurs only during piling). Similarly, the effect of behavioural disturbance is reversible as receptors are expected to recover within hours/days. It is predicted that the impact will affect the receptor directly. Whilst the impact could result in some measurable changes to a very small number of individuals that are disturbed (i.e. interruption of feeding or breeding) there would be no population-level consequences of disturbance. The magnitude is therefore considered to be **negligible**.

Sensitivity of the receptor

Auditory injury

Harbour porpoise

4.9.2.115 Kastelein *et al*. (2013) reported that hearing impairment as a result of exposure to piling sound is likely to occur where the source frequencies overlap the range of peak sensitivity for the receptor species rather than across the whole frequency hearing spectrum. An experiment undertaken as a part of this study demonstrated that for simulated piling sound (broadband spectrum), harbour porpoise hearing around 125 kHz (the key frequency for echolocation) was not affected. Instead, a measurable threshold shift in hearing was induced at frequencies of 4 kHz to 8 kHz, although the magnitude of the hearing shift was relatively small (2.3 dB to 3.6 dB re 1 µPa SPL at 4 kHz to 8 kHz) due to the lower received SELs at these frequencies. This was due to most of the energy from the simulated piling occurring in lower frequencies (Kastelein *et al*., 2013). Subsequent study confirmed sensitivity declined sharply above 125 kHz (Kastelein *et al*., 2017).

4.9.2.116 The duty cycle of fatiguing sounds is also likely to affect the magnitude of a hearing shift, e.g. hearing may recover to some extent during inter-pulse intervals (Kastelein *et al*., 2014). Other studies reported that whilst a threshold shift can accumulate across multiple exposures, the resulting shift will be less than the shift from a single, continuous exposure with the same total SEL (Finneran *et al*., 2015).

4.9.2.117 In order to minimise exposure to sound, cetaceans are able to undertake some self-mitigation measures, e.g. the animal can change the orientation of its head so that sound levels reaching the ears are reduced, or it can suppress hearing sensitivity by one or more neurophysiological auditory response control mechanisms in the middle ear, inner ear, and/or central nervous system. Kastelein *et al*. (2020) highlighted the lack of reproducibility of TTS in a harbour porpoise after exposure to repeated airgun sounds, and suggested the discrepancies may be due to self-mitigation.

4.9.2.118 It is important to note that extrapolating the results from captive bred studies to how animals may respond in the natural environment should be treated with caution as there are discrepancies between experimental and natural environmental conditions. In addition, the small number of test subjects would not account for intraspecific differences (i.e. differences between individuals) or interspecific differences (i.e. extrapolating to other species) in response. However, based on current scientific evidence, PTS is a permanent and irreversible hearing impairment. It is therefore anticipated that harbour porpoise is sensitive to this effect as the loss of hearing would affect key life functions (e.g. mating and maternal fitness, communication, foraging, predator detection) and could lead to a change in an animal's health (chronic) or vital rates (acute) (Erbe *et al*., 2018). In addition to studies conducted in controlled environments, there is also evidence on sound-induced hearing loss, based on inner ear analysis in a free-ranging harbour porpoise (Morell *et al*., 2021). Considering the above, a potential consequence of a disruption in key life functions is that the health of impacted animals would deteriorate and potentially lead to reduced birth rate in females and mortality of individuals (Costa, 2012).

4.9.2.119 The assessment of sensitivity provided below takes into account the uncertainty surrounding the effects of PTS on survival and reproduction and the importance of sound for echolocation, foraging and communication in all cetaceans.

4.9.2.120 Although a threshold shift may occur outside of the most sensitive hearing range, the occurrence of PTS in harbour porpoise, due to the species reliance on hearing, could be detrimental to an individual's capacity for survival and reproduction. Harbour porpoise is therefore deemed to have limited resilience, low recoverability and is of international value. The sensitivity of the receptor to PTS is therefore considered to be **high.**

Bottlenose dolphin, short-beaked common dolphin, Risso's dolphin

4.9.2.121 Individual dolphins experiencing PTS would suffer a biological effect that could impact the animal's health and vital rates (Erbe *et al*., 2018). Bottlenose dolphin, short-beaked common dolphin and Risso's dolphin are all classed as high-frequency cetaceans (Southall *et al*., 2019). As described for harbour porpoise in section 4.9.2.115 there are frequency-specific differences in the onset and growth of a sound-induced threshold shift in relation to the characteristics of the sound source and hearing sensitivity of the receiving species. For example, exposure of two captive bottlenose dolphins to an impulsive sound source between 3k Hz and 80k Hz found that there was increased susceptibility to auditory fatigue between frequencies of 10 kHz to 30 kHz (Finneran and Schlundt, 2013). The SEL_{cum} threshold incorporates hearing sensitivities of marine mammals and the magnitude of effects for high-frequency cetaceans are considerably smaller compared to the very high-frequency (e.g. harbour porpoise) and low-frequency (e.g. minke whale) species, highlighting that species such as bottlenose dolphin, short-beaked common dolphin and Risso's dolphin are less sensitive to the frequency components of the piling sound signal. The assessment considered the irreversibility of the effects (i.e. as noted for harbour porpoise) and importance of sound for echolocation, foraging and communication in small, toothed cetaceans.

4.9.2.122 The assessment of sensitivity provided below takes into account the uncertainty surrounding the effects of PTS on survival and reproduction and the importance of sound for echolocation, foraging and communication in all cetaceans.

4.9.2.123 Bottlenose dolphin, short-beaked common dolphin and Risso's dolphin are deemed to have limited resilience to PTS, low recoverability and international value. The sensitivity of the receptors to PTS is therefore, considered to be **high**.

Minke whale

4.9.2.124 Empirical evidence of hearing sensitivities for minke whales is limited, although studies suggest that their vocalisation frequencies are likely to overlap with anthropogenic sounds. Minke whale does not echolocate but likely use sound for communication and, like other mysticete whales, are able to detect sound via a skull vibration enabled bone conduction mechanism (Cranford and Krysl, 2015). Baleen whales have estimated functional hearing range between 17 Hz and 35k Hz and are likely that they rely on low frequency hearing (Ketten and Mountain, 2009). A strong reaction to a 15k Hz ADD has been recorded in controlled exposure study on free ranging minke whale in Iceland suggesting that this frequency is at the likely upper limit of their hearing sensitivity (Boisseau *et al*., 2021). As described for harbour porpoise, there are likely to be frequency-specific differences in the onset and growth of a sound-induced threshold shift in relation to the characteristics of the sound source and hearing sensitivity of the receiving species.

4.9.2.125 The assessment of sensitivity provided below takes into account the uncertainty surrounding the effects of PTS on survival and reproduction and the importance of sound for echolocation, foraging and communication in all cetaceans.

4.9.2.126 Minke whale is deemed to have limited resilience to PTS, low recoverability and international value. The sensitivity of the receptor to PTS is therefore, considered to be **high.**

Harbour seal and grey seal

4.9.2.127 Seals rely on sound for communication and predator avoidance (Deecke *et al*., 2002), rather than for foraging. They detect swimming fish with their vibrissae (Schulte-Pelkum *et al*., 2007), however, in certain conditions, they may also listen to sounds produced by vocalising fish in order to hunt for prey. Thus, likely ecological consequences of a sound induced threshold shift in seals are a reduction in fitness, reproductive output and longevity (Kastelein *et al*., 2018). Hastie *et al*., (2015) reported that, based on calculations of SEL of tagged harbour seals during the construction of the Lincs Offshore Wind Farm (Greater Wash, UK), at least half of the tagged seals would have received sound levels from pile driving that exceeded auditory injury thresholds for pinnipeds (PTS). However, population estimates indicated that the relevant population trend is increasing and therefore, although there are many other ecological factors that will influence the population health, predicted levels of PTS did not affect a sufficient numbers of individuals to cause a decrease in the population trajectory (Hastie *et al*., 2015). However, it has been noted that due to paucity of data on effects of sound on seal hearing, the exposure criteria used are intentionally conservative and therefore predicted numbers of individuals likely to be affected by PTS presented in the study were also highly conservative.

4.9.2.128 Reichmuth *et al*. (2019) reported the first confirmed case of PTS following a known acoustic exposure event in a seal. The study included evaluation of the underwater hearing sensitivity of a trained harbour seal before and immediately following exposure to 4.1 kHz tonal fatiguing stimulus (SPL_{rms} was increased from 117 to 182 dB re 1 μPa), and rather than the expected pattern of TTS onset and growth, an abrupt threshold shift of >47 dB (i.e. the difference between the pre-exposure and post-exposure hearing thresholds in dB) was observed half an octave above the exposure frequency. Hearing at 4.1 kHz recovered within 48 hours, however, there was a PTS of at least 8 dB at 5.8 kHz, and hearing loss was evident for more than ten years.

4.9.2.129 Seals rely on hearing much less than cetaceans and therefore it is anticipated that they would exhibit some tolerance to the effects of underwater sound (i.e. is it unlikely to cause a change in either reproduction or survival rates). In addition, in order to minimise exposure to sound, it has been proposed that seals are able to undertake some self-mitigation measures, e.g. reduce their hearing sensitivity in the presence of loud sounds in order to reduce their perceived SPL (Kastelein *et al*., 2018).

4.9.2.130 Telemetry data (presented in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement) confirmed that there is a high level of connectivity between the Morgan marine mammal study area and the Pen Llŷn a'r Sarnau/Llyen Peninsula, the Sarnau SAC and the Pembrokeshire Marine/Sir Benfro Forol SAC and the Cardigan Bay SAC and lower levels of connectivity with grey seals SACs at further distances from the Morgan Generation Assets. Therefore, individuals from these designated sites have a potential to be present within the injury range during piling at Morgan Generation Assets. The same applies to harbour seals from the Strangford Lough SAC and Murlough SAC, as five harbour seals tagged in the Northern Ireland MU showed the connectivity with these designated sites and north of the Morgan marine mammal study area.

4.9.2.131 Harbour seal and grey seal are deemed to have limited resilience to PTS, low recoverability and international value. The sensitivity of the receptor to PTS is therefore, considered to be **high.**

Behavioural Disturbance

Harbour porpoise

4.9.2.132 Given that harbour porpoise is vulnerable to heat loss through radiation and conduction and has a high metabolic requirement, it needs to forage frequently to lay down sufficient fat reserves for insulation. Kastelein *et al*. (1997) conducted a study on six, non-lactating, harbour porpoise and found that they require between 4% and 9.5% of their body weight in fish per day. It has been reported that in the wild, porpoises forage almost continuously day and night to achieve their required calorific intake (Wisniewska *et al*., 2016) and therefore they are vulnerable to starvation if their foraging is interrupted. Although, based on the aerial data, modelled densities of harbour porpoise within Morgan marine mammal study area were higher during winter, other studies consider porpoises to be present year around in the Irish sea (for more details see Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement). Therefore harbour porpoise could be vulnerable to piling at any time of year.

4.9.2.133 The responsiveness as a result of behavioural disturbance due to increased underwater sound is context specific. Ellison *et al*. (2012) reported following factors as important in determining the likelihood of a behavioural response and therefore their sensitivity, e.g. the activity state of the receiving animal, the nature and novelty of the sound (i.e. previous exposure history), as well as the spatial relation between sound source and receiving animal.

4.9.2.134 In recent study, Kastelein *et al.* (2022) studied effects of six piling sounds (average in the pool of up to 135 dB re 1 µPa^{2}s) on one harbour porpoise in experimental conditions. The study found that after each test period (exposing animal to piling sounds for 15 minutes) in which the harbour porpoise responded to the sound by behavioural reaction (e.g. changes in respiration rate, moving away from the sound source), and behaviour was observed to return to normal immediately. At sea measurements reported by Brandt *et al.* (2011) observed reduced porpoise acoustic activity within a 2.6 km range from a piling site 24 hours to 72 hours after sounds stopped, although shorter return times were recorded after application of sound abatement methods such as air bubble screens (approximately six hours). The discrepancy between times required for harbour porpoise to return to affected area in the pool versus at sea are likely to relate to the SEL experienced by the porpoises, which at sea depends on their distance from the piling location (Kastelein *et al.,* 2022). The study also reported that the frequency content of sounds is an important factor determining the response of harbour porpoises and that the high-frequency part of the spectrum of impulsive pile driving has a relatively large effect on their behaviour.

4.9.2.135 Empirical evidence from monitoring at offshore wind farms during construction (Brandt *et al*., 2011) suggests that during pile driving there will be a proportional decrease in avoidance at greater distances from the pile driving source and therefore it is unlikely to lead to 100% avoidance of all individuals exposed. Measurements at Horns Rev Offshore Wind Farm demonstrated 100% avoidance in harbour porpoises at up to 4.8 km from the piles, whilst at greater distances (10 km plus) the proportion of animals displaced reduced to <50% (Brandt *et al*., 2011). Subsequently, Graham *et al*. (2019) used data from piling at the Beatrice Offshore Wind Farm and suggested that harbour porpoise may adapt to increased sound disturbance over the course of the piling phase, thereby showing a degree of tolerance and behavioural adaptation. This study also demonstrated that the probability of occurrence of harbour porpoise (measured as porpoise positive minutes) increased exponentially moving further away from the sound source. Similarly, Brandt *et al*., (2018) reported that detections of harbour porpoise declined several hours before the start of pling within the vicinity (up to 2 km) of the construction site and were reduced for about one to two hours post-piling, whilst at the maximum effect distances (from 17 km out to approximately 33 km) avoidance only occurred during the hours of piling. Porpoise detections during piling were found at sound exposure levels exceeding 143 dB re 1 μPa^2s SEL_{ss} and at lower received levels – at greater distances from the source – there was little evident decline in porpoise detections (Brandt *et al*., 2018). Studies described above corroborate the dose-response relationship between received sound levels and declines in porpoise detections although noting that the extent to which responses could occur will be context-specific such that, particularly at lower received levels (i.e. 130 dB to 140 dB re 1 μPa^2s SEL_{ss}), detectable responses may not be evident from region to region.

4.9.2.136 Building on earlier work presented in Southall *et al*. (2007) and the expanding literature in this area, Southall *et al*. (2021) introduced a concept of behavioural response severity spectrum (from zero to nine for free-ranging marine mammals) with progressive severity of possible responses within three response categories: survival (e.g. resting, navigation, defence), feeding (e.g. search, consumption, energetics), and reproduction (e.g. mating, parenting). For example, at the point of the spectrum rated seven to nine, where sensitivity is highest, displacement is likely to occur resulting in movement of animals to areas with an increased risk of predation and/or with sub-optimal feeding grounds. A failure of vocal mechanisms to compensate for sound can result in interruption of key reproductive behaviour including mating and socialising, causing a reduction in an individual's fitness leading to potential breeding failure and impact on survival rates.

4.9.2.137 There are limitations of the single step-threshold approach for strong disturbance and mild disturbance as it does not account for inter-, or intra-specific variance or context-based variance. However, according to Southall *et al*. (2021), harbour porpoise within the area modelled as 'strong disturbance' would be most sensitive to behavioural effects and therefore may have a response score of seven or above. Mild disturbance (score four to six) could lead to effects such as changes in swimming speed and direction, minor disruptions in communication, interruptions in foraging, or disruption of parental attendance/nursing behaviour (Southall *et al*., 2021). Therefore, at the lower end of the behavioural response spectrum, the potential severity of effects is reduced and whilst there may be some detectable responses that could result in effects on the short-term health of animals, these are less likely to impact on an animals' survival rate.

4.9.2.138 Although harbour porpoise may be able to avoid the disturbed area and forage elsewhere, there may be a potential effect on reproductive success of some individuals. As mentioned previously, it is anticipated that there would be some adaptability to the elevated sound levels from piling and therefore survival rates are not likely to be affected. Due to uncertainties associated with the effects of behavioural disturbance on vital rates of harbour porpoise, the assessment is highly conservative as it assumes the same level of sensitivity for both strong and mild disturbance, noting that for the latter the sensitivity is likely to be lower.

4.9.2.139 Harbour porpoise is deemed to have some resilience to behavioural disturbance, high recoverability and international value. The sensitivity of the receptor to behavioural disturbance is therefore, considered to be **medium.**

Bottlenose dolphin, short-beaked common dolphin, Risso's dolphin

4.9.2.140 Bottlenose dolphin, short-beaked common dolphin and Risso's dolphin are not thought to be as vulnerable to disturbance as harbour porpoise; with larger body sizes and lower metabolic rates, the necessity to forage frequently is lower.

4.9.2.141 There is limited information regarding the specific sensitivities of high frequency cetaceans to disturbance from piling sound as most studies have focussed on harbour porpoise. A study of the response of bottlenose dolphin to piling sound during harbour construction works at the Nigg Energy Park in the Cromarty Firth (northeast Scotland) found that there was weak but a measurable response to impact and vibration piling with animals reducing the amount of time they spent in the vicinity of the construction works (Graham *et al*., 2017). Fernadez-Betelu *et al*. (2021) investigated dolphin detections in the Moray Firth during impact piling at the Beatrice and Moray Offshore Wind Farms and found surprising results at small temporal scales with an increase in dolphin detections on the south Moray coast on days with impulsive sound compared to days without with predicted maximum received levels in coastal areas of 128 dB re 1 μPa^2s and 141 dB re 1 μPa^2s respectively. The authors of this study warn that caution must be exercised in interpreting these results as increased click changes do not necessarily equate to larger groups sizes but may be due to a modification in behaviour (e.g. an increase in vocalisations during piling) (Fernadez-Betelu *et al*., 2021). It is important to note that the results of this study suggest that impulsive sound generated during piling at the offshore wind farms did not cause any displacement of bottlenose dolphins from their population range.

4.9.2.142 The severity spectrum presented by Southall *et al*. (2021) (as discussed in paragraph 4.9.2.136) applies across all marine mammals considered in this chapter and therefore it is expected that, as described for harbour porpoise, strong disturbance in the near field could result in displacement whilst mild disturbance over greater ranges would result in other, less severe behavioural responses.

4.9.2.143 Short-beaked common dolphin exhibit seasonal shifts around the UK. Individuals move onto continental waters in the summer (coinciding with the mating/calving period) and come back to inshore waters during winter. As they tend to move towards the Celtic Shelf and into the west English Channel and St. George's Channel, probability of presence within Morgan marine mammal study area is low. No short-beaked common dolphin were recorded during the 24 months of Morgan site-specific digital aerial surveys (for more details see Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement).

4.9.2.144 Bottlenose dolphin are largely coastally distributed in relation to the Morgan marine mammal study area and are more abundant during summer and autumn compared to late winter and early spring months (Baines and Evans, 2012). This is demonstrated by site specific aerial surveys with bottlenose dolphin records in June 2021 (for more details see Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement).

4.9.2.145 Risso's dolphin are mostly common in Manx territorial waters and there is potential for these species to be present in the vicinity of Morgan marine mammal study area in summer months (for more detail see Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement). Therefore, due to their distribution and seasonality these species are unlikely to be disturbed equally as a result of piling for all months of the year; they are likely to be more disturbed in summer than winter months. Additionally, these is no indication that waters within the Morgan marine mammal study area are important for foraging or breeding for these species, though the waters to the south and east of the Isle of Man may be.

4.9.2.146 Bottlenose dolphin, short-beaked common dolphin and Risso's dolphin are likely to avoid the disturbed area. Whilst there may some impacts to reproduction in closer proximity to the source (i.e. within the area of 'strong disturbance') for those that are impacted, this is unlikely to have an effect on survival rates, given that some tolerance is expected to build up over the course of the piling. It is anticipated that animals would return to previous activities once the impact had ceased.

4.9.2.147 Bottlenose dolphin, short-beaked common dolphin and Risso's dolphin are deemed to have some resilience to behavioural disturbance, high recoverability and international value. The sensitivity of the receptor to behavioural disturbance is therefore, considered to be **medium.**

Minke whale

4.9.2.148 Minke whale occurs seasonally within the Morgan marine mammal study area. Although sandeel is thought to be the key food resource for minke whale within the North Sea, the distribution of minke whale seems to mirror the distribution of herring in Manx and Irish waters (Howe, 2018a). Given its reliance on herring, the disturbance from areas that are important for herring could have implications on the health and survival of disturbed individuals. Herring habitat in the vicinity of the Morgan Generation Assets is described in volume 2, chapter 3: Fish and shellfish ecology of the Environmental Statement. The majority of the Morgan fish and shellfish ecology study area was considered as unsuitable sediment for herring spawning, although significant spawning areas were identified to the northwest of the Morgan fish and shellfish ecology study area, and to the north, east and northeast of the Isle of Man. The displacement of minke whales could lead to reduced foraging for disturbed individuals particularly since minke whales maximise their energy storage whilst on feeding grounds (Christiansen *et al*., 2013a).

4.9.2.149 It is expected that for minke whale, as described by the Southall *et al*. (2021), strong disturbances in the nearfield could result in displacement whilst mild disturbance over larger ranges would result in other, less severe behavioural responses. In terms of context the Morgan Generation Assets is situated in a region of relatively high levels of existing sound disturbance. Therefore, minke whales that occur within the Morgan marine mammal study area are subject to underwater sound from existing activities and may to some extent be desensitised to increased sound levels, particularly in the far field where mild disturbance could occur.

4.9.2.150 Minke whale is deemed to have some resilience to behavioural disturbance, high recoverability and international value. The sensitivity of the receptor to behavioural disturbance is therefore, considered to be **medium**.

Harbour seal and grey seal

4.9.2.151 Mild disturbance has the potential to disturb seals, however this constitutes only slight changes in behaviour, such as changes in swimming speed or direction, and is unlikely to result in population-level effects. Although there are likely to be alternative foraging sites for both harbour seal and grey seal, barrier effects as a result of installation of pin piles could either prevent seals from travelling to forage from haul-out sites or force seals to travel greater distances than is usual during periods of piling. Strong disturbance could result in displacement of seals from an area.

4.9.2.152 Hastie *et al*. (2021) measured the relative influence of perceived risk of a sound (silence, pile driving, and a tidal turbine) and prey patch quality (low density versus high density), in grey seal in an experimental pool environment. Foraging success was highest under silence, but under tidal turbine and pile driving treatments success was similar at the high-density prey patch but significantly reduced under the low-density prey patch. Therefore, avoidance rates were dependent on the quality of the prey patch as well as the perceived risk from the anthropogenic sound and it can be anticipated that such decisions are consistent with a risk/profit balancing approach.

4.9.2.153 Seal behaviour during offshore wind farm installation has been studied based on empirical data. Russell *et al*. (2016) studied movements of tagged harbour seal during piling at the Lincs Offshore Wind Farm in the Greater Wash and reported significant avoidance of the wind farm by harbour seal. Within this study, seal abundance significantly reduced over a distance of up to 25 km from the piling activity and there was a 19% to 23% decrease in usage within this range. However, the displacement was limited to pile driving activity only, with harbour seal returning rapidly to baseline levels of activity within two hours of cessation of the piling (Russell *et al*., 2016). Aarts *et al*. (2018) reported reactions of tracked grey seal to pile driving during construction of the Luchterduinen and Gemini wind farms as diverse, ranging from altered surfacing and diving behaviour, changes in swimming direction, or coming to a halt. In some cases, however, no apparent changes in diving behaviour or movement were observed (Aarts *et al*., 2018). Similar to the conclusions drawn by Hastie *et al*. (2021) the study at the Luchterduinen and Gemini wind farms suggested animals were balancing risk against ecological gains (e.g. seals might choose to accept the risk of pile-driving rather than take the risk of leaving a known foraging area to seek prey elsewhere). Whilst approximately half of the tracked grey seal were absent from the pile-driving area altogether, this may be because animals were drawn to other more profitable feeding areas as opposed to active avoidance of the sound, although a small sample size (n = 36 animals) means that no firm conclusions could be reached. It was notable that, in some cases, grey seal exposed to pile-driving at distances shorter than 30 km returned to the same area on subsequent trips. This suggests that the incentive to go to the area was stronger than potential deterrence effect of underwater sound from pile driving in some seals.

4.9.2.154 Changes in behaviour and subsequent barrier effects have a potential to affect the ability of phocid seals to accumulate the energy reserves prior to both reproduction and lactation (Sparling *et al*., 2006). As a strategy to maximise energy allocation to reproduction, female seals increase their foraging effort (including increased diving behaviour) before the breeding season. Especially during the third trimester of pregnancy, grey seal accumulate reserves of subcutaneous blubber which they use to synthesize milk during lactation (Hall *et al*., 2001). Therefore, during this period, grey seal forging at sea may be most vulnerable, as maternal energy storage is extremely important to offspring survival and female fitness (Mellish *et al*., 1999; Hall *et al*., 2001). As a result, potential exclusion from foraging grounds during this time could affect reproduction rates and probability of survival.

4.9.2.155 Depending on the breeding strategy of particular species, phocid seals may also be vulnerable to disturbance during the lactation period. Altered behaviour could have a particular impact on harbour seal during lactating periods between June and August, when female harbour seal spend much of their time in the water with their pups, and foraging is more restricted than during other periods (Thompson and Härkönen, 2008). Consequences of disturbance may include reduced fecundity, reduced fitness, and reduced reproductive success. Although harbour seal may be able to avoid the disturbed area and forage elsewhere, there may be an energetic cost to having to move greater distances to find food, and therefore there may be a potential effect on reproductive success of some individuals. The lactation period for grey seal is shorter (lasting around 17 days; Sparling *et al*., 2006) with females remaining mostly on shore, fasting. Additionally, as grey seal females do not forage often during lactation, it is expected that they may exhibit some tolerance to disturbance as they would not spend as much time in sea, where they can be affected by underwater sound. Note, however, that following lactation female grey seal return to the water and must forage extensively to build up lost energy reserves.

4.9.2.156 Harbour seal and grey seal are deemed to have some resilience to behavioural disturbance, high recoverability and international value. The sensitivity of the receptor to behavioural disturbance is therefore, considered to be **medium**.

Significance of the effect

Auditory injury

4.9.2.157 A summary of the significance of effect for injury (PTS) from elevated underwater sound from piling during the construction phase is presented in Table 4.29.

Harbour porpoise, bottlenose dolphin, short-beaked common dolphin and Risso's dolphin

4.9.2.158 Overall, with primary and tertiary mitigation applied, the magnitude of the impact is deemed to be **negligible** and the sensitivity of the receptor is considered to be **high**. There would be no change to the international value of these species. The effect on bottlenose dolphin, short-beaked common dolphin and Risso's dolphin will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Minke whale

4.9.2.159 Overall, with primary and tertiary mitigation applied, the magnitude of the impact is deemed to be **low** and the sensitivity of the receptor is considered to be **high**. Whilst there may be some residual effect with a small number of animals potentially exposed to sound levels that could elicit PTS this is unlikely to affect the international value of the species as there is no long-term decline in the regional population predicted as demonstrated with the iPCoD modelling assessment. The effect on minke whale will be of **minor adverse** significance, which is not significant in EIA terms.

Grey seal and harbour seal

4.9.2.160 Overall, with primary and tertiary mitigation applied, the magnitude of the impact is deemed to be **negligible** and the sensitivity of the receptor is considered to be **high**. There would be no change to the international value of these species. The effect on grey seal and harbour seal will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Table 4.29: Summary of the significance of effect of PTS from elevated underwater sound from piling during the construction phase.

Species	Magnitude of impact	Sensitivity of receptor	Significance of effect
Harbour porpoise	Negligible	High	Minor adverse
Bottlenose dolphin	Negligible	High	Minor adverse
Short-beaked common dolphin	Negligible	High	Minor adverse
Risso's dolphin	Negligible	High	Minor adverse
Minke whale	Low	High	Minor adverse
Grey seal	Negligible	High	Minor adverse
Harbour seal	Negligible	High	Minor adverse

Behavioural disturbance

4.9.2.161 A summary of the significance of effect for disturbance from elevated underwater sound from piling during the construction phase is presented in Table 4.30.

Harbour porpoise

4.9.2.162 Overall, the magnitude of the impact is deemed to be **low** and the sensitivity of the receptor is considered to be **medium**. The effects are unlikely to affect the international value of the species in the context of the CIS MU as there is no long-term decline in the regional population predicted as demonstrated with the iPCoD modelling assessment. The effect on harbour porpoise will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

4.9.2.163 There is, however, predicted to be a spatial overlap with the North Anglesey Marine/Gogledd Môn Forol SAC and consequently this will be considered as part of the HRA Stage 2 Information to Support Appropriate Assessment (ISAA) (Document Reference E1.1).

Bottlenose dolphin

4.9.2.164 Overall, the magnitude of the impact is deemed to be **low** and the sensitivity of the receptor is considered to be **medium**. The effects are unlikely to affect the international value of the species in the context of the IS MU as there is no long-term decline in the regional population predicted, as demonstrated by iPCoD modelling. The effect is therefore considered to be of **minor adverse** significance, which is not significant in EIA terms.

Short-beaked common dolphin and Risso's dolphin

4.9.2.165 Overall, the magnitude of the impact is deemed to be **low** and the sensitivity of the receptor is considered to be **medium**. The effects are unlikely to affect the international value of short-beaked common dolphin or Risso's dolphin in the context of the CGNS MU. The effect is therefore considered to be of **minor adverse** significance, which is not significant in EIA terms.

Minke whale

4.9.2.166 Overall, the magnitude of the impact is deemed to be **low** and the sensitivity of the receptor is considered to be **medium**. The effects are unlikely to affect the international value of the species in the context of the CGNS MU as there is no long-term decline in the regional population predicted, as demonstrated with the iPCoD modelling assessment. The effect is therefore considered to be of **minor adverse** significance, which is not significant in EIA terms.

Grey seal

4.9.2.167 Overall, the magnitude of the impact is deemed to be **low** and the sensitivity of the receptor is considered to be **medium**. The effects are unlikely to affect the international value of the species in the context of the GSRP or the OSPAR Region III reference population as there is no long-term decline in the regional population predicted for either reference population, as demonstrated with the iPCoD modelling assessment. The effect is therefore considered to be of **minor adverse** significance, which is not significant in EIA terms.

Harbour seal

4.9.2.168 Overall, the magnitude of the impact is deemed to be **negligible** and the sensitivity of the receptor is considered to be **medium**. The effects are unlikely to affect the international value of the species in the context of the HSRP. The effect is therefore considered to be of **minor adverse** significance, which is not significant in EIA terms.

Table 4.30: Summary of the significance of effect of disturbance from elevated underwater sound from piling during the construction phase.

Species	Magnitude of impact	Sensitivity of receptor	Significance of effect
Harbour porpoise	Low	Medium	Minor adverse
Bottlenose dolphin	Low	Medium	Minor adverse
Short-beaked common dolphin	Low	Medium	Minor adverse
Risso's dolphin	Low	Medium	Minor adverse

Species	Magnitude of impact	Sensitivity of receptor	Significance of effect
Minke whale	Low	Medium	Minor adverse
Grey seal	Low	Medium	Minor adverse
Harbour seal	Negligible	Medium	Minor adverse

Further mitigation measures

4.9.2.169 The project alone assessment of injury and disturbance from elevated underwater sound during piling has no significant effect in EIA terms. However, recognising the potential contribution to elevated underwater sound in the regional marine mammal study area (see section 4.11.1), the Applicant has committed to the development of an Underwater sound management strategy which is secured in the deemed marine licences within the draft DCO (with an Outline underwater sound management strategy included with the application for consent, Document Reference J13) to reduce the magnitude of impact such that any residual significant effects from the project alone are reduced to a non-significant level (on the basis of a refined project envelope and programme).

4.9.2.170 The Outline underwater sound management strategy (Document Reference J13) will set out the process for investigating options to manage underwater sound levels (such as NAS, temporal and spatial piling restrictions, piling methods, soft start) in order to reduce the magnitude for the Morgan Generation Assets. The Underwater sound management strategy (Document Reference J13) will be developed in consultation with the licensing authority and SNCBs.

4.9.3 Injury and disturbance from elevated underwater sound during UXO clearance

4.9.3.1 Clearance of UXO prior to commencement of construction may result in the detonation (high order) of UXO. This activity has the potential to generate some of the highest peak sound pressures of all anthropogenic underwater sound sources (von Benda-Beckman *et al.,* 2015), and is considered a high energy, impulsive sound source. The potential effects of this activity will depend on sound source characteristics, the receptor species, distance from the sound source and sound attenuation within the environment.

4.9.3.2 Further detail on sound modelling of UXO clearance are provided in Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement. For high order detonation, acoustic modelling was undertaken following the methodology described in Soloway and Dahl (2014). Estimates were conservative as the charge is assumed to be freely standing in mid-water, unlike a UXO which would be resting on or partially buried in the seabed and could potentially be buried, degraded or subject to other significant attenuation. In addition, the explosive material is likely to have deteriorated over time, so maximum sound levels are likely to be over-estimates of true sound levels. Frequency-dependent weighting functions were applied to allow comparison with marine mammal hearing weighted thresholds.

4.9.3.3 For low order techniques, according to Robinson *et al.* (2020), low order deflagration results in a much lower amplitude of peak sound pressure than high order detonations, and therefore acoustic modelling has been based on the methodology described in paragraph 4.9.3.2 but using a smaller donor charge size.

Construction phase

Magnitude of impact

4.9.3.4 Potential effects of underwater sound from high order UXO clearance on marine mammals include mortality, physical injury or auditory injury. The duration of impact (elevated sound) for each UXO detonation is very short (seconds) therefore behavioural effects are considered to be negligible in this context. TTS is presented as a temporary auditory injury but also represents a threshold for disturbance (for the onset of a moving away response) (see paragraph 4.9.3.19 for detailed discussion). Specific sound modelling for the Morgan Generation Assets was carried out using published and peer-reviewed criteria to determine PTS and TTS ranges for marine mammal receptors (Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement). A project-specific Outline MMMP (Document Reference J17) will be developed in order to reduce the potential to experience injury.

4.9.3.5 As outlined in Table 4.17, it is anticipated that up to 13 UXOs within the Morgan Array Area are to be cleared. The absolute maximum UXO size is assumed to be 907 kg (representing the MDS), the most common size is 130 kg and the smallest UXO size is 25 kg, thus all sizes have been assessed. A low order clearance donor charge of 0.08 kg is assumed whilst low-yield donor charges are multiples of 0.75 kg (up to four required for the largest UXO). For donor charges for high-order clearance activities, charge weights of 1.2 kg (the most common) and 3.5 kg (single barracuda blast charge) have been included.

4.9.3.6 The clearance activities will be tide and weather dependant. The aim is to enable clearance of one UXO per tide (a maximum of two clearance events per day), during the hours of daylight and good visibility. There is an assumption of up to 0.5 kg NEQ clearance shot for neutralisation of residual explosive material at each location.

Permanent threshold shift (PTS)

4.9.3.7 PTS ranges for low order and low yield UXO clearance activities are presented in Table 4.31, donor charges used in high order UXO clearance presented in Table 4.32 and high order clearance of UXO presented in Table 4.33. The number of animals predicted to experience PTS due to low order disposal is presented in Table 4.34, donor charges used in high order UXO in Table 4.35 and high order clearance in Table 4.36.

4.9.3.8 It is considered that there is a small risk that a low order clearance could result in high order detonation of UXO, and therefore the assessment considered both high order and low order techniques. With regard to UXO detonation (low order techniques as well as high order events), due to a combination of physical properties of high frequency energy, the sound is unlikely to still be impulsive in character once it has propagated more than a few kilometres (see Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement). The NMFS (2018) guidance suggested an estimate of 3 km for transition from impulsive to continuous (although this was not subsequently presented in the later guidance, Southall *et al*., 2019). Hastie *et al*. (2019) suggest that some measures of impulsiveness (for seismic airguns and pile-driving) change markedly within approximately 10 km of the source. Therefore, caution should be used when interpreting any results with predicted injury ranges in the order of tens of kilometres as the PTS ranges are likely to be significantly lower than those predicted.

4.9.3.9 An explosive mass of 907 kg (absolute maximum high order explosion) yielded the largest PTS ranges for all species, with the greatest injury range (15,370 m) seen for harbour porpoise (using the SPL_{pk} metric) (Table 4.33). However, the most likely (common) 130 kg charge sees this injury range reduce to 8,045 m for harbour porpoise (SPL_{pk}). Conservatively, the number of harbour porpoise that could be potentially injured, based on the Welsh Marine Mammal Atlas density of 0.262 animals per km^2 (Table 4.12), was estimated as 195 animals for the absolute maximum 907 kg UXO high order explosion (using the SPL_{pk} metric) equating to 0.31% of the CIS MU. Predicted numbers were much smaller for the most likely (common) 130 kg and 25 kg UXOs with up to 54 animals and 18 animals potentially experiencing PTS respectively (using the SPL_{pk} metric). For low order techniques, the largest range of 2,290 m was predicted from the 4 x 0.75 kg low-yield charges, which could injure up to 5 harbour porpoises within this range.

4.9.3.10 The underwater sound assessment (Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement) found that the maximum injury (PTS) range estimated for bottlenose dolphin, short-beaked common dolphin and Risso's dolphin using the SPL_{pk} metric is 890 m for the detonation of charge size of 907 kg (absolute maximum), but this is reduced to 464 m for 130 kg (most likely (common) and 268 m for 25 kg. Therefore conservatively, during high order detonation of any size of UXO the maximum number of individuals that could be potentially injured for any of these species was estimated as no more than one (based on densities presented in Table 4.12. With reference to the wider populations of these species, this equated to very small proportions of the relevant MUs (0.001% for bottlenose dolphin, 0.0000007% for short-beaked common dolphin and 0.001% for Risso's dolphin). For low order techniques, the injury ranges were considerably lower with a maximum of 133 m from the 4 x 0.75 kg low-yield charges estimated at no more than one animal of any species likely to be present within this range.

4.9.3.11 The underwater sound assessment (Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement) found that the maximum injury (PTS) range estimated for minke whale using the SEL_{cum} metric is 4,215 m for the detonation of a charge size of 907 kg (absolute maximum), but this is reduced to 1,705 m for the most likely (common) maximum 130 kg and 775 m for 25 kg. Therefore conservatively, the number of individuals that could be potentially injured was estimated as less than one animal for 907 kg UXO high order explosion, which equates to 0.005% of the CGNS MU, and less than one animal for 130 kg UXO and 25 kg UXO. For low order techniques, the maximum range predicted was up to 406 m and there would be no more than one animal potentially injured within this range.

4.9.3.12 The underwater sound assessment found that the maximum injury (PTS) range estimated for seals using the SPL_{pk} metric was 3,015 m for the detonation of charge size of 907 kg (absolute maximum), but this was reduced to 1,580 m for 130 kg and 910 m for 25 kg. Therefore conservatively, the number of grey seal that could be potentially injured, based on the Carter *et al. (*2022) densities, was estimated as up to two animals for 907 kg UXO high order explosion (absolute maximum), which equates to 0.009% of the GSRP or 0.002% of the OSPAR Region III reference population. For the 130 kg (most likely (common) maximum) and 25 kg UXO size, and low order techniques, there would be no more than one animal potentially affected. The number of harbour seal that could be potentially injured was estimated as less than one animal for the 907 kg UXO high order explosion which equates to up to 0.0001% of the HSRP.

For the 130 kg and 25 kg UXO size, and low order techniques, there would be no more than one animal potentially affected.

Table 4.31: Potential PTS ranges for Low Order and Low Yield UXO clearance activities.

Charge Size	PTS range (m)				
	Threshold	VHF	HF	LF	PCW
0.08 kg low-order donor charge	SPL_{pk}	685	40	122	135
	SEL_{cum}	190	2	47	9
0.5 kg clearing shot	SPL_{pk}	1,265	73	223	247
	SEL_{cum}	421	4	115	22
2 x 0.75 kg low-yield charge	SPL_{pk}	1,820	105	322	357
	SEL_{cum}	650	7	196	38
4 x 0.75 kg low-yield charge	SPL_{pk}	2,290	133	406	449
	SEL_{cum}	840	10	275	53

Table 4.32: Potential PTS ranges for donor charges used in High Order UXO clearance activities.

Charge Size	PTS range (m)				
	Threshold	VHF	HF	LF	PCW
1.2 kg – donor charge	SPL_{pk}	1,690	98	299	331
	SEL_{cum}	596	6	176	34
3.5 kg – donor charge	SPL_{pk}	2,415	140	427	473
	SEL_{cum}	885	10	297	57

Table 4.33: Potential PTS ranges for High Order clearance of UXOs.

Charge Size	PTS range (m)				
	Threshold	VHF	HF	LF	PCW
25 kg UXO – high order explosion	SPL_{pk}	4,645	268	825	910
	SEL_{cum}	1,645	27	775	147
130 kg UXO – high order explosion	SPL_{pk}	8,045	464	1,425	1,580
	SEL_{cum}	2,520	61	1,705	323
907 kg UXO – high order explosion	SPL_{pk}	15,370	890	2,720	3,015
	SEL_{cum}	3,820	151	4,215	800

Table 4.34: Number of animals with the potential to experience PTS due to Low Order and Low Yield UXO clearance activities.

Threshold	Estimated number of animals						
	Harbour Porpoise	Bottlenose Dolphin	Short-beaked common dolphin	Risso's dolphin	Minke whale	Grey seal	Harbour seal
0.08 kg low-order donor charge							
SPL_{pk}	<1	<1	<1	<1	<1	<1	<1
SEL_{cum}	<1	<1	<1	<1	<1	<1	<1
0.5 kg clearing shot							
SPL_{pk}	2	<1	<1	<1	<1	<1	<1
SEL_{cum}	<1	<1	<1	<1	<1	<1	<1
2 x 0.75 kg low-yield charge							
SPL_{pk}	3	<1	<1	<1	<1	<1	<1
SEL_{cum}	<1	<1	<1	<1	<1	<1	<1
4 x 0.75 kg low-yield charge							
SPL_{pk}	5	<1	<1	<1	<1	<1	<1
SEL_{cum}	<1	<1	<1	<1	<1	<1	<1

Table 4.35: Number of animals with the potential to experience PTS due to donor charges used in High Order UXO clearance activities.

Threshold	Estimated number of animals						
	Harbour Porpoise	Bottlenose Dolphin	Short-beaked common dolphin	Risso's dolphin	Minke whale	Grey seal	Harbour seal
1.2 kg donor charge for high-order UXO disposal							
SPL_{pk}	3	<1	<1	<1	<1	<1	<1
SEL_{cum}	<1	<1	<1	<1	<1	<1	<1
3.5 kg donor blast-fragmentation charge for high-order UXO disposal							
SPL_{pk}	5	<1	<1	<1	<1	<1	<1
SEL_{cum}	<1	<1	<1	<1	<1	<1	<1

Table 4.36: Number of animals with the potential to experience PTS due to High Order clearance of UXOs.

Threshold	Estimated number of animals						
	Harbour Porpoise	Bottlenose Dolphin	Short-beaked common dolphin	Risso's dolphin	Minke whale	Grey seal	Harbour seal
25 kg UXO – high order explosion							
SPL_{pk}	18	<1	<1	<1	<1	<1	<1
SEL_{cum}	3	<1	<1	<1	<1	<1	<1
130 kg UXO – high order explosion							
SPL_{pk}	54	<1	<1	<1	<1	<1	<1
SEL_{cum}	6	<1	<1	<1	<1	<1	<1
90 7kg UXO – high order explosion							
SPL_{pk}	195	<1	<1	<1	<1	2	<1
SEL_{cum}	12	<1	<1	<1	1	<1	<1

4.9.3.13 For the purposes of this assessment, it has been assumed that the maximum design scenario will be clearance of UXO with a NEQ of 907 kg as an absolute maximum, cleared by either low order or high order techniques although clearance of UXO with an NEQ of 130 kg is considered the more likely (common) scenario (Table 4.16). Primary mitigation can be employed to reduce the risk of injury by using low order techniques to clear UXOs where possible, noting however, that low order techniques are not always possible and are dependent upon the individual situations surrounding each UXO, therefore both low order and high order techniques are included in the assessment.

4.9.3.14 With primary measures in place (i.e. using low order techniques) the assessment found (based upon the absolute maximum 907 kg UXO) that there would be a risk of injury over a range of 2,290 m (for harbour porpoise using the SPL_{pk} metric) that would require further mitigation (Table 4.31). Where low order/low yield measures are not possible there is a maximum risk of injury (predicted for harbour porpoise) out to ~15 km for a 907 kg UXO (absolute maximum) and ~ 8 km for a 130 kg UXO (most likely (common) maximum). Therefore, adopting standard industry practice (JNCC, 2010b) tertiary mitigation will be applied as part of a MMMP (Document Reference J17) as an annex of the Underwater sound management strategy (with an Outline underwater sound management strategy submitted as part of the application, Document Reference J13) (Table 4.17).

4.9.3.15 The injury ranges (for both low order and high order clearance) are considerably larger than the standard 1,000 m mitigation zone recommended for UXO clearance (JNCC, 2010b) and there are often difficulties in detecting marine mammals (particularly harbour porpoise) over such large ranges (McGarry *et al*., 2017). Visual surveys note that there is often a significant decline in detection rate with increasing sea state (Embling *et al*., 2010; Leaper *et al*., 2015). Tertiary mitigation will therefore also include the use of ADDs and potentially scare charges to deter animals from the injury zone (Table 4.17). The efficacy of such deterrence will depend upon the device selected and reported ranges of effective deterrence vary. One of the loudest devices available, the Lofitech ADD, operates at a range of frequencies and may be suitable as a multi-species deterrent. Brandt *et al.* (2012) reported effective deterrence of harbour porpoise out to 7.5 km whilst Dähne *et al.* (2017) suggest detectable deterrence to 12 km. Olesiuk *et al.* (2002) report a displacement range of 3.5 km for the Airmar dB plus II ADD whilst Kyhn *et al.* (2015) report effective deterrence to 2.5 km for harbour porpoise. A full review of available devices is provided in McGarry *et al.* (2020).

4.9.3.16 In addition to the ADD, deterrence can also be achieved through the use of soft start charges, the application of which will be discussed and agreed with consultees post-submission, once more information on the size and type of UXOs are known. Details of appropriate tertiary mitigation as set out in the MMMP (Document Reference J17) (an annex to the Underwater sound management strategy; Document Reference J13) will be discussed and agreed with consultees post-consent. To illustrate what this may entail for high order clearance of the most likely scenario (130 kg NEQ), based on a swim speed of 1.5 m/s for harbour porpoise, a total of 89 minutes of deterrence activities would be required for animals to clear the risk zone (as per the Outline MMMP, Document Reference J17).

4.9.3.17 Adopting a precautionary approach, and assuming application of tertiary measures as part of the Morgan Generation Assets, the assessment considered the magnitude for a high order detonation (the absolute maximum 907 kg UXO). The magnitude of impact is predicted to be of local to regional spatial extent (depending on species), very short-term duration, intermittent and, although the impact itself is reversible (i.e. the elevation in underwater sound only occurs during the detonation event), the effect of injury on sensitive receptors is permanent. It is predicted that the impact will affect the receptor directly. With tertiary mitigation applied it is anticipated that, for most species, animals would be deterred from the injury zone and therefore the likelihood of PTS would be removed. The magnitude is therefore considered to be **negligible** (for bottlenose dolphin, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal).

4.9.3.18 For harbour porpoise the ranges of effect are large for high order clearance, and there is considered to be a residual risk of PTS to a number of individuals, therefore conservatively (based upon the absolute maximum 907 kg UXO), the magnitude is considered to be **medium** for harbour porpoise. Whilst it is difficult to quantify this residual risk (due to uncertainties over the predicted ranges of effect and the potential ranges over which deterrence measures are effective, alongside assessing on the MDS of high order clearance which may be refined following site-investigation surveys), it is anticipated that there would be some measurable changes at an individual level but that this would not manifest to population-level effects due to the small proportion of the CIS MU potentially affected.

Behavioural displacement (TTS as a proxy)

4.9.3.19 A second threshold assessed was the onset of TTS where the resulting effect would be a potential temporary loss in hearing. Whilst similar ecological functions would be inhibited in the short term due to TTS, these are reversible on recovery of the animal's hearing and not considered likely to lead to any long-term effects on the individual. However, the onset of TTS also corresponds to a moving away or 'fleeing response' as this is the threshold at which animals experience disturbance and are likely to move away from the ensonified area. Thus, the onset of TTS also reflects the threshold at which strong disturbance could occur (it represents the boundary between the most severe disturbance levels and the start of physical auditory impacts on animals).

4.9.3.20 As previously described in paragraph 4.9.1.19, the sound is unlikely to be impulsive in character once it has propagated more than a few kilometres (detailed discussion in paragraphs 1.5.5.26 to 1.5.5.29 of Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement). This is particularly important when interpreting results for TTS with ranges of up to ~ 35 km as these are likely to be substantially lower than predicted.

4.9.3.21 As before, the assessment of strong disturbance considered low order and low yield UXO clearance activities (Table 4.37), donor charges for high order UXO disposal (Table 4.38) and high order explosions (Table 4.39). The largest ranges using SPL_{pk} were predicted for clearance of the 907 kg UXO (absolute maximum) with potential strong disturbance/moving away response over a distance of up to ~28 km for harbour porpoise (Table 4.39). Ranges predicted for all other species using SPL_{pk} were smaller, however, for minke whale a larger strong disturbance range of ~34 km was predicted using the SEL_{cum} threshold.

Table 4.37: Potential strong disturbance (TTS used as a proxy) ranges for Low Order and Low Yield UXO clearance activities.

Charge Size	TTS range (m)				
	Threshold	VHF	HF	LF	PCW
0.08 kg low-order donor charge	SPL_{pk}	1,265	73	224	247
	SEL_{cum}	153	23	655	182
0.5 kg clearing shot	SPL_{pk}	2,325	134	411	455
	SEL_{cum}	155	56	1,585	182
2 x 0.75 kg low-yield charge	SPL_{pk}	3,350	194	593	660
	SEL_{cum}	156	95	2,665	183
4 x 0.75 kg low-yield charge	SPL_{pk}	4,220	244	750	830
	SEL_{cum}	156	131	3,670	183

Table 4.38: Potential strong disturbance (TTS used as a proxy) ranges for donor charges for high order UXO.

Charge Size	TTS range (m)				
	Threshold	VHF	HF	LF	PCW
1.2kg	SPL_{pk}	3,110	180	551	610
	SEL_{cum}	155	85	2,400	183
3.5kg	SPL_{pk}	4,445	257	790	875
	SEL_{cum}	157	141	3,940	183

Table 4.39: Potential strong disturbance (TTS used as a proxy) ranges for High Order clearance of UXOs.

Charge Size	TTS range (m)				
	Threshold	VHF	HF	LF	PCW
25 kg UXO – high order explosion	SPL_{pk}	8,555	494	1,515	1,680
	SEL_{cum}	159	343	9,325	183
130 kg UXO – high order explosion	SPL_{pk}	14,825	855	2,625	2,905
	SEL_{cum}	160	680	17,755	183
907 kg UXO – high order explosion	SPL_{pk}	28,320	1,635	5,015	5,550
	SEL_{cum}	162	1,380	34,365	6,470

4.9.3.22 The number of animals that could potentially experience TTS due to low order and low yield UXO clearance activities is presented in Table 4.37, donor charges for high order UXO disposal in Table 4.38 and high order explosions in Table 4.39. As seen for PTS the highest number of animals affected, based on high order detonation of a 907 kg UXO (absolute maximum), was found for harbour porpoise where up to 661 animals could experience strong disturbance within the 28.32 km range, equating to 1.06% of the CIS MU (based on SPL_{pk}). Based on SEL_{cum}, the number of grey seal within a predicted 6.47 km strong disturbance range was estimated as six animals (0.04% of the GSRP, and 0.01% of the OSPAR Region III reference population). For minke whale up to 65 animals could occur within the 34.36 km strong disturbance range (0.32% of the CGNS MU, based on the SEL_{cum} metric). For all other species the number of animals predicted to be disturbed was very small with no more than one animal within the predicted effect zones.

4.9.3.23 Behavioural effects are reversible and therefore animals are anticipated to fully recover following cessation of the activity. It is, however, recognised that where tertiary mitigation applies to reduce the risk of PTS, deterrence measures (i.e. ADD and soft start charges) by their nature would contribute to, rather than reduce, the moving away response.

Table 4.40: Number of animals with the potential to experience strong disturbance (TTS used as a proxy) due to low order UXO detonations.

Threshold	Estimated Number of Animals with the Potential to be Disturbed						
	Harbour Porpoise	Bottlenose Dolphin	Short-beaked common dolphin	Risso's dolphin	Minke whale	Grey seal	Harbour seal
0.08 kg low-order donor charge							
SPL_{pk}	2	<1	<1	<1	<1	<1	<1
SEL_{cum}	2	<1	<1	<1	<1	<1	<1
0.5 kg clearing shot							
SPL_{pk}	5	<1	<1	<1	<1	<1	<1
SEL_{cum}	6	<1	<1	<1	<1	<1	<1
2 x 0.75 kg low-yield charge							

Threshold	Estimated Number of Animals with the Potential to be Disturbed						
	Harbour Porpoise	Bottlenose Dolphin	Short-beaked common dolphin	Risso's dolphin	Minke whale	Grey seal	Harbour seal
SPL_{pk}	10	<1	<1	<1	<1	<1	<1
SEL_{cum}	9	<1	<1	<1	<1	<1	<1
4 x 0.75 kg low-yield charge							
SPL_{pk}	15	<1	<1	<1	<1	<1	<1
SEL_{cum}	12	<1	<1	<1	<1	<1	<1

Table 4.41: Number of animals with the potential to experience strong disturbance (TTS used as a proxy) due to donor charges high order UXO.

Threshold	Estimated Number of Animals with the Potential to be Disturbed						
	Harbour Porpoise	Bottlenose Dolphin	Short-beaked common dolphin	Risso's dolphin	Minke whale	Grey seal	Harbour seal
1.2 kg donor charge for high-order UXO disposal							
SPL_{pk}	8	<1	<1	<1	<1	<1	<1
SEL_{cum}	7	<1	<1	<1	<1	<1	<1
3.5 kg donor blast-fragmentation charge for high-order UXO disposal							
SPL_{pk}	17	<1	<1	<1	<1	<1	<1
SEL_{cum}	12	<1	<1	<1	<1	<1	<1

Table 4.42: Number of animals with the potential to experience strong disturbance (TTS used as a proxy) due to High Order clearance of UXOs.

Threshold	Estimated Number of Animals with the Potential to be Disturbed						
	Harbour Porpoise	Bottlenose Dolphin	Short-beaked common dolphin	Risso's dolphin	Minke whale	Grey seal	Harbour seal
25 kg UXO – high order explosion							
SPL_{pk}	61	<1	<1	<1	<1	<1	<1
SEL_{cum}	24	<1	<1	<1	5	<1	<1
130 kg UXO – high order explosion							
SPL_{pk}	181	<1	<1	<1	<1	2	<1
SEL_{cum}	39	<1	<1	<1	18	2	<1
907 kg UXO – high order explosion							
SPL_{pk}	661	<1	<1	<1	2	4	<1

Threshold	Estimated Number of Animals with the Potential to be Disturbed						
	Harbour Porpoise	Bottlenose Dolphin	Short-beaked common dolphin	Risso's dolphin	Minke whale	Grey seal	Harbour seal
SEL_{cum}	66	<1	<1	<1	65	6	<1

4.9.3.24 Adopting a precautionary approach, and with tertiary measures adopted, the assessment considered the magnitude of a high order detonation. The magnitude of disturbance resulting from a high order detonation is predicted to be of regional spatial extent, very short-term duration, intermittent and both the impact itself (i.e. the elevation in underwater sound during detonation event) and effect of disturbance is reversible (TTS represents a non-trivial disturbance but not permanent injury). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low** for all species.

Sensitivity of receptor

Permanent Threshold Shift

4.9.3.25 The main feature of the acoustical properties of explosives is a short shock wave, comprising a sharp rise in pressure followed by an exponential decay with a time constant of a few hundred microseconds (Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement). The interactions of the shock and acoustic waves create a complex pattern in shallow water, and this was investigated further by Von Benda-Beckmann *et al*. (2015). Harbour porpoise was most often studied in the scientific literature due to their high sensitivity to sound. The effects of explosives on harbour porpoise in the southern North Sea was studied by Von Benda-Beckmann *et al*. (2015). The study measured SEL and peak overpressure (in kPa) at distances up to 2 km from the explosions of seven aerial bombs (charge mass of 263 kg and 121 kg) detonated at approximately 26 m to 28 m depth, on a sandy substrate. The results suggested that the largest distance at which a risk of ear trauma could occur was at 500 m and that sound-induced PTS was likely to occur greater than the 2 km range that was measured during the study since the SEL recorded at this distance was 191 dB re 1 μPa^2s (i.e. 1 dB above the 'very likely to occur' threshold). Von Benda-Beckmann *et al*. (2015) also modelled possible ranges for 210 explosions that had been logged by the Royal Netherland Navy (RNLN) and the Royal Netherlands Meteorological Institute (RNMI) over a two-year period (2010 and 2011). Using the empirical measurements of SEL out to 2 km, the authors found that the effect distances ranged between hundreds of metres to just over 10 km (for charges ranging from 10 kg up to 1,000 kg). Near the surface, where porpoises are known to spend a large proportion of time (e.g. 55% based on Teilmann *et al*., 2007) the SELs were predicted to be lower with effect distances for the onset of PTS just below 5 km. However, whilst the model could provide a reasonable estimate of the SEL within 2 km (since the empirical measurements were made out to this point), estimates above this distance required further validation since the uncorrected model systematically overestimated SEL.

4.9.3.26 Estimating how individuals are exposed to sound over time depends on an animals' mobility. Aarts *et al.* (2016) demonstrated that harbour porpoise movement strategy affects the cumulative number of animals acoustically exposed to underwater explosions. The study estimated the number of animals receiving temporary or permanent hearing loss due to underwater detonations of recovered explosives (mostly WWII aerial bombs) and found when porpoises remained in a local area to detonations, fewer animals would receive PTS and TTS than those free roaming, but more individuals would be subjected to repeated exposures.

4.9.3.27 Salomons *et al*. (2021) analysed the sound measurements performed near two detonations of UXO (charge masses of 140 kg and 325 kg) and derived a PTS effect distance in the range 2.5 km to 4 km (using weighted SEL values and threshold levels from Southall *et al*. (2019)). When comparing the experimental data and model predictions, the same study concluded thar harbour porpoise are at risk of permanent hearing loss at distances of several kilometres, i.e. distance between 2 km and 6 km based on 140 kg and 325 kg charge masses, respectively.

4.9.3.28 Due to paucity of studies on these species, less is known about the sensitivity of bottlenose dolphin, short-beaked common dolphin, Risso's dolphin and minke whale to UXO detonation. During a clearance of relatively small explosives (35 kg charge) at an important feeding area for a resident community of bottlenose dolphin in Portugal, acoustic pressure levels in excess of 170 dB re 1 µPa (SPL_{rms})were measured and despite pressure levels being 60 dB re 1 µPa (SPL_{rms}) higher than ambient sound, no adverse effects were recorded in the behaviour or appearance of the resident community (Santos *et al*., 2010). Nonetheless, other studies reported that although dolphins experienced external injuries consistent with inner ear damage due to explosives, they expressed little change in surface behaviour near blast areas (Ketten, 1993).

4.9.3.29 Robinson *et al*. (2020) found that using low order UXO disposal methods offers a substantial reduction in acoustic output over traditional high-order detonations, with the peak SPL_{pk} and SEL_{cum} observed being typically > 20 dB lower for the deflagration of the same sized munition (a reduction factor of just over ten in SPL_{pk} and 100 in acoustic energy). The study reported that the acoustic output depends on the size of the shaped charge, rather than the size of the UXO itself. Considering the above, compared to high-order methods, Robinson *et al*. (2020) provided evidence that low order techniques offer the potential for greatly reduced acoustic sound exposure of marine mammals.

4.9.3.30 All marine mammals are deemed to have limited resilience to PTS, low recoverability and international value. The sensitivity of the receptors to PTS is therefore, considered to be **high.**

Behavioural Disturbance (TTS as a proxy)

4.9.3.31 Although underwater sound as a result of UXO clearance has the potential to produce behavioural disturbance, there are no agreed thresholds for the onset of a behavioural response generated as a result of a single explosion. Thresholds for the onset of behavioural disturbance from detonation of explosives exist (Finneran and Jenkins, 2012) following the proposed approach by Southall *et al.* (2007), but these are intended for repeated impulsive events (detonations) over a 24 hour period and therefore not suitable for single detonations of a UXO. Finneran and Jenkins (2012) states for these single detonations, behavioural disturbance is likely to be limited to 'a short-lived startle reaction' and therefore does not use any unique behavioural disturbance thresholds for marine mammals exposed to single explosive events.

4.9.3.32 Southall *et al*. (2007) recommended that the use of TTS onset as an auditory effect may be most appropriate for single pulses (such as UXO detonation) and therefore it has been applied to inform the assessment.

4.9.3.33 Given that TTS is a temporary and reversible hearing impairment, it is anticipated that any animals experiencing this shift in hearing would recover after they have moved beyond the injury zone are no longer exposed to elevated sound levels. The implication of animals experiencing TTS, leading to potential displacement, is not fully understood, but it is likely that aversive responses to anthropogenic sound could temporarily affect life functions as described for PTS. Therefore, in this respect animals exposed to sound levels that could induce TTS have similar susceptibility as those exposed to sound levels that could induce PTS. There is an important distinction, however, given that TTS is only temporary hearing impairment, it is less likely to lead to acute effects and will largely depend on recoverability. The degree and speed of hearing recovery will depend on the characteristics of the sound the animal is exposed to, and on the degree of shift in hearing experienced.

Harbour porpoise

4.9.3.34 SEAMARCO (2011) measured recovery rates of harbour porpoise following exposure to a piling playback sound source of 175 dB re 1 μPa^{2}s (SEL) over 120 minutes and found that recovery to the pre-exposure threshold was estimated to be complete within 48 minutes following exposure (the higher the hearing threshold shift, the longer the recovery).

4.9.3.35 Kastelein *et al*. (2021) found that the susceptibility to TTS depends on the frequency of the fatiguing sound causing the shift and the greatest TTS depends on the SPL (and related SEL). In a series of studies measuring TTS occurrence in harbour porpoise at a range of frequencies typical of high amplitude anthropogenic sounds, the greatest shift in mean TTS occurred at 0.5 kHz with hearing recovery within 60 minutes after the fatiguing sound stopped. Scientific understanding of the biological effects of TTS is limited to the results of controlled exposure studies on small numbers of captive animals (reviewed in Finneran, 2015). Extrapolating these results to how animals may respond in the natural environment should be treated with caution as it is not possible to exactly replicate natural environmental conditions, and the small number of test subjects would not account for intraspecific differences (i.e. differences between individuals) or interspecific differences (i.e. extrapolating to other species) in response.

Bottlenose dolphin, short-beaked common dolphin and Risso's dolphin

4.9.3.36 Finneran *et al*. (2000) investigated the behavioural and auditory responses of two captive bottlenose dolphins to sounds that simulated distant underwater explosions. The animals were exposed to an intense sound once per day and no auditory shift (i.e. TTS) greater than 6 dB in response to levels up to 221 dB re 1 μPa p-p (peak-peak) was observed. Behavioural shifts, such as delaying approach to the test station and avoiding the 'start' station, were recorded at 196 dB and 209 dB re 1 μPa p-p for the two dolphins and continued at higher levels. There are several caveats to this study (discussed in Nowacek *et al*. (2007)), (i.e. the signals used in this study were distant and the study measured masked-hearing signals). The animals used in the experiment were also trained and rewarded for tolerating high levels of sound and subsequently, it can be anticipated that behavioural disruption would likely be observed at lower levels in other contexts.

4.9.3.37 Whilst there are no available species-specific recovery rates for mid-frequency cetaceans to TTS, there is no evidence to suggest that recovery will be significantly different to harbour porpoise recovery rates. It can be anticipated that all three species would be able to tolerate the effect without any impact on reproduction or survival rates with the ability to return to previous behavioural states or activities once the impacts had ceased.

Minke whale

4.9.3.38 Few studies are available on reactions of minke whales to impulsive sounds, however several studies indicate that mysticetes in general may react to pile driving sound at considerable distances (Tougaard *et al.,* 2021). Sivle *et al.* (2015) exposed a single minke whale to simulated sonar sounds between 1 and 2 kHz. At received sound levels equivalent to 146 dB re 1 µPa^{2}s SEL, the minke whale responded by swimming away. Boisseau *et al*. (2021) observed minke whale showing clear avoidance behaviour to an operational 15 kHz ADD, at signals at the likely upper limit of their hearing sensitivity. Tougaard *et al.* (2021) noted that it is difficult to extract robust response thresholds for minke whale, however, sound levels at which responses occur appear to be considerably higher than for harbour porpoise (by some 40 to 50 dB) indicating a lower sensitivity to the sound.

4.9.3.39 Whilst there are no species-specific recovery rates to TTS available for minke whale, there is no evidence to suggest that recovery will be significantly different to harbour porpoise recovery rates. It is anticipated that minke whale would be able to tolerate the effect without any impact on reproduction or survival rates and is expected to return to previous behavioural states or activities once the impacts had ceased.

Harbour seal and grey seal

4.9.3.40 Kastelein *et al*. (2018) measured recovery rates of harbour seal following exposure to a sound source of 193 dB re 1 µPa^{2}s (SEL_{cum}) over 360 minutes and found that recovery from TTS to the pre-exposure baseline was estimated to be complete within 72 minutes following exposure. These results are in line with findings reported in SEAMARCO (2011), which showed that for small TTS values, recovery in seals was around 30 minutes, and the higher the hearing threshold shift, the longer the recovery. Kastelein *et al*. (2019) also reported relatively fast recovery, with full hearing recovery within two hours following exposure.

4.9.3.41 Considering the above, in most cases, impaired hearing for a short time is anticipated to have little effect on the total foraging period of a seal. If hearing is impaired for longer periods (hours or days) the impact has the potential to be ecologically significant (SEAMARCO, 2011). Nevertheless, the findings of studies presented in this section indicate that seal species are less vulnerable to TTS than harbour porpoise for the sound bands tested. It is also expected that animals would move beyond the injury range prior to the onset of TTS. The assessment considered that both grey seal and harbour seal are likely to be able to tolerate the effect without any impact on both reproduction and survival rates and would be able to return to previous behavioural states or activities once the impacts had ceased.

4.9.3.42 All marine mammals are deemed to have some resilience to behavioural disturbance, high recoverability and international value. The sensitivity of the receptor to TTS is therefore, considered to be **low.**

Significance of effect

4.9.3.43 In the case that a low order technique is not possible, or results in a high order detonation (as per paragraph 4.9.3.8) conclusions presented in 4.9.3.44 onwards are based on the assessment for high order clearance.

Auditory injury

4.9.3.44 Overall, with primary and tertiary mitigation applied, for bottlenose dolphin, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal, the magnitude of the impact is deemed to be **negligible** and the sensitivity of the receptors is considered to be **high**. There is not anticipated to be any effect on the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

4.9.3.45 Overall, with primary and tertiary mitigation applied, for harbour porpoise, the magnitude of the impact is deemed to be **medium,** and the sensitivity of the receptor is considered to be **high**. On the basis of the absolute maximum high order detonation, there may be some residual effect with a small number of animals potentially exposed to sound levels that could elicit PTS. The effect will, therefore, be of **moderate adverse** significance, which is significant in EIA terms.

4.9.3.46 Mitigation measures via the MMMP (secured in the deemed marine licences within the draft DCO (Document Reference C1)), will be developed in accordance with the Outline MMMP (Document Reference J17), included as part of the application, to reduce the residual risk of injury to harbour porpoise. The details of which will be agreed post-consent when further information is available regarding the type/size of UXO to be cleared. There is a general hierarchy of preferred mitigation with regard to UXO (as detailed in Table 4.17), with a preference to avoid UXO, and then clear with low order techniques if possible. Where detonation of UXO using low order techniques occurs this is considered to be primary mitigation (noting, however, that it is not possible to fully commit to this measure at this stage) and would reduce the risk to negligible, therefore not significant. However, if low order/low yield clearance is not possible, and measures adopted as part of the Morgan Generation Assets do not fully mitigate (as detailed in the Outline MMMP (Document Reference J17)), further measures are considered in the Underwater sound management strategy (Document Reference J13) discussed below. A more detailed assessment of mitigation will be undertaken post-consent as further information on the number, condition, and type of UXOs becomes available to inform the MMMP (Document Reference J17) and will be developed in consultation with the licensing authority and SNCBs.

Further mitigation measures

4.9.3.47 The project alone assessment of injury from elevated underwater sound during UXO clearance concludes a significant effect in EIA terms, for harbour porpoise only. The project alone assessment of disturbance from elevated underwater sound during UXO clearance concludes no significant effect in EIA terms, for all other marine mammal receptors. The Applicant has committed to the development of an Underwater sound management strategy (Document Reference J13) to manage underwater sound levels associated with significant impacts from the project alone, to reduce the magnitude of impacts such that there will be no residual significant effect.

4.9.3.48 The Underwater sound management strategy will present relevant further mitigation options (such as NAS, temporal and spatial restrictions, low order clearance methods, soft start) in order to manage underwater sound levels so as to reduce the magnitude of impacts for the project alone. The Applicant has prepared an Outline underwater sound management strategy (Document Reference J13) which is secured in the deemed marine licences within the draft DCO (Document Reference C1), which establishes a process of investigating options to manage underwater sound levels, in consultation with the licensing authority and SNCBs and agreeing prior to construction, mitigation measures that will be implemented to reduce the magnitude of impacts such that there will be no residual significant effect from the Morgan Generation Assets (in this case, on harbour porpoise). These further measures would also reduce impacts associated with underwater sound for other marine mammal receptors.

Behavioural disturbance (TTS used as a proxy)

4.9.3.49 Overall, with tertiary mitigation applied, the magnitude of the impact for all species is deemed to be **low** and the sensitivity of the receptor is considered to be **low**. There is not anticipated to be any effect on the international value of any marine mammal species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

4.9.4 Injury and disturbance from elevated underwater sound due to vessel use and other (non-piling) sound producing activities

4.9.4.1 Increased vessel movements during the construction, operations and maintenance, and decommissioning phases have the potential to result in a range of effects to marine mammals such as avoidance behaviour or displacement and masking of vocalisations or changes in vocalisation rate.

4.9.4.2 The assessment of impacts from elevated underwater sound due to vessel use and other (non-piling) sound producing activities is based on a vessel and/or activity basis, considering the maximum injury/disturbance range as assessed in Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement. However, several activities could be potentially occurring at the same time and therefore ranges of effects may extend from several vessels/locations where the activity is carried out and potentially overlap.

Construction phase

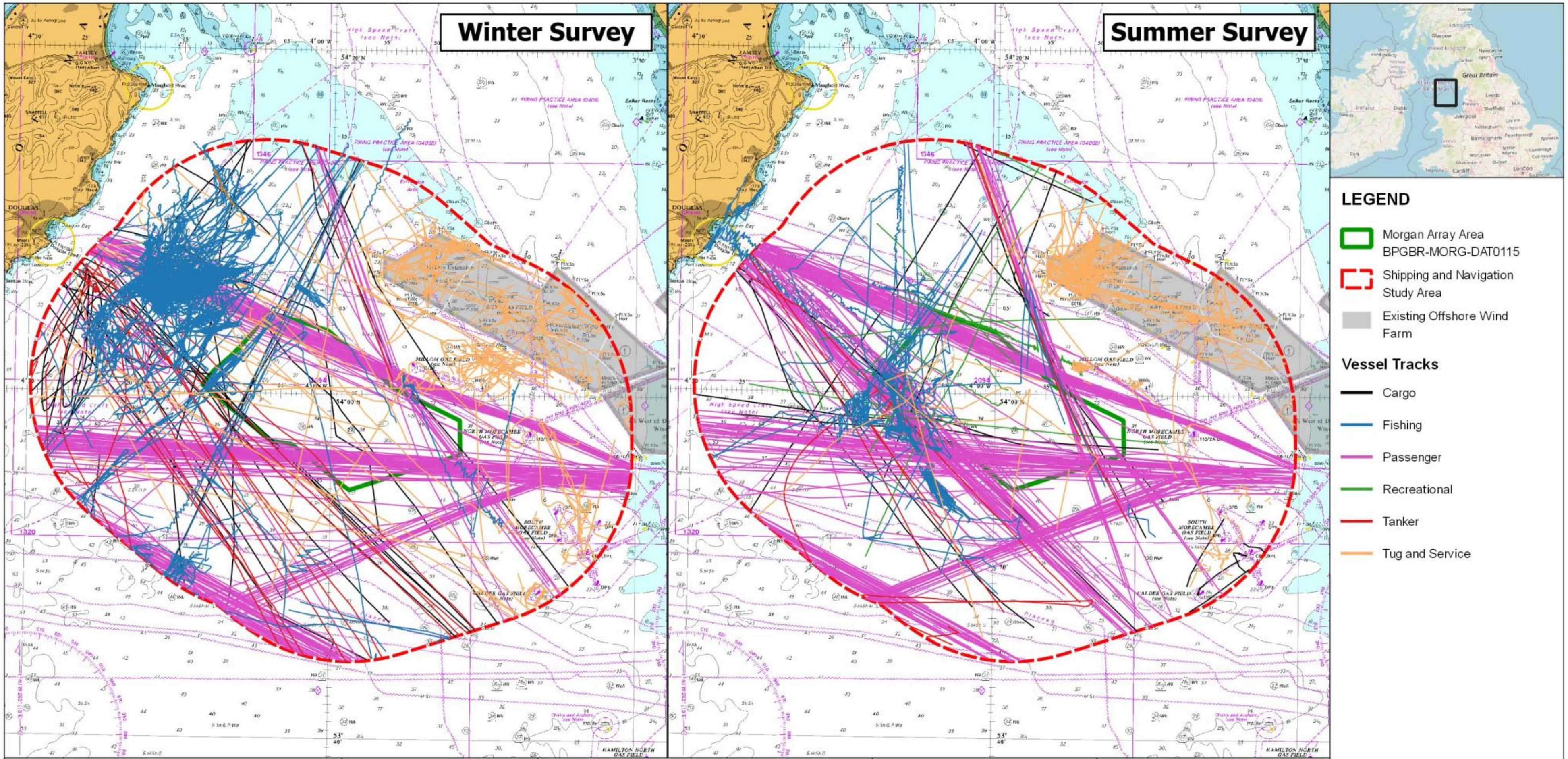
Magnitude of impact

Auditory injury

4.9.4.3 During the construction phase of the Morgan Generation Assets, the increased levels of vessel activity, in association with construction activities in the Morgan Array Area, will contribute to the total underwater sound levels.

4.9.4.4 As per section 4.7.1, the MDS for construction activities associated with the Morgan Array Area is for up to a total of 69 vessels on site at any one time. This includes a maximum of 22 main installation and support vessels, carrying out 521 trips. Eight tug/anchor handlers will carry out 74 return trips. Seven cable lay installation and support vessels will carry out 56 return trips across the construction period. One guard vessel will carry out 50 return trips. Six survey vessels will carry out 31 return trips. A maximum of eight seabed preparation vessels for boulder removal, grapnel, pre-sweep and levelling will carry out 19 return trips. Twelve crew transfer vessels will carry out 1,135 return trips. Three scour protection installation vessels will carry out 41 return trips, and two cable protection vessels will carry out two return trips.

4.9.4.5 Whilst this will lead to an uplift in vessel activity, the movements will be limited to within the Morgan Array Area and are likely to follow existing shipping routes to/from the ports. Approximately 3,166 vessels in total pass through the Morgan Array Area per year (Volume 4, Annex 7.1: Navigational Risk Assessment (NRA) of the Environmental Statement). Vessel traffic activity shows a seasonal trend that peaks over the summer months (May to August) and decreases in the winter months (November to February) (Figure 4.24). This is primarily due to an increase in ferry service operations and recreational activity. The NRA demonstrated that much of the Morgan marine mammal study area experienced over 640 vessel trips per year (Figure 4.25). The majority of vessels crossing the Morgan Array Area are commercial cargo, tanker and passenger vessels and commercial traffic is largely concentrated where the route crosses the approaches to Liverpool and the associated ferry routes. Any vessel movements associated with the Morgan Generation Assets will be contained within the Morgan Array Area and are likely to follow existing shipping routes to and from the ports.



Service Layer Credits: © British Crown and OceanWise, 2023. All rights reserved. License No. EK001-FN1001-004281. OpenStreetMap contributors.	**Data Sources:** Admiralty Chart 1826. NASH Survey Data: Winter 2021 and Summer 2022	**Geodetic Information:** Datum: ETRS 1989 Projection: ETRS89 / UTM zone 30N Scale@271.5mm x 154mm: 1:630,000	0 2.5 5 nm; 0 5 10 km	NASH MARITIME
Project Name: MORGAN OFFSHORE WIND PROJECT	**Drawing Title:** All Vessel Tracks for Winter 2021 and Summer 2022 Surveys		**Drawing Number:** NASH-MG-SN-006-00	

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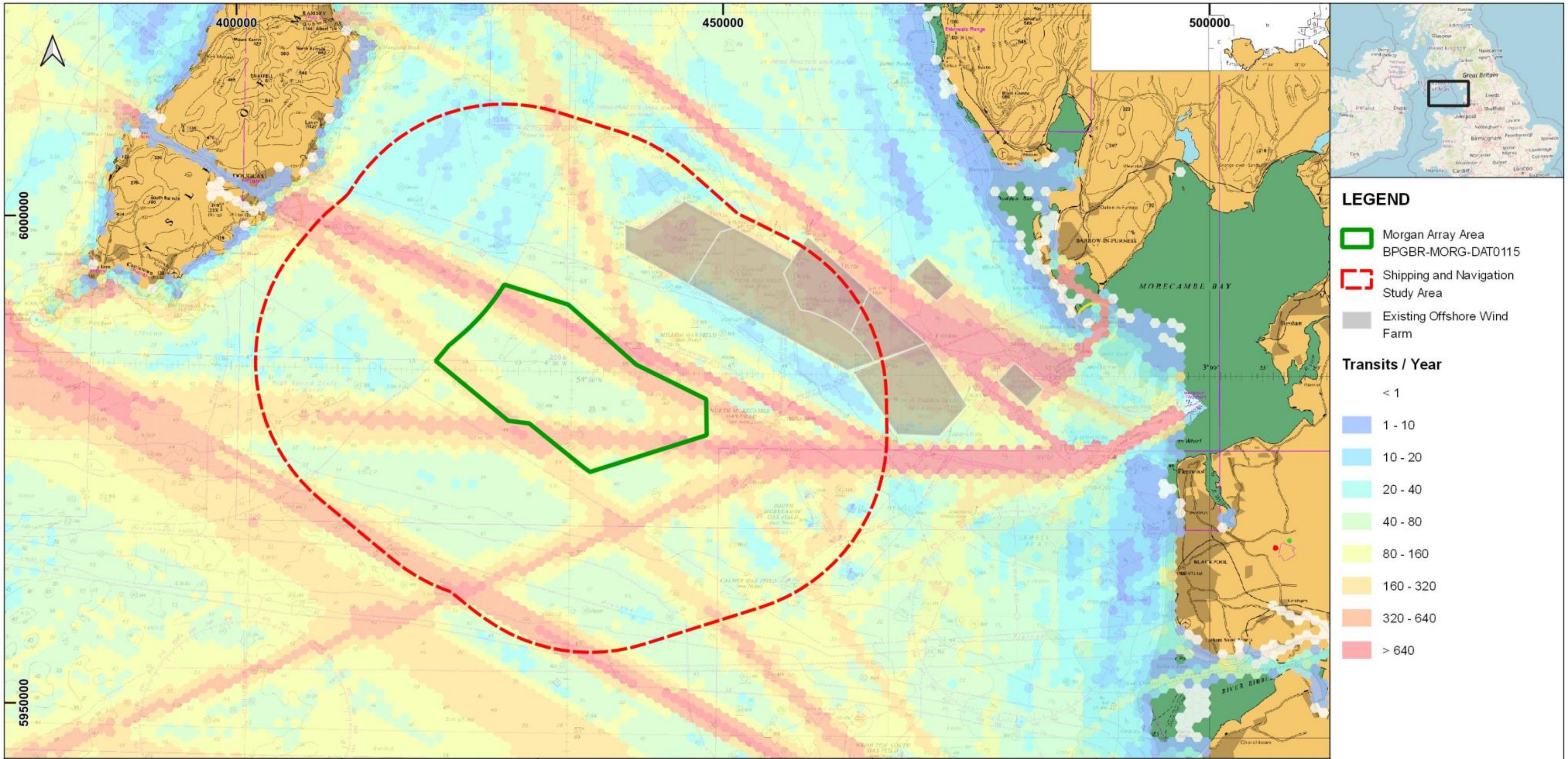
Figure 4.24: Vessel traffic survey data within the shipping and navigation study area (source: vessel traffic surveys).



Data Sources: Admiralty Chart 1826. MarineTraffic 2022 AIS Data

Geodetic Information: Datum: ETRS 1989 Projection: ETRS89 / UTM zone 30N Scale@271.5mm x 154mm: 1:600,000

0 2.5 5 nm
0 5 10 km

NASH MARITIME

Project Name: MORGAN OFFSHORE WIND PROJECT

Drawing Title: Vessel Transit Density (2022)

Drawing Number: NASH-MG-SN-007-00

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Figure 4.25: Annualised vessel traffic density within the shipping and navigation study area (source: Marine Traffic, 2022).

4.9.4.6 The main drivers influencing the magnitude of the impact are vessel type, speed and ambient sound levels (Wilson *et al*., 2007). Baseline levels of vessel traffic in the Morgan marine mammal study area are at a high level, largely due to ferry routes. For example, in 2022, commercial ferry routes based on annual data from 2022 (see Volume 2 Chapter 7: Shipping and Navigation of the Environmental Statement) between the UK mainland (Liverpool, Heysham) and the Isle of Man (Douglas) totalled approximately 1,451 annual crossings, between the UK mainland (Liverpool) and Northern Ireland (Belfast) 1,098 crossings, and UK mainland (Heysham) and Northern Ireland (Warrenpoint) 1,099 crossings. Two routes operate between UK mainland and Ireland, totalling approximately 606 crossings between UK mainland (Heysham) and Ireland (Dublin) and 1,627 crossings between UK mainland (Liverpool) and Ireland (Dublin), in 2022. This highlights that there is a high ferry vessel baseline alone in the area. For more information on vessel baselines see Volume 2, Chapter 7: Shipping and navigation of the Environmental Statement.

4.9.4.7 As described in the NRA (Volume 4, Annex 7.1: Navigational Risk Assessment of the Environmental Statement), occasional vessel traffic movements associated with jack-ups and other platforms also occur in the region.

4.9.4.8 Other sound-generating activities for the Morgan Generation Assets will include drilled piling and cable burial (Table 4.16). Up to 100% of overall piles are anticipated to require drilling (up to 64 four-legged turbine jacket foundations with a diameter of 3.8 m, plus four four-legged OSP jacket foundations with a diameter of 3.5 m) with up to two concurrent drilling vessels (Table 4.16). Burial of inter-array cables (390 km) will also occur, with 60 km of interconnector cables via seabed preparation activities (including boulder clearance, sandwave clearance), ploughing, trenching and jetting; cable burial and rock dumping. See Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement for more information about SELs associated with the above construction activities.

4.9.4.9 A detailed underwater sound modelling assessment has been carried out to investigate the potential for injurious and behavioural effects on marine mammals resulting from elevated underwater sound (non-impulsive sound), using the latest criteria (Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement). A conservative assumption has been made that all individual marine mammals will respond aversively to increases in vessel sound (i.e. that there is no intra or inter-specific variation or context-dependent differences). The distance over which effects may occur will, however, vary according to the species, the ambient sound levels, hearing ability, vertical space use and behavioural response differences. Furthermore vessels and construction sound will be temporary and transitory, as opposed to permanent and fixed.

4.9.4.10 SELs have been estimated for each vessel type based on 24 hours continuous operation, although it is important to note that it is highly unlikely that any marine mammal would stay at a stationary location or within a fixed radius of a vessel for 24 hours. Therefore, the acoustic modelling has been undertaken based on an animal swimming away from the source (or the source moving away from an animal) (

4.9.4.11 Table 4.19).

4.9.4.12 The sound modelling results indicate that the threshold for PTS was not exceeded for any species for all vessels, drilled piling and all cable burial activities. Therefore, there is a negligible risk of PTS occurring to marine mammals as a result of elevated underwater sound due to vessel use, drilled piling or cable burial activities. Acoustic modelling was also conducted for TTS for completeness (see Volume 3, Annex 3.1:

Underwater sound technical report of the Environmental Statement), however ranges indicated are likely to be overestimates given that, for continuous sources such as vessel sound, thresholds do not take into account any ambient sound levels in the region (which is already has high levels of shipping activity, see paragraph 4.9.4.5).

4.9.4.13 Ranges modelled for TTS were between <10 m and 145 m for vessels (based on harbour porpoise), and between <10 m and 145 m for drilled piling and cable burial activities. Whist the likelihood of auditory injury is extremely low, the maximum duration of the construction phase is up to four years (48 months).

4.9.4.14 The impact is predicted to be of limited spatial extent, medium term duration, intermittent and, although the impact itself is reversible (i.e. the elevation in underwater sound only occurs during the activities), the effect of PTS is permanent. It is predicted that the impact will affect the receptor directly. Since the PTS threshold was not predicted to be exceeded for any activities or species, the magnitude is considered to be **negligible**.

Behavioural disturbance

4.9.4.15 Disturbance from vessel sound is likely to occur only where vessel sound associated with the construction of the Morgan Generation Assets exceeds the background ambient sound level. As discussed in paragraphs 4.9.4.5 to 4.9.4.7, the Morgan Generation Assets is located in a relatively busy shipping area and therefore background sound levels are likely to be relatively high. For impulsive sound sources there is an understanding of the difference between strong and mild disturbance, whereas for non-impulsive (continuous) sound sources such as from vessels, there is only a single available threshold (120 dB re 1 µPa (SPL_{rms})), (the Level B harassment threshold[3]) (NMFS, 2005), which is proposed as the basis for the onset of a strong behavioural reaction. (JNCC *et al.* (2010) state that 'it is most unlikely that a passing vessel would cause more than trivial disturbance. It is the repeated or chronic exposure to vessel noise that could cause disturbance'. Therefore it is important to consider when viewing these potential disturbance radii that the 120 dB re 1 µPa SPL_{rms}) criterion is highly precautionary, does not consider background sound levels, and that ambient sound levels in the area could well exceed this value (Xodus, 2014). As such, an understanding of background underwater sound level is valuable when assessing potential effects from elevated underwater sound due to vessel use.

4.9.4.16 Furthermore, NMFS (2005) highlights that it is possible that sound pressure levels in the local environment will already be as high as the continuous behavioural disturbance threshold of 120 dB re 1 µPa SPL_{rms} for marine mammals much of the time, and therefore represents an over-precautionary assessment and therefore may not necessarily result in strong displacement of animals. In their maps of shipping sound of the North-East Atlantic, Farcas *et al.* (2020) showed areas of high shipping densities often exceeded 120 dB re 1 µPa (SPL_{rms}), with total underwater sound exceeding 121 dB re 1 µPa (SPL_{rms}) in areas of the east Irish Sea and annual median ship sound surpassing 20 dB excess (sound above modelled natural background sound) in the Irish Sea. This combined with worst case assumptions made in the modelling can mean ranges are highly over-precautionary.

[3] Level B harassment is defined as "any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering, to a point where such behavioral patterns are abandoned or significantly altered" NMFS (2005).

4.9.4.17 A detailed underwater sound modelling assessment has been carried out to investigate the potential for behavioural effects on marine mammals resulting from increased vessel sound and other activities (Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement). The estimated ranges within which there is a potential for disturbance to marine mammals are presented in Table 4.43.

4.9.4.18 Survey and support vessels, CTV and scour/cable protection/seabed preparation/installation vessels resulted in the greatest modelled disturbance out to 3,627 m for all marine mammal species (Table 4.43). The greatest disturbance range for other non-vessel continuous sound behavioural effects was predicted to be 2,270 m due to underwater sound from cable laying activities. In comparison, sandwave clearance, installation vessels, construction vessels (Dynamic Positioning (DP)), rock placement vessels and cable installation vessels also all resulted in a predicted disturbance range of 2,270 m; vessels for boulder clearance and offshore construction vessel had a disturbance range of 340 m; tug/anchor handlers had a disturbance range of 1,354 m; and jack-up rigs had a disturbance range of <10 m.

Table 4.43: Estimated disturbance ranges for marine mammals as a result of vessels and other activities (N/E = not exceeded) based on the NMFS sound threshold value for continuous sound (120 dB re 1 µPa SPL_{rms})

Threshold	Disturbance range (m)
Vessels	
Survey vessel and support vessel, Crew Transfer Vessel (CTV), scour/cable protection/seabed preparation/installation vessel	3,627
Sandwave clearance, installation vessel, construction vessel (using Dynamic Positioning), rock placement vessel and cable installation vessel	2,270
Tug/anchor handler, guard vessel	1,354
Boulder clearance, offshore construction vessel	340
Jack-up rig	<10
Other activities	
Cable trenching	3,119
Cable laying	2,270
Drilled piling	390
Jack-up rig	N/E

4.9.4.19 Ranges for disturbance for vessels are presented up to the 120 dB re 1 µPa (SPL_{rms}) threshold, and as there is no differentiation between mild and strong disturbance for continuous underwater sound (just one single fixed threshold for Level B harassment), which assumes 100% of animals above this threshold are disturbed (the single step-function criterion used in the NMFS thresholds assume a "all-or-none" threshold). In reality, for those animals disturbed there is likely to be a proportional response (i.e. not all animals will be disturbed to the same extent), but there is no dose-response curve available to apply in the context of non-impulsive sound sources for key species in the Irish Sea. Dose-response curves for vessels have been created for killer whales (Joy *et al*., 2019), thus indicating there is evidence of proportional response to vessel sound.

4.9.4.20 It must be noted that thresholds that relate to single exposure parameters (e.g. received sound level) for behavioural responses across species and sound types may lead to over-simplification in prediction effects. Ideally differences between species, situational context, spatial scales and interacting effects of multiple stressors would be quantified to predict effects, but Southall *et al.* (2021) highlights few studies report this critical data in a systematic structured way. Tyrack and Thomas (2019) demonstrated using the RLp50 step function can lead to underestimates of animals impacted (e.g. number affected was underestimated by a factor of 280), but highlighted their approach was far more complex to apply than the single threshold approach preferred by regulators (it requires combining dose response function with animal and stressor distribution). Furthermore, the dose-response function used was derived from experiments performed on free-swimming killer whales exposed to a steadily increasing level of sonar sounds (Miller *et al*., 2014) and therefore a dose-response specifically for continuous sound (such as those in Joy *et al.* 2019) would be more appropriate.

4.9.4.21 Furthermore, animals in areas of high shipping are frequently exposed to vessel sound, and it has been suggested vessel type and speed rather than presence are relevant factors (e.g. 75% of all negative reactions of harbour porpoise in south west Wales were in response to high-speed planing-hulled vessels, with the remainder being neutral responses (Oakley *et al.*, 2017)) and reactions are different dependent on vessel type, distance and speed (Wisniewska *et al.,* 2018) (see 4.9.4.30 for further discussion). It is important to note that the life history of an individual and the context will also influence the likelihood of an individual to exhibit an aversive response to sound, and it must be highlighted that these impacts will not be continuous over the four year construction programme.. Therefore, given the limited quantitative information available, as described above, any simplified calculation would likely lead to an unrealistic overestimation of the number of animals likely to be disturbed. As such, this value has not been quantified.

4.9.4.22 Whilst it is difficult to quantify the response ranges based on a simple threshold approach (e.g. because it does not take into account context), empirical evidence suggests that for similar areas with existing vessel traffic, acoustic activity (and therefore presence of some marine species) may be reduced. Benhemma-Le Gall *et al.* (2021) suggested increased vessel activity (and other construction activities) led to a decrease in porpoise acoustic detections and activity at distances of up to 4 km. Porpoise responses decreased as the mean vessel distance increased (−24% at 3 km) until no apparent response was observed at 4 km. Similarly, McQueen *et al.* (2020) used a distance threshold of 5 km as a point of comparison for screening potential marine mammal habitat displacement (behavioural avoidance), based upon the relative size of the dredging area and habitat range of receptors. Verboom *et al.* (2014) also suggested a porpoise never approaches the study dredging ship in full operation at less than 5 km. Wisniewska *et al.* (2018) used sound and movement recording tags to detect fine-scale responses in harbour porpoise to sound from vessels, and determined that foraging may be temporarily disrupted up to 7 km. Graham *et al.* (2019) indicated higher vessel activity within 1 km was significantly associated with an increased probability of response in harbour porpoise.

4.9.4.23 Therefore, to give a quantitative indication of impact, a range of distances from empirical studies (1 km to 7 km) have been used as an effective impact range and the numbers of animals predicted to be disturbed is presented in Table 4.44 (noting this distance is based upon VHF species and does not account for different hearing groups, and is likely to be precautionary). The numbers disturbed presented are more likely to represent fast moving vessels such as a CTV (of which there are a maximum of 14 on site at one time) as opposed to slow-moving vessels such as boulder clearance or jack-up rigs that show much smaller modelled disturbance ranges (Table 4.43).

Table 4.44: Potential number of animals predicted to be disturbed per vessel for a range between 1 km (minimum) and 7 km (maximum).

Species	MU	Number of animals disturbed (1 km)	% MU	Number of animals disturbed (7 km)	% MU
Harbour porpoise	CIS MU	<1	0.001%	41	0.07%
Bottlenose dolphin	IS MU	<1	0.001%	<1	0.07%
Short-beaked common dolphin	CGNS MU	<1	0.000001%	<1	0.00003%
Risso's dolphin	CGNS MU	<1	0.0008%	5	0.04%
Minke whale	CGNS MU	<1	0.0002%	3	0.01%
Grey seal	GSRP OSPAR Region III reference population	<1	0.001% 0.00000002%	7	0.05% 0.0000008%
Harbour seal	HSRP	<1	0.00001%	<1	0.0005%

4.9.4.24 The impact is predicted to be of local spatial extent, medium-term duration, intermittent and reversible (i.e. the elevation in underwater sound only occurs during the activities). Similarly, the effect of behavioural disturbance is reversible as receptors are expected to recover within hours/days. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low**.

Sensitivity of receptor

4.9.4.25 Increased vessel movements during all phases of the Morgan Generation Assets have the potential to result in a range of effects on marine mammals including injury as a result of elevated underwater sound; avoidance behaviour or displacement; and masking of vocalisations or changes in vocalisation rate.

Auditory injury

4.9.4.26 The sensitivity of marine mammal receptors to auditory injury has been assessed in piling (section 4.9.1) and is not reiterated here.

4.9.4.27 All marine mammals are deemed to have limited resilience to auditory injury, low recoverability and international value. The sensitivity of the receptor is therefore, considered to be **high.**

Behavioural disturbance

4.9.4.28 Disturbance levels for marine mammal receptors will be dependent on individual hearing ranges and background sound levels within the vicinity. Sensitivity to vessel sound is most likely related to the marine mammal activity at the time of disturbance (IWC, 2006; Senior *et al*., 2008), and the level of response dependent on upon vessel type and behaviour (e.g. heading, speed) (Oakley *et al.,* 2017; Hermannsen *et al*., 2019).

4.9.4.29 Cetaceans can both be attracted to and disturbed by vessels. For example, resting dolphins are likely to avoid vessels, foraging dolphins will ignore them, and socialising dolphins may approach vessels (Richardson *et al*., 1995). Anderwald *et al.* (2013) showed within their study that bottlenose dolphins were positively correlated with total number of boats and number of utility vessels, but minke whales and grey seals were displaced by high levels of vessel traffic.

4.9.4.30 Harbour porpoise is particularly sensitive to high frequency sound and likely to avoid vessels. Wisniewska *et al*. (2018) studied the change in foraging rates of harbour porpoise in response to vessel sound in coastal waters with high traffic rates. The results show that occasional high-sound levels coincided with vigorous fluking, bottom diving, interrupted foraging and even cessation of echolocation, leading to significantly fewer prey capture attempts at received levels greater than 96 dB re 1 µPa (SPL_{rms}) (16 kHz third-octave). Heinänen and Skov (2015) found that the occurrence of harbour porpoise declines significantly when the number of vessels in a 5 km^2 area exceeds 20,000 ships per year (approximately 80 ships per day or 18 ships per km^2). A recent study by Benhemma-Le Gall *et al*. (2021) suggested increased vessel activity (and other construction activities) led to a decrease in porpoise acoustic detections and activity at distances of up to 4 km, when comparing occurrence and foraging activity between two offshore windfarms in the Moray Firth.

4.9.4.31 Other species of dolphin (e.g. short-beaked common dolphin) are regularly sighted near vessels and may also approach vessels (e.g. bow-riding). However, dolphins are also known to show aversive behaviours to vessel presence, including increased swimming speed, greater time travelling, less time resting or socialising, avoidance, increased group cohesion and longer dive duration (Toro *et al*., 2021; Marley *et al.*, 2017; Miller *et al*., 2008). Meza *et al.* (2020) found increased foraging in bottlenose dolphin and short-beaked common dolphin behavioural budgets, but a decrease in time spent foraging by harbour porpoise when exposed to purse seine vessels in the Istanbul Strait, which has high levels of human pressure with many vessels in a narrow space.

4.9.4.32 A study on concurrent ambient sound levels on social whistle calls produced by bottlenose dolphins in the west North Atlantic (Fouda *et al.,* 2018), demonstrated increases in ship sounds (both within and below the dolphins' call bandwidth) resulted in simplified vocal calls, with higher dolphin whistle frequencies and a reduction in whistle contour complexity. This sound-induced simplification of whistles may reduce the information content in these acoustic signals and decrease effective communication, parent–offspring proximity or group cohesion. This upward shift in whistle frequency has also been observed in bottlenose dolphin related to vessel presence in Walvis Bay, Namibia (Heiler, 2016).

4.9.4.33 Reactions of marine mammals to vessel sound are often linked to changes in the engine and propeller speed (Richardson *et al*., 1995). Watkins (1986) reported avoidance behaviour in baleen whales from loud or rapidly changing sound sources, particularly where a boat approached an animal. Disturbance in dolphins and porpoises is likely to be associated with the presence of small, fast-moving vessels as they are more sensitive to high frequency sound, whilst baleen whales, such as minke whale, are likely to be more sensitive to slower moving vessels emitting lower frequency sound. Pirotta *et al*. (2015) found that transit of vessels (moving motorised boats) 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 sound, resulted in disturbance.

4.9.4.34 Anderwald *et al*. (2013) suggested that in the study of displacement responses to construction-related vessel traffic, minke whale and grey seal were avoiding the area due to sound rather than vessel presence. In the same study, the presence of bottlenose dolphin was positively correlated with overall vessel numbers, as well as the number of construction vessels. It was, however, unclear whether the bottlenose dolphin were attracted to the vessels themselves or to particularly high prey concentrations within the study area at the time. Richardson (2012) investigated the effect of disturbance on bottlenose dolphin community structure in Cardigan Bay and found that group size was significantly smaller in areas of high vessel traffic.

4.9.4.35 Common reactions of pinnipeds to approaching vessels includes increased alertness (Henry and Hammill, 2001), head raising (Niemi, *et al*., 2013) and flushing off haul-out sites into the sea (Jansen *et al.,* 2015; Andersen *et al.,* 2012; Blundell and Pendleton, 2015; Johnson and Acevedo-Gutiérrez, 2007), but studies focused on presence of vessel rather than vessel sound. In a recent study on behaviour of grey and harbour seal to ship sound, a tagged grey seal changed its diving behaviour, switching rapidly from a dive ascent to descent (Mikkelsen *et al*., 2019). Pérez Tadeo *et al*. (2021) assessed the responses of grey seal to ecotourism during breeding and pupping seasons at White Strand Beach in southwest Ireland and found vessels approaching within 500 m of the beach showed strong influence on the proportion of grey seal entering the water and increase in vigilance and decrease in resting behaviour. This is similar to a previous study on harbour seal which showed avoidance behaviour or alert reactions in harbour seal when vessels approach within 100 m of a haul-out (Paterson *et al*., 2005). This disturbance to seal haul-outs could have negative consequences during the pupping season, due to trade-offs between feeding and nursing (see paragraph 4.9.4.35). Harbour seal have been shown to be alerted and move away when a boat approaches (Anderson *et al.*, 2012; Blundell and Pendleton, 2015), but this response varies by season. For example, they exhibit weaker and shorter lasting responses during the breeding season, appearing more reluctant to flee and return to haul-out site after being disturbed (Andersen *et al.*, 2012), likely attributed to a trade-off between fleeing and nursing, rather than habituation. In a study of harbour seal in Alaska, haul out probability was negatively affected by vessels, with cruise ships having the strongest effect (Blundell and Pendleton, 2015).

4.9.4.36 The presence of vessels in foraging grounds could also result in reduced foraging success. Christiansen *et al*. (2013b) found that the presence of whale-watching boats within an important feeding ground for minke whale led to a reduction in foraging activity and as a capital breeder such a reduction could lead to reduced reproductive success since female body condition is known to affect foetal growth (Christiansen *et al*., 2014). However, it is worth noting that the study was conducted in Faxafloi Bay in Iceland where baseline sound levels (compared to the Irish Sea) are very low (McGarry *et al*., 2017). In addition, a subsequent study conducted by Christiansen and Lusseau (2015) in the same study area found no significant long-term effects of disturbance from whale-watching on vital rates since whales moved into disturbed areas when sandeel numbers were lower across their wider foraging area. However, a study on grey seal by Hastie *et al*. (2021) demonstrated how foraging context is important when interpreting avoidance behaviour and should be considered when predicting the effects of anthropogenic activities, with avoidance rates depending on the perceived risk (e.g. silence, pile driving sound, operational sound from tidal turbines) versus the quality of the prey patch. It highlights that sound exposure in different prey patch qualities may result in markedly different avoidance behaviour and should be considered when predicting impacts in EIAs. Given the existing levels of vessel activity in the Morgan shipping and navigation study area it is expected that marine mammals could tolerate the effects of disturbance without any impact on reproduction and survival rates and would return to previous activities once the impact had ceased.

4.9.4.37 There is some evidence of tolerance to boat traffic, and anthropogenic sounds and activities in general (Vella *et al.*, 2002), and therefore a slight increase from the existing levels of traffic in the vicinity of the Morgan Generation Assets may not necessarily result in high levels of disturbance. The Liverpool Bay area already has a high level of anthropogenic activities as a baseline (see paragraph 4.9.4.5). Whilst it cannot be assumed that tolerance to a stressor is evidence of absence of detrimental consequences for targeted animals (e.g. physiological responses are not readily detectable in free-ranging animals), there is multi-species evidence of animals remaining in areas of high vessel traffic. Seal bulls have been known to approach fishing vessels in Liverpool Bay (Dobson, 2002, pers comm). High co-occurrence between grey seal/harbour seal and shipping traffic within 50 km of the coastline near to haul out sites were shown in a national scale assessment of seals and shipping in the UK (Jones *et al*, 2017).

4.9.4.38 Regarding cetaceans, Thompson *et al*. (2011) (Scottish Natural Heritage (SNH) commissioned report) undertook a modelling study which predicted that increased vessel movements associated with offshore wind development in the Moray Firth would not have a negative effect on the local population of bottlenose dolphin, although it did note that foraging may be disrupted by disturbance from vessels which was also suggested by Benhemma-Le Gall *et al.* (2021) (see paragraph 4.9.4.30). Potlock *et al.* (2023) used C-POD detections of sonar activity as a proxy for vessel disturbance during construction of wind turbines foundations off Blyth, Northumberland. The vessel sonar variable was significant in both the dolphin (potentially bottlenose dolphin and/or white-beaked dolphin) and harbour porpoise models. The effect size was substantial in both species, with around eight minutes of sonar occurrence per hour leading to a 50% decline in harbour porpoise occurrence and around 13 min of sonar occurrence per hour leading to a 50% decline in dolphin occurrence. Despite this, dolphin occurrence during and after construction were not significantly different to the occurrence before the construction phase. Similarly, the increase in harbour porpoise occurrence across this study suggests that construction and post-construction vessel activity did not result in any overall decline in area usage (Potlock *et al.,* 2023).

4.9.4.39 Bottlenose dolphin have been found to both increase and decrease whistle frequencies in noisy environments, avoiding acoustic masking and improving signal transmission (Heiler *et al.,* 2016; May-Collado and Wartzok, 2008; La Manna *et al.,* 2013; Rako Gospić and Picciulin, 2016; Peters, 2018). These findings suggest that if marine mammals depend on specific areas to maintain their activities and the benefits exceed the cost of disturbance, animals show tolerance instead of site avoidance (Antichi *et al.,* 2022). As such, marine mammals could continue to regularly visit the areas where they may be affected by the vessel presence (Rako Gospić and Picciulin, 2016; Antichi *et al.,* 2022). For example, Wisniewska *et al.* (2018) found tagged porpoises did not appear to avoid highly trafficked areas (where large ship traffic concentrates in deeper channels that allow access to ports or open water) perhaps because these overlapped with important foraging habitats (deep waters which may aggregate important prey items).

4.9.4.40 Furthermore, Joy *et al.* (2019) conducted a voluntary commercial vessel slowdown trial through 16 nm of shipping lanes which overlapped with critical habitat of at-risk southern resident killer whales. Disturbance metrics were simplified to a "lost foraging time" measure, and demonstrated (when compared to baseline sound levels in the region) the slowdown trial achieved 22% reduction in 'potential lost foraging time' for killer whales (with 40% reductions when 100% of vessels were under the 11 knot speed limit). Vessels involved in the construction phase are likely to be travelling at a speed slower than 14 knots. With the exception of CTVs, most vessels involved in the construction phase are likely to be travelling considerably slower than this (Laist, 2001), and all vessels will be required to follow an Offshore EMP (which includes measures to minimise disturbance to marine mammals and rafting birds from transiting vessels (Document Reference J15)) (Table 4.17). All marine mammals are deemed to have some tolerance to behavioural disturbance, high recoverability and international value. The sensitivity of the receptor is therefore, considered to be **medium**.

Significance of effect

Auditory injury

4.9.4.41 Overall, the magnitude of the impact is deemed to be **negligible** and the sensitivity of the receptor is considered to be **high**. There would be no change to the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Behavioural disturbance

4.9.4.42 Overall, with measures adopted (implemented via an EMP), the magnitude of the impact is deemed to be **low** and the sensitivity of the receptor is considered to be **medium**. There would be no change to the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Operations and maintenance phase

Magnitude of impact

4.9.4.43 Vessel use during operations and maintenance phase of the Morgan Generation Assets may lead to injury and/or disturbance to marine mammals. Vessel types which will be required during the operations and maintenance phase include those used during routine inspections, geophysical surveys, repairs and replacements of navigational equipment, removal of marine growth, replacement of corrosion protection anodes, painting, replacement of access ladders and boat landings, modifications to/replacement of J-tubes, replacement of consumables, minor repairs and replacements to wind turbines or OSPs, major component replacement to wind turbines or OSPs, inter-array/interconnector cable repair or reburial (Table 4.16). This will involve crew transfer vessels/workboats, jack up vessels, cable repair vessels, service operation vessels (SOVs) or similar vessels, excavators/backhoe dredgers. Up to a maximum of 16 vessels will be on site at any one time, and up to 719 operations and maintenance vessel movements (return trips) will be carried out each year (608 CTVs/workboats, 25 jack-up vessels, six cable repair vessels, 78 SOV or similar and two excavators/backhoe dredgers) (Table 4.16).

4.9.4.44 The uplift in vessel activity during the operations and maintenance is considered to be relatively small in the context of the baseline levels of vessel traffic in the Morgan marine mammal study area described in paragraph 4.9.4.7. Presence of the operational wind farm may divert some of the shipping routes and therefore, current traffic within the Morgan array area, which is not associated with Morgan Generation Assets, is likely to be reduced. It is likely that this reduction will be ultimately counterbalanced by presence of maintenance vessels. Vessel movements will be within the Morgan array area and will follow the measures to minimise disturbance to marine mammals within the Offshore EMP (which includes measures to minimise disturbance to marine mammals and rafting birds from transiting vessels (Document Reference J15)). The Offshore EMP will be issued to all project vessel operators to minimise the potential for collision risk as described in Table 4.17.

4.9.4.45 The size and sound outputs from vessels during the operations and maintenance phase will be similar to those used in the construction phase and therefore will result in a similar maximum design spatial scenario (Table 4.16). However, the number of vessel round trips and their frequency is much lower for the operations and maintenance phase compared to the construction phase.

Auditory injury

4.9.4.46 An overview of potential impacts for auditory injury to marine mammals from elevated underwater sound due to vessel use and other (non-piling) sound producing activities as well as associated effects (auditory injury) are described in paragraph 4.9.4.3 for the construction phase and have not been reiterated here for the operations and maintenance phase. The impact is predicted to be of limited spatial extent, long term duration, intermittent and although the impact itself is reversible (i.e. the elevation in underwater sound only occurs during the activities), the effect of PTS (if it were to occur) is permanent. It is predicted that the impact will affect the receptor directly. Since the PTS threshold was not predicted to be exceeded for any activities or species, the magnitude is considered to be **negligible**.

Behavioural disturbance

4.9.4.47 An overview of potential impacts from elevated underwater sound due to vessel use and other (non-piling) sound producing activities as well as associated effects (behavioural disturbance) are described in paragraph 4.9.4.15 for the construction phase with behavioural disturbance ranges presented in Table 4.43 and have not been reiterated here for the operations and maintenance phase. The impact is predicted to be of local spatial extent, long-term duration, intermittent and reversible (i.e. the elevation in underwater sound only occurs during the activities). Similarly, the effect of behavioural disturbance is reversible as receptors are expected to recover within hours/days. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low.**

Sensitivity of receptor

Auditory injury

4.9.4.48 The sensitivity of marine mammal receptors to auditory injury has been assessed in paragraph 4.9.4.26 and is not reiterated here. All marine mammals are deemed to be of medium vulnerability, low recoverability and international value. The sensitivity of the receptor is therefore, considered to be **high**.

Behavioural disturbance

4.9.4.49 The sensitivity of the receptors during the operational and maintenance is not expected to differ from the sensitivity of the receptors during the construction phase. The sensitivity of marine mammal receptors to elevated underwater sound due to vessel use and other (non-piling) sound producing activities is as described previously in 4.9.4.28. All marine mammals have some tolerance to behavioural disturbance, high recoverability, and international value. The sensitivity of the receptor is therefore, considered to be **medium**.

Significance of effect

Auditory injury

4.9.4.50 Overall, the magnitude of the impact is deemed to be **negligible** and the sensitivity of the receptor is considered to be **high**. There would be no change to the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Behavioural disturbance

4.9.4.51 Overall, with designed in mitigation measures where vessels will follow the Offshore EMP , the magnitude of the impact is deemed to be **low** and the sensitivity of the receptor is considered to be **medium**. There would be no change to the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

4.9.4.52 Vessel use during the decommissioning phase of Morgan Generation Assets may lead to injury and/or disturbance to marine mammals. Vessel types which will be required during the decommissioning phase include those used during removal of foundations, cables and cable protection (Table 4.16).

4.9.4.53 Maximum levels of underwater sound during decommissioning would be from underwater cutting required to remove structures. This is likely to be much less than pile driving and therefore impacts would be less than as assessed during the construction phase (see paragraph 4.9.4.3 to 4.9.4.27). Piled solutions are assumed to be cut off at or below the seabed.

4.9.4.54 Since the numbers and types of vessel used to remove infrastructure (and hence their size and outputs) are expected to be similar to those used for installation, therefore potential impacts from elevated underwater sound due to vessel use and other (non-piling) sound producing activities is expected to result in a similar maximum design spatial scenario as the construction phase. The magnitude of the impact of the decommissioning phase for both auditory injury and disturbance as a result of elevated underwater sound due to vessel use, for all marine mammal receptors, is therefore not expected to differ or be greater than that assessed for the construction phase.

Auditory injury

4.9.4.55 An overview of potential impacts from elevated underwater sound due to vessel use and other (non-piling) sound producing activities as well as associated effects (auditory injury) are described in paragraph 4.9.4.3 *et seq*. for the construction phase and has not been reiterated here for the decommissioning phase. The impact is predicted to be of local spatial extent, medium term duration, intermittent and although the impact itself is reversible (i.e. the elevation in underwater sound only occurs during the activities), the effect of PTS (if it were to occur) is permanent. It is predicted that the impact will affect the receptor directly. Since the PTS threshold was not predicted to be exceeded for any activities or species, the magnitude is considered to be **negligible**.

Behavioural disturbance

4.9.4.56 An overview of potential impacts from elevated underwater sound due to vessel use and other (non-piling) sound producing activities as well as associated effects (behavioural disturbance) are described in paragraph 4.9.4.15 for the construction phase with behavioural disturbance ranges presented in Table 4.43 and has not been reiterated here for the decommissioning phase. The impact is predicted to be of local spatial extent, medium term duration, intermittent and reversible (i.e. the elevation in underwater sound only occurs during the activities). Similarly, the effect of behavioural disturbance is reversible as receptors are expected to recover within hours/days. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low**.

Sensitivity of receptor

Auditory injury

4.9.4.57 The sensitivity of marine mammal receptors to auditory injury has been assessed in paragraph 4.9.4.26 *et seq.* and is not reiterated here. All marine mammals are deemed to have limited tolerance to auditory injury, low recoverability and international value. The sensitivity of the receptor is therefore, considered to be **high**.

Behavioural disturbance

4.9.4.58 The sensitivity of the receptors during the decommissioning phase is not expected to differ from the sensitivity of the receptors during the construction phase. The sensitivity of marine mammal receptors to elevated underwater sound due to vessel use and other (non-piling) sound producing activities is as described previously in paragraph 4.9.4.28 *et seq*. All marine mammals, which are IEFs of international value, are deemed to have limited tolerance to behavioural disturbance, high recoverability and international value. The sensitivity of the receptor is therefore, considered to be **medium**.

Significance of effect

Auditory injury

4.9.4.59 Overall, the magnitude of the impact is deemed to be **negligible** and the sensitivity of the receptor is considered to be **high.** There would be no change to the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Behavioural disturbance

4.9.4.60 Overall, measures adopted where vessels will follow the Offshore EMP , the magnitude of the impact is deemed to be **low** and the sensitivity of the receptor is considered to be **medium**. There would be no change to the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

4.9.5 Increased likelihood of injury due to collision with vessels

Construction phase

Magnitude of impact

4.9.5.1 Vessel traffic associated with the Morgan Generation Assets has the potential to lead to an increase in vessel movements within the Morgan marine mammal study area. This increase in vessel movement could lead to an increase in interactions between marine mammals and vessels during offshore construction. Whilst a broad range of vessel types are involved in collisions with marine mammals (Laist *et al.*, 2001), vessels travelling at higher speeds pose a higher risk because of the potential for a stronger impact (Schoeman *et al*., 2020). The severity of lesions seems also to be a function of speed. Laist *et al.* (2001) reported among collisions with lethal or severe injuries, 89% of the 28 vessels investigated were moving at 14 kn or faster.

4.9.5.2 Collisions of vessels with marine mammals have the potential to result in both fatal and non-fatal injuries (Laist *et al*., 2001; Vanderlaan and Taggart, 2007; Cates *et al*., 2017). Evidence for fatal collisions has been gathered from carcasses washing up on beaches (Laist *et al*., 2001; Peltier *et al*., 2019), carcasses caught on vessel bows (Laist *et al*., 2001; Peltier *et al*., 2019) and floating carcasses; injuries including propeller cuts, significant bruising, oedema, internal bleeding radiating from a specific site, fractures and ship paint marks have strongly suggested ship strike as cause of death (Jensen and Silber, 2003; Douglas *et al*., 2008). Fatalities from ship strikes, however, often go unreported (Authier *et al*., 2014). For non-fatal injuries there is evidence of animals which have survived ship strikes with no discernible injury; animals which survive with non-fatal injuries from propellers have been widely documented (Wells *et al*., 2008; Luksenburg, 2014).

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

4.9.5.4 Vessel traffic associated with construction activities will result in an increase in vessel movements within the Morgan marine mammal study area as up to 1,878 return trips by construction vessels may be made throughout the construction phase (Table 4.16). This increase, described in more detail in paragraph 4.9.4.3, could lead to an increase in interactions between marine mammals and vessels. Vessels travelling at 7 m/s (or 14 knots) or faster are those most likely to cause death or serious injury to marine mammals (Laist *et al*., 2001; Wilson *et al*., 2007). Vessels involved in the construction phase are likely to be travelling at a speed slower than 14 knots, which is appropriate for species found within the marine mammal study areas. However, for larger slow-moving species such as humpback whale *Megaptera novaeangliae* (which are rare sightings in the Irish Sea), studies have shown a slower speed may be favourable to reduce likelihood of ship strikes (Vanderlaan and Taggart, 2007), with 10 knots adopted for mandatory limits on the US East coast for the conservation of North Atlantic Right Whale for example (NOAA, 2020). With the exception of CTVs, most vessels involved in the construction phase are likely to be travelling considerably slower than this (Laist *et al.*, 2001), and all vessels will be required to follow an Offshore

EMP (which includes measures to minimise disturbance to marine mammals and rafting birds from transiting vessels (Document reference J15)).

4.9.5.5 The Offshore EMP outlines instructions for vessel behaviour and vessel operators, including advice to operators to not deliberately approach marine mammals and to avoid sudden changes in course or speed (Table 4.17). Therefore, with measures adopted as part of the Morgan Generation Assets in place, the likelihood of collision is anticipated to be reduced and would only be present for transiting vessels (as opposed to stationary). A reduction in vessel speed has been successful in reducing collision risk for whales and is the preferred measure from the International Whaling Commission to implement when vessels cannot be re-routed for smaller marine species (IWC, 2014; International Maritime Organization, 2016).

4.9.5.6 A proportion of vessels involved in construction will be relatively small in size (e.g. tugs, vessels carrying ROVs, crew transfer vessels, dive boats, barges and RIBs) and due to good manoeuvrability would be able to move to avoid marine mammals, if detected (Schoeman *et al*., 2020). Larger vessels with lower manoeuvrability may need larger distances to avoid an animal, however they will also be travelling at slower speeds and have more time to react when a marine mammal is detected. In addition, the sound emissions from vessels involved in the construction phase are likely to deter animals from the potential zone of impact. The vessel movements will likely be contained within the Morgan Array Area and are likely to follow existing shipping routes to and from the ports.

4.9.5.7 With measures adopted as part of the Morgan Generation Assets in place to reduce the likelihood of collision, the impact is predicted to be of limited spatial extent, medium term duration, intermittent and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is, conservatively, considered to be **low**.

Sensitivity of receptor

4.9.5.8 Marine mammals are able to detect and avoid vessels in advance, particularly when conducting activities such as seismic surveys (Koski *et al.,* 2009). However, it remains unclear why some individuals do not always move out of the path of an approaching vessel (Schoeman *et al*., 2020) with analysis of data showing various interacting factors (e.g. ambient underwater sound, can affect the ability of marine mammals to detect approaching ships (Gerstein *et al.* 2005). It has been suggested that behaviours such as resting, foraging, nursing, and socialising could distract animals from detecting the risk posed by vessels regardless of detection abilities (Dukas, 2002; Gerstein *et al.* 2005). There can be consequences to this lack of response to disturbance for all marine mammals; behavioural habituation can result in decreased wariness of vessel traffic, which has the potential to result in an increased collision risk (Cates *et al*., 2017). Vessel strikes are known to be a cause of mortality in marine mammals (Carrillo and Ritter, 2010), and it is possible that mortality from vessel strikes is under-recorded (Van Waerebeek *et al*., 2007), particularly for smaller marine mammals (Schoeman *et al*., 2020).

4.9.5.9 Collisions between vessels and large whales can often lead to death or serious injury (Kraus, 1990), but as discussed in paragraph 4.9.5.2, collisions between cetaceans and vessels are not necessarily lethal on all occasions (Van Waerbeek *et al*., 2007). Although all types of vessels may hit whales, most lethal and serious injuries are caused by large ships (e.g. 80 m or longer) and vessels travelling at speeds faster than 14 knots (Laist *et al.* 2001).

4.9.5.10 Given that harbour porpoises are small and highly mobile and considering their potential avoidance responses to vessel sound (see paragraph 4.9.4.30), it can be anticipated that they will largely avoid vessel collisions. The UK Cetacean Stranding's Investigation Programme (CSIP) (CSIP, 2015) reported results of post-mortem analysis conducted on 53 harbour porpoise strandings in 2015. A cause of death was established in 51 examined individuals (approximately 96% of examined cases) and, of these, only four (8%) had died from physical trauma of unknown cause, which could have been vessel strikes (CSIP, 2015).

4.9.5.11 Vessel strikes can result in lethal or non-lethal injuries to dolphins (Schoeman *et al.,* 2020). Olson *et al.* (2022) reported that evidence from long-term photo-identification data shows that only one out of a group of 277 bottlenose dolphins present within the study region exhibit marks indicative of vessel interactions. Van Waerbeek *et al*. (2007) reported that bottlenose dolphin is one of the species that may receive a moderate impact from collisions, however these may be sustainable at species level because many strikes are nonlethal.

4.9.5.12 For seals, trauma ascribed to collisions with vessels has been identified in <2% of both live stranded (Goldstein *et al*., 1999) and dead stranded seals in the USA (Swails, 2005). The Onoufriou *et al*. (2016) study in the Moray Firth, Scotland showed that seals utilise the same areas as vessels during trips between haul-outs and foraging sites but that seals tended to remain beyond 20m from vessels with only three instances over 2,241 days of seal activity resulted in passes at <20 m.

4.9.5.13 Although the potential of collision as a result of construction traffic is relatively low, given the high hearing sensitivity of marine mammals, the consequences of collision risk could be fatal. All marine mammal receptors would be highly vulnerable to a collision, and the effect could cause changes in both the reproduction and survival of individuals if an injury is sustained, leading to potential population level effects if enough animals were impacted. However, there is a high likelihood that marine mammals will avoid vessels well in advance of collision risk, as they will be disturbed over a wide distance by underwater sound from vessels and move away, and therefore, collision risk is minimised.

4.9.5.14 Therefore, on the basis that not all collisions that do occur are lethal, there is considered to be a medium potential for recovery. Necropsies and observations of whales surviving a vessel strike have provided information about the relationship between the severity of injury (e.g. depth of laceration, anatomical site of injury) and vessel speed (Rommel *et al*., 2007; Vanderlaan and Taggart, 2007; Conn and Silber, 2013; Wiley *et al*., 2016; Combs, 2018) but this is highly species dependent and needs further investigation to support mitigation appropriate for each species. Furthermore, factors such as interspecific differences in bone strength may result in different risks of incurring blunt force trauma (Clifton *et al*., 2008) and provide further complex variability in lethality of collisions.

4.9.5.15 All marine mammals are deemed to have some resilience/survivability (largely due to avoidance behaviour and the argument that not all collisions are fatal), medium recoverability and international value. The sensitivity of the receptor is therefore, considered to be **medium**.

Significance of effect

4.9.5.16 Overall, the magnitude of the impact is deemed to be **low** and the sensitivity of the receptor is considered to be **medium**. There would be no change to the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Operations and maintenance phase

Magnitude of impact

4.9.5.17 Operations and maintenance vessel use during the operations and maintenance phase of the Morgan Generation Assets may lead to injury to marine mammals due to collision with vessels. Vessel types which will be required during the operations and maintenance phase include those used during routine inspections, geophysical surveys, repairs and replacements of navigational equipment, removal of marine growth, replacement of corrosion protection anodes, painting, replacement of access ladders and boat landings, modifications to/replacement of J-tubes, replacement of consumables, minor repairs and replacements to wind turbines or OSPs, major component replacement to wind turbines or OSPs, and inter-array/interconnector cable repair or reburial (Table 4.16). The types of vessels are similar to those presented for the MDS for the construction phase. An overview of the potential impacts due to vessel presence and associated effects (collision) are described in paragraph 4.9.4.43 for the construction phase and have not been reiterated here for the operations and maintenance phase.

4.9.5.18 With measures adopted as part of Morgan Generation Assets in place to reduce the risk of collision, the impact is predicted to be of local spatial extent, long term duration, intermittent and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low**.

Sensitivity of receptor

4.9.5.19 The sensitivity of the receptors during the operations and maintenance phase is not expected to differ from the sensitivity of the receptors during the construction phase. Therefore, the sensitivity of marine mammal receptors to collision risk is as described previously in paragraph 4.9.5.8 *et seq*.

4.9.5.20 All marine mammals are deemed to have some tolerance (largely due to avoidance behaviour), medium recoverability and international value. The sensitivity of the receptor is therefore, considered to be **medium**.

Significance of effect

4.9.5.21 Overall, the magnitude of the impact is deemed to be **low** and the sensitivity of the receptor is considered to be **medium**. There would be no change to the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

4.9.5.22 An overview of the potential impacts due to vessel presence and associated effects (collision) are described in paragraph 4.9.4.43 for the construction phase and have not been reiterated here for the decommissioning phase.

4.9.5.23 Vessel use during the decommissioning phase of the Morgan Generation Assets may lead to injury to marine mammals due to collision with vessels. Vessel types which will be required during the decommissioning phase include those used during removal of foundations (Table 4.16). The types of vessels used during the decommissioning will result in a similar MDS as the construction phase.

4.9.5.24 With measures adopted as part of Morgan Generation Assets in place to reduce the risk of collision, the impact is predicted to be of local spatial extent, medium term duration, intermittent, and whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low**.

Sensitivity of receptor

4.9.5.25 The sensitivity of the receptors during the decommissioning phase is not expected to differ from the sensitivity of the receptors during the construction phase. Therefore, the sensitivity of marine mammal receptors to collision risk is as described previously in paragraph 4.9.5.8 *et seq*.

4.9.5.26 All marine mammals are deemed to have some tolerance (largely due to avoidance behaviour), medium recoverability and international value. The sensitivity of the receptor is therefore, considered to be **medium**.

Significance of effect

4.9.5.27 Overall, the magnitude of the impact is deemed to be **low** and the sensitivity of the receptor is considered to be **medium**. There would be no change to the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

4.9.6 Injury and disturbance from elevated underwater sound generated from site investigation survey sources

4.9.6.1 Site investigation surveys during the construction phase have the potential to cause direct or indirect effects (including injury or disturbance) on marine mammal IEFs. A detailed underwater sound modelling assessment has been carried out to investigate the potential for injurious and behavioural effects on marine mammals as a result of geophysical and geotechnical surveys, using the latest criteria (Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement), which is drawn upon in the assessment below.

Summary of sound modelling

4.9.6.2 It is understood that several sonar-like sources will potentially be used for geophysical surveys, including MBES, SSS, SBES, SBP and sparkers (as an example of UHRS) (typical site investigation sources and associated sound level parameters are set out in Table 4.16). The equipment likely to be used can typically work at a range of signal frequencies, depending on the distance to the bottom and the required resolution. For sonar-like sources the signal is highly directional, acts like a beam and is emitted in pulses. Sonar-based sources are considered by the NMFS (2018) as continuous (non-impulsive) because they generally comprise a single (or multiple discrete) frequency as opposed to a broadband signal with high kurtosis, high peak pressures and rapid rise times (see Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement). Unlike the sonar-like survey sources, the UHRS is likely to utilise a sparker, which produces an impulsive, broadband source signal. A full description of the source sound levels for geophysical survey activities is provided in Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement.

4.9.6.3 For geotechnical surveys, site activities include boreholes, CPTs and vibrocores. These site investigation surveys will involve the use of several geophysical/geotechnical survey vessels and take place over a period of up to eight months.

4.9.6.4 As detailed in Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement, for geophysical surveying the resulting injury and disturbance ranges for marine mammals are based on a comparison to the non-impulsive thresholds set out in Southall *et al*. (2019). CPT distances are based on a comparison to the Southall *et al*. (2019) thresholds for impulsive sound (with the distances presented in brackets for peak SPL thresholds) whereas borehole drilling and vibro-core results are compared against the non-impulsive thresholds. Borehole drilling source levels were reported as 142 dB to 145 dB re 1 µPa (SPL_{rms}) at 1 m, indicating little to no disturbance.

Construction phase

Magnitude of impact

Auditory injury

4.9.6.5 Potential sound impacts from site investigation survey sources will depend on the characteristic of the source, survey design, frequency bands and water depth. Sonar like sources have very strong directivity which effectively means that there is only potential for injury when a marine mammal is directly below the sound source. Once the animal moves outside of the main beam, there is no potential for injury. This section provides estimated ranges for injury of marine mammals in the construction phase of the Morgan Generation Assets.

4.9.6.6 With respect to the ranges within which there is a potential of PTS to occur as a result of geophysical investigation activities, based on the SEL_{cum} metric, the maximum PTS is expected to occur out to 254 m for harbour porpoise due to SBP (chirp/pinger) (Table 4.45). For dolphin species the maximum PTS is expected to occur out to 41 m due to MBES, for minke whale and pinniped species out to 40 m due to SBP (Table 4.45).

4.9.6.7 With respect to the ranges within which there is a potential of PTS occurring to marine mammals as a result of geotechnical investigation activities, PTS thresholds were not exceeded for most marine mammal species, except harbour porpoise and minke whale. PTS is expected to occur during cone penetration testing, out to a maximum of 55 m and 4 m for harbour porpoise and minke whale (SEL_{cum} metric) respectively, and for vibro-coring to a maximum of 79 m for harbour porpoise (SEL_{cum} metric) .

4.9.6.8 The number of marine mammals with the potential to be injured within modelled ranges for PTS are presented in Table 4.47. These estimates are based on the most up to date species-specific density estimates (Table 4.12). Due to low injury ranges, for all marine species, there is the potential for no more than one animal to experience PTS (or no animals where the threshold is not exceeded) as a result of geophysical and geotechnical site investigation surveys. The site-investigation surveys are considered to be short term as they will take place over a period of several months (typically up to two months). Mitigation for injury during geophysical surveys using a sub-surface sensor from a conventional vessel will involve the use of MMObs and PAM to ensure that the risk of injury over the defined mitigation zone is reduced in line with JNCC guidance (JNCC, 2017). The largest range was predicted as 254 m (for SBP) and it is considered that standard industry measures will be effective at reducing the risk of injury over this distance.

Table 4.45: Potential PTS ranges (for marine mammals during for geophysical site investigation surveys. Based on comparison to Southall *et al*. (2019) SEL_{cum} thresholds (N/E = threshold not exceeded).

[1]Non-impulsive threshold used from Southall *et al.* (2019).

[2]Impulsive threshold used from Southall *et al.* (2019).

Activity	LF	HF	VHF	PCW
	PTS (m)	PTS (m)	PTS (m)	PTS (m)
MBES	12	41	68	25
SSS	2	2	41	6
SBES	12	12	68	25
SBP (chirp/pinger)[1]	40	40	254	40
UHRS (sparker)[2]	N/E	N/E	11	N/E

Table 4.46: Potential PTS ranges for marine mammals during geotechnical site investigation surveys. Based on comparison to Southall *et al*. (2019) SEL_{cum} thresholds (N/E = threshold not exceeded).

*Comparison to ranges for SPLpk where threshold was exceeded (shown in brackets).

Activity	LF	HF	VHF	PCW
	PTS (m)	PTS (m)	PTS (m)	PTS (m)
Borehole drilling	N/E	N/E	N/E	N/E
Cone penetration testing	4	N/E	55 (14)*	N/E
Vibro-coring	N/E	N/E	79	N/E

Table 4.47: Estimated number of animals with the potential to experience PTS from geophysical and geotechnical site investigation surveys.

Activity	Estimated number of animals with the potential to be impacted						
	Harbour Porpoise	Bottlenose Dolphin	Short-beaked common dolphin	Risso's dolphin	Minke whale	Grey seal	Harbour seal
Geophysical activities							
MBES	<1	<1	<1	<1	<1	<1	<1
SSS	<1	<1	<1	<1	<1	<1	<1
SBES	<1	<1	<1	<1	<1	<1	<1
SBP (chirp/pinger)	<1	<1	<1	<1	<1	<1	<1
UHRS (sparker)	<1	0	0	0	0	0	0
Geotechnical activities							

Activity	Estimated number of animals with the potential to be impacted						
	Harbour Porpoise	Bottlenose Dolphin	Short-beaked common dolphin	Risso's dolphin	Minke whale	Grey seal	Harbour seal
Borehole drilling	0	0	0	0	0	0	0
Cone penetration testing	<1	0	0	0	<1	0	0
Vibro-coring	<1	0	0	0	0	0	0

4.9.6.9 Pre-construction site investigation surveys will involve the use of several geophysical/geotechnical survey vessels. Site-investigation surveys are considered to be short term as they will take place over up to a period of several months (typically up to two months). These will be carried out pre-construction but also may be carried out periodically as part of seabed and cable protection surveys based on consenting requirements. The potential impacts of underwater sound associated with vessel movements are described in section 4.9.4.

4.9.6.10 Overall, with tertiary mitigation applied where required, the impact of site investigation surveys leading to PTS is predicted to be of very limited spatial extent, short-term duration, intermittent and whilst the impact itself will occur during the pre-construction phase only, the effect of PTS will be permanent. It is predicted that the impact will affect the receptor directly. The magnitude is, therefore, considered to be **negligible**.

Behavioural disturbance

4.9.6.11 The estimated maximum ranges for onset of disturbance are based on the sound level being greater than the 120 dB re 1 μPa (SPL_{rms}) threshold applicable for all marine mammals (see paragraph 4.9.1.25).

4.9.6.12 The disturbance ranges as a result of geophysical and geotechnical site-investigation surveys (Table 4.48) will be higher than those presented for PTS. Most of the predicted ranges are within 100s of meters, however the largest distance over which the disturbance could occur is out to approximately 17.3 km for a SBP. This is due to the higher source levels for this piece of equipment compared to other types of survey equipment.

Table 4.48: Disturbance ranges for marine mammals during geophysical and geotechnical site investigation surveys.

Activity	Disturbance range (all species) (m)
Geophysical	
MBES	830
SSS	310
SBES	830
SBP (chirp/pinger)	17,300
UHRS (sparker)	637 (mild disturbance)

Activity	Disturbance range (all species) (m)
	95 (strong disturbance)
Geotechnical	
Borehole drilling	1,320 (strong disturbance)
Cone penetration testing	1,350 (mild disturbance)
	158 (strong disturbance)
Vibro-coring	8,845

4.9.6.13 For geophysical surveys the maximum disturbance ranges were predicted for the SBP with mild disturbance up to 17.3 km. For geotechnical surveys the maximum disturbance ranges were predicted for vibro-coring up to 8.845 km (Table 4.48)

4.9.6.14 For impulsive sound sources (UHRS (sparker) and cone penetration testing) the number of marine mammals potentially disturbed within the modelled ranges for behavioural response are estimated using the most up to date species specific density estimates (Table 4.12). The largest distance over which mild disturbance could occur is out to 1,350 m, and the largest distance over which strong disturbance could occur is out to 158 m. Quantitatively, for cone penetration testing, this would lead to maximum disturbance of up to two harbour porpoise. For all other species, and for all species for UHRS (sparker) less than one animal has the potential to be disturbed.

4.9.6.15 As stated in paragraph 4.9.4.19, for impulsive sound sources there is an understanding of the difference between strong and mild disturbance, whereas for non-impulsive (continuous) sound sources (MBES, SSS, SBES, SBP (chirp/pinger), borehole drilling and vibro-coring), there is only a single available threshold (120 dB re 1 μPa (SPL_{rms})) for Level B disturbance (NMFS, 2005) which is a strong behavioural reaction. Ranges for disturbance for non-impulsive sound sources (MBES, SSS, SBES, SBP (chirp/pinger), borehole drilling and vibro-coring), are presented up to the 120 dB re 1μPa (SPL_{rms}) threshold (Table 4.48). However, for those animals disturbed, there is likely to be a proportional response (i.e. not all animals will be disturbed to the same extent), but there is no dose-response curve available to apply in the context of non-impulsive sound sources (except for killer whale, see 4.9.4.19). It is important to note that the life history of an individual and the context will also influence the likelihood of an individual to exhibit an aversive response to sound, and it must be highlighted that these potential impacts will not be continuous over the construction phase, instead carried out over a shorter number of days within the period. Furthermore, this threshold does not take into account ambient sound levels in the area which may be already above the 120 dB re 1 μPa (SPL_{rms}) (see Farcas *et al.* (2020)).

4.9.6.16 Therefore, given the limited quantitative information available, as described above, any simplified calculation would likely lead to an unrealistic overestimation of the number of animals likely to be disturbed. As such, this value has not been quantified. However, all geotechnical and geophysical surveys will be of medium duration (up to several months), activities are likely to be intermittent, and animals are expected to recover quickly after cessation of the survey activities. The magnitude of the impact could result in a minor alteration to the distribution of marine mammals.

4.9.6.17 The impact of site investigation surveys leading to behavioural effects is predicted to be of local spatial extent, medium term duration, intermittent and the effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after surveys have ceased). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low**.

Sensitivity of receptor

Auditory injury

4.9.6.18 For geotechnical surveys, injury to marine mammals is unlikely to occur beyond a few tens of metres and sound from vessels themselves is likely to deter marine mammals beyond this range. The maximum range for PTS from geophysical surveys (SBP) is 254 m for harbour porpoise. Sills *et al*. (2020) evaluated TTS onset levels for impulsive sound in seals following exposure to underwater sound from a seismic air gun and found transient shifts in hearing thresholds at 400 Hz were apparent following exposure to four to ten consecutive pulses (SEL_{cum} 191 dB to 195 dB re 1 µPa^{2}s; 167 dB to 171 dB re 1 µPa^{2}s with frequency weighting for phocid carnivores in water). Matthews *et al.* (2021) used a modelling approach to compare potential effects of a non-impulsive sound source (marine vibroseis (MV)) and impulsive seismic sources (air gun) on marine mammals. The study found few marine mammals could be expected to be exposed to potentially injurious sound levels for either source type, but fewer were predicted for MV arrays than air gun arrays. They found estimated number of animals exposed to sound levels was dependent on the selection of evaluation criteria, with more behavioural disturbance predicted for MV arrays compared to air gun arrays when using SPL but the opposite when using frequency-weighted sound fields and a multiple-step, probabilistic, threshold function. Matthews *et al.* (2021) therefore demonstrated the importance of using both SPL_{pk} and SEL threshold metrics, as they relate to different characteristics of both impulsive and continuous sound (e.g. SEL looks at accumulative exposure over a set duration whilst SPL_{pk} measures acute exposure to high-amplitude sounds).

4.9.6.19 Ruppel *et al*., (2022) categorised marine acoustic sources into four tiers based on their potential to injure marine mammals using physical criteria about the sources (e.g. source level, transmission frequency, directionality, beamwidth, and pulse repetition rate). Those in Tier Four were considered unlikely to result in 'incidental take' (i.e. loss of individuals) of marine mammals and therefore termed *de minimis,* and included most high resolution geophysical sources (MBES, SSS, SBP, low powered sparkers). They also suggested that surveys that simultaneously deploy multiple, non-impulsive *de minimis* sources are unlikely to result in incidental take of marine mammals.

4.9.6.20 Marine mammals are deemed have limited resilience to PTS, low recoverability and international value. The sensitivity of the receptor to PTS from elevated underwater sound during site investigation surveys is therefore, considered to be **high**.

Behavioural disturbance

4.9.6.21 The transmission frequencies of many commercial sonar systems (approximately 12 kHz to 1800 kHz) overlap with the hearing and vocal ranges of many species (Richardson *et al*., 1995), and whilst many are high frequency sonar systems with peak frequencies well above marine mammal hearing ranges, it is possible that relatively high levels of sound are also produced as sidebands at lower frequencies (Hayes and Gough, 1992) so may elicit behavioural responses in marine mammals.

4.9.6.22 Hermannsen *et. al.* (2015) reported on the source characteristics and propagation of broadband pulses (10 Hz up to 120 kHz) from a small airgun, confirming that there are substantial medium-to-high frequency components in airgun pulses, indicating that small odontocetes and seals may be affected by even a single airgun. However, findings indicate that in the context of exposure to sonar-like sound sources (e.g.

MBES, SBES) marine mammals may show subtle behavioural responses but factors such as species, behavioural context, location, and prey availability may be as important or even more important than the acoustic signals themselves (Ruppel *et. al.,* 2022). MacGillivray *et al*. (2014) compared sound level above hearing threshold as a function of horizontal distance, for seven acoustic sources including air guns, SBP, MBES and SSS. Weighting sounds according to hearing sensitivity allows assessment of relative risks associated with exposure and whilst this analysis did not directly relate to potential for behavioural responses, it allowed comparison of modelled acoustic sources. Modelling indicated that odontocetes were most likely to hear sounds from mid-frequency sources (fishery, communication, and hydrographic systems), mysticetes from low-frequency sources (SBP and airguns), and pinnipeds from both mid and low-frequency sources. For all species, modelled sensation levels were lowest for the high-frequency sources (e.g. SSS and MBES) which operate at the upper limits of the audible spectrum.

4.9.6.23 In a study on MBES surveys in 2020, Kates Varghese *et al.* (2020) showed that the only marine mammal metric that was identified as changing was vocalisation rate. Neither displacement nor changes in foraging were observed. Quick *et. al.* (2016) demonstrated that tagged short-finned pilot whale *Globicephala macrorhynchus* that were exposed to a SBES, did not change their foraging behaviour, but variance in directionality of movement was observed, suggesting increased vigilance while the SBES was active. However, the authors acknowledged that the range of behaviours exhibited could not be directly attributed to SBES operation, and that changes in behaviour were unlikely to be biologically significant. Cholewiak *et. al.* (2017) investigated the impact of SBES on toothed whales, recording fewer beaked whale vocalisations when the source was actively transmitting suggesting that animals either move away from the area or reduced foraging activity (although findings were not statistically significant).

4.9.6.24 Studies have largely focused on the effects of multi-array seismic surveys on marine mammals, and therefore evidence for behavioural responses to sonar-like sources (e.g. MBES, SSS, SBPs) is less widely available. Multi-array impulsive sound sources are broadband in character (i.e. produce sound across a wide range of frequencies), unlike sonar-like sources which typically produce more tonal sound either at a discrete frequency or a range of discrete frequencies. However, findings from studies of multi-array impulsive sources may be useful in supporting predictions of behavioural responses of marine mammals to geophysical survey sources in general, given the overlap of parameters that typically characterise sound sources (i.e. transmission frequency; source level; pulse duration) (see MacGillivray *et al.*, 2014; Ruppel *et al.,* 2022). Whilst evidence on the behavioural responses of melon-headed whales *Peponocephala electra* (or similar species) to MBES is limited, an Independent Scientific Review Panel (ISRP) deemed a 12 kHz MBES to be the most plausible trigger for an extreme behavioural response in melon-headed whale, which resulted in a mass group stranding in a shallow lagoon in Madagascar in 2008 (Southall *et al*., 2013) (an area where such open-ocean species would not usually frequent). Whilst an unequivocal cause and effect relationship between MBES and the strandings cannot be concluded, the paper states that intermittent, repeated sounds of this nature could present a salient and potential aversive stimulus and suggests potential for such behavioural responses (or indirect injury) from MBES should be considered in environmental assessments (Southall *et al*., 2013).

4.9.6.25 Fine-scale data from harbour porpoise equipped with high-resolution location and dive loggers when exposed to airgun pulses at ranges of 420 m to 690 m with sound level estimates of 135 dB to 147 dB re 1µPa^{2}s (SEL) show different responses to sound exposure (van Beest *et al*., 2018). One individual displayed rapid and directed movements away from the exposure site whilst two individuals used shorter and shallower dives (compared to natural behaviour) immediately after exposure. This sound-induced movement typically lasted for eight hours or less, with an additional 24 hour recovery period until natural behaviour was resumed.

4.9.6.26 Results from 201 seismic surveys in the UK and adjacent waters demonstrated that cetaceans (including bottlenose dolphin, short-beaked common dolphin and minke whale) can be disturbed by seismic exploration (Stone and Tasker, 2006). Small odontocetes showed the strongest lateral spatial avoidance, moving out of the area, whilst mysticetes and killer whale showed more localised spatial avoidance, orienting away from the vessel and increasing distance from source but not leaving the area completely.

4.9.6.27 A study by Sarnocińska *et al*. (2020) indicated temporary displacement or change in harbour porpoise echolocation behaviour in response to a 3D seismic survey in the North Sea. No general displacement was detected from 15 km away from any seismic activity but decreases in echolocation signals were detected up to 8 km to 12 km from the active airguns. Taking into account findings of other studies (Dyndo *et al.,* 2015; Tougaard *et al.,* 2015) harbour porpoise disturbance ranges due to airgun sound are predicted to be smaller than to pile driving sound at the same energy. The reason for this is that the perceived loudness of the airgun pulses is predicted to be lower than for pile driving sound due to less energy at the higher frequencies where porpoise hearing is better (Sarnocinska *et al.,* 2020). Similarly, Thompson *et al*. (2013) used PAM and digital aerial surveys to study changes in the occurrence of harbour porpoise across a 2,000 km^2 study area during a commercial two-dimensional seismic survey in the North Sea and found acoustic detections decreased significantly during the survey period in the impact area compared with a control area, but this effect was small in relation to natural variation. Animals were typically detected again at affected sites within a few hours, and the level of response declined through the ten-day survey suggesting exposure led to some tolerance of the activity (Thompson *et al.,* 2013). This study suggested that prolonged seismic survey sound did not lead to broader-scale displacement into suboptimal or higher-risk habitat. Likewise, a ten-month study of overt responses to seismic exploration in humpback whale, sperm whale *Physeter macrocephalus* and Atlantic spotted dolphin *Stenella frontalis*, demonstrated no evidence of prolonged or large-scale displacement of each species from the region during the survey (Weir, 2008).

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

4.9.6.29 Aside from displacement or avoidance, other behavioural responses have been demonstrated (Wright and Consentino, 2015). Responses to seismic surveys have included cessation of singing (Melcón *et al.,* 2012) and alteration of dive and respiration patterns which may lead to energetic burdens on the animals (Gordon *et al.*, 2004). In some cases, behavioural responses may lead to greater effects than expected, such as strandings (Cox *et al*., 2006; Tyack *et al*., 2006) or interruptions to migration (Heide-Jørgensen *et al*., 2013). However such responses are highly context-dependent and variable, depending on factors such as the activity of the animal at the time (Robertson *et al.,* 2013), prior experience to exposure (Andersen *et al.,* 2012), extent or type of disturbance (Melcón *et al*., 2012), environment in which they inhabit Heide-Jørgensen *et al*., 2013) and the type of survey (as discussed in section 4.9.6.19).

4.9.6.30 It is expected that, to some extent, marine mammals will be able to withstand temporary elevated levels of underwater sound during site investigation surveys and behavioural responses are highly species and context specific (evidenced by paragraph 4.9.6.22 *et seq*). Marine mammals are deemed to have some resilience, high recoverability and international value. The sensitivity of the receptor to disturbance from elevated underwater sound during site investigation surveys is therefore considered to be **medium.**

Significance of effect

4.9.6.31 Overall, the magnitude of the impact of PTS is deemed to be **low** and the sensitivity of the receptor is considered to be **high**. There would be no change to the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

4.9.6.32 Overall, the magnitude of the impact of disturbance is deemed to be **low** and the sensitivity of the receptor is considered to be **medium**. There would be no change to the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

4.9.7 Underwater sound from wind turbine operation

Operations and maintenance phase

Magnitude of impact

4.9.7.1 Sound from wind turbines comes in two forms, namely the aerodynamic sound from the blades moving through the air leading to the characteristic ‘swish-swish’ sound and the mechanical sound associated with machinery housed in the nacelle of the wind turbine (Marmo *et al.,* 2013). As aerodynamic sound travels through the surrounding air to the interface between the air and water, due to the large impedance contrast it is almost entirely reflected and therefore little aerodynamic sound enters the marine environment.

4.9.7.2 Sound levels from operating windfarms are likely to be audible to marine mammals, particularly under scenarios where wind speeds increase as well as the size of the turbine. The Morgan Generation Assets will consist of up to 64 of the largest wind turbines. Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement assumed an average wind speed of 10 m/s. The assessment is based upon the largest wind turbine size (as modelled in Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement), as this would result in the greatest range of effect, thus for a larger number of smaller turbines (i.e.. up to 96 foundations) the effect ranges would be smaller, although the number of locations would increase.

Auditory injury

4.9.7.3 Potential injury ranges for marine mammals were calculated based on 24 hours exposure for a static animal (Table 4.49). This conservative approach suggested that minke whale would need to remain within 5 m of an operational wind turbine for period of 24 hours to reach the PTS threshold (Table 4.49). Unlike seals, which have been reported as foraging around operational wind turbine structures most likely due to the growth of benthic communities on the introduced hard substrate (Russell *et al.*, 2014) baleen whales are unlikely to move close turbine foundations as there would be limited benefit in terms of foraging. Therefore, occurrence of minke whale within 5 m of operational wind turbines is considered highly unlikely to occur.

Table 4.49: PTS range for marine mammals as a result of sound produced during operation of wind turbines (static animal; 24 hour exposure; SEL_{cum}). N/E = not exceeded.

Species	PTS threshold (SEL_{cum})	PTS range (m)
Harbour porpoise (VHF)	173 dB re 1 µPa²s	N/E
Bottlenose dolphin, short-beaked common dolphin, Risso's dolphin (HF)	198 dB re 1 µPa²s	N/E
Minke whale (LF)	199 dB re 1 µPa²s	5
Grey seal, harbour seal (PCW)	201 dB re 1 µPa²s	N/E

4.9.7.4 The impact is predicted to be of local spatial extent (up to 5 m range), long term duration, intermittent and the effect will be of medium to low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **negligible**.

Behavioural Disturbance

4.9.7.5 The underwater sound modelling (see Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement) predicted that potential behavioural disturbance to all species of marine mammal could occur within approximately 160 m of each wind turbine, based on the sound contour plot 120 dB re 1µPa (SPL_{rms}) contours.

4.9.7.6 The impact is predicted to be of local spatial extent, long term duration, intermittent and the effect will be of medium to low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low**.

Sensitivity of receptor

4.9.7.7 Thomsen *et al.* (2006) reported at 100 m distance from 1.5 MW turbines, underwater sound would be audible to both harbour porpoise and harbour seal. At a greater distance of 1,000 m the signal to ambient or background sound ratio is too low for detection in harbour porpoise, however, detection by harbour seal might be possible. However, the authors caveat these results as ambient sound values used in this study were extrapolated from measurements obtained in the Baltic, while the ambient sound in most parts of the North Sea is much higher and will decrease the radius of detection significantly.

4.9.7.8 The early measurements of underwater sound due to operational turbines were reviewed Madsen *et al.* (2006) who concluded that the underwater sound from operating wind turbines is limited to low frequencies (below 1 kHz) and of low intensity and would therefore be unlikely to affect marine mammals with main hearing sensitivities at higher frequencies (i.e. VHF and HF cetaceans and PCW) (see Figure 1.4 in Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement).

4.9.7.9 As discussed in Stöber and Thomsen (2021), studies using long term frequency data from wind farm with 5 MW turbines (Alpha Ventus, Germany) found that whilst operational sound can be identified, levels hardly exceed beyond ambient sound levels in areas near main shipping traffic routes thus marine mammals in high traffic areas may not be able to discern operational wind turbine sound from background levels. Analysis of individual frequencies predicted a correlation between SPLs and the operational status of the wind turbines as well as the wind speed, but the total impact of the operational sound was considered to be mostly negligible (Stöber and Thomsen, 2021).

4.9.7.10 Nedwell *et al.* (2007) analysed measurements of underwater sound inside and outside of four different offshore wind farms in British waters. Results showed that the operational sound levels were low and only exceeded background levels close to the wind turbines (<1 km). For example, the results for Kentish Flats (30 3 MW turbines) showed that for harbour seal the perceived sound levels were just a few decibels higher inside the wind farm than outside, and the report stated that as the perceived level of sound was low, there was predicted to be no effect on individuals. It must be noted that whilst this study is well-known, the sound level metrics used in the study have not been widely adopted for impact assessment, therefore the sound level values in the paper have not been presented here to avoid any confusion or comparisons with the metrics now commonly adopted for assessment purposes. However, qualitatively the study provides some indication of the low sensitivity of marine mammals to wind turbine operational sound.

4.9.7.11 Tougaard *et al*. (2009) studied recordings of underwater sound from three wind farms in Denmark (450 kW, 500 kW and 2 MW turbines) and found that turbine sound was only measurable above ambient sound at frequencies below 500 Hz. Total sound pressure level was in the range 109 to 127 dB re 1μPa (SPL_{rms}), measured at distances between 14 m and 20 m from the foundations. This study estimated the maximum distance where harbour seal could perceive the sound for different wind farms to be between 2.5 m and 10 km. For porpoises, 63 m maximum distance of perception was found. The study concluded that the sound is unlikely to exceed injury thresholds at any distance from the turbines and the sound is considered incapable of masking acoustic communication by harbour seal and harbour porpoise.

4.9.7.12 Marmo *et al.* (2013) reported that rotational imbalances tend to occur at very low frequencies (<50 Hz), while gear meshing and electromagnetic interactions tend to occur at low to moderate frequencies (8 Hz to 2 kHz). Wind turbines produce vibration and related sound between 0.5 Hz to 2 kHz which overlaps frequency bands that are detectable by species living in UK waters (Marmo *et al.,* 2013), although noting that these frequencies only overlap the peak sensitivities for LF cetaceans. The same study modelled vibration produced by a generic 6 MW wind turbine across the 10 Hz to 2 kHz frequency band and predicted that modelled sound levels are likely to be audible to marine mammals particularly at wind speeds of approximately 15 m/s when the generic wind turbines are producing maximum power. Species with hearing specialised to low frequency, such as minke whale, may in certain circumstances detect the wind farm at least 18 km away and are the species most likely to be affected by sound from operational wind turbines. Harbour seal, grey seal and bottlenose dolphin are not considered to be at risk of displacement by the operational wind farm modelled.

4.9.7.13 Stöber and Thomsen (2021) collated 16 scientific publications about underwater sound levels related to the operation of offshore wind turbines and found that the broadband rms ranged from 129 to 166 dB re 1 μPa at 1 m and showed a general increasing trend with increasing nominal power output (MW). Using the regression line for peak spectral levels, authors predicted an underwater source level of 177 dB re 1µPa (SPL_{rms}) at 1 m for a geared turbine with a nominal power of 10 MW. Whilst the 10 MW example was predicted to cause behavioural disturbance of up to 6.3 km (based on the 120 dB re 1 µPa SPL_{rms} threshold) this was below typical sound levels for main installation vessels (see section 4.9.4).

4.9.7.14 It is therefore considered likely that large amounts of shipping sound, present in the vicinity of the Morgan Generation Assets, would mask operational wind farm sound. This, however, is likely to be a function of distance and if animals are close to the Morgan Generation Assets, then the operational sound may still be detected. Moreover, considering that studies so far have been for smaller wind turbines than those in the MDS at the time of writing this assessment, it is important to highlight that conclusions presented in this section has been based on the latest available data.

4.9.7.15 Conservatively, it is considered that there is a potential that the ability of cetaceans to find their prey may be hindered to some extent within the Morgan Generation Assets due to the potential masking of acoustic cues from large operational wind turbines. However, man-made structures in the marine environment are known to act as artificial reefs, providing structure and habitat for many fish species and attracting small pelagic fish, thus increasing food availability for cetaceans and pinnipeds in the presence of offshore wind farms and attracting marine mammal species (further information is given in Volume 2, Chapter 3: Fish and shellfish ecology of Environmental Statement and Volume 2, Chapter 2: Benthic subtidal ecology of the Environmental Statement).

4.9.7.16 Section 4.9.8 provides more details about changes in prey availability and indirect impacts on marine mammals. Evidence for positive effects have been reported where species such as harbour porpoise, minke whale, white-beaked dolphin, harbour seal and grey seal have been frequently recorded around offshore wind farms (Scheidat *et al*., 2011; Lindeboom *et al*., 2011; Russell *et al.,* 2014; Diederichs *et al*., 2008).

Auditory injury

4.9.7.17 All marine mammals are deemed to have limited resilience to PTS, low recoverability and international value. Due to the permanence of the effect, the sensitivity of the receptor to PTS is therefore, considered to be **high**.

Behavioural disturbance

4.9.7.18 All marine mammals are deemed to have some resilience to behavioural disturbance, high recoverability and international value. The sensitivity of the receptor is therefore, considered to be **medium**.

Significance of effect

Auditory injury

4.9.7.19 Overall, the magnitude of the impact is deemed to be **negligible** and the sensitivity of the receptor is considered to be **high**. There would be no change to the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Behavioural disturbance

4.9.7.20 Overall, the magnitude of the impact is deemed to be **low** and the sensitivity of the receptor is considered to be **medium**. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

4.9.8 Changes in fish and shellfish communities affecting prey availability

4.9.8.1 Potential effects on fish assemblages during the construction, operations and maintenance and decommissioning phases of the Morgan Generation Assets, as identified in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement, may have indirect effects on marine mammals. The assessment includes temporary habitat loss/disturbance, long term habitat loss, increased SSC and associated sediment deposition, underwater sound impacting fish and shellfish receptors, EMFs from subsea electrical cabling, as well as colonisation of hard structures.

4.9.8.2 The key prey species for marine mammals include small shoaling fish from demersel or pelagic habitats, particularly gadoids (e.g. Atlantic cod *Gadus morhua*; haddock *Melanogrammus aeglefinus*; whiting *Merlangius merlangus;* Atlantic herring*;* European sprat*;* sandeels; mackerel; flatfish (e.g. plaice *Pleuronectes platessa*; sole *spp.*; European flounder *Platichthys flesus*; common dab *Limanda limanda*) and cephalopods.

4.9.8.3 These prey species have been identified as being of regional importance within the Morgan Generation Assets fish and shellfish ecology study area (see Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement). For example, there are important spawning and nursery grounds for plaice, dover sole *Solea solea*, Atlantic cod, whiting, sandeel, Atlantic herring, mackerel and European sprat. There are also nursery grounds for haddock, tope *Galeorhinus galeus* and spurdog *Squalus acanthias*. Consequently, negative effects on fish receptors may have indirect adverse effects on marine mammal receptors.

Construction phase

Magnitude of impact

4.9.8.4 Potential impacts on marine mammal prey species during the construction phase have been assessed in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement using the appropriate MDSs for these receptors. Construction impacts include temporary habitat loss/disturbance, long term habitat loss, increased SSC and associated sediment deposition, underwater sound impacting fish and shellfish receptors, as well as colonisation of hard structures. A summary of the impact assessment for fish and shellfish is given below in paragraph 4.9.8.5 *et seq.*

4.9.8.5 The installation of infrastructure within the Morgan Generation Assets may lead to temporary subtidal habitat loss/disturbance as a result of a range of activities including use of jack-up vessels during foundation installation, installation of inter-array, interconnector and anchor placements associated with these activities.

4.9.8.6 There is the potential for temporary habitat loss/disturbance to affect up to 61,422,400 m^2 of subtidal seabed during the construction phase, which equates to approximately 6.43% of the area within the Morgan Array Area overall (as detailed in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement), although only a small proportion of this will be impacted at any one time. For long term habitat loss, up to 760,452 m^2 may be lost (see Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement).

4.9.8.7 Habitat loss/disturbance could potentially affect spawning, nursery or feeding grounds of fish and shellfish receptors, which will impact those feeding higher up the food chain. However, as suggested in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement, only a small proportion of the maximum footprint of habitat loss/disturbance may be affected at any one time during the construction phase and areas will start to recover immediately after cessation of construction activities in the vicinity. Additionally, habitat disturbance during the construction phase will also expose benthic infaunal species from the sediment, potentially offering foraging opportunities to some fish and shellfish species (e.g. opportunistic scavenging species) immediately after completion of works.

4.9.8.8 There is also the potential for underwater sound during construction piling to result in injury and/or disturbance to fish and shellfish communities. Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement determined the impact of underwater sound was predicted to be of regional spatial extent, medium term duration, intermittent and of high reversibility, with the soundscape returning to near-baseline conditions upon completion of construction activities. For most marine species, the magnitude was deemed to be low. Whilst most fish species were low sensitivity, sprat, sandeel, cod and herring have medium sensitivity, and this may lead to effects on minke whale prey availability given how tightly tied they are to herring stocks. This is due to the short term, intermittent nature of the impact, and the relatively small proportion of spawning habitats affected at any one time (given the broadscale nature of these habitats). There is potential for significant impacts to herring spawning, due to the proximity of the Morgan Generation Assets to the nearby herring spawning grounds. This increased level of impact could occur if piling takes place during the herring spawning period (September to October). Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement determined a moderate adverse significant effect for herring as a result of underwater sound.

4.9.8.9 Herring has been shown to be an important prey species for harbour porpoise (Santos *et al.* (2004), alongside many other prey species (e.g. whiting, sandeel, haddock, saithe, pollock, Norway pout, poor-cod, cod, ling, blue whiting) (see further detail in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement). Herring and cod are key species for bottlenose dolphin in the UK (Pesante *et al.* (2008); Nuuttila *et al.* (2017); Santos *et al*. (2001) however, they have an opportunistic diet with a wide range of prey species in the Irish Sea, such as mackerel, seabass, whiting, salmon, sandeel, saithe, pollock, haddock, poor-cod (Pesante *et al.* (2008); Nuuttila *et al.* (2017); Evans and Hintner (2013); Hernandez-Milian *et al*. (2011) and therefore it is highly likely can adapt to changes in prey availability. Hernandez-Milian *et al.* (2015) for example identified 37 prey taxa in stomach contents from 12 bottlenose dolphin. Short-beaked common dolphin have a varied diet which often consists of small schooling fish including cod and herring (see further detail in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement). Risso's dolphin are almost exclusively teuthophagic, with herring and cod not forming a key prey item for this species. Minke whale appear to be tightly tied to herring stocks in the Irish Sea around the Isle of Man (detailed in Volume 4, Annex 4.1: Marine Mammal technical report of the Environmental Statement), however specific feeding information on animals in this area is lacking. Sandeel are the key food resource for minke whale throughout the North Sea, with sprat, shad and herring also preferred prey items (Robinson and Tetley, 2007). Samples taken from the stomach contents of specimens within the North Sea determined that in UK waters the dominant prey items were sandeels, followed by clupeids and to a lesser extent mackerel (Robinson *et al.,* 2007). It is assumed that if herring are disturbed from an area as a result of underwater sound, marine mammals are likely to be disturbed from the same or greater area. However, given that minke whale are tightly tied to herring stocks, it can be assumed that minke whale prey availability would be impacted.

4.9.8.10 As discussed in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement, grey seal are generalist feeders, and take a wide variety of prey including sandeels, gadoids (cod, whiting, haddock, ling) and flatfish (plaice, sole, flounder, dab). Similarly harbour seal are opportunistic, generalist feeders and their diet varies both seasonally and from region to region.

4.9.8.11 Therefore, whilst there may be certain prey species that make up the main part of their diet, all marine mammals in this assessment are considered to be generalist opportunistic feeders and are thus not reliant on a single prey species (with the exception of Risso's dolphins which predominantly feed on cephalopods). Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement concluded that most marine mammal prey species would not be exposed to significant adverse effects as a result of the Morgan Generation Assets. Given that marine mammals are wide-ranging in nature with the ability to exploit numerous food sources, there would be a variety of prey species available for foraging. Furthermore, the Underwater sound management strategy (with an Outline underwater sound management strategy included as part of the application, Document Reference J13), secured in the deemed marine licences within the draft DCO, will present a review of relevant additional mitigation options in order to reduce the magnitude of impacts leading to significant effects (for the project alone) on fish and shellfish receptors (such as cod and herring spawning grounds) to a non-significant effect which would benefit associated marine mammal predators.

4.9.8.12 Other potential impacts assessed in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement include increased SSCs and associated sediment deposition, both of which may result in short-term avoidance of affected areas by fish and shellfish receptors. Adult fish have high mobility and may show avoidance behaviour in areas of high sedimentation (EMU, 2004), however, there may be impacts on the hatching success of fish and shellfish larvae and consequential effects on the viability of spawning stocks due to limited mobility (Bisson and Bilby, 1982; Berli *et al*., 2014). However as described in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement most juvenile fish expected to occur in the Morgan Fish and Shellfish Ecology study area will be largely unaffected by the relatively low-level temporary increases in SSC and any potential impacts will be short in duration, returning to baseline levels relatively quickly. Whilst herring eggs have higher sensitivity to the smothering effects of increased sediment deposition, and sensitivity of this receptor was deemed to be medium, the magnitude of impact was deemed to be low therefore for all receptors, the effect was of minor adverse significance which will not impact marine mammals.

4.9.8.13 A moderate adverse effect, which is significant in EIA terms was predicted for herring as a result of underwater sound during the construction phase of the Morgan Generation Assets (Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement). No other significant adverse effects were predicted to occur to fish and shellfish receptors (marine mammal prey) as a result of the construction of the Morgan Generation Assets. As such, changes in prey availability on marine mammals were predicted to be of local spatial extent, medium-term duration, intermittent and high reversibility. The magnitude was therefore considered to be **low**.

Sensitivity of receptor

4.9.8.14 Although there is interspecific variation in foraging strategies (e.g. income versus capital breeders as discussed in 4.9.1.34), marine mammals often exploit a range of different prey items switching prey sources depending on season and availability, and sometimes covering extensive distances to forage in areas of high productivity. Whilst species may show a degree of site-fidelity (e.g. bottlenose dolphin are semi-resident in Cardigan Bay and grey and harbour seal often return to the same haul-out locations), largely marine mammals are not confined to a particular location and can, and will, freely move to occupy available areas of suitable habitat within large home ranges. Given that the impacts of construction to prey resources will be localised and largely restricted to the boundaries of the Morgan Generation Assets, only a small area will be affected when compared to available foraging habitat in the Irish and Celtic Seas.

4.9.8.15 With respect to underwater sound, marine mammals occurring within the predicted impact areas for fish and shellfish also have the potential to be directly affected (injury/disturbance) and it is likely that the effects to prey resources (e.g. behavioural displacement) will occur over a similar, or lesser, extent and duration as those for marine mammals. There would, therefore, be no additional displacement of marine mammals as a result of any changes in prey resources during construction, as they would already be potentially disturbed as a result of underwater sound during piling. In addition, as prey resources are displaced from the areas of potential impact, marine mammals are likely to follow in order to exploit these resources.

4.9.8.16 The fish and shellfish communities found within the Morgan Fish and Shellfish Ecology study area (see Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement) are characteristic of the fish and shellfish assemblages in the wider Irish Sea. It is therefore reasonable to assume that due to the highly mobile nature of marine mammals, there will be similar prey resources available in the wider area. There may be an energetic cost associated with increased travelling and two species, harbour porpoise and harbour seal, may be particularly vulnerable to this effect. Harbour porpoise has a high metabolic rate and only a limited energy storage capacity, which limits their ability to buffer against diminished food while harbour seal typically forage close to haul out sites, i.e. within nearest 50 km. Despite this, if animals do have to travel further to alternative foraging grounds, the impacts are expected to be short term in nature and reversible (i.e. elevated underwater sound would occur during piling only). For example, responses by harbour porpoise to pile-driving sounds documented at two offshore wind projects in Denmark indicated a return to activity levels normal for the construction period a few days after pile-driving ceased (Tougaard *et al*., 2005, 2003). Displacement may also vary between species, for example Russell *et al*. (2016) showed for harbour seal there was no significant displacement during construction, and displacement was limited to piling activity (within 2 hours of cessation of pile driving, seals were distributed as per non-piling scenario). It is likely that during construction marine mammals may temporarily shift their foraging efforts to other areas within or around the Morgan Generation Assets due to disturbances to benthic habitat and associated resources (Fiorentino and Wieting, 2014). Therefore, it is expected that all marine mammal receptors would be able to tolerate the effect without any impact on reproduction and survival rates and would be able to return to previous activities once the impact had ceased.

4.9.8.17 Minke whale has the potential to be particularly vulnerable to potential effects on herring. In the Irish Sea, two known herring stocks exist and minke whale seem to mirror these stocks in Manx waters. The Manx herring stock are known to spawn on the east coast of the island, in September to October (Bowers, 1969), hence the presence of minke whale on the east coast during these months. During the summer months, the Manx stock and Mourne stock are found together off the west coast of the island (Bowers, 1980). Anderwald *et al*. (2012) studied flexibility of minke whale in their habitat use and found that although significantly higher sighting rates often occur in habitats associated with sandeel presence, an area of high occupancy by minke whale coincided with high densities of sprat during spring. Hence, the low energetic cost of swimming in minke whale and their ability to switch between different prey according to their seasonal availability indicates that these species would be able to respond to temporal changes in pelagic prey concentrations.

4.9.8.18 Most marine mammals, except for minke whale, are deemed to be resilient to changes in prey availability, have high recoverability and high international value. The sensitivity of the receptor is therefore, considered to be **low**.

4.9.8.19 For minke whale, due to their reliance on herring as a primary food source in the Irish Sea, they are deemed to have some resilience to changes in prey availability, have high recoverability and international value. The sensitivity of the receptor is therefore, considered to be **medium**.

Significance of effect

4.9.8.20 Overall, the magnitude of the impact is deemed to be **low** for all species and the sensitivity of the receptor is considered to be **low** for all species, except for minke whale, which is **medium**. There would be no change to the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Operations and maintenance phase

4.9.8.21 Potential impacts on marine mammal prey species during the operations and maintenance phase have been assessed in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement, using the appropriate MDS for these receptors. These include temporary habitat loss/disturbance, long term habitat loss, increased SSC and associated sediment deposition, EMFs from subsea electrical cabling, as well as colonisation of hard structures.

4.9.8.22 Impacts, with the exception of EMF from subsea electrical cabling, are the same or less than those described for the construction phase in paragraph 4.9.2.23 *et seq*. Operational sound was not assessed in in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement but impacts on marine mammal prey availability will be less than those in construction phase due to lower underwater sound levels.

4.9.8.23 During the operations and maintenance phase, there may be impacts from EMF from subsea cables. Fish and shellfish species (particularly elasmobranchs) are able to detect applied or modified magnetic fields, and may exploit magnetic fields to detect prey, predators or conspecifics in the local environment to assist with feeding, predator avoidance, navigation, orientation and social or reproductive behaviours. The presence and operation of inter-array and interconnector cables will result in emissions of localised electrical and magnetic fields, which could potentially affect the sensory mechanisms of some species of fish and shellfish. However, the impact of EMF on fish and shellfish was predicted to be of local spatial extent, long term duration, continuous and high reversibility (when the cables are decommissioned) and of minor adverse significance.

4.9.8.24 Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement also considers long-term habitat loss in the operations and maintenance phase, but highlights the reality is not a loss of habitat, but rather a change in a sedimentary habitat and replacement with hard artificial substrates. Given marine mammals are flexible predators that can switch prey if required, such changes are unlikely to affect prey availability in the long term. Potential colonisation of hard structures could occur within hours or days after construction by demersal and semi-pelagic fish species (Anderson, 2011), with more complex communities later likely attracted to the developing algal and suspension feeder communities as potential new sources of food (Karlsson *et al*., 2022). Feeding opportunities or the prospect of encountering other individuals in the newly introduced heterogenous environment (Langhamer, 2012) may attract fish aggregations from the surrounding areas, which may increase the carrying capacity of the area in the long-term, and thus lead to a change or increase in prey availability for marine mammals.

Magnitude of impact

4.9.8.25 The impact on marine mammals is predicted to be of local spatial extent, long-term duration, continuous and the effect on marine mammals is of high reversibility. Whilst most impacts are considered to be adverse there is the potential for some beneficial effect with respect to introduction of hard substrate which could increase prey availability for some species. The magnitude for both adverse and beneficial impacts is considered to be **low**.

Sensitivity of receptor

4.9.8.26 Following placement on the seabed, submerged parts of the wind turbines provide hard substrate for the colonisation by high diversity and biomass in the flora and fauna. Faecal deposits of dominant communities of suspension feeders are likely to alter the surrounding seafloor communities by locally increasing food availability (Degraer *et al*., 2020). Higher trophic levels, such as fish and marine mammals, are likely to benefit from locally increased food availability and/or shelter and therefore have the potential to be attracted to forage within the Morgan Array Area. However, still relatively little is known about the distribution and diversity of marine mammals around offshore anthropogenic structures.

4.9.8.27 Species such as harbour porpoise, minke whale, white-beaked dolphin, harbour seal and grey seal were frequently recorded around offshore oil and gas structures (Todd *et al*., 2016; Delefosse *et al*., 2018; Lindeboom *et al*., 2011). Acoustic results from a T-POD measurement within a Dutch windfarm found that relatively more harbour porpoises are found in the wind farm area compared to the two reference areas (Scheidat *et al*., 2011; Lindeboom *et al*., 2011). Authors of this study concluded that this effect is directly linked to the presence of the wind farm due to increased food availability as well as the exclusion of fisheries and reduced vessel traffic in the wind farm (shelter effect). Similarly, during research on a Danish wind farm, no statistical differences were detected in the presence of harbour porpoises between inside and outside the wind farm (Diederichs *et al*., 2008). Diederichs *et al*. (2008) suggested that a small increase in detections during the night at hydrophones deployed in proximity to single wind turbines may indicate increased foraging behaviour near the monopiles.

4.9.8.28 Russell *et al.* (2014) monitored the movements of tagged harbour seal within two active wind farms in the North Sea and demonstrated that animals commonly showed grid-like movement patterns which strongly suggested that the structures were used for foraging.

4.9.8.29 Whilst there is some mounting evidence of potential benefits of man-made structures in the marine environment (Birchenough and Degrae, 2020), the statistical significance of such benefits and details about trophic interactions in the vicinity of artificial structures and their influence on ecological connectivity remain largely unknown (Petersen and Malm, 2006; Inger *et al*., 2009; Rouse *et al.,* 2020, McLean *et al.,* 2022; Elliott and Birchenough, 2022). Additional details about inter-related effects on marine organisms are provided in section 4.12.

4.9.8.30 Overall, the sensitivity of marine mammals during the operations and maintenance phase is not expected to differ from the sensitivity of the receptors during the construction phase described in paragraph 4.9.8.14. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

4.9.8.31 Overall, the magnitude of the impact is deemed to be **low** and the sensitivity of the receptor is considered to be **low**. The effect will, therefore, be of **minor adverse significance**, which is not significant in EIA terms. This is likely to be a conservative prediction as there is some evidence (although with uncertainties) that marine mammal populations are likely to benefit from introduction of hard substrates and associated fauna during the operations phase. However, neither adverse, nor beneficial effects are likely to change the conservation value of the marine mammal receptors.

Decommissioning

4.9.8.32 Potential impacts on marine mammal prey species during the deconstruction phase have been assessed in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement using the appropriate MDS for these receptors. These include temporary habitat loss/disturbance, Underwater sound impacting fish and shellfish receptors, long term habitat loss, increased SSCs and associated sediment deposition, colonisation of hard structures.

Magnitude of impact

4.9.8.33 The magnitude of the impact is as described for the construction phase in paragraph 4.9.2.23 *et seq*. The impact on marine mammals is predicted to be of local spatial extent, long-term duration, continuous and the effect on marine mammals is of high reversibility. The magnitude is therefore, considered to be **low**.

Sensitivity of receptor

4.9.8.34 The sensitivity of marine mammals during the decommissioning phase is not expected to differ from the sensitivity of the receptors during the construction phase described in paragraph 4.9.8.14 *et seq.* The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

4.9.8.35 Overall, the magnitude of the impact is deemed to be **low** and the sensitivity of the receptor is considered to be **low**. There would be no change to the international value of these species. The effect will, therefore, be **of minor adverse significance**, which is not significant in EIA terms.

4.9.9 Future monitoring

4.9.9.1 No marine mammal monitoring to test the predictions made within the impact assessment is considered necessary.

4.10 Cumulative effect assessment methodology

4.10.1 Methodology

4.10.1.1 The CEA takes into account the impact associated with the Morgan Generation Assets together with the Morgan and Morecambe Offshore Wind Farms: Transmission Assets, the Morecambe Generation Assets, and other projects and plans. The projects and plans selected as relevant to the CEA presented within this chapter are based upon the results of a screening exercise (see Volume 5, Annex 5.1: CEA screening matrix of the Environmental Statement). Each project has been considered on a case by case basis for screening in or out of this chapter's assessment based upon data confidence, effect-receptor pathways and the spatial/temporal scales involved.

4.10.1.2 The marine mammals CEA methodology has followed the methodology set out in Volume 1, Chapter 5: EIA methodology of the Environmental Statement. The cumulative assessment considers two scenarios; Morgan Generation Assets plus Morgan and Morecambe Offshore Wind Farms: Transmission Assets, and Morgan Generation Assets plus Morgan and Morecambe Offshore Wind Farms: Transmission Assets and the Morecambe Generation Assets. These cumulative scenarios are followed by the cumulative assessment of all projects, plans and activities considered alongside the Morgan Generation Assets. This assessment has been allocated into 'tiers' reflecting their current stage within the planning and development process. This tiered approach is adopted to provide a clear assessment of the Morgan Generation Assets alongside other projects, plans and activities.

4.10.1.3 The cumulative assessment has been undertaken as follows:

- Morgan Generation Assets plus Morgan and Morecambe Offshore Wind Farms: Transmission Assets
- Morgan Generation Assets plus Morgan and Morecambe Offshore Wind Farms: Transmission Assets and the Morecambe Generation Assets
- Morgan Generation Assets and Tier 1 projects, plans and activities which are:
  - Under construction
  - Permitted application
  - Submitted application
  - Those currently operational that were not operational when baseline data were collected, and/or those that are operational but have an ongoing impact
- Morgan Generation Assets, Tier 1 and Tier 2 projects, plan and activities in where:
  - Scoping report has been submitted and is in the public domain
- Morgan Generation Assets, Tier 1, Tier 2 and Tier 3 includes those projects, plan and activities where:
  - Scoping report has not been submitted and is not in the public domain
  - Identified in the relevant Development Plan

– Identified in other plans and programmes.

4.10.1.4 This tiered approach is adopted to provide a clear assessment of the Morgan Generation Assets alongside other projects, plans and activities.

4.10.1.5 The CEA screening area initially focussed on projects within the extent of the harbour porpoise CIS MU, rather than the entire extent of the largest MU: the CGNS MU. This was to ensure a proportionate and pragmatic approach was taken, focussing on a region within which receptor-impact pathways are likely (since cumulative effects from the Morgan Generation Assets within the Irish Sea were considered unlikely to occur with projects in the North Sea, for example). However in order to refine the assessment to a more species-specific approach, only projects within the Irish Sea MU will be used for CEA for bottlenose dolphin (see paragraph A.1.1.1.72). For grey seal, following consultation feedback from NRW (see Table 4.5), an extended screening area was applied (OSPAR Region III) instead of the GSRP. Only offshore wind projects were included in this extended screening area to allow for a more proportionate approach to the CEA. For harbour seal, the HSRP is used as the relevant screening area. This approach was agreed with the marine mammal EWG (Table 4.5; minutes and responses available in the Technical engagement plan appendices Part 1 (Document Reference E4.1)).

4.10.1.6 The specific projects, plans and activities scoped into the CEA, are outlined in Table 4.50 and shown in Figure 4.26.

Table 4.50: List of other projects, plans and activities considered within the CEA.

*Included in the grey seal extended screening area (OSPAR Region III) and lie outside of the CIS MU screening area.

Project/Plan name	Status	Distance from the Morgan Array Area (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Morgan Generation Assets
Tier 1						
Mona Offshore Wind Project	Submitted but not yet determined	11.1	Offshore Wind Farm	2026 to 2029	2030 to 2065	Construction and operational activities for the Morgan Generation Assets may overlap with construction and operational activities of Mona Offshore Wind Project.
Awel y Môr Offshore Wind Farm	Consented	46.8	Offshore Wind Farm (500 MW capacity)	2026 to 2029	2030 to 2055	Construction and operational activities for the Morgan Generation Assets may overlap with construction and operational activities of Awel y Môr Offshore Wind Farm.
West Anglesey Demonstration Zone tidal site	Permitted but not yet implemented	79.3	Tidal Demonstration Zone	2021 to 2023	2024 to 2061	Operational activities for the Morgan Generation Assets may overlap with operational activities of West Anglesey Tidal Demonstration Zone.
Mainstream, Renewable Power Ltd- Site Investigations	Submitted but not yet determined	104.2	Offshore Wind Farm: site investigations	n/a	Unknown	There is potential for construction activities for the Morgan Generation Assets to overlap with site investigation activities for Mainstream Dublin Northeast Wind.
Statkraft North Irish Sea Array (NISA) Site Investigations	Operational	107.6	Offshore Wind Farm: site investigations	n/a	2021 to 2026	Construction activities for the Morgan Generation Assets may overlap with site

Project/Plan name	Status	Distance from the Morgan Array Area (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Morgan Generation Assets
						investigation activities for the Statkraft NISA.
Site Investigations for the proposed Sunrise Offshore Wind Farm	Submitted but not yet determined	124.7	Offshore Wind Farm: site investigations	n/a	Unknown	There is potential for construction activities for the Morgan Generation Assets to overlap with site investigation activities for Sunrise Offshore Wind Farm.
ESB Wind Development Limited Site Investigations at Sea Stacks Offshore Wind	Submitted but not yet determined	127.4	Offshore Wind Farm: site investigations	n/a	Unknown	There is potential for construction activities for the Morgan Generation Assets to overlap with site investigation activities for ESB Sea Stacks Offshore Wind.
Site Investigations for proposed Offshore Wind Farm off counties Wicklow and Dublin	Submitted but not yet determined	133.1	Offshore Wind Farm: site investigations	n/a	Unknown	There is potential for construction activities for the Morgan Generation Assets to overlap with site investigation activities for Banba Offshore Wind Farm.
RWE Renewables Ireland Site Investigations for Dublin Array Offshore Wind Farm	Submitted but not yet determined	134.4	Offshore Wind Farm: site investigations	n/a	Unknown	There is potential for construction activities for the Morgan Generation Assets to overlap with site investigation activities for RWE Renewables Dublin Array Offshore Wind Farm.
Site Investigations for the proposed Wicklow	Submitted but not yet determined	149.7	Offshore Wind Farm: site investigations	n/a	Unknown	There is potential for construction activities for the Morgan Generation Assets to overlap with site

Project/Plan name	Status	Distance from the Morgan Array Area (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Morgan Generation Assets
Project offshore wind farm						investigation activities for Wicklow Project Offshore Wind Farm.
Shelmalere Offshore Wind Farm - Site Investigations	Submitted but not yet determined	182.8	Offshore Wind Farm: site investigations	n/a	Unknown	There is potential for construction activities for the Morgan Generation Assets to overlap with site investigation activities for Shelmalere Offshore Wind Farm.
Project Erebus	Under Construction	289.9	Floating Demonstration Projects	2024 to 2026	2027 to 2052	Construction activities for the Morgan Generation Assets may overlap with operational activities of Project Erebus.
SSE Renewables Celtic Sea surveys	Submitted but not yet determined	260.8	Offshore Wind Farm: site investigations	n/a	Unknown	There is potential for construction activities for the Morgan Generation Assets to overlap with site investigation activities for SSE Renewables Celtic Sea Offshore Wind Farm.
ESB Wind Development Limited Site Investigations off Waterford and Cork Coasts - Helvick Head Offshore Wind	Submitted but not yet determined	289.2	Offshore Wind Farm: site investigations	n/a	Unknown	There is potential for construction activities for the Morgan Generation Assets to overlap with site investigation activities for ESB Helvick Head Offshore Wind .
White Cross Offshore Wind Farm	Submitted but not yet determined	319.6	Test and Demonstration Floating Wind Farm	2026 to 2027	2027 to unknown	Construction and operational activities for the Morgan Generation Assets may overlap with construction and operational activities of

Project/Plan name	Status	Distance from the Morgan Array Area (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Morgan Generation Assets
						White Cross Offshore Wind Farm.
ESB Celtic Offshore Wind - Site Investigations	Submitted but not yet determined	325.3	Offshore Wind Farm: site investigations	n/a	Unknown	There is potential for construction activities for the Morgan Generation Assets to overlap with site investigation activities for ESB Celtic Offshore Wind.
Simply Blue Energy (Kinsale) Limited surveys	Submitted but not yet determined	359.2	Floating Offshore Wind Farm: site investigations	n/a	Unknown	There is potential for construction activities for the Morgan Generation Assets to overlap with site investigation activities for Simply Blue Energy (Kinsale) Limited surveys.
Site Investigations for the proposed Kinsale Project offshore wind farm	Submitted but not yet determined	383.0	Offshore Wind Farm: site investigations	n/a	Unknown	There is potential for construction activities for the Morgan Generation Assets to overlap with site investigation activities for Kinsale Project Offshore Wind Farm.
Twin Hub	Permitted but not yet implemented	407.7	Floating offshore wind platforms (32 MW)	2024 to 2026	2026 to unknown	Construction and operational activities at Morgan Generation Assets may overlap with operational activities of Twin Hub.
Tier 2						
Mooir Vannin Offshore Wind Farm	Pre-application	4.8	Offshore wind farm	2030 to 2032	Unknown	There is potential for operational activities at the Morgan Generation Assets

Project/Plan name	Status	Distance from the Morgan Array Area (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Morgan Generation Assets
						to overlap with construction and operational activities at Mooir Vannin Offshore Wind Farm.
Morecambe Offshore Windfarm: Generation Assets	Pre-application	11.2	Offshore Wind Farm	2026 to 2029	2030 to 2089	Construction and operational activities at the Morgan Generation Assets may overlap with construction and operational activities at Morecambe Generation Assets.
North Channel Wind 2	Pre-application	107.2	Floating Offshore Wind Farm	2027 to 2030	Unknown	There is potential for construction and operational activities at the Morgan Generation Assets to overlap with construction and operational activities at North Channel Wind 2.
North Irish Sea Array Offshore Wind Farm	Pre-application	107.6	Offshore Wind Farm	2025 to 2027	2027 to 2059	Construction and operational activities at the Morgan Generation Assets may overlap with construction and operational activities at North Irish Sea Array Offshore Wind Farm.
Oriel Offshore Wind Farm	Pre-application	119.4	Offshore Wind Farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Oriel Offshore Wind Farm

Project/Plan name	Status	Distance from the Morgan Array Area (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Morgan Generation Assets
Dublin Array Offshore Wind Farm	Pre-application	134.4	Offshore Wind Farm	2026 to 2028	2029 to 2062	Construction and operational activities at the Morgan Generation Assets may overlap with construction and operational activities at Dublin Array.
North Channel Wind 1	Pre-application	135.0	Floating Offshore Wind Farm	2027 to 2030	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at North Channel Wind 1.
Codling Wind Park Offshore Wind Farm	Pre-application	141.2	Offshore Wind Farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Codling Wind Park Offshore Wind Farm
Arklow Bank Wind Park Phase 2	Pre-application	107.6	Offshore Wind Farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Arklow Bank Wind Park Phase 2
Project Valorous	Pre-application	170.5	Early commercial Floating Offshore Wind Farm	2028 to 2029	2029 to 2054	Construction and operational activities for the Morgan Generation Assets may overlap with construction

Project/Plan name	Status	Distance from the Morgan Array Area (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Morgan Generation Assets
						and operational activities of Project Valorous.
Shelmalere Offshore Wind Farm	Pre-application	201.4	Offshore Wind Farm	2028 to 2029	2030 to 2055	Construction and operational activities for the Morgan Generation Assets may overlap with construction and operational activities of Shelmalere Offshore Wind Farm.
North Celtic Sea Offshore Wind Farm	Pre-application	277.0	Offshore Wind Farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at North Celtic Sea Offshore Wind Farm
Llŷr 2	Pre-application	295.0	Floating Demonstration Project	2025 to 2026	2026 to 2051	Construction and operational activities at the Morgan Generation Assets may overlap with operational activities at Llŷr 2.
Llŷr 1	Pre-application	298.5	Floating Demonstration Project	2025 to 2026	2026 to 2051	Construction and operational activities at the Morgan Generation Assets may overlap with operational activities at Llŷr 1.
Inis Ealga Marine Energy Park	Pre-application	327.0	Floating Offshore Wind Farm	2028 to 2030	2030 to unknown	Construction and operational activities at the Morgan Generation Assets may overlap with construction and operational activities at

Project/Plan name	Status	Distance from the Morgan Array Area (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Morgan Generation Assets
						Inis Ealga Marine Energy Park.
Simply Blue Emerald	Pre-application	359.2	Floating Offshore Wind Farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Simply Blue Emerald.
Project Ilen	Pre-application	427.4	Floating Offshore Wind Farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Project Ilen.
*Spiorad na Mara – Offshore Wind Project	Pre-application	530.3	Offshore wind farm	2028 to unknown	2030 to unknown	There is potential for construction and operational activities for the Morgan Generation Assets to overlap with construction and operational activities for Spiorad na Mara – Offshore Wind Project.
Tier 3						
Eni Hynet CCS	Pre-application	31.0	Carbon Capture and Storage project in Liverpool Bay	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Eni Hynet CCS.

Project/Plan name	Status	Distance from the Morgan Array Area (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Morgan Generation Assets
Isle of Man to UK Interconnector 2	Pre-application	N/A	A new 70 MW to 100 MW HVAC interconnector to be deployed by 2030 between Pulrose substation and northwest England Distribution network.	Before 2030	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at the Isle of Man to UK Interconnector 2.
MaresConnect	Pre-application	48.2	Subsea and underground electricity interconnector cable between Republic of Ireland and North Wales	2026 to 2028	2028 to unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at MaresConnect.
Lir Offshore Array*	Pre-application	80.5	Offshore wind farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Lir Offshore Array.
Setanta Offshore Wind Project	Pre-application	107.6	Offshore wind farm	2027 to 2029	2030 to unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Setanta Offshore Wind Project.
Cooley Point Offshore Wind Farm	Pre-application	108.1	Offshore wind farm	Unknown	Unknown	There is potential for construction and/or operational activities at the

Project/Plan name	Status	Distance from the Morgan Array Area (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Morgan Generation Assets
						Morgan Generation Assets to overlap with construction and/or operational activities at Cooley Point Offshore Wind Farm.
Clogher Head Offshore Wind Farm	Pre-application	114.3	Offshore wind farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Clogher Head Offshore Wind Farm.
Realt na Mara*	Pre-application	127.1	Offshore wind farm	2028 to 2029	2030 to unknown	There is potential for construction and operational activities at the Morgan Generation Assets to overlap with construction and operational activities at Realt na Mara.
Codling Wind Park Extension Offshore Wind Farm	Pre-application	141.2	Offshore wind farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Codling Wind Park Extension Offshore Wind Farm.
Mac Lir*	Pre-application	143.9	Offshore wind farm	2028 to 2029	2030 to unknown	There is potential for construction and operational activities at the Morgan Generation Assets to

Project/Plan name	Status	Distance from the Morgan Array Area (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Morgan Generation Assets
						overlap with construction and operational activities at Mac Lir.
Nomadic Offshore Wind*	Pre-application	220.8	Floating Offshore Wind Farm	Unknown	2030 to unknown	There is potential for construction and operational activities for the Morgan Generation Assets to overlap with construction and operational activities at Nomadic Offshore Wind.
Celtic Sea Array Offshore Wind Farm	Submitted but not yet determined	260.8	Offshore Wind Farm (1.2 GW capacity)	2027 to 2029	2030 to unknown	Construction and operational activities at the Morgan Generation Assets may overlap with construction and operational activities at Celtic Sea Array Offshore Wind Farm.
Blackwater Offshore Wind Farm	Pre-application	266.0	Offshore wind farm (1.5 GW capacity)	2027 to 2029	2030 to unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Blackwater Offshore Wind Farm.
Malin Sea Wind*	Pre-application	225.84	Floating Offshore Wind Farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and operational activities at Malin Sea Wind.

Project/Plan name	Status	Distance from the Morgan Array Area (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Morgan Generation Assets
Bore Array*	Pre-application	272.9	Offshore wind farm	2027 to 2029	2030 to unknown	There is potential for construction and operational activities at the Morgan Generation Assets to overlap with construction and operational activities at Bore Array.
Celtic Horizon*	Pre-application	273.6	Offshore wind farm	2027 to 2029	2030 to unknown	There is potential for construction and operational activities at the Morgan Generation Assets to overlap with construction and operational activities at Celtic Horizon.
Haven Offshore Array Wind Farm*	Pre-application	248.0	Offshore wind farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and operational activities at Haven Offshore Array Wind Farm.
Machair Wind – Hybrid Energy Project*	Pre-application	255.0	Offshore wind farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and operational activities at Machair Wind – Hybrid Energy Project.
South Pembrokeshire Demonstration Zone	Submitted but not yet determined	278.2	Wave energy demonstration project	Unknown	Unknown	There is potential for construction and/or operational activities at the

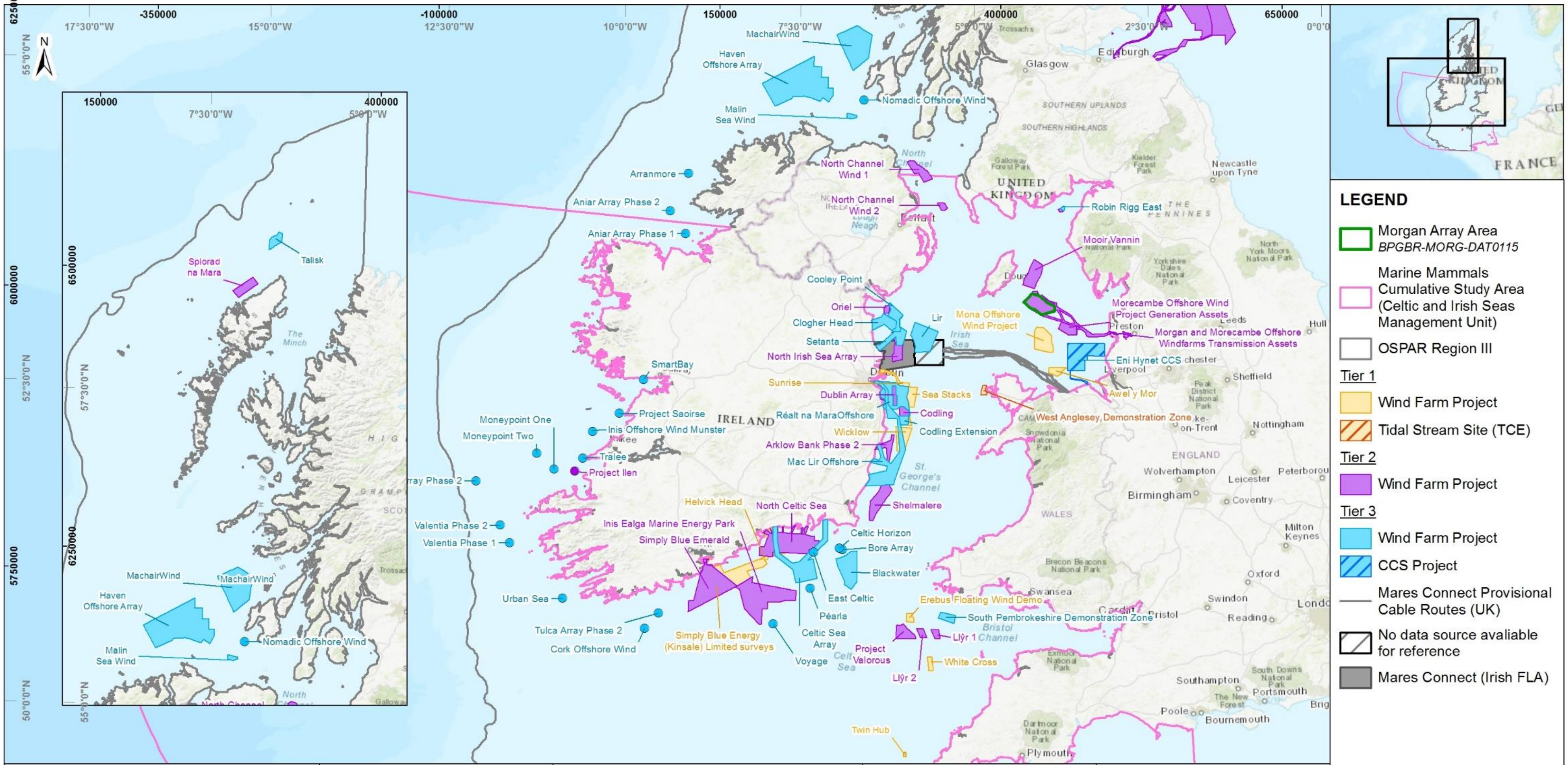
Project/Plan name	Status	Distance from the Morgan Array Area (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Morgan Generation Assets
						Morgan Generation Assets to overlap with construction and/or operational activities at South Pembrokeshire Demonstration Zone.
East Celtic*	Pre-application	290.7	Offshore wind farm	Unknown	2030 to unknown	There is potential for construction and operational activities at the Morgan Generation Assets to overlap with construction and operational activities at East Celtic.
Aniar Offshore Array Phase 1 (Fixed)*	Pre-application	307.3	Offshore wind farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Aniar Offshore Array (Fixed).
Péarla Offshore Wind Farm*	Pre-application	317.5	Offshore wind farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Péarla Offshore Wind Farm.
Arranmore offsjore wind project*	Pre-application	319.8	Offshore wind farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction

Project/Plan name	Status	Distance from the Morgan Array Area (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Morgan Generation Assets
						and/or operational activities at Arranmore.
Aniar Offshore Array Phase 2 (Floating) *	Pre-application	325.4	Floating Offshore Wind Farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Aniar Offshore Array (Floating).
Voyage Offshore Array*	Pre-application	362.9	Floating Offshore Wind Farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Voyage Offshore Array.
Project Saoirse	Pre-application	373.5	Wave energy demonstration project	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Project Saoirse.
Inis Offshore Wind Munster	Pre-application	383.0	Offshore wind farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Inis Offshore Wind Munster.

Project/Plan name	Status	Distance from the Morgan Array Area (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Morgan Generation Assets
Tralee*	Pre-application	416.5	Offshore wind farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Tralee.
Tulca Offshore Array Phase 2*	Pre-application	427.2	Offshore wind farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Tulca Offshore Array Phase 2.
Moneypoint Offshore One*	Pre-application	443.9	Offshore wind farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Moneypoint Offshore One.
Cork Offshore Wind Project	Pre-application	445.4	Offshore wind farm	2028 to 2029	2030 to unknown	There is potential for construction and operational activities at the Morgan Generation Assets to overlap with construction and operational activities at Cork Offshore Wind Project.
Urban Sea*	Pre-application	488.4	Floating Offshore Wind Farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets

Project/Plan name	Status	Distance from the Morgan Array Area (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Morgan Generation Assets
						to overlap with construction and/or operational activities at Urban Sea.
Rian Offshore Array Phase 1*	Pre-application	488.8	Floating Offshore Wind Farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Rian Offshore Array Phase 1.
Valentia Phase 1*	Pre-application	505.8	Floating Offshore Wind Farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Valentia Phase 1.
Valentia Phase 2*	Pre-application	506.8	Floating Offshore Wind Farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Valentia Phase 2.
Rian Offshore Array Phase 2*	Pre-application	513.4	Floating Offshore Wind Farm	Unknown	Unknown	There is potential for construction and/or operational activities at the Morgan Generation Assets to overlap with construction and/or operational activities at Rian Offshore Array Phase 2.

Project/Plan name	Status	Distance from the Morgan Array Area (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Morgan Generation Assets
Talisk*	Pre-application	537.0	Floating Offshore Wind Farm	2028 to 2029	2030 to unknown	There is potential for construction and operational activities at the Morgan Generation Assets to overlap with construction and operational activities at Talisk.



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Project Name: MORGAN OFFSHORE WIND PROJECT	Drawing Title: OTHER PROJECTS, PLANS AND ACTIVITIES SCREENED INTO THE CEA WITH DIRECT IMPACTS ON MARINE MAMMALS	Drawing Number: RPSE-MG-ES-MAM-E013-02	

VER	DATE	DETAILS	BY	CHECK
00	15/11/23	First Issue	MJ	LB
02	26/02/24	Revision	NG	LB

Figure 4.26: Other projects, plans and activities screened into the CEA with direct impacts on marine mammals.

[1] Point data has been used for some projects where further details (such as an area of search) are not available.

Table 4.51: Temporal time scale for potential cumulative projects with direct impacts on marine mammals.

Cells shaded in blue refer to construction not started, green refer to construction phase, grey to operations and maintenance phase.

Project	Distance from the Morgan Array Area (km)	2024	2025	2026	2027	2028	2029	2030 onward	Operational end date
Tier 1									
Morgan Generation Assets	N/A				**Piling**	**Piling**			2064
Mona Offshore Wind Project	11.1				**Piling**	**Piling**			2064
Awel y Môr	46.8					**Piling**			2055
West Anglesey Demonstration Zone	79.3								2061
Project Erebus	289.9		**Piling**	**Piling**					2052
White Cross Offshore Wind Farm	319.6			**Piling**	**Piling**				Unknown
Twin Hub	407.7								Unknown
Tier 2									
Arklow Bank Wind Park Phase 2	107.6	Unknown							
Codling Wind Park Offshore Wind Farm	141.2	Unknown							
Dublin Array Offshore Wind Farm	134.4								
Eni Hynet CCS	31.0	Unknown							
Inis Ealga Marine Energy Park	327.0								
Llŷr 1	298.5								
Llŷr 2	295.0								
North Celtic Sea Offshore Wind Farm	277.0	Unknown							

Partners in UK offshore wind

MORGAN OFFSHORE WIND PROJECT: GENERATION ASSETS

Project	Distance from the Morgan Array Area (km)	2024	2025	2026	2027	2028	2029	2030 onward	Operational end date
North Channel Wind 1	135.0								
North Channel Wind 2	107.2								
North Irish Sea Array Offshore Wind Farm	107.6								
Mooir Vannin Offshore Wind Farm	4.8								
Morecambe Generation Assets	11.2				Piling	Piling			2089
Morgan and Morecambe Offshore Wind Farms: Transmission Assets	0.0				Piling	Piling			2064
Oriel Offshore Wind Farm	119.4	Unknown							
Project Ilen	427.4	Unknown							
Project Valorous	170.5								
Shelmalere Offshore Wind Farm	201.4								2055
Simply Blue Emerald	359.2	Unknown							
Spiorad na Mara – Offshore Wind Project*	530.3	Unknown							
Tier 3									
Aniar Offshore Array (Fixed)*	307.3	Unknown							
Aniar Offshore Array (Floating)*	325.4	Unknown							
Arranmore*	319.8	Unknown							
Blackwater Offshore Wind Farm	266.0								
Bore Array*	272.9								
Celtic Horizon*	273.6								

Partners in UK offshore wind

MORGAN OFFSHORE WIND PROJECT: GENERATION ASSETS

Project	Distance from the Morgan Array Area (km)	2024	2025	2026	2027	2028	2029	2030 onward	Operational end date
Celtic Sea Array Offshore Wind Farm	260.8								
Clogher Head Offshore Wind Farm	114.3	Unknown							
Codling Wind Park Extension Offshore Wind Farm	141.2	Unknown							
Cooley Point Offshore Wind Farm	108.1	Unknown							
Cork Offshore Wind Project	445.4	Unknown							
East Celtic*	290.7	Unknown							
Eni Hynet CCS	31.0	Unknown							
Haven Offshore Array Wind Farm	248.0	Unknown							
Inis Offshore Wind Munster	383.0	Unknown							
Lir Offshore Array*	80.5	Unknown							
Machair Wind – Hybrid Energy Project	255.0	Unknown							
Mac Lir*	143.9								
Malin Sea Wind	225.84	Unknown							
MaresConnect	48.2								
Moneypoint Offshore One*	443.9	Unknown							
Nomadic Offshore Wind*	227.3	Unknown							
Péarla Offshore Wind Farm*	317.5	Unknown							
Project Saoirse	373.5	Unknown							
Realt na Mara*	127.1								

Partners in UK offshore wind

Project	Distance from the Morgan Array Area (km)	2024	2025	2026	2027	2028	2029	2030 onward	Operational end date
Rian Offshore Array Phase 1*	488.8	Unknown							
Rian Offshore Array Phase 2*	513.4	Unknown							
Setanta Offshore Wind Project	107.6								
Talisk*	537.0								
Tralee*	416.5	Unknown							
Tulca Offshore Array Phase 2*	427.2	Unknown							
Urban Sea*	488.4	Unknown							
Valentia Phase 1*	505.8	Unknown							
Valentia Phase 2*	506.8	Unknown							
Voyage Offshore Array*	362.9	Unknown							

4.10.2 Maximum design scenario

4.10.2.1 The MDS identified in section 4.7.1 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. The cumulative effects presented and assessed in this section have been selected from the Project Design Envelope provided in Volume 1, Chapter 3: Project description, of the Environmental Statement as well as the information available on other projects and plans, in order to inform an MDS. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the Project Design Envelope (e.g. different wind turbine layout), to that assessed here, be taken forward in the final design scheme.

4.10.2.2 Some of the potential impacts considered within the Morgan Generation Assets alone assessment are specific to a particular phase of development (e.g. construction, operations and maintenance or decommissioning). Where there is no spatial or temporal overlap with the activities during certain phases of the Morgan Generation Assets, potential impacts associated with other projects listed in Table 4.50, may be excluded from further consideration.

4.10.2.3 The assessment of cumulative effects with relevant projects is based on information available in the public domain. Only potential impacts screened in for the assessment for Morgan Generation Assets alone are considered (Table 4.16). In this regard, where an impact has been considered in the relevant projects' Environmental Statement (Tier 1 projects) or screened in as a result of inclusion in the available scoping report (Tier 2 projects), a potential for cumulative effects is considered and the impact will be considered further in section 4.11. potential impacts scoped out from individual assessments of respective projects or from the Morgan Generation Assets alone assessment are not considered further. An example of an impact that is scoped out from further assessment is underwater sound from wind turbine operation, as this impact has not been scoped into any of the assessments of projects listed in Table 4.50 for which operations and maintenance phase overlaps with the operations and maintenance phase of the Morgan Generation Assets. Projects with available temporal information are listed out in individual bullet points in the MDS in Table 4.52.

4.10.2.4 Given the limited data on Tier 3 projects available at the time of writing, projects were screened in initially based on temporal and/or spatial overlap as a precautionary approach. However, there is limited/no information on the construction/operation dates, nor foundation types proposed, with which to undertake any kind of meaningful assessment. Therefore, for potential impacts arising from piling for example, which require more detailed parameters, there is not sufficient information to carry out a quantitative assessment.

Table 4.52: Maximum design scenario considered for the assessment of potential cumulative effects on marine mammals.

[a] C=construction, O=operations and maintenance, D=decommissioning

*These offshore wind projects are only included in the grey seal extended screening area (OSPAR region III) and lie outside of the CIS MU screening area.

Potential cumulative effect	Phase[a]			Maximum Design Scenario	Justification
	C	O	D		
Injury and disturbance from underwater sound generated during piling	✓	×	×	Maximum design scenario as described for the Morgan Generation Assets (Table 4.16) assessed cumulatively with the following other projects/plans: **Tier 1** • Awel y Môr Offshore Wind Farm • Project Erebus • Mona Offshore Wind Project • White Cross Offshore Wind Farm. **Tier 2** • Dublin Array Offshore Wind Farm • Inis Ealga Marine Energy Park • Llŷr 1 • Llŷr 2 • Morecambe Generation Assets • Morgan and Morecambe Offshore Wind Farms: Transmission Assets • North Channel Wind 1 • North Channel Wind 2 • North Irish Sea Array Offshore Wind Farm • Project Valorous • Shelmalere Offshore Wind Farm • Spiorad na Mara – Offshore Wind Project*	The ZoI for pile driving can extend beyond the boundaries of proposed projects listed in Table 4.50 and therefore, adopting a precautionary approach, the assessment has screened in projects within the CIS MU whose construction phases overlap temporally with the construction phase for the Morgan Generation Assets. Projects whose construction phase finishes in a year preceding the commencement of construction phase at the Morgan Generation Assets (2025) were screened in as the sequential piling at respective projects could lead to a longer duration of impact. MDS for each project is presented in section 4.11.1.

Potential cumulative effect	Phase[a] C	O	D	Maximum Design Scenario	Justification
				• Projects with no temporal information available: Arklow Bank Wind Park Phase 2, Codling Wind Park Offshore Wind Farm, North Celtic Sea Offshore Wind Farm, Oriel Offshore Wind Farm, Project Ilen, Simply Blue Emerald. **Tier 3** • Blackwater Offshore Wind Farm • Celtic Sea Array Offshore Wind Farm • Bore Array • Celtic Horizon • Cork Offshore Wind Project • Mac Lir • Talisk* • Realt na Mara • Setanta Offshore Wind Project • MaresConnect • Projects with no temporal information available: Aniar Offshore Array (Fixed), Aniar Offshore Array (Floating), Arranmore, Clogher Head Offshore Wind Farm, Codling Wind Park Extension Offshore Wind Farm, Cooley Point Offshore Wind Farm, Inis Offshore Wind Munster, East Celtic, Haven Offshore Array Wind Farm, Lir Offshore Array, Machair Wind – Hybrid Energy Project, Malin Sea Wind, Moneypoint Offshore One, Nomadic Offshore Wind, Péarla Offshore Wind Farm, Project Saoirse, Rian Offshore Array Phase 1, Rian Offshore Array Phase 2, South Pembrokeshire Demonstration Zone, Tralee, Tulca Offshore Array Phase 2, Urban Sea, Valentia Phase 1, Valentia Phase 2 and Voyage Offshore Array.	
Injury and disturbance from elevated underwater sound	✓	×	×	Maximum design scenario as described for the Morgan Generation Assets (Table 4.16) assessed cumulatively with the following other projects/plans:	Though none of the Tier 1 wind projects assessed pre-construction site surveys as an effect pathway, a

Potential cumulative effect	Phase[a] C	O	D	Maximum Design Scenario	Justification
generated from site investigation survey sources				**Tier 1** • Mona Offshore Wind project. There are up to 14 Tier 1 site investigation surveys identified in the CEA screening area for marine mammals: • ESB Celtic Offshore Wind - Site Investigations off Waterford and Cork • ESB Wind Development Limited Site Investigations at Sea Stacks Offshore Wind off Dublin and Wicklow • ESB Wind Development Limited Site Investigations off Waterford and Cork Coasts - Helvick Head Offshore Wind • Mainstream, Renewable Power Ltd- Site Investigations off Co, Dublin • RWE Renewables Ireland Site Investigations for Dublin Array Offshore Wind Farm • Shelmalere Offshore Wind Farm - Site Investigations off Counties Wexford and Wicklow • Site Investigations for proposed Wicklow Project Offshore Wind Farm, off Counties Wicklow and Dublin • Site Investigations for the proposed Kinsale Project offshore wind farm, off County Cork • Site Investigations for the proposed Sunrise Offshore Wind Farm, off Counties Dublin and Wicklow • Site Investigations for the proposed Wicklow Project offshore wind farm, off County Wicklow • SSE Renewables Celtic Sea surveys • Statkraft North Irish Sea Array (NISA) Site Investigations • Simply Blue Energy (Kinsale) Limited surveys.	quantitative approach has been taken to Tier 1 projects to allow assessment of this impact. Whilst there are 14 Tier 1 site-investigation surveys identified in the screening process, there are limitations on the number of survey vessels that could carry out such surveys at one time and therefore highly unlikely that all would overlap temporally. Potentially up to 14 site-investigations were identified during screening, within the CIS MU. Surveys typically occur over short durations (typically up to 2 months) (based on expert judgment). Therefore as a conservative approach it is assumed as a worst case scenario that up to two surveys (in addition) could overlap with the Morgan site-investigation surveys, as agreed with the marine mammal EWG (September 2023, technical note; see Table 4.5. MDS for each project is presented in section 4.11.3.
Injury and disturbance from underwater sound from UXO detonation	✓	×	×	Maximum design scenario as described for the Morgan Generation Assets (Table 4.16) assessed cumulatively with the following other projects/plans:	The ZoI for UXO clearance can extend beyond the boundaries of other proposed offshore wind farms. Therefore, of proposed projects listed in Table 4.50, the

Potential cumulative effect	Phase[a] C	O	D	Maximum Design Scenario	Justification
				Tier 1 • Awel y Môr Offshore Wind Farm • Project Erebus • Mona Offshore Wind Project • White Cross Offshore Wind Farm. **Tier 2** • Inis Ealga Marine Energy Park • Llŷr 1 • Llŷr 2 • Morecambe Generation Assets • North Channel Wind 1 • North Channel Wind 2 • Project Valorous • Shelmalere Offshore Wind Farm • Projects with no temporal information available: Codling Wind Park Offshore Wind Farm, North Celtic Sea Offshore Wind Farm, Project Ilen, Simply Blue Emerald. **Tier 3** • Blackwater Offshore Wind Farm • Celtic Sea Array Offshore Wind Farm • Bore Array • Celtic Horizon • Cork Offshore Wind Project • Mac Lir	cumulative assessment has screened in projects within the CIS MU whose construction phases (which would include pre-construction UXO clearance) overlap temporally with the construction phase for the Morgan Generation Assets. Note, projects with completed UXO clearance campaigns are screened out of the assessment. Projects whose construction phase finishes in a year preceding the commencement of construction phase at the Morgan Generation Assets (2025) were screened in as the sequential UXO clearance at respective projects could lead to a longer duration of impacts affecting marine mammals. MDS for each project is presented in section 4.11.2.

Potential cumulative effect	Phase[a] C	O	D	Maximum Design Scenario	Justification
				• Talisk* • Realt na Mara • Setanta Offshore Wind Project • MaresConnect • Projects with no temporal information available: Aniar Offshore Array (Fixed), Aniar Offshore Array (Floating), Arranmore, Clogher Head Offshore Wind Farm, Codling Wind Park Extension Offshore Wind Farm, Cooley Point Offshore Wind Farm, Eni Hynet CCS, Inis Offshore Wind Munster, East Celtic, Haven Offshore Array Wind Farm, Lir Offshore Array, Machair Wind – Hybrid Energy Project, Malin Sea Wind, Moneypoint Offshore One, Nomadic Offshore Wind, Péarla Offshore Wind Farm, Project Saoirse, Rian Offshore Array Phase 1, Rian Offshore Array Phase 2, South Pembrokeshire Demonstration Zone, Tralee, Tulca Offshore Array Phase 2, Urban Sea, Valentia Phase 1, Valentia Phase 2 and Voyage Offshore Array.	
Disturbance from vessel use and other (non-piling) sound producing activities	✓	✓	✓	**Construction:** Maximum design scenario as described for the Morgan Generation Assets (Table 4.16) assessed cumulatively with the following other projects/plans: **Tier 1** • Awel y Môr • Project Erebus • West Anglesey Demonstration Zone tidal site • Mona Offshore Wind Project • White Cross Offshore Wind Farm • Twin Hub. **Tier 2**	It is expected that each project will contribute to the increase of vessel traffic and hence to the amount of sound from vessel traffic in the environment during the construction, operations and maintenance and decommissioning phases. Therefore, of proposed projects listed in Table 4.50, the cumulative assessment has screened in projects within the CIS MU whose construction, operations and maintenance and decommissioning phases overlap temporally with the construction, operations and maintenance and decommissioning phases for the Morgan Generation Assets. MDS for each project is presented in section 4.11.3.

Potential cumulative effect	Phase[a]			Maximum Design Scenario	Justification
	C	O	D		
				• Arklow Bank Wind Park Phase 2 • Codling Wind Park Offshore Wind Farm • Dublin Array Offshore Wind Farm • Inis Ealga Marine Energy Park • Llŷr 1 • Llŷr 2 • Morecambe Offshore Windfarm Generation Assets • North Celtic Sea Offshore Wind Farm • North Channel Wind 1 • North Channel Wind 2 • North Irish Sea Array Offshore Wind Farm • Oriel Offshore Wind Farm • Project Valorous • Shelmalere Offshore Wind Farm • Simply Blue Emerald • Wind Project Ilen. **Tier 3** • Blackwater Offshore Wind Farm • Celtic Sea Array Offshore Wind Farm • Bore Array • Celtic Horizon • Cork Offshore Wind Project • Mac Lir • Talisk* • Realt na Mara	

Potential cumulative effect	Phase[a] C	O	D	Maximum Design Scenario	Justification
				• Setanta Offshore Wind Project • MaresConnect Projects with no temporal information available: Aniar Offshore Array (Fixed), Aniar Offshore Array (Floating), Arranmore, Clogher Head Offshore Wind Farm, Codling Wind Park Extension Offshore Wind Farm, Cooley Point Offshore Wind Farm, Eni Hynet CCS, Inis Offshore Wind Munster, East Celtic, Haven Offshore Array Wind Farm, Lir Offshore Array, Machair Wind – Hybrid Energy Project, Malin Sea Wind, Moneypoint Offshore One, Nomadic Offshore Wind, Péarla Offshore Wind Farm, Project Saoirse, Rian Offshore Array Phase 1, Rian Offshore Array Phase 2, South Pembrokeshire Demonstration Zone, Tralee, Tulca Offshore Array Phase 2, Urban Sea, Valentia Phase 1, Valentia Phase 2 and Voyage Offshore Array. **Operations and maintenance:** Maximum design scenario as described for the Morgan Generation Assets (Table 4.16) assessed cumulatively with the following other projects/plans: **Tier 1** • Awel y Môr • Project Erebus • West Anglesey Demonstration Zone tidal site • Mona Offshore Wind Project • White Cross Offshore Wind Farm • Twin Hub. **Tier 2** • Arklow Bank Wind Park Phase 2 • Codling Wind Park Offshore Wind Farm	

Potential cumulative effect	Phase[a] C	O	D	Maximum Design Scenario	Justification
				• Dublin Array Offshore Wind Farm • Inis Ealga Marine Energy Park • Llŷr 1 • Llŷr 2 • Morecambe Offshore Windfarm Generation Asset • Mooir Vannin Offshore Wind Farm • North Channel Wind 1 • North Channel Wind 2 • North Irish Sea Array Offshore Wind Farm • Oriel Offshore Wind Farm • Project Valorous • Shelmalere Offshore Wind Farm • Projects with no temporal information available: Oriel Offshore Wind Farm, Arklow Bank Wind Park Phase 2, Simply Blue Emerald, Wind Project Ilen and North Celtic Sea Offshore Wind Farm,. **Tier 3** • Blackwater Offshore Wind Farm • Celtic Sea Array Offshore Wind Farm • Bore Array • Celtic Horizon • Cork Offshore Wind Project • Mac Lir • Talisk* • Realt na Mara • Setanta Offshore Wind Project	

Potential cumulative effect	Phase[a] C	O	D	Maximum Design Scenario	Justification
				• MaresConnect • Projects with no temporal information available: Aniar Offshore Array (Fixed), Aniar Offshore Array (Floating), Arranmore, Clogher Head Offshore Wind Farm, Codling Wind Park Extension Offshore Wind Farm, Cooley Point Offshore Wind Farm, Eni Hynet CCS, Inis Offshore Wind Munster, East Celtic, Haven Offshore Array Wind Farm, Lir Offshore Array, Machair Wind – Hybrid Energy Project, Malin Sea Wind, Moneypoint Offshore One, Nomadic Offshore Wind, Péarla Offshore Wind Farm, Project Saoirse, Rian Offshore Array Phase 1, Rian Offshore Array Phase 2, South Pembrokeshire Demonstration Zone, Tralee, Tulca Offshore Array Phase 2, Urban Sea, Valentia Phase 1, Valentia Phase 2 and Voyage Offshore Array, South Pembrokeshire Demonstration Zone. **Decommissioning:** *There are currently no known projects which will result in a cumulative effect during this phase of the Morgan Generation Assets.*	
Injury due to increased likelihood of collision with vessels	✓	✓	✓	**Construction:** Maximum design scenario as described for the Morgan Generation Assets (Table 4.16) assessed cumulatively with the following other projects/plans: **Tier 1** • Awel y Môr • Project Erebus • West Anglesey Demonstration Zone tidal site • Mona Offshore Wind Project • White Cross Offshore Wind Farm.	It is expected that each project will contribute to the increase of vessel traffic and hence to the potential likelihood of collision during the construction, operations and maintenance and decommissioning phases. However, the risk of collision would be expected to be localised to within the close vicinity of the respective projects. Nevertheless, of proposed projects listed in Table 4.50, the cumulative assessment has screened in projects within the CIS MU whose construction, operations and decommissioning phases overlap temporally with the construction, operations and maintenance and decommissioning phases for the Morgan Generation Assets. MDS for each project is presented in section 4.11.5.

Potential cumulative effect	Phase[a] C	O	D	Maximum Design Scenario	Justification
				Tier 2 • Arklow Bank Wind Park Phase 2 • Codling Wind Park Offshore Wind Farm • Dublin Array Offshore Wind Farm • Inis Ealga Marine Energy Park • Llŷr 1 • Llŷr 2 • Morecambe Offshore Windfarm Generation Asset • North Channel Wind 1 • North Channel Wind 2 • North Irish Sea Array Offshore Wind Farm • Oriel Offshore Wind Farm • Project Valorous • Shelmalere Offshore Wind Farm • Projects with no temporal information available: Oriel Offshore Wind Farm, Arklow Bank Wind Park Phase 2, Simply Blue Emerald, Wind Project Ilen, North Celtic Sea Offshore Wind Farm. **Tier 3** • Blackwater Offshore Wind Farm • Celtic Sea Array Offshore Wind Farm • Bore Array • Celtic Horizon • Cork Offshore Wind Project • Mac Lir • Talisk*	

Potential cumulative effect	Phase[a]			Maximum Design Scenario	Justification
	C	O	D		
				• Realt na Mara • Setanta Offshore Wind Project • MaresConnect Projects with no temporal information available: Aniar Offshore Array (Fixed), Aniar Offshore Array (Floating), Arranmore, Clogher Head Offshore Wind Farm, Codling Wind Park Extension Offshore Wind Farm, Cooley Point Offshore Wind Farm, Inis Offshore Wind Munster, East Celtic, Haven Offshore Array Wind Farm, Lir Offshore Array, Machair Wind – Hybrid Energy Project, Malin Sea Wind, Moneypoint Offshore One, Nomadic Offshore Wind, Péarla Offshore Wind Farm, Project Saoirse, Rian Offshore Array Phase 1, Rian Offshore Array Phase 2, South Pembrokeshire Demonstration Zone, Tralee, Tulca Offshore Array Phase 2, Urban Sea, Valentia Phase 1, Valentia Phase 2 and Voyage Offshore Array. **Operations and maintenance:** Maximum design scenario as described for the Morgan Generation Assets (Table 4.16) assessed cumulatively with the following other projects/plans: **Tier 1** • Awel y Môr • Project Erebus • West Anglesey Demonstration Zone tidal site • Mona Offshore Wind Project • White Cross Offshore Wind Farm. **Tier 2** • Arklow Bank Wind Park Phase 2 • Codling Wind Park Offshore Wind Farm	

Potential cumulative effect	Phase[a] C	O	D	Maximum Design Scenario	Justification
				• Dublin Array Offshore Wind Farm • Inis Ealga Marine Energy Park • Llŷr 1 • Llŷr 2 • Morecambe Offshore Windfarm Generation Assets • Mooir Vannin Offshore Wind Farm • North Channel Wind 1 • North Channel Wind 2 • North Irish Sea Array Offshore Wind Farm • Oriel Offshore Wind Farm • Project Valorous • Shelmalere Offshore Wind Farm • Oriel Offshore Wind Farm • Arklow Bank Wind Park Phase 2 • Simply Blue Emerald • Wind Project Ilen • North Celtic Sea Offshore Wind Farm. **Tier 3** • Blackwater Offshore Wind Farm • Celtic Sea Array Offshore Wind Farm • Bore Array • Celtic Horizon • Cork Offshore Wind Project • Mac Lir • Talisk*	

Potential cumulative effect	Phase[a]			Maximum Design Scenario	Justification
	C	O	D		
				• Realt na Mara • Setanta Offshore Wind Project • MaresConnect Projects with no temporal information available: Aniar Offshore Array (Fixed), Aniar Offshore Array (Floating), Arranmore, Clogher Head Offshore Wind Farm, Codling Wind Park Extension Offshore Wind Farm, Cooley Point Offshore Wind Farm, Inis Offshore Wind Munster, East Celtic, Haven Offshore Array Wind Farm, Lir Offshore Array, Machair Wind – Hybrid Energy Project, Malin Sea Wind, Moneypoint Offshore One, Nomadic Offshore Wind, Péarla Offshore Wind Farm, Project Saoirse, Rian Offshore Array Phase 1, Rian Offshore Array Phase 2, South Pembrokeshire Demonstration Zone, Tralee, Tulca Offshore Array Phase 2, Urban Sea, Valentia Phase 1, Valentia Phase 2 and Voyage Offshore Array. **Decommissioning:** *There are currently no known projects which will result in a cumulative effect during this phase of the Morgan Generation Assets.*	

Potential cumulative effect	Phase[a]			Maximum Design Scenario	Justification
	C	O	D		
Effects on marine mammals due to changes in prey availability	✓	✓	✓	**Construction:** Maximum design scenario as described for the Morgan Generation Assets (Table 4.16) assessed cumulatively with projects listed in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement. **Operations and maintenance:** Maximum design scenario as described for the Morgan Generation Assets (Table 4.16) assessed cumulatively with projects listed in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement. **Decommissioning:** Maximum design scenario as described for the Morgan Generation Assets (Table 4.16)) assessed cumulatively with projects listed in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement.	It is expected that potential cumulative effects on fish and shellfish communities, as identified in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement, may have indirect effects on marine mammals. For the purposes of the fish and shellfish ecology assessment of potential effects (i.e. in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement), cumulative effects have been assessed within a representative 50 km buffer from the Morgan Generation Assets. This 50 km buffer applies to all impacts considered in the fish and shellfish assessment, except underwater sound, where a larger buffer of 100 km has been used to account for the greater zone of influence associated with construction phase. For marine mammals, MDS for each project is presented in section 4.11.6.

4.11 Cumulative effects assessment

4.11.1.1 A description of the significance of cumulative effects upon marine mammal receptors arising from each identified impact is given below.

4.11.1.2 The CEA is presented in a series of tables (one for each potential cumulative impact), and considers the following:

- Scenario 1: Morgan Generation Assets together with the Morgan and Morecambe Offshore Wind Farms: Transmission Assets
- Scenario 2: Morgan Generation Assets together with the Morecambe Generation Assets and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets
- Tier 1, Tier 2 and Tier 3: Morgan Generation Assets together with the Morgan and Morecambe Offshore Wind Farms: Transmission Assets and other relevant projects and plans.

4.11.1 Injury and disturbance from elevated underwater sound during piling

4.11.1.1 As for the assessment of the Morgan Generation Assets alone, the risk of injury in terms of PTS to most of the marine mammal receptors, as a result of elevated underwater sound due to piling, would be expected to be localised to within the close vicinity of the respective projects. It is also anticipated that standard offshore wind industry mitigation and monitoring methods (which include soft starts and visual and acoustic monitoring of marine mammals as standard) will be applied during construction, thereby reducing the magnitude of impact. Therefore, there is very low potential for significant cumulative impacts for injury (PTS) from elevated underwater sound during pilling and the cumulative assessment focuses on disturbance only.

4.11.1.2 A full assessment of the cumulative impacts of injury and disturbance from elevated underwater sound during piling has been conducted and is presented in Appendix A, section A.1 *et seq.* A summary of the assessment has been presented below in Table 4.53.

Table 4.53: Injury and disturbance from elevated underwater sound during piling.

Morgan and Morecambe Offshore Wind Farms: Transmission Assets is referred to as 'Transmission Assets'

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
Construction			
Magnitude of impact	The cumulative effects assessment for Scenario 1 considers the following: • Disturbance of animals as a result of piling at projects under Scenario 1 • Where cumulative numbers of animals potentially disturbed are presented, the numbers are summed • One OSP is considered under both the Morgan Generation Assets and Transmission Assets and therefore the number of days of piling and number of animals disturbed on each day of piling is conservative • Cumulative iPCoD modelling was conducted for Morgan Generation Assets and Transmission Assets for harbour porpoise, bottlenose dolphin, minke whale and grey seal to support the CEA • Given the overlap of projects and proximity of piling events, it is expected that animals would be disturbed over a very similar area and a large proportion of disturbance contours are predicted to overlap. Therefore, any cumulative disturbance numbers presented are likely to be overestimates • The area of strong disturbance is predicted to be larger compared to the Morgan Generation Assets alone and	The cumulative effects assessment for Scenario 2 considers the following: • Approach and overview assumptions in line with Scenario 1 • One OSP is considered under both the Morgan Generation Assets and Transmission Assets; and two OSPs are considered under both the Transmission Assets and the Morecambe Generation Assets applications • Cumulative iPCoD modelling was conducted for Morgan Generation Assets alongside the Transmission Assets and Morecambe Generation Assets for harbour porpoise, bottlenose dolphin, minke whale and grey seal to support the CEA. The cumulative impact is predicted to be of regional spatial extent, medium term duration and intermittent for all marine mammal species. The effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The cumulative impact is unlikely to lead to population-level consequences as a result of disturbance and the magnitude is therefore considered to be **low** for all marine mammal species.	The cumulative effects assessment for Scenario 3 considers the following: • Approach in line with Scenario 1 and Scenario 2. **Tier 1** • Tier 1 projects include Mona Offshore Wind Project, Awel y Môr Offshore Wind Farm, White Cross Offshore Wind Farm and Project Erebus • There is the potential for temporal overlap of Morgan Generation Assets with Mona Offshore Wind Project, Awel y Môr Offshore Wind Farm, White Cross Offshore Wind Farm, potentially resulting in a larger cumulative area of disturbance. Construction at Project Erebus will complete prior to commencement of piling at the Morgan Generation Assets. Therefore, whilst there will not be an increase in cumulative area of disturbance, temporally, Project Erebus would contribute to a slightly longer duration of piling. • Cumulative numbers of animals potentially disturbed are presented for the Morgan Generation Assets with Mona Offshore Wind Project, Awel y Môr Offshore Wind Farm and White Cross Offshore Wind

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
	cumulative piling will result in an increased duration of the impact and subsequently affect animals over longer timescales • It is considered that there is low potential for a long-term cumulative effects on marine mammals as a result of cumulative piling for Scenario 1. The cumulative impact is predicted to be of regional spatial extent, medium term duration and intermittent for all marine mammal species. The effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The cumulative impact is unlikely to lead to population-level consequences as a result of disturbance and the magnitude is therefore considered to be **low** for all marine mammal species.		Farm. These calculations take into account the timelines of respective projects; animals are likely to recover from disturbance between piling events therefore numbers of animals potentially disturbed at Project Erebus are not combined. • Population modelling was conducted for Morgan Generation Assets alongside all Tier 1 projects that fall within the relevant reference population areas: harbour porpoise (CIS MU), bottlenose dolphin (IS MU), minke whale (CGNS MU) and grey seal (GSRP). This meant that all Tier 1 projects were included for all species within the exception of bottlenose dolphin which included only Morgan Generation Assets alongside Mona Offshore Wind Project and Awel y Môr Offshore Wind Farm (within the IS MU). The cumulative impact is predicted to be of regional spatial extent, medium term duration and intermittent for all marine mammal species. The effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. For harbour porpoise, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal, the cumulative impact is unlikely to lead to population-level consequences as a result of disturbance and the magnitude is therefore considered to be **low.**

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			For bottlenose dolphin the cumulative impact could result in potential reductions to reproductive success for individuals within the Irish Sea MU population. Disturbance in offshore areas during piling could lead to a longer duration over which individuals may be displaced from key areas; cumulative piling has the potential to displace animals from important winter habitats in the vicinity of Liverpool Bay intermittently over 5 years. Based on the iPCoD modelling these changes are not enough to significantly affect the population trajectory over a generational scale (i.e. the trajectory falls within natural variation), however, there may be a small reduction in population size for the impacted population. In the context of a possible declining bottlenose dolphin Irish Sea MU population, which is relatively small (n= 293) the magnitude is conservatively, considered to be **medium.** **Tier 2** • Tier 2 projects (n = 19) considered are set out in Table 4.52 and in Appendix A, Table A. 4 • EIA Scoping Reports submitted for Tier 2 projects do not provide detailed information about impacts of underwater sound generated from piling and therefore it is not possible to undertake a full, quantitative assessment • Quantitative information is available for Tier 2 projects Transmission Assets and

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			Morecambe Generation Assets, and is provided under Scenario 1 and Scenario 2, and is therefore not reiterated here • Population modelling was conducted for Morgan Generation Assets alongside Tier 1 projects and Tier 2 projects, Transmission Assets and Morecambe Offshore Wind Farm Generation Assets, alongside, combined, for harbour porpoise, bottlenose dolphin, minke whale and grey seal. The results of the iPCoD modelling showed for all species modelled that there was no noticeable difference in the iPCoD model outputs with the addition of the Tier 2 projects, compared to Tier 1 projects • In the context of the wider available habitat within the cumulative marine mammal study area, it is not anticipated that cumulative piling will result in long-term population-level effects on any of the species, except for bottlenose dolphin. Whilst cumulative piling at Tier 2 projects could further contribute to the cumulative effects on bottlenose dolphin within the IS MU, at the time of writing, information is not available for other Tier 2 projects to provide quantification for this, for these projects. The cumulative impact is predicted to be of regional spatial extent, medium term duration and intermittent for all marine mammal species. The effect of behavioural disturbance is reversible. It is predicted that

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			the impact will affect the receptor directly. For harbour porpoise, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal, the cumulative impact is unlikely to lead to population-level consequences as a result of disturbance and the magnitude is therefore considered to be **low.** For bottlenose dolphin the cumulative impact could result in potential reductions to reproductive success during an animal's lifetime for the Irish Sea MU population. Disturbance in offshore areas during piling could lead to a longer duration over which individuals may be displaced from key areas; cumulative piling has the potential to displace animals from important winter habitats in the vicinity of Liverpool Bay intermittently over 5 years. Based on the iPCoD modelling these changes are not enough to significantly affect the population trajectory over a generational scale (i.e. the trajectory falls within natural variation), however, there may be a small reduction in population size for the impacted population. In the context of a small, possibly declining bottlenose dolphin Irish Sea MU population, the magnitude is conservatively, considered to be **medium.** **Tier 3** • Tier 3 projects screened into the assessment within the cumulative marine mammal study area are set out in Table 4.52 (n = 32) and include those projects which were screened in under the

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			extended CEA screening area for grey seal (OSPAR Region III) (n = 14) • However, grey seal telemetry data suggests connectivity to projects outside of the GSRP is unlikely and therefore there is limited potential for a receptor impact pathway • Projects were screened in precautionarily based on their location within the CEA screening area, though there is limited/no information on the construction/operation dates or project design with regards to piling. Whilst there is a potential for piling activities to be taking place intermittently across the Irish Sea and wider Celtic Sea, it was not possible to undertake any kind of meaningful assessment. As such the magnitude for Tier 1, Tier 2 and Tier 3 projects combined is concluded to be no different to the magnitude for Tier 1 and Tier 2 projects combined.
Sensitivity of receptor	The sensitivity of the different marine mammal key receptors to behavioural disturbance from elevated underwater sound due to piling is as described in paragraph 4.9.2.115 *et seq* for the Morgan Generation Assets alone and is not reiterate here. All marine mammal key receptors are deemed to have some resilience to behavioural disturbance, exhibit high recoverability and are considered of international value. The sensitivity of the receptor is therefore considered to be **medium.**		
Significance of effect	Overall, for all marine mammal species, the magnitude of the cumulative impact is low and the sensitivity of the receptor is medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant.	Overall, for all marine mammal species, the magnitude of the cumulative impact is low and the sensitivity of the receptor is medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant.	**Tier 1, Tier 2, Tier 3** Overall, for harbour porpoise, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal, the magnitude of the cumulative impact is low and the sensitivity of the receptor is medium. The cumulative effect will, therefore, be of

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			minor adverse significance, which is not significant. For bottlenose dolphin, the magnitude of the cumulative impact is medium and the sensitivity of the receptor is medium. The cumulative effect will, therefore, be of **moderate adverse** significance for the bottlenose dolphin IS MU population, which is significant in EIA terms. The applicant will seek to address this potential significant effect on the Irish Sea MU bottlenose dolphin population.
Further mitigation and residual significance	N/A	N/A	Whilst the project alone assessment determined there would be no significant effect in EIA terms for bottlenose dolphin, the Morgan Generation Assets may contribute to the cumulative impact in the context of the Irish Sea MU and therefore the Applicant has committed to the development of an Underwater sound management strategy (with an Outline underwater sound management strategy submitted as part of the application, Document Reference J13), secured in the deemed marine licences, to reduce the magnitude associated with significant impacts such that there will be no residual significant effect for the project alone. The Underwater sound management strategy (with an Outline underwater sound management strategy submitted as part of the application, Document Reference J13) will present a review of relevant mitigation options (such as NAS, temporal and spatial piling

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			restrictions, piling methods, soft start) in order to reduce the magnitude for the project alone, in order to minimise the contribution to any cumulative effect. In this case, relevant mitigation options may be applied to reduce the magnitude for bottlenose dolphin. The Underwater sound management strategy (Outline underwater sound management strategy, Document Reference J13) will be developed in consultation with the licensing authority and SNCBs post-consent.

4.11.2 Injury and disturbance from elevated underwater sound during UXO clearance

4.11.2.1 As for the assessment of the Morgan Generation Assets alone, the duration of impact (elevated underwater sound) for each UXO detonation is very short (seconds) but the elevations in subsea sound during clearance could potentially lead to PTS and behavioural effects. Given that there are no published thresholds for behavioural effects from UXO clearance, the use of the TTS-onset threshold was considered as a proxy for disturbance and referred to as such in this section) (see paragraph 4.9.3.19 for more details).

4.11.2.2 The cumulative assessment has not considered Morgan Generation Assets alongside both the Transmission Assets and Morecambe Offshore Windfarm Generation Assets (A.1.1.2.1 *et seq*) on the basis that the Transmission Assets PEIR already accounts for all UXO predicted to occur under the Morecambe Generation Assets application and therefore this would represent duplication. Scenario 1 (A.1.1.2.1 *et seq*) presents the assessment of Morgan Generation Assets alongside the Transmission Assets, and Scenario 2 presents the assessment of Morgan Generation Assets alongside relevant Tier 1, Tier 2 and Tier 3 projects (A.1.1.2.18 *et seq*).

4.11.2.3 A full assessment of the cumulative impacts of injury and disturbance from elevated underwater sound during UXO clearance has been conducted and is presented in Appendix A, section A.1.1.2. A summary of the assessment has been presented below in Table 4.54.

Table 4.54: Injury and disturbance from elevated underwater sound during UXO clearance.

Morgan and Morecambe Offshore Wind Farms: Transmission Assets is referred to as 'Transmission Assets'

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
Magnitude of impact	The cumulative effects assessment for Scenario 1 considers the following: • Number of UXO requiring clearing at each project: – 13 UXO at Morgan Generation Assets – 51 UXO at the Transmission Assets (13 of which are a double-count of UXO at Morgan Generation Assets; 38 of which are unique to Transmission Assets) • Both projects present a range of impacts for low order clearance as well as low-yield donor charges, however the assessment is based on high order clearance of 907 kg • Number of animals likely to experience PTS and behavioural disturbance (using TTS as a proxy) as a result of UXO clearance was established for both projects, with and without primary measures (for PTS) • The Transmission Assets PEIR, in line with the Morgan Generation Assets identified that clearance of UXO with an NEQ of 130 kg is considered the more likely (common) maximum scenario. As such, the numbers presented are expected to be highly precautionary. Proposed mitigation measures for UXO clearance include the application of a UXO-specific MMMP, using low order techniques, where possible, as the primary mitigation measure alongside other measures as may be agreed with Natural England and the MMO (such as including the use of MMObs, PAM and ADDs) • With primary measures in place the Transmission Assets PEIR found that there would be a residual risk of injury over a range of 2,290 m (based on clearance of 907 kg UXO) that would require additional tertiary measures and therefore the Transmission Assets will be adopting standard industry practice (JNCC, 2010b) tertiary measures as part of an	The cumulative effects assessment for Scenario 1 considers the following: **Tier 1** • Approach is as per Scenario 1 • Tier 1 projects assessed include Mona Offshore Wind Project, Awel y Môr Offshore Wind Farm, White Cross Offshore Wind Farm and Project Erebus • The number of UXO expected to require clearing, alongside a range of charge sizes and UXO sizes were presented for each project • Number of animals likely to experience PTS as a result of UXO clearance was presented for each project • Number of animals likely to experience behavioural disturbance as a result of UXO clearance was presented for each project. A number of approaches was applied including: – Using TTS as a proxy for disturbance – EDRs (for harbour porpoise) – 25 km disturbance ranges (for grey seal) • All projects set out intentions of implementing UXO-specific MMMPs • A spatial MDS would occur where UXO clearance activities coincide at the respective projects considered in the CEA. This is, however, highly unlikely, as due to safety reasons UXO clearance activities would take place before other construction activities commence. Sequential UXO clearance is therefore more likely for Tier 1 projects noting, however, that there may be some overlap in pre-construction activities of Mona Offshore Wind Project and Awel y Môr Offshore

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
	Outline MMMP (Document Reference J17), discussed and agreed with consultees post-consent • UXO clearance at both projects will occur as a discrete stage within the overall construction phase and therefore will not coincide continuously over the duration of temporal overlap. Furthermore, each clearance event results in a very short duration of sound emission (seconds) and therefore the impact will be short in duration and unlikely to overlap. <u>PTS</u> The magnitude of the cumulative impact is predicted to be of local to regional spatial extent, very short-term duration, intermittent and, although the impact itself is reversible (i.e. elevated underwater sound during the detonation event only), the effect of injury on sensitive receptors is permanent. It is predicted that the impact will affect the receptor directly. In line with UXO guidance (JNCC, 2010b), assuming standard industry measures applied for each project, it is anticipated that for most species animals would be deterred from the injury zone and therefore the risk of PTS would be reduced. The magnitude is therefore considered to be negligible for bottlenose dolphin, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal. For harbour porpoise, PTS ranges are large and there is considered to be a residual risk of PTS to a small number of individuals, even with the application of standard industry measures. The magnitude is therefore considered to be **medium**. <u>Behavioural disturbance (using TTS-onset as a proxy)</u> The magnitude of cumulative impact (elevated underwater sound due to UXO clearance) resulting from a high order detonation is predicted to be of regional spatial extent, short-term duration, intermittent and both the impact itself (i.e. elevated underwater sound during the detonation event only) and effect of behavioural disturbance is reversible. It is predicted	Wind Farm with Morgan Generation Assets, based on indicative construction timelines • UXO clearance at each of these projects will occur as a discrete stage within the overall construction phase and therefore will not coincide continuously over the duration of temporal overlap. Furthermore, each clearance event results in a very short duration of sound emission (seconds) and the impact will be short in duration and unlikely to overlap. <u>PTS</u> The magnitude of the cumulative impact is predicted to be of local to regional spatial extent, very short-term duration, intermittent and, although the impact itself is reversible (i.e. elevated underwater sound during the detonation event only), the effect of injury on sensitive receptors is permanent. It is predicted that the impact will affect the receptor directly. In line with UXO guidance (JNCC, 2010b), assuming standard industry measures applied for each project, it is anticipated that for most species animals would be deterred from the injury zone and therefore the risk of PTS would be reduced. The magnitude is therefore considered to be negligible for bottlenose dolphin, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal. For harbour porpoise, PTS ranges are large and there is considered to be a residual risk of PTS to a small number of individuals, even with the application of standard industry measures. The magnitude is therefore considered to be **medium**. <u>Behavioural disturbance (using TTS-onset as a proxy)</u> The magnitude of cumulative impact (elevated underwater sound due to UXO clearance) resulting from a high order detonation is predicted to be of regional spatial extent, short-term duration, intermittent and both the impact itself (i.e. elevated underwater sound during the detonation event only) and effect of behavioural disturbance is reversible. It is predicted

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
	that the impact will affect the receptor directly. The magnitude is therefore considered to be **low** for all species.	that the impact will affect the receptor directly. The magnitude is therefore considered to be **low** for all species. **Tier 2** • The assessment for Tier 2 projects, Transmission Assets and Morecambe Offshore Wind Farm Generation Assets are set out in Scenario 1 and Scenario 2 • For all other Tier 2 projects (set out in Table 4.52; n = 14), EIA Scoping Reports do not provide detailed information on UXO clearance activities. Projects screened in for this cumulative assessment are expected to involve similar construction activities to those described for the Morgan Generation Assets alone, including UXO clearance activities • Projects are likely to have effects similar to the Morgan Generation Assets and will likely have similar mitigation (e.g. MMMPs or separate marine licenses) to avoid injury; but at this stage a more detailed assessment cannot be presented • Adopting a precautionary approach, and assuming application of standard industry measures (such as MMObs, PAM and ADDs) measures, the assessment considered the magnitude of impact for a high order detonation. PTS The magnitude of the cumulative impact is predicted to be of local to regional spatial extent, very short-term duration, intermittent and, although the impact itself is reversible (i.e. elevated underwater sound during the detonation event only), the effect of injury on sensitive receptors is permanent. It is predicted that the impact will affect the receptor directly. In line with UXO guidance, assuming standard industry measures applied for each project, it is anticipated that for most species animals would be deterred from the injury zone and therefore the risk of PTS would be reduced. The magnitude is therefore considered to be negligible for bottlenose dolphin, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
		harbour seal. For harbour porpoise, PTS ranges are large and there is considered to be a residual risk of PTS to a small number of individuals, even with the application of standard industry measures. The magnitude is therefore considered to be **medium**. <u>Behavioural disturbance (using TTS-onset as a proxy)</u> The magnitude of cumulative impact resulting from a high order detonation is predicted to be of regional spatial extent, short-term duration, intermittent and both the impact itself (i.e. elevated underwater sound during the detonation event only) and effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low** for all species. **Tier 3** • The construction of the Morgan Generation Assets, together with construction phase of Tier 1, Tier 2 and Tier 3 projects may lead to cumulative injury and disturbance to marine mammals from underwater sound generated during UXO clearance • Tier 3 projects screened into the assessment (precautionarily based on their location) are set out in Table 4.52 (n = 12) • There is limited/no information on the construction/operation dates or whether UXO clearance will be considered in respective EIA assessments. Although temporal and/or spatial overlap with Tier 3 projects cannot be discounted, at current time it is not possible to undertake any kind of meaningful assessment. As such the magnitude for Tier 1, Tier 2 and Tier 3 projects combined is concluded to be no different to the magnitude for Tier 1 and Tier 2 projects combined.

<table>
<tr><th></th><th>Scenario 1
Morgan Generation Assets
+ Transmission Assets</th><th>Scenario 2:
Morgan Generation Assets + Transmission Assets
+ Tier 1, Tier 2, Tier 3 projects</th></tr>
<tr><td>Sensitivity of receptor</td><td colspan="2"><u>PTS</u>
As a result of UXO clearance, all marine mammals are deemed to have limited resilience, low recoverability and international value. The sensitivity of the receptors to PTS is therefore, considered to be high.
<u>Behavioural disturbance (using TTS-onset as a proxy)</u>
As a result of UXO clearance, all marine mammals are deemed to have some resilience, high recoverability and international value. The sensitivity of the receptor to TTS is therefore, considered to be low.</td></tr>
<tr><td>Significance of effect</td><td><u>PTS</u>
With tertiary measures applied, for bottlenose dolphin, short-beaked common dolphin, Risso’s dolphin, minke whale, grey seal and harbour seal the magnitude of the cumulative impact is deemed to be negligible and the sensitivity of the receptors is considered to be high. There is not anticipated to be any effect on the international value of these species. The cumulative effect will, therefore, be of minor adverse significance, which is not significant in EIA terms.
For harbour porpoise, with tertiary mitigation applied, the magnitude of the cumulative impact is deemed to be medium, and the sensitivity of the receptors is considered to be high. On the basis of high order detonation, there may be some residual effect with a small number of animals potentially exposed to sound levels that could elicit PTS. The cumulative effect will, therefore, be of moderate adverse significance, which is significant in EIA terms.
<u>Behavioural disturbance (using TTS-onset as a proxy)</u>
With standard industry measures applied, the magnitude of the cumulative impact for all species is deemed to be low and the sensitivity of the receptor is considered to be low. There is not anticipated to be any effect on the international value of any marine mammal species. The cumulative effect will, therefore, be of minor adverse significance, which is not significant in EIA terms.</td><td>Tier 1, Tier 2, Tier 3
<u>PTS</u>
With tertiary applied, for bottlenose dolphin, short-beaked common dolphin, Risso’s dolphin, minke whale, grey seal and harbour seal the magnitude of the cumulative impact is deemed to be negligible and the sensitivity of the receptors is considered to be high. There is not anticipated to be any effect on the international value of these species. The cumulative effect will, therefore, be of minor adverse significance, which is not significant in EIA terms.
For harbour porpoise, with tertiary mitigation applied, the magnitude of the cumulative impact is deemed to be medium, and the sensitivity of the receptors is considered to be high. On the basis of high order detonation, there may be some residual effect with a small number of animals potentially exposed to sound levels that could elicit PTS. The cumulative effect will, therefore, be of moderate adverse significance, which is significant in EIA terms.
<u>Behavioural disturbance (using TTS-onset as a proxy)</u>
With standard industry measures applied, the magnitude of the cumulative impact for all species is deemed to be low and the sensitivity of the receptor is considered to be low. There is not anticipated to be any effect on the international value of any marine mammal species. The cumulative effect will, therefore, be of minor adverse significance, which is not significant in EIA terms.</td></tr>
</table>

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
Further mitigation and residual significance	The Applicant has committed to the development of an Outline Underwater sound management strategy (Document Reference J13) (to be developed and agreed with stakeholders, post-consent) to reduce the magnitude of sound levels associated with significant impacts (see paragraphs A.1.1.2.16 and A.1.1.2.17)	With the aim to reduce any potential impact from the project alone, primary and tertiary mitigation measures adopted as part of the Morgan Generation Assets are detailed in the Outline MMMP (Document Reference J17) to reduce the potential residual risk of injury to marine mammals, and in particular to harbour porpoise. The applicant has also committed to an Underwater sound management strategy (with an Outline underwater sound management strategy included as part of the application, Document Reference J13) to reduce any potential residual effects from the project alone (see paragraphs A.1.1.2.66 and A.1.1.2.67)

4.11.3 Injury and disturbance from elevated underwater sound generated from site investigation survey sources

4.11.3.1 Pre-construction site investigation surveys will be undertaken to provide detailed information on seabed conditions and morphology, to identify the presence/absence of any potential obstructions or hazards and to verify the seabed geology layers. Pre-construction site investigation surveys are likely to include geophysical and geotechnical surveys which will be conducted within, and in the vicinity of, the footprint of the Morgan Array Area and for those projects outlined in Table 4.50.

4.11.3.2 Geophysical surveys and geotechnical surveys are detailed in section 4.9.6, presenting those commonly undertaken as best practice for offshore wind projects (note that the frequencies and sound levels for sonar equipment have been included based on Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement).

4.11.3.3 The risk of injury to marine mammal receptors in terms of PTS as a result of underwater sound due to site investigation surveys would be expected to be localised to within the close vicinity of the respective projects. The assessment for the Morgan Generation Assets found that the injury ranges are expected to be relatively small, and the magnitude of the impact has been conservatively assessed to be low (section 4.9.6). Therefore, there is very low potential for cumulative impacts for injury from elevated underwater sound due to site investigation surveys and the cumulative assessment provided in Table 4.55 focuses on disturbance only. Since the cumulative assessment focuses on behavioural disturbance as a result of site-investigation activities (with animals likely to recover within hours from the disturbance), where surveys were completed prior to the commencement of construction at Morgan Generation Assets, these were screened out from further consideration.

4.11.3.4 The impact of injury and disturbance from underwater sound generated from pre-construction survey sources was not presented in the Morecambe Generation Assets PEIR marine mammal chapter (Morecambe Offshore Wind Ltd, 2023). As such, the cumulative assessment has not considered Morgan Generation Assets alongside the Morecambe Generation Assets. Scenario 1 therefore presents the assessment of Morgan Generation Assets alongside the Transmission Assets, and Scenario 2 presents the assessment of Morgan Generation Assets alongside relevant Tier 1, Tier 2 and Tier 3 projects (Table 4.55).

Table 4.55: Injury and disturbance from elevated underwater sound generated from site investigation survey sources.

Morgan and Morecambe Offshore Wind Farms: Transmission Assets is referred to as 'Transmission Assets'

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
Magnitude of impact	The cumulative effects assessment for Scenario 1 considers the following: • The distance from the Morgan Generation Assets to the Transmission Assets; based on the overlap of the two projects, if pre-construction site investigation surveys were to temporally overlap, spatial overlap of disturbance ranges would occur. As such, animals are likely to be displaced from an area comparable to disturbance contours at the Morgan Generation Assets alone • Although the duration of site-investigation surveys is considered to be short term and localised for each project, surveys will occur intermittently over a number of years. The impact of site investigation surveys leading to behavioural effects is predicted to be of local to regional spatial extent, medium term duration, intermittent and high reversibility (elevated underwater sound occurs only during surveys). The effect of behavioural disturbance is reversible (with behavioural characteristics returning to baseline levels soon after surveys have ceased). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low.**	The cumulative effects assessment for Scenario 2 considers the following: **Tier 1** • Up to 14 Tier 1 site investigation surveys were identified in the CEA screening area for marine mammals, alongside Mona Offshore Wind Project • Surveys typically occur over short durations (up to two months). As a conservative approach it is assumed as a worst case scenario that up to two additional surveys could overlap with the Morgan Generation Assets site-investigation surveys at any one point (as agreed with the EWG, September 2023, technical note; Table 4.5). There are limitations on the number of survey vessels that could carry out such surveys at one time and therefore highly unlikely that all would overlap temporally • Disturbance ranges for Morgan Generation Assets alone for most site investigation equipment types was modelled at within 100s of meters. The greatest range was predicted for SBPs (17.3 km) • Based on the distance from the Morgan Generation Assets to the Mona Offshore Wind Project (11.1 km) if pre-construction site investigation surveys were to temporally overlap, spatial overlap of disturbance ranges could occur. As such, animals have the potential to be displaced from an area greater than the Morgan Generation Assets alone • Based on the distance from the Morgan Generation Assets to the identified 14 site investigation surveys

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
		(Table 4.50; minimum distance is 104.2 km at Mainstream Renewable Power Ltd- Site Investigations, off County Dublin), if pre-construction site investigation surveys were to temporally coincide with the Morgan Generation Assets disturbance contours are unlikely to overlap. This assumes the same disturbance ranges as Morgan Generation Assets and does not take into account differences in water column depth, pressure, temperature gradients, salinity as well as water surface and seabed conditions at the different site-investigation survey locations (see Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement for detail) • The duration of site-investigation surveys is considered to be short term and localised for each project. Surveys will occur intermittently over a number of years with isolated surveys occurring at different points in time throughout CEA screening area, though up to two are assumed to be occurring in addition to Morgan Generation Assets at the same time. The impact of site investigation surveys leading to behavioural effects is predicted to be of local to regional spatial extent, medium term duration, intermittent and high reversibility (elevated underwater sound occurs only during surveys). The effect of behavioural disturbance is reversible (with animals returning to baseline levels soon after surveys have ceased). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low**. **Tier 2** • Given the temporal overlap, the construction phase of the Morgan Generation Assets alongside Tier 1 projects and the Tier 2 project Transmission Assets (see Scenario 1) could

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
		lead to disturbance to marine mammals as a result of sound generated by pre-construction site investigation surveys • However, given the approach (described above for Scenario 2) to assessing two additional site investigation surveys alongside those for Morgan Generation Assets, the conclusions for Tier 1 and Tier 2 projects are the same • The duration of site-investigation surveys is considered to be short term and localised for each project. Surveys will occur intermittently over a number of years with isolated surveys occurring at different points in time throughout the cumulative marine mammal study area, though up to two are assumed to be occurring in addition to Morgan Generation Assets at the same time. **Tier 3** There is no spatial or temporal overlap of site investigation surveys during the construction phase of Morgan Generation Assets with survey activities associated with Tier 3 projects listed in Table 4.50, and therefore Tier 3 projects have been excluded from further consideration. The impact of site investigation surveys leading to behavioural effects is predicted to be of local to regional spatial extent, medium term duration, intermittent and high reversibility (elevated underwater sound occurs only during surveys). The effect of behavioural disturbance is reversible (with animals returning to baseline levels soon after surveys have ceased). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low**.

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
Sensitivity of receptor	The sensitivity of marine mammals to Injury and disturbance from elevated underwater sound generated from site investigation survey sources is as described in paragraph 4.9.6.18 for the Morgan Generation Assets alone. Marine mammal receptors are deemed to have some resilience, high recoverability and international value. The sensitivity of the receptors to disturbance from elevated underwater sound during pre-construction site investigation surveys is therefore considered to be **medium**.	
Significance of effect	Overall, the magnitude of the impact of disturbance is deemed to be low and the sensitivity of the receptor is considered to be medium. There would be no change to the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.	**Tier 1, Tier 2** Overall, the magnitude of the impact of disturbance is deemed to be low and the sensitivity of the receptor is considered to be medium. There would be no change to the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

4.11.4 Injury and disturbance from elevated underwater sound due to vessel use and other (non-piling) sound producing activities

4.11.4.1 As for the assessment of the Morgan Generation Assets alone, the risk of injury in terms of PTS to marine mammal receptors as a result of underwater sound due to vessel use and other (non-piling) sound producing activities would be expected to be very low. The assessment for Morgan Generation Assets alone (section 4.9.4) identified PTS thresholds were unlikely to be exceeded (paragraph 4.9.4.12) and therefore the magnitude of the impact and associated effect (PTS) occurring in marine mammals has been assessed as negligible. Given the above, there is very low potential for cumulative impacts to cause injury as a result of elevated underwater sound due to vessel use and other (non-piling) sound producing activities. Instead, the cumulative assessment focuses on disturbance only for this impact.

4.11.4.2 An assessment of the potential for cumulative impacts as a result of Injury and disturbance from elevated underwater sound due to vessel use and other (non-piling) sound producing activities has been presented for Morgan Generation Assets alongside relevant Tier 1, Tier 2 and Tier 3 projects in Table 4.56 below.

Table 4.56: Injury and disturbance from elevated underwater sound due to vessel use and other (non-piling) sound producing activities.

Morgan and Morecambe Offshore Wind Farms: Transmission Assets is referred to as 'Transmission Assets'

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
Construction phase			
Magnitude of impact	The cumulative effects assessment for Scenario 1 considers the following: • It is a standard practice that estimated ranges over which behavioural disturbance may occur are presented for different vessel types in isolation • For the Morgan Generation Assets, maximum disturbance ranges of up to approximately 3.6 km were predicted for survey vessel, support vessels, crew transfer vessel, scour/cable protection/seabed preparation and installation vessels. It is likely that several activities could be potentially occurring at the same time across the projects and therefore disturbance ranges may extend from several vessels/locations. However (as discussed in paragraphs 4.9.4.22 and 4.9.4.23) a range of distances from empirical studies (1 km to 7 km) were used as effective impact ranges • The Transmission Assets MDS identified: – up to 70 construction vessels on site at any one time – The greatest modelled disturbance range for vessels at the Transmission Assets was 20 km, for survey and support vessels, crew transfer vessels,	The cumulative effects assessment for Scenario 2 considers the following: • The approach is as per Scenario 1 • As per Scenario 1, a range of distances from empirical studies (1 km to 7 km) were used as effective impact ranges • The Morecambe Offshore Wind Farm Generation Assets MDS identified: – up to 30 vessels on site at any one time – The assessment of disturbance as a result of vessels considered the maximum number of vessels in the context of modelling undertaken by Heinänen and Skov (2015) (thresholds level, in terms of impact, equating to approximately two vessels per km²). The assessment concluded that the number of vessels would not exceed the Heinänen and Skov (2015) threshold, as 30 vessels within the windfarm site of 125 km² would equate to less than 0.24 vessels per km². As a precautionary approach the assessment for all species was based on a disturbance impact range of 2 km, based on studies by Brandt *et al.*	The cumulative effects assessment for Scenario 3 considers the following: **Tier 1** • The approach is as per Scenario 1 • As per Scenario 1, it is assumed that modelled disturbance distances are likely to be overestimated, as per Benhemma-Le Gall *et al.* (2021) (a decrease in porpoise activity in response to vessels beyond 4 km from the source) • Tier 1 projects (and respective distances from the Morgan Array Area) assessed include: Mona Offshore Wind Project (11.1 km); Awel y Môr Offshore Wind Farm (46.8 km); West Anglesey Demonstration Zone tidal site (79.3 km); Project Erebus (289.9 km); Twin Hub (407.7 km) and White Cross Offshore Wind Farm (319.6 km). • The Mona Offshore Wind Project MDS identified: – For the Mona Array Area, up to a total of 69 construction vessels on site at any one time. For the Mona Offshore Cable Corridor and Access Areas, up to a total of 17 construction vessels on site at any one time, and up to 12

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
	scour/cable protection and seabed preparation/installation vessels – Modelled disturbance ranges for cable trenching activities were 18 km • Introduction of vessels will not be a novel impact for marine mammals present in the area and therefore marine mammals are anticipated to demonstrate some degree of tolerance to sound from vessels (see discussion in paragraph 4.9.4.37) • Vessel activity is expected to be localised to each project, the duration of vessel activity is considered to be medium term (throughout the construction phase of the Morgan Generation Assets) and vessel movements will occur intermittently over a number of years • Whilst disturbance ranges such as 7 km could potentially affect animals over regional scales, many vessels associated with the construction of the Morgan Generation Assets are likely to also be associated with the construction of the Transmission Assets and therefore cumulative vessel numbers will not be significantly higher than the Morgan Generation Assets alone. As such, vessel numbers have not been summed, cumulatively. The cumulative impact is predicted to be of local to regional spatial extent, long term duration, intermittent and both the impact itself (i.e. elevated underwater sound due to vessel use) and effect of behavioural	(2018) and Benhemma-Le Gall *et al.* (2021) • Introduction of vessels will not be a novel impact for marine mammals present in the area and therefore marine mammals are anticipated to demonstrate some degree of tolerance to sound from vessels (see discussion in paragraph 4.9.4.37) • Vessel activity is expected to be localised to each project, the duration of vessel activity is considered to be medium term (throughout the construction phase of the Morgan Generation Assets) and vessel movements will occur intermittently over a number of years • Whilst disturbance ranges of up to 7 km could potentially affect animals over regional scales, many vessels associated with the construction of the Transmission Assets are likely to also be associated with both the Morgan Generation Assets and the Morecambe Offshore Wind Farm Generation Assets and therefore vessel numbers have not been summed, cumulatively. The cumulative impact is predicted to be of local to regional spatial extent, long term duration, intermittent and both the impact itself (i.e. elevated underwater sound due to vessel use) and effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.	vessels at any one time associated with the landfall cable installation. – Based on a sound modelling assessment, the maximum disturbance range is 5.38 km. • The Awel y Môr Offshore Wind Farm Project MDS identified: – Up to 101 construction vessels in total, of which 35 may be on site during peak period – The Environmental Statement assumed that based on Benhemma-Le Gall *et al.* (2021), harbour porpoise and other cetaceans may be displaced up to 4 km from construction vessels – Identified localised behavioural disturbance ranges for harbour porpoise and grey seal (avoidance reported up to 5 km from dredging activities). There was a reduction in bottlenose dolphin presence and, during the initial dredge operations, bottlenose dolphins were absent for five weeks. • The West Anglesey Demonstration Zone tidal site Project MDS identified: – up to 16 vessels on site at any one time during the operations and maintenance phase – The maximum behavioural disturbance range across all species was predicted in harbour porpoise for two percussive

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
	disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.		drilling rigs and cutter-suction dredging as up to 530 m and 580 m, respectively • The White Cross Offshore Wind Farm Project MDS identified: – Up to five vessels on site at any one time during the construction phase – The assessment concluded that the number of vessels would not exceed the Heinänen and Skov (2015) threshold (five vessels within 49.4 km^2 would equate to approximately 0.1 vessels per km^2) – The Environmental Statement assumed that based on Benhemma-Le Gall *et al.* (2021), disturbance ranges for non-piling activities (other than vessels) would be up to 4 km from construction vessels • The Project Erebus MDS identified: – Up to two crew transfer vessels on site per day during the operations and maintenance phase (assumed stationary or slow moving) – The maximum predicted behavioural disturbance range for large vessels was assessed as 480 m for minke whale • Twin Hub MDS identified: – Two floating platforms hosting leaning wind turbines with potential capacity of up to 32 MW

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			– Vessels may include anchor handling tugs and cable lay vessels but no quantification of vessel movement is included in the marine licence • Introduction of vessels will not be a novel impact for marine mammals present in the area and therefore marine mammals are anticipated to demonstrate some degree of tolerance to sound from vessels (see discussion in paragraph 4.9.4.37) • Vessel activity is expected to be localised to each project, the duration of vessel activity is considered to be medium term (throughout the construction phase of the Morgan Generation Assets) and vessel movements will occur intermittently over a number of years • Vessels such as boulder clearance, jack-up rigs, tug/anchor handlers and guard vessels will have smaller disturbance ranges (between 1 to 4 km) and therefore the extent of effect will be local. Where vessels may disturb animals up to ranges of 7 km, this represents a larger proportion of the Irish and Celtic Seas and may potentially affect animals over regional scales. Nevertheless, most of the vessels will be associated with the construction phases of Awel y Môr Offshore Wind Farm, Mona Offshore Wind Project and Morgan Generation Assets and all three projects are located within an area of relatively low marine mammal densities (except bottlenose dolphin, see Volume 4,

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			Annex 4.1: Marine mammal technical report of the Environmental Statement) • There may be an uplift in vessel activity within the cumulative marine mammal study area. However, assessments are based on respective projects' MDSs, therefore vessels present at any one time are likely to be lower. In addition, vessel movements will be confined to the array areas and/or offshore cable corridor routes and are likely to follow existing shipping routes. As such, it would not be realistic to present a sum of all vessels anticipated within each offshore wind farm as per respective MDSs. The cumulative impact is predicted to be of local to regional spatial extent, long term duration, intermittent and both the impact itself (i.e. elevated underwater sound due to vessel use and other activities) and effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**. **Tier 2** • The assessment for Tier 2 projects, Transmission Assets and Morecambe Offshore Wind Farm Generation Assets are set out in Scenario 1 and Scenario 2 • For all other Tier 2 projects (set out in Table 4.52; n = 18), EIA Scoping Reports do not provide detailed information on vessel numbers.

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			• The impact for each of these Tier 2 projects is predicted to be localised to within the close vicinity of the respective projects. As paragraphs 4.9.4.22 and 4.9.4.23 distances of between 1 km and 7 km (Brandt *et al.,* 2018; McQueen *et al.* 2020; Benhemma-Le Gall *et al.* 2021; Wisniewska *et al.* 2018) have been suggested for disturbance • Although animals may be disturbed from isolated project areas at different points in time, and cumulatively could lead to a larger area of disturbance at any one time compared to the Morgan Generation Assets alone (assuming activities overlapped temporally), in the context of the wider habitat available within the Celtic and Irish Seas regional study area, the scale of the disturbance effects is considered to be small. The cumulative impact is predicted to be of local to regional spatial extent, long term duration, intermittent and both the impact itself (i.e. elevated underwater sound due to vessel use and other activities) and effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**. **Tier 3** • The Isle of Man to UK Interconnector 2, Lir Offshore Array and MaresConnect are located within 50 km of Morgan Generation Assets. All other Tier 3

	Scenario 1: Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			projects (set out in Table 4.52; n = 10) are all located over 100 km away from the Morgan Generation Assets • The construction timelines for the Isle of Man to UK Interconnector 2 and Lir Offshore Array are not yet available, but given that they are in pre-application stage, the construction phase may overlap temporally towards the end of the Morgan Generation Assets construction phase • It is anticipated that the construction phase of MaresConnect (estimated 2026, with operations phase commencing in 2029) may overlap temporally with construction activities at Morgan Generation Assets (MaresConnect, 2023). Maintenance of the cable during the operations phase typically involves considerably fewer vessels and round trips compared to construction • Whilst this has the potential to increase vessel numbers in the Irish Sea this is not expected to be significantly larger than that already assessed for Morgan Generation Assets alongside Tier 1 and Tier 2 projects. The cumulative impact is predicted to be of local to regional spatial extent, long term duration, intermittent and both the impact itself (i.e. elevated underwater sound due to vessel use and other activities) and effect of behavioural disturbance is reversible. It is predicted that the impact will affect the

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			receptor directly. The magnitude is therefore, considered to be **low**.
Sensitivity of receptor	The sensitivity of marine mammals to elevated underwater sound due to vessel use and other (non-piling) sound producing activities is as described in paragraph 4.9.4.28 *et seq*. All marine mammals are deemed to have some tolerance to behavioural disturbance, high recoverability and international value. The sensitivity of the receptor is therefore, considered to be **medium**.		
Significance of effect	Overall, with standard industry measures in place (such as an Offshore EMP), the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. There would be no change to the international value of these species. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.	Overall, with standard industry measures in place (such as an Offshore EMP), the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. There would be no change to the international value of these species. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.	**Tier 1, Tier 2, Tier 3** Overall, with standard industry measures in place (such as an EMP), the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. There would be no change to the international value of these species. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.
Operations and maintenance phase			
Magnitude of impact	The cumulative effects assessment for Scenario 1 considers the following: • The approach is as per the construction phase • The Transmission Assets MDS identified: – up to 19 vessels on site at any one time • The duration of vessel activity is considered to be long term (throughout the operations and maintenance phase of the Morgan Generation Assets) and localised for each project with vessel movements occurring intermittently over the lifetime of Morgan Generation Assets. The	The cumulative effects assessment for Scenario 2 considers the following: • The approach is as per the construction phase • The Morecambe Generation Assets MDS identified: – up to 10 vessels on site at any one time • The duration of vessel activity is considered to be long term (throughout the operations and maintenance phase of the Morgan Generation Assets) and localised for each project with vessel movements occurring intermittently over the lifetime of	The cumulative effects assessment for Scenario 3 considers the following: **Tier 1** • The approach is as per the construction phase • The range of vessels used in operations and maintenance activities will be similar to those employed during the construction phases of cumulative projects although fewer vessels are likely to be involved but over a longer duration • The Mona Offshore Wind Project MDS identified:

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
	cumulative number of vessels at any given time is expected to be lower for the operations and maintenance phase compared to the construction phase, and many vessels associated with the construction of the Morgan Generation Assets are likely to also be associated with the construction of the Transmission Assets and therefore cumulative vessel numbers will not be significantly higher than the Morgan Generation Assets alone, therefore vessel numbers have not been summed, cumulatively • Therefore, the magnitude of the impact and associated effect (disturbance) as a result of elevated underwater sound due to vessel use and other activities, for all marine mammal receptors, is expected to be less than that assessed for the construction phase. However, considering that the duration of the impact will be longer, over the decadal operating lifetime of the Morgan Generation Assets, a precautionary approach has been taken in assessing the magnitude. The cumulative impact is predicted to be of local to regional spatial extent, long term duration, intermittent and both the impact itself (i.e. elevated underwater sound due to vessel use and other activities) and effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.	Morgan Generation Assets. The cumulative number of vessels at any given time is expected to be lower for the operations and maintenance phase compared to the construction phase, and many vessels associated with the construction of the Transmission Assets are likely to also be associated with both the Morgan Generation Assets and the Morecambe Offshore Wind Farm Generation Assets and therefore vessel numbers have not been summed, cumulatively • Therefore, the magnitude of the impact and associated effect (disturbance) as a result of elevated underwater sound due to vessel use and other activities, for all marine mammal receptors, is expected to be less than that assessed for the construction phase. However, considering that the duration of the impact will be longer, over the decadal operating lifetime of the Morgan Generation Assets, a precautionary approach has been taken in assessing the magnitude. The cumulative impact is predicted to be of local to regional spatial extent, long term duration, intermittent and both the impact itself (i.e. elevated underwater sound due to vessel use and other activities) and effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.	– Up to 21 vessels on site at any one time – Up to 849 vessel movements per year – Assessment approach is as per construction phase • The Awel y Môr Offshore Wind Farm Project MDS identified: – numerous different vessel types would be conducting round trips to and from port and the array area, but only two jack-up vessels and two SOVs would be present at any one time – Assessment approach is as per construction phase • The West Anglesey Demonstration Zone tidal site MDS identified: – up to two drilling activities, two cable installation activities, two cable protection activities and 16 vessels on site at any one time – maximum behavioural disturbance range across all species was predicted in harbour porpoise for two percussive drilling rigs and cutter-suction dredging as up to 530 m and 580 m, respectively • The White Cross Offshore Wind Farm MDS identified: – Up to five vessels on site at any one time during the construction phase (no numbers provided for operations phase – this is likely to be lower)

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			– Assessment approach is as per construction phase • The Project Erebus Project MDS identified: – Up to two crew transfer vessels on site per day during the operations and maintenance phase (assumed stationary or slow moving) – The maximum predicted behavioural disturbance range for large vessels was assessed as 480 m for minke whale • Twin Hub MDS identified: – Two floating platforms hosting leaning wind turbines with potential capacity of up to 32 MW – Vessels may include anchor handling tugs and cable lay vessels but no quantification of vessel movement is included in the marine licence • The duration of vessel activity is considered to be long term (throughout the operations and maintenance phase of the Morgan Generation Assets) and localised for each project with vessel movements occurring intermittently over the lifetime of Morgan Generation Assets. The cumulative number of vessels at any given time is expected to be lower for the operations and maintenance phase compared to the construction phase. Therefore, the magnitude of the impact and associated effect (disturbance) as a

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			result of elevated underwater sound due to vessel use and other activities, for all marine mammal receptors, is expected to be less than that assessed for the construction phase. However, considering that the duration of the impact will be longer, over the decadal operating lifetime of the Morgan Generation Assets, a precautionary approach has been taken in assessing the magnitude. The cumulative impact is predicted to be of local to regional spatial extent, long term duration, intermittent and both the impact itself (i.e. elevated underwater sound due to vessel use and other activities) and effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**. **Tier 2** • The approach is as per the construction phase • The assessment for Tier 2 projects, Transmission Assets and Morecambe Offshore Wind Farm Generation Assets are set out in Scenario 1 and Scenario 2 • The range of vessels used in operations and maintenance activities in other Tier 2 projects (identified in Table 4.52) will be similar to those employed during the construction phases of cumulative projects although fewer vessels are likely to be involved but over a longer duration

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			• The number of vessels present during the operations and maintenance phases of respective projects in isolation is considered to be smaller than for the construction phase. Nevertheless, cumulatively it could be expected that the total number of vessel movements will exceed the existing average traffic levels • Qualitatively, the impact would lead to a larger area of disturbance within the cumulative marine mammal study area compared to the Morgan Generation Assets alone. Although animals may be disturbed from isolated project areas at different points in time, in the context of the wider habitat available the scale of the disturbance effects (which would be localised) is considered to be small. The cumulative impact is predicted to be of local to regional spatial extent, long term duration, intermittent and both the impact itself (elevated underwater sound due to vessel use and other activities) and effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**. **Tier 3** • Isle of Man to UK Interconnector 2, Lir Offshore Array and MaresConnect are located within 50 km of Morgan Generation Assets. All other Tier 3 projects (set out in Table 4.52; n = 10) are

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			all located over 100 km away from the Morgan Generation Assets • Cable maintenance during the operations phase typically involves considerably smaller numbers of vessels and round trips compared to construction activities. Whilst this has the potential to increase vessel numbers in the Irish Sea this is not expected to be significantly larger than that already assessed for Morgan Generation Assets alongside Tier 1 and Tier 2 projects. The cumulative impact is predicted to be of local to regional spatial extent, long term duration, intermittent and both the impact itself (elevated underwater sound due to vessel use and other activities) and effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.
Sensitivity of receptor	The sensitivity of marine mammals to elevated underwater sound due to vessel use and other (non-piling) sound producing activities is as described in paragraph 4.9.4.28 *et seq*. All marine mammals are deemed to have some tolerance, high recoverability and international value. The sensitivity of the receptor is therefore, considered to be **medium**		
Significance of effect	Overall, with standard industry measures in place (such as vessel provisions within the EMP), the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. There would be no change to the international value of these species. The cumulative effect will, therefore,	Overall, with standard industry measures in place (such as vessel provisions within the EMP), the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. There would be no change to the international value of these species. The cumulative effect will, therefore,	Overall, with standard industry measures in place (such as vessel provisions within the EMP), the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. There would be no change to the international value of these species. The cumulative effect will, therefore,

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
	be of **minor adverse** significance, which is not significant in EIA terms.	be of **minor adverse** significance, which is not significant in EIA terms.	be of **minor adverse** significance, which is not significant in EIA terms.

4.11.5 Increased likelihood of injury due to collision with vessels

4.11.5.1 Cumulatively assessing the impact of the Morgan Generation Assets in combination with the Transmission Assets and Morecambe Generation Assets, would not result in a notable increase to the magnitude of the impact, due to the existing conservative approach of the project alone assessment for Transmission Assets having accounted for vessels which fall under the MDS for both Morgan Generation Assets and Morecambe Generation Assets. However, from a precautionary perspective, an assessment of Morgan Generation Assets against the Transmission Assets has been presented in Scenario 1 and an assessment of Morgan Generation Assets against the Transmission Assets and Morecambe Offshore Windfarm Generation Assets has been presented in Scenario 2.

4.11.5.2 An assessment of the potential for cumulative impacts as a result of Increased likelihood of injury due to collision with vessels has been presented for Morgan Generation Assets alongside relevant Tier 1, Tier 2 and Tier 3 projects in Table 4.57 below.

Table 4.57: Increased likelihood of injury due to collision with vessels

Morgan and Morecambe Offshore Wind Farms: Transmission Assets is referred to as 'Transmission Assets'

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
Construction phase			
Magnitude of impact	The cumulative effects assessment for Scenario 1 considers the following: • Numbers and types of vessel associated with construction phase of Transmission Assets are set out in Table 4.56 • Cumulatively, as described in Table 4.56, the total number of vessels associated with construction of the two projects will represent an increase in vessel activity within the cumulative marine mammal study area. Considering that the assessment is based on MDSs, the number of vessels present at the two projects at any given time will in reality be lower. In addition, the Transmission Assets PEIR has accounted for vessels which fall under the MDS for both the Transmission Assets and Morgan Generation Assets • Vessels involved in the two projects are likely to be travelling slowly, at a speed that is unlikely to pose a significant collision risk to marine mammals (below 14 to 15 knots; Laist *et al.*, 2001, Wilson *et al.*, 2007). Guidance in the USA (NOAA, 2020) suggests lower speeds in relation to larger slow-moving species such as humpback whale, however this is less	The cumulative effects assessment for Scenario 2 considers the following: • Approach is as per Scenario 1 • Numbers and types of vessel associated with construction phase of Morecambe Generation Assets are set out in Table 4.56 • Cumulatively, as described in Table 4.56, the total number of vessels associated with construction of the projects will represent an increase in vessel activity within the cumulative marine mammal study area. Considering that the assessment is based on MDSs, the number of vessels present at the projects at any given time will in reality be lower. In addition, the Transmission Assets assessment PEIR has accounted for vessels which fall under the MDS for the Transmission Assets, Morgan Generation Assets and Morecambe Generation Assets. With standard industry measures in place to reduce the risk of collision (such as the implementation of an Offshore EMP ; see Table 4.17), the impact is predicted to be of limited spatial extent, medium term duration, intermittent and, whilst the risk will only occur during vessel transits, the effect of collision	The cumulative effects assessment for Scenario 3 considers the following: **Tier 1** • Approach is as per Scenario 1 • Given the temporal overlap, the construction of the Morgan Generation Assets Project, together with construction and operations and maintenance phases of Tier 1 projects may lead to cumulative disturbance to marine mammals from vessel use and other (non-piling) sound producing activities • Numbers and types of vessel associated with construction and operation and maintenance phases of Mona Offshore Wind Project; Awel y Môr Offshore Wind Farm; West Anglesey Demonstration Zone tidal site; White Cross Offshore Wind Farm; Twin Hub and Project Erebus are set out in Table 4.56. • Cumulatively, as described in Table 4.56, total number of vessels associated in construction and operation of respective projects will represent an increase in vessel activity within the Irish Sea and wider Celtic Sea regional study area. Considering that the assessment is based on the MDS, the number of vessels

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
	appropriate for species found in in the Irish Sea • All vessels associated with the Morgan Generation Assets will be required to follow an Offshore EMP (Table 4.17) • In addition, sound emissions from vessels will likely deter animals from the potential zone of impact • Given that vessel movements will be confined to project areas and are likely to follow existing shipping routes to/from port, collision risk is expected to be localised to within the boundaries of the respective projects. Additionally, works will take place in an area characterised by relatively high levels of traffic and both projects will adhere to best practice protocols • The duration of vessel activity is considered to be medium term (throughout the construction phase of Morgan Generation Assets) and localised for each project, however vessel movements will occur intermittently over this period • It is not anticipated that the cumulative level of vessel activity during construction will cause an increase of collisions with marine mammals. With standard industry measures in place to reduce the risk of collision (such as the implementation of an Offshore EMP; see Table 4.17), the impact is predicted to be of limited spatial extent, medium term duration, intermittent and, whilst the risk will only occur	on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is, conservatively, considered to be **low**.	present at respective projects at any given time will in reality be lower • The duration of vessel activity is considered to be medium term (throughout the construction phase of Morgan Generation Assets) and localised for each project, however vessel movements will occur intermittently over a number of years. With standard industry measures in place to reduce the risk of collision (such as the implementation of an Offshore EMP ; see Table 4.17), the impact is predicted to be of limited spatial extent, medium term duration, intermittent and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is, conservatively, considered to be **low**. **Tier 2** • Given the temporal overlap, the construction of the Morgan Generation Assets Project, together with construction and operations and maintenance phases of Tier 1 and Tier 2 projects may lead to cumulative disturbance to marine mammals from vessel use and other (non-piling) sound producing activities • The assessment for Tier 2 projects, Transmission Assets and Morecambe Offshore Wind Farm Generation Assets are set out in Scenario 1 and Scenario 2

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
	during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is, conservatively, considered to be **low**.		• For all other Tier 2 projects (set out in Table 4.52; n = 14), EIA Scoping Reports do not provide detailed information on vessel numbers • The types of vessels involved in construction activities at the other offshore wind farms are anticipated to be similar to those identified for construction of the Morgan Generation Assets • The duration of vessel activity is considered to be medium term (throughout the construction phase of Morgan Generation Assets) and localised for each project, however vessel movements will occur intermittently over a number of years. Although the exact number of vessels associated with most Tier 2 projects is unknown, cumulatively across the sites there will be an increase in vessel activity within the cumulative marine mammal study area. If the construction phase at all Tier 2 projects were to occur simultaneously, vessels associated with each project would contribute further to the increase over a number of years. With standard industry measures in place to reduce the risk of collision (such as the implementation of an Offshore EMP see Table 4.17), the impact is predicted to be of limited spatial extent, medium term duration, intermittent and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			affect the receptor directly. The magnitude is, conservatively, considered to be **low**. **Tier 3** • Given the temporal overlap, the construction of the Morgan Generation Assets Project, together with construction and operations and maintenance phases of Tier 1, Tier 2 and Tier 3 projects may lead to cumulative disturbance to marine mammals from vessel use and other (non-piling) sound producing activities • Isle of Man to UK Interconnector 2, Lir Offshore Array and MaresConnect are located within 50 km of Morgan Generation Assets. All other Tier 3 projects (set out in Table 4.52; n = 10) are located over 100 km away from the Morgan Generation Assets • The construction timelines for the Isle of Man to UK Interconnector 2 and Lir Offshore Array are not yet available, but given that they are in pre-application stage, the construction phases may overlap temporally towards the end of the Morgan Generation Assets construction phase • It is anticipated that the construction phase of MaresConnect (estimated 2026, with operations phase commencing in 2029) may overlap temporally with construction activities at Morgan Generation Assets (MaresConnect, 2023). Maintenance of the cable during the operations phase typically involves considerably fewer

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			vessels and round trips compared to construction • Therefore, it is anticipated that these will not add substantially to the number of vessels present during the construction of the Morgan Generation Assets and that the potential for cumulative effects is unlikely. With standard industry measures in place to reduce the risk of collision (such as the implementation of an Offshore EMP see Table 4.17), the impact is predicted to be of limited spatial extent, medium term duration, intermittent and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is, conservatively, considered to be **low**.
Sensitivity of receptor	The sensitivity of marine mammals to collision risk is as described in paragraph 4.9.5.8 for Morgan Generation Assets alone. Whilst there are no seal haul-out sites in the Morgan marine mammal study area, there are grey seal and harbour seal haul-out sites within the cumulative marine mammal study area and therefore cumulatively there is the potential for increase in the likelihood of vessel collision. All marine mammals are deemed to have some tolerance (largely due to avoidance), medium recoverability and international value. The sensitivity of the receptor is therefore considered to be **medium**.		
Significance of effect	Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. There would be no change to the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.	Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. There would be no change to the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.	**Tier 1, Tier 2, Tier 3** Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. There would be no change to the international value of these species. The effect will, therefore, be

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			of **minor adverse** significance, which is not significant in EIA terms.
Operations and maintenance			
Magnitude of impact	The cumulative effects assessment for Scenario 1 considers the following: • The range of vessels used in operation and maintenance activities of both projects will be similar to those employed during the construction phases (as set out in Table 4.56) • The duration of vessel activity is considered to be long term (throughout the operations and maintenance phase of the Morgan Generation Assets) and localised for each project, however vessel movements will occur intermittently over the lifetime of the Morgan Generation Assets. The cumulative number of vessels is expected to be lower for the operations and maintenance phase compared to the construction phase (see Table 4.56) of the Morgan Generation Assets • Although the number of vessel movements during the operations and maintenance phase represents an increase in collision risk over the existing levels of vessel traffic, sound emissions from vessels will likely deter animals from the potential zone of impact. Additionally, given that vessel movements will be confined to the project areas and are likely to follow existing shipping routes to and from port, the risk of collision to marine mammals is expected to be largely	The cumulative effects assessment for Scenario 2 considers the following: • The approach is as per Scenario 1 • The range of vessels used in operation and maintenance activities of both projects will be similar to those employed during the construction phases (as set out in Table 4.56) • The duration of vessel activity is considered to be long term (throughout the operations and maintenance phase of the Morgan Generation Assets) and localised for each project, however vessel movements will occur intermittently over the lifetime of the Morgan Generation Assets. The cumulative number of vessels is expected to be lower for the operations and maintenance phase compared to the construction phase (see Table 4.56) of the Morgan Generation Assets. With standard industry measures in place to reduce the risk of collision, the impact is predicted to be of limited spatial extent, medium term duration, intermittent and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The	The cumulative effects assessment for Scenario 3 considers the following: **Tier 1** • Given the temporal overlap, the construction of the Morgan Generation Assets Project, together with construction and operations and maintenance phases of Tier 1 projects may lead to cumulative disturbance to marine mammals from vessel use and other (non-piling) sound producing activities • The approach is as per Scenario 1 • The range of vessels used in operation and maintenance activities of relevant projects (Mona Offshore Wind Project; Awel y Môr Offshore Wind Farm; West Anglesey Demonstration Zone tidal site; White Cross Offshore Wind Farm; Twin Hub; and Project Erebus) is as set out in Table 4.56. • The duration of vessel activity is considered to be long term (throughout the operations and maintenance phase of the Morgan Generation Assets) and localised for each project, however vessel movements will occur intermittently over the lifetime of the Morgan Generation Assets. The cumulative number of vessels is expected to be lower for the operations and maintenance phase compared to the

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
	localised to within the boundaries of the respective projects. With standard industry measures in place to reduce the risk of collision, the impact is predicted to be of limited spatial extent, medium term duration, intermittent and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is, conservatively, considered to be **low**.	magnitude is, conservatively, considered to be **low**.	construction phase (see Table 4.56) of the Morgan Generation Assets. With standard industry measures in place to reduce the risk of collision, the impact is predicted to be of limited spatial extent, medium term duration, intermittent and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is, conservatively, considered to be **low**. **Tier 2** • The operations and maintenance phase of the Morgan Generation Assets, together with operations and maintenance phases of Tier 1 and Tier 2 projects have the potential to result in cumulative risk of collision to marine mammals • The approach is as per Scenario 1 • The assessment for Tier 2 projects, Transmission Assets and Morecambe Offshore Wind Farm Generation Assets are set out in Scenario 1 and Scenario 2 • The range of vessels used in operation and maintenance activities of other Tier 2 projects (identified in Table 4.52) are anticipated to be similar to those identified for the Morgan Generation Assets, such as vessels used during routine inspections, repairs and replacement of equipment, major component replacement, painting or other coatings,

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			removal of marine growth and replacement of access ladders • The duration of vessel activity is considered to be long term (throughout the operations and maintenance phase of the Morgan Generation Assets) and localised for each project, however vessel movements will occur intermittently over the lifetime of the Morgan Generation Assets. The cumulative number of vessels is expected to be lower for the operations and maintenance phase compared to the construction phase of the Morgan Generation Assets. **Tier 3** Tier 3 projects are in pre-application phase and no Environmental Statement is available to inform a quantitative assessment. Maintenance of cable or offshore wind farm typically involves considerably smaller numbers of vessels and round trips compared to construction. Considering the vessel activity within the Irish Sea, it is anticipated that these will not add substantially to the number of vessels present during the operations and maintenance phases of the Morgan Generation Assets, Tier 1 and Tier 2 projects and that the potential for cumulative effects is unlikely. With standard industry measures in place to reduce the risk of collision, the impact is predicted to be of limited spatial extent, medium term duration, intermittent and, whilst the risk will only occur during vessel transits,

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is, conservatively, considered to be **low**.
Sensitivity of receptor	The sensitivity of marine mammals to collision risk is as described in the construction phase above. All marine mammals are deemed to have some tolerance (largely due to avoidance), medium recoverability and international value. The sensitivity of the receptor is therefore considered to be **medium**.		
Significance of effect	Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. There would be no change to the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.	Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. There would be no change to the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.	**Tier 1, Tier 2, Tier 3** Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. There would be no change to the international value of these species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

4.11.6 Changes in fish and shellfish communities affecting prey availability

4.11.6.1 Impacts on fish and shellfish receptors have been assessed in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement, and therefore a brief overview of impacts on marine mammals due to changes in prey availability, and a summary of magnitude, sensitivity and significance for Morgan Generation Assets alone is presented in section 4.9.8. An assessment of the potential for cumulative impacts as a result of Changes in fish and shellfish communities affecting prey availability has been presented for Morgan Generation Assets alongside relevant Tier 1, Tier 2 and Tier 3 projects in Table 4.58 below.

Table 4.58: Changes in fish and shellfish communities affecting prey availability.

Morgan and Morecambe Offshore Wind Farms: Transmission Assets is referred to as 'Transmission Assets'

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
Construction phase			
Magnitude of impact	The cumulative effects assessment for Scenario 1 considers the following: • Potential cumulative impacts on marine mammals as a result of changes to the fish and shellfish community may occur as a result of the construction of Morgan Generation Assets alongside Transmission Assets • Potential cumulative impacts identified in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement, which have the potential to effect marine mammal prey include: – temporary habitat loss/disturbance – long term habitat loss and colonisation of hard structures – increased SSC and associated sediment deposition – underwater sound impacting fish and shellfish receptors – EMF from subsea electrical cabling. Potential cumulative impacts from Morgan Generation Assets and Transmission Assets on marine mammal prey species during the construction phase of Morgan Generation Assets have been assessed in Volume 2, Chapter 3: Fish and shellfish ecology of Environmental Statement, which identified:	The cumulative effects assessment for Scenario 2 considers the following: • The approach is as per Scenario 1 • Potential cumulative impacts identified in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement, which have the potential to effect marine mammal prey, are as per Scenario 1 • Potential cumulative impacts from Morgan Generation Assets and Morecambe Generation Assets on marine mammal prey species during the construction phase of Morgan Generation Assets have been assessed in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement (as per Scenario 1), which identified: – Temporary habitat loss: ○ Total cumulative temporary habitat loss and disturbance: up to 128.91 km^2 ○ The significance for temporary habitat loss for fish and shellfish was assessed as negligible to minor, and therefore is unlikely to result in changes in prey availability in marine mammals – Permanent habitat loss:	The cumulative effects assessment for Scenario 3 considers the following: **Tier 1** • The construction of the Morgan Generation Assets Project together with activities at Tier 1 projects (offshore wind farms, dredging activities, aggregate extraction activities and cables and pipelines) may lead to potential cumulative impacts as a result of changes to the fish and shellfish community. • The approach is as per Scenario 1 • The potential cumulative impacts identified in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement, which have the potential to effect marine mammal prey, are as per Scenario 1 • Potential cumulative impacts from Morgan Generation Assets alongside Tier 1 projects, on marine mammal prey species during the construction phase of Morgan Generation Assets have been assessed in Volume 2, Chapter 3: Fish and shellfish ecology of Environmental Statement (as per Scenario 1), which identified: – Temporary habitat loss:

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
	• Temporary habitat loss/disturbance: – Total cumulative temporary habitat loss and disturbance: up to 125.45 km^2 – The significance for temporary habitat loss for fish and shellfish was assessed as minor adverse, and therefore is unlikely to result in changes in prey availability in marine mammals • Long term habitat loss/introduction and colonisation of hard structures: – Total cumulative area of permanent hard structures (equating to long term habitat loss): up to 2.84 km^2 – Colonisation of hard structures may commence within the four-year construction phase, and continue into the operation and maintenance phase – The significance for long-term habitat loss; and introduction and colonisation of hard structures for fish and shellfish was assessed as negligible to minor adverse significance, and therefore is unlikely to result in changes in prey availability in marine mammals • Increased SSC and associated sediment deposition: – Seabed preparation and installation of foundations and cables for the two projects may increase SSC and associated sediment deposition. However, resultant plumes from aggregate extraction or dredging would be advected on the tidal currents, travel	○ Total cumulative area of permanent hard structures (equating to long term habitat loss): up to 3.29 km^2 ○ Colonisation of hard structures may commence within the four-year construction phase, and continue into the operation and maintenance phase ○ The significance for long-term habitat loss for fish and shellfish was assessed as negligible to minor, therefore is unlikely to result in changes in prey availability in marine mammals • For all other impacts considered in the cumulative scenario of Morgan Generation Assets alongside Transmission Assets and Morecambe Generation Assets, the assessment is as per Scenario 1. The cumulative impact is predicted to be of local to regional spatial extent, long term duration, intermittent and both the impact itself (i.e. elevated underwater sound due to vessel use) and effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low**.	○ Total cumulative temporary habitat loss and disturbance: up to 136.17 km^2 ○ The significance for temporary habitat loss for fish and shellfish was assessed as negligible to minor, and therefore is unlikely to result in changes in prey availability in marine mammals – Permanent habitat loss: ○ Total cumulative area of permanent hard structures (equating to long term habitat loss): up to 5.54 km^2 ○ Colonisation of hard structures may commence within the four-year construction phase, and continue into the operation and maintenance phase ○ The significance for long-term habitat loss for fish and shellfish was assessed as negligible to minor, therefore resulting effects due to prey availability on marine mammals are minimal • For all other impacts considered in the cumulative scenario of Morgan Generation Assets alongside Tier 1 projects, the assessment is as per Scenario 1. The cumulative impact is predicted to be of local to regional spatial extent, long term duration, intermittent and both the impact itself (i.e. elevated underwater sound due to vessel use) and effect of behavioural disturbance is reversible. It is predicted that

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
	in parallel, and not towards one another, and are unlikely to interact – Temporarily overlapping construction activities at the Transmission Assets may result in increased suspended sediment concentration; however, these activities would be of limited spatial extent and frequency and are unlikely to interact with sediment plumes from the Morgan Generation Assets. The cumulative significance of the effect on fish and shellfish receptors as a result of SSC was estimated as minor adverse and therefore this is unlikely to impact marine mammals • Underwater sound impacting fish and shellfish receptors – Underwater sound from piling and UXO clearance associated with the construction phase of Morgan Generation Assets, have the potential to result in impacts to fish and shellfish receptors – The cumulative significance of effect on fish and shellfish receptors as a result of underwater sound was assessed as minor adverse for most fish and shellfish ecology receptors. For herring, there was overlap of 135 dB re 1 µPa (SPL_{pk}) contours with spawning grounds, and minor overlap of 160 dB re 1 µPa (SPL_{pk}) with low intensity spawning grounds. On this basis, a precautionary moderate adverse		the impact will affect the receptor directly. The magnitude is therefore considered to be low. **Tier 2** • The construction of the Morgan Generation Assets Project together with activities at Tier 1 and Tier 2 projects (offshore wind farms, dredging activities, aggregate extraction activities and cables and pipelines) may lead to potential cumulative impacts as a result of changes to the fish and shellfish community • The potential cumulative impacts identified in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement, which have the potential to effect marine mammal prey, are as per Tier 1 • The assessment for Tier 2 projects Transmission Assets and Morecambe Offshore Wind Farm Generation Assets are set out in Scenario 1 and Scenario 2. For all other Tier 2 projects, EIA Scoping Reports do not provide sufficient detailed information to undertake a quantitative assessment (set out in Table 4.52). Volume 2, Chapter 3: Fish and shellfish ecology of Environmental Statement has therefore presented a magnitude of impact, for all impacts, in line with the cumulative assessment for Tier 1 projects. The cumulative magnitude of impact for marine mammals, as a result of changes in fish and shellfish communities affecting prey availability for Tier 1 and Tier 2 projects is

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
	significant effect is predicted for herring. It is assumed that if herring are disturbed from an area as a result of underwater sound, marine mammals are likely to be disturbed from the same or greater area. Conservatively there could still be an effect on minke whale prey availability, given how tightly tied they are to herring stocks (see discussion in paragraph 4.9.8.8 *et seq.*). However, whilst there may be certain prey species that make up the main part of their diet, all marine mammals in this assessment are considered to be generalist opportunistic feeders and are thus not reliant on a single prey species (with the exception of Risso's dolphins which predominantly feed on cephalopods). The cumulative impact is predicted to be of local to regional spatial extent, long term duration, intermittent and both the impact itself (i.e. elevated underwater sound due to vessel use) and effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low.**		therefore not expected to differ from the cumulative assessment for Tier 1 projects. The cumulative impact is predicted to be of local to regional spatial extent, long term duration, intermittent and both the impact itself (i.e. elevated underwater sound due to vessel use) and effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low**. **Tier 3** • The construction of the Morgan Generation Assets Project together with activities at Tier 1, Tier 2 and Tier 3 projects (offshore wind farms, dredging activities, aggregate extraction activities and cables and pipelines) may lead to potential cumulative impacts as a result of changes to the fish and shellfish community • Potential cumulative impacts identified in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement, which have the potential to effect marine mammal prey, include: – temporary habitat loss/disturbance, – long term habitat loss and colonisation of hard structures – increased SSC and associated sediment deposition – Electromagnetic Fields (EMF) from subsea electrical cabling. • The laying and burying of the MaresConnect interconnector cable and

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			the Isle of Man to UK Interconnector 2 may involve introduction of cable protection (assumed as the MDS) which will represent long term habitat loss and will likely follow standard jet trenching and cable protection installation, causing temporary habitat disturbance. it is expected that the cable protection will only represent a small increase of introduced hard structures and so will have only a minor cumulative impact. The likely jet trenching activities for the laying and burying of the cables for both projects will run concurrently and interaction of SSC plumes on spring tide events may occur. Given construction activities at the project are expected to occur between 2026 and 2028, there may be overlap with Morgan Generation Assets construction phase and therefore there is some potential for cumulative effects on marine mammal prey species. • The cumulative magnitude of impact for marine mammals, as a result of changes in fish and shellfish communities affecting prey availability for Tier 1, Tier 2 and Tier 3 projects is therefore not expected to differ from the cumulative assessment for Tier 1 projects. The cumulative impact is predicted to be of local to regional spatial extent, long term duration, intermittent and both the impact itself (i.e. elevated underwater sound due to vessel use) and effect of behavioural disturbance is reversible. It is predicted that

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			the impact will affect the receptor directly. The magnitude is therefore considered to be **low.**
Sensitivity of receptor	The sensitivity of marine mammals to changes in prey availability was as described in paragraph 4.9.8.14 *et seq.* for Morgan Generation Assets alone. Most marine mammals, except for minke whale, are deemed to be able to tolerate changes in prey availability, have high recoverability and international value. The sensitivity of the receptor is therefore, considered to be **low**. For minke whale, due to their reliance on herring, sprat and sandeel as a primary food source in the Irish Sea, they are deemed have some tolerance to changes in prey availability, have high recoverability and international value. The sensitivity of the receptor is therefore considered to be **medium**.		
Significance of effect	Overall, the cumulative magnitude of the impacts is deemed to be low for all species, and the sensitivity of the receptor is considered to be low for all species except minke whale, which is medium. There would be no change to the international value of these species. Taking into account the medium sensitivity of minke whale to changes in herring, sprat and sandeel stocks, the cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.	Overall, the cumulative magnitude of the impacts is deemed to be low for all species, and the sensitivity of the receptor is considered to be low for all species except minke whale, which is medium. There would be no change to the international value of these species. Taking into account the medium sensitivity of minke whale to changes in herring, sprat and sandeel stocks, the cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.	Overall, the cumulative magnitude of the impacts is deemed to be low for all species, and the sensitivity of the receptor is considered to be low for all species except minke whale, which is medium. There would be no change to the international value of these species. Taking into account the medium sensitivity of minke whale to changes in herring, sprat and sandeel stocks, the cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.
Operations and maintenance phase			
Magnitude of impact	The cumulative effects assessment for Scenario 1 considers the following: • Cumulative impacts on marine mammals as a result of changes to the fish and shellfish community may occur as a result of the construction of Morgan Generation Assets alongside Transmission Assets • Potential cumulative impacts identified in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement,	The cumulative effects assessment for Scenario 2 considers the following: • Cumulative impacts on marine mammals as a result of changes to the fish and shellfish community may occur as a result of the construction of Morgan Generation Assets alongside Transmission Assets • Potential cumulative impacts identified in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement,	The cumulative effects assessment for Scenario 3 considers the following: **Tier 1** • Cumulative impacts on marine mammals as a result of changes to the fish and shellfish community may occur as a result of the construction of Morgan Generation Assets alongside Tier 1 projects

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
	which have the potential to effect marine mammal prey include: – long term habitat loss and colonisation of hard structures – EMF from subsea electrical cabling • Long term habitat loss and colonisation of hard structures: – the effects on fish and shellfish receptors arising during operations and maintenance activities at Transmission Assets are likely to be very localised, and are as described for the construction phase • EMF from subsea electrical cabling: – Impacts from EMFs emitted from subsea electrical cabling has the potential to impact fish and shellfish receptors – Minimum burial depth for cables will be 0.5 m, likely limiting EMFs to within a few metres from the cable, with impacts expected to be similar across the two projects. – The cumulative significance of the effect on fish and shellfish receptors as a result of EMF from subsea electrical cabling was estimated as minor adverse and therefore this is unlikely to impact marine mammals. No significant adverse cumulative effects were predicted to occur to fish and shellfish species (marine mammal prey) as a result of the operations and maintenance of the	which have the potential to effect marine mammal prey are as per Scenario 1 • For all impacts considered in the cumulative scenario of Morgan Generation Assets alongside Transmission Assets and Morecambe Generation Assets, the assessment is as per Scenario 1. No significant adverse cumulative effects were predicted to occur to fish and shellfish species (marine mammal prey) as a result of the operations and maintenance of the Morgan Generation Assets in combination with the Transmission Assets and Morecambe Offshore Wind Farm Generation Assets (Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement). Whilst most impacts are considered to be adverse there is the potential for some beneficial effects with respect to introduction of hard substrate which could increase prey availability for some species. Therefore, changes in prey availability on marine mammals were predicted to be of local spatial extent, medium-term duration, continuous and high reversibility. The magnitude was therefore, considered to be low.	• Potential cumulative impacts identified in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement, which have the potential to effect marine mammal prey are as per Scenario 1 • Long term habitat loss and colonisation of hard structures: – the effects on fish and shellfish receptors arising during operations and maintenance activities at Tier 1 projects are likely to be very localised, and are as described for the construction phase • EMF from subsea electrical cabling: – Impacts from EMFs emitted from subsea electrical cabling has the potential to impact fish and shellfish receptors – Minimum burial depth for cables will be 1 m at the Awel y Môr Offshore wind Farm, and 0.5 m at the Mona Offshore Wind Project, likely limiting EMFs to within a few metres from the cable, with impacts expected to be similar across the two projects – The cumulative significance of the effect on fish and shellfish receptors as a result of EMF from subsea electrical cabling was estimated as minor adverse and therefore this is unlikely to impact marine mammals. No significant adverse cumulative effects were predicted to occur to fish and shellfish

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
	Morgan Generation Assets in combination with the Transmission Assets (Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement). Whilst most impacts are considered to be adverse there is the potential for some beneficial effects with respect to introduction of hard substrate which could increase prey availability for some species. Therefore, changes in prey availability on marine mammals were predicted to be of local spatial extent, medium-term duration, continuous and high reversibility. The magnitude was therefore, considered to be **low**.		species (marine mammal prey) as a result of the operations and maintenance of the Morgan Generation Assets in combination with the Transmission Assets (Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement). Whilst most impacts are considered to be adverse there is the potential for some beneficial effects with respect to introduction of hard substrate which could increase prey availability for some species. Therefore, changes in prey availability on marine mammals were predicted to be of local spatial extent, medium-term duration, continuous and high reversibility. The magnitude was therefore, considered to be **low**. **Tier 2** • Cumulative impacts on marine mammals as a result of changes to the fish and shellfish community may occur as a result of the construction of Morgan Generation Assets alongside Tier 1 and Tier 2 projects • The potential cumulative impacts identified in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement, which have the potential to effect marine mammal prey, are as per Tier 1 • The assessment for Tier 2 projects Transmission Assets and Morecambe Offshore Wind Farm Generation Assets are set out in Scenario 1 and Scenario 2 • For all other Tier 2 projects, EIA Scoping Reports do not provide sufficient detailed information to undertake a quantitative

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			assessment (set out in Table 4.52). Volume 2, Chapter 3: Fish and shellfish ecology of Environmental Statement has therefore presented a magnitude of impact, for all impacts, in line with the cumulative assessment for Tier 1 projects. The cumulative magnitude of impact for marine mammals, as a result of changes in fish and shellfish communities affecting prey availability for Tier 1 and Tier 2 projects is therefore not expected to differ from the cumulative assessment for Tier 1 projects • The cumulative impact is predicted to be of local to regional spatial extent, long term duration, intermittent and both the impact itself (i.e. elevated underwater sound due to vessel use) and effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low. **Tier 3** • Cumulative impacts on marine mammals as a result of changes to the fish and shellfish community may occur as a result of the construction of Morgan Generation Assets alongside Tier 1, Tier 2 and Tier 3 projects • The potential cumulative impacts identified in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement, which have the potential to effect marine mammal prey, are as per Tier 1

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			• The proposed operations and maintenance phase of the MaresConnect Wales-Ireland Interconnector Cable will likely overlap with the operations and maintenance phase of the Morgan Generation Assets, leading to a potential cumulative impact. At the time of writing, no specifications are publicly available. The anticipated operational lifetime is expected to start in 2029. There is no temporal information available for the Isle of Man to UK Interconnector 2, however there is potential for the operations and maintenance phase to overlap with the operations and maintenance phase of the Morgan Generation Assets • The installation of electrical cables is likely to involve introduction of cable protection which will represent long term habitat loss and areas available for colonisation. It is expected that the cable protection will only represent a small increase of introduced hard structures proportional to the entire CEA fish and shellfish ecology study area, and so will have only a minor cumulative impact. Effects of EMF on fish and shellfish receptors are expected to be small and limited to directly around the cable • The cumulative magnitude of impact for marine mammals, as a result of changes in fish and shellfish communities affecting prey availability for Tier 1, Tier 2 and Tier 3 projects is therefore not expected to

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
			differ from the cumulative assessment for Tier 1 projects. The cumulative impact is predicted to be of local to regional spatial extent, long term duration, intermittent and both the impact itself (i.e. elevated underwater sound due to vessel use) and effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low.**
Sensitivity of receptor	The sensitivity of marine mammals to changes in prey availability is as described for the construction phase and in paragraph 4.9.8.14 *et seq.* for the Morgan Generation Assets alone assessment. Most marine mammals, except for minke whale, are deemed to be able to tolerate changes in prey availability, have high recoverability and international value. The sensitivity of the receptor is therefore, considered to be **low**.		
Significance of effect	Overall, the cumulative magnitude of the impacts is deemed to be low for all species, and the sensitivity of the receptor is considered to be low for all species except minke whale, which is medium. There would be no change to the international value of these species. Taking into account the medium sensitivity of minke whale to changes in herring, sprat and sandeel stocks, the cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.	Overall, the cumulative magnitude of the impacts is deemed to be low for all species, and the sensitivity of the receptor is considered to be low for all species except minke whale, which is medium. There would be no change to the international value of these species. Taking into account the medium sensitivity of minke whale to changes in herring, sprat and sandeel stocks, the cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.	Overall, the cumulative magnitude of the impacts is deemed to be low for all species, and the sensitivity of the receptor is considered to be low for all species except minke whale, which is medium. There would be no change to the international value of these species. Taking into account the medium sensitivity of minke whale to changes in herring, sprat and sandeel stocks, the cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.
Decommissioning			
Magnitude of impact	The cumulative effects assessment for Scenario 1 considers the following: • Cumulative impacts on marine mammals as a result of changes to the fish and	The cumulative effects assessment for Scenario 2 considers the following: • Cumulative impacts on marine mammals as a result of changes to the fish and	The cumulative effects assessment for Scenario 3 considers the following: • Cumulative impacts on marine mammals as a result of changes to the fish and

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
	shellfish community may occur as a result of the decommissioning of Morgan Generation Assets alongside Transmission Assets. • Potential cumulative impacts identified in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement, which have the potential to effect marine mammal prey include: – temporary habitat loss/disturbance, – long term habitat loss and colonisation of hard structures – increased SSC and associated sediment deposition • Long term habitat loss – up to 2.77 km^2 of cumulative permanent habitat loss/habitat alteration as a result of infrastructure being left *in situ* – up to 1.52 km^2 of cumulative permanent habitat loss due to the presence of cable protection and scour protection – The cumulative significance of the effect on fish and shellfish receptors as a result of long term habitat loss was estimated as minor adverse and therefore this is unlikely to impact marine mammals. • Introduction and colonisation of hard structures:	shellfish community may occur as a result of the decommissioning of Morgan Generation Assets alongside Transmission Assets and Morecambe Offshore Wind Farm Generation Assets. • Potential cumulative impacts identified in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement, which have the potential to effect marine mammal prey are as per Scenario 1. • Long term habitat loss – up to 4.74 km^2 of cumulative permanent habitat loss/habitat alteration as a result of infrastructure being left *in situ* – up to 1.52 km^2 of cumulative permanent habitat loss due to the presence of wind turbine foundations, cable protection and scour protection – The cumulative significance of the effect on fish and shellfish receptors as a result of long term habitat loss was estimated as minor adverse and therefore this is unlikely to impact marine mammals • For all other impacts considered in the cumulative scenario of Morgan Generation Assets alongside Transmission Assets and Morecambe Generation Assets, the assessment is as per Scenario 1. No significant adverse cumulative effects were predicted to occur to fish and shellfish species (marine mammal prey) as a result of the	shellfish community may occur as a result of the decommissioning of Morgan Generation Assets alongside Mona Offshore Wind Project, which is the only Tier 1 project in which the decommissioning phase will overlap with the Morgan Generation Assets. • Potential cumulative impacts identified in Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement, which have the potential to effect marine mammal prey are as per Scenario 1. • Long term habitat loss – up to 2.14 km^2 of cumulative permanent habitat loss/habitat alteration as a result of infrastructure being left *in situ* at the Morgan Generation Assets and Mona Offshore Wind Project – up to 1.52 km^2 of cumulative permanent habitat loss due to the presence of wind turbine foundations, cable protection and scour protection – The cumulative significance of the effect on fish and shellfish receptors as a result of long term habitat loss was estimated as minor adverse and therefore this is unlikely to impact marine mammals • For all other impacts considered in the cumulative scenario of Morgan Generation Assets alongside Transmission Assets

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
	– The expected magnitude of the introduction of hard substrata will be similar or lower to the previous phases, due to leaving in place scour protection and cable protection only. Colonisation of hard structures will mostly therefore occur due to the presence of these structures. • <u>Increased SSC and associated sediment deposition:</u> – Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement identified that limited information is currently available for decommissioning the Morgan Generation Assets regarding increased SSC and sediment deposition, however, The expected magnitude of increased SSC and sediment deposition will be less than the construction phase. – The cumulative significance of the effect on fish and shellfish receptors as a result of increased SSC and associated sediment deposition was estimated as minor adverse and therefore this is unlikely to impact marine mammals No significant adverse cumulative effects were predicted to occur to fish and shellfish species (marine mammal prey) as a result of the decommissioning phase of the Morgan Generation Assets in combination with the Transmission Assets (Volume 2, Chapter 3: Fish and shellfish ecology of the	decommissioning phase of the Morgan Generation Assets in combination with the Transmission Assets and Morecambe Offshore Wind Farm Generation Assets (Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement). Whilst most impacts are considered to be adverse there is the potential for some beneficial effects with respect to introduction of hard substrate which could increase prey availability for some species. Therefore, changes in prey availability on marine mammals were predicted to be of local spatial extent, medium-term duration, continuous and high reversibility. The magnitude was therefore, considered to be **low**.	and Morecambe Generation Assets, the assessment is as per Scenario 1 No significant adverse cumulative effects were predicted to occur to fish and shellfish species (marine mammal prey) as a result of the operations and maintenance of the Morgan Generation Assets in combination with Tier 1 and Tier 2 projects (Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement). Whilst most impacts are considered to be adverse there is the potential for some beneficial effects with respect to introduction of hard substrate which could increase prey availability for some species. Therefore, changes in prey availability on marine mammals were predicted to be of local spatial extent, medium-term duration, continuous and high reversibility. The magnitude was therefore, considered to be low. **Tier 2** The assessment for Tier 2 projects, Transmission Assets and Morecambe Offshore Wind Farm Generation Assets are set out in Scenario 1 and Scenario 2. No significant adverse cumulative effects were predicted to occur to fish and shellfish species (marine mammal prey) as a result of the decommissioning phase of the Morgan Generation Assets in combination with Tier 1 and Tier 2 projects (Volume 2, Chapter 3: Fish and shellfish ecology of the Environmental Statement). Whilst most impacts are considered to be adverse there is

	Scenario 1 Morgan Generation Assets + Transmission Assets	Scenario 2: Morgan Generation Assets + Morecambe Generation Assets + Transmission Assets	Scenario 3: Morgan Generation Assets + Transmission Assets + Tier 1, Tier 2, Tier 3 projects
	Environmental Statement). Whilst most impacts are considered to be adverse there is the potential for some beneficial effects with respect to introduction of hard substrate which could increase prey availability for some species. Therefore, changes in prey availability on marine mammals were predicted to be of local spatial extent, medium-term duration, continuous and high reversibility. The magnitude was therefore, considered to be **low**.		the potential for some beneficial effects with respect to introduction of hard substrate which could increase prey availability for some species. Therefore, changes in prey availability on marine mammals were predicted to be of local spatial extent, medium-term duration, continuous and high reversibility. The magnitude was therefore, considered to be low.
Sensitivity of receptor	The sensitivity of marine mammals to changes in prey availability is as described for the construction phase. Most marine mammals, except for minke whale, are deemed to be able to tolerate changes in prey availability, have high recoverability and international value. The sensitivity of the receptor is therefore, considered to be **low**.		
Significance of effect	Overall, the cumulative magnitude of the impacts is deemed to be low for all species, and the sensitivity of the receptor is considered to be low for all species except minke whale, which is medium. There would be no change to the international value of these species. Taking into account the medium sensitivity of minke whale to changes in herring, sprat and sandeel stocks, the cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.	Overall, the cumulative magnitude of the impacts is deemed to be low for all species, and the sensitivity of the receptor is considered to be low for all species except minke whale, which is medium. There would be no change to the international value of these species. Taking into account the medium sensitivity of minke whale to changes in herring, sprat and sandeel stocks, the cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.	Overall, the cumulative magnitude of the impacts is deemed to be low for all species, and the sensitivity of the receptor is considered to be low for all species except minke whale, which is medium. There would be no change to the international value of these species. Taking into account the medium sensitivity of minke whale to changes in herring, sprat and sandeel stocks, the cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

4.11.7 Future monitoring

4.11.7.1 No marine mammal monitoring to test the predictions made within the impact assessment is considered necessary.

4.12 Transboundary effects

4.12.1.1 A screening of potential transboundary impacts has been carried out and has identified that there was potential for significant transboundary effects with regard to marine mammals from the Morgan Generation Assets upon the interests of other states. This was due to the highly mobile nature of marine mammal species.

4.12.1.2 Screening of transboundary effects are given in Volume 3, Chapter 5.2: Transboundary impacts screening of the Environmental Statement. Potential transboundary effects could occur where elevations in underwater sound, particularly during construction piling, could ensonify large areas causing wide-ranging disturbance of marine mammals. The underwater sound disturbance contours predicted for piling extended across the Irish Sea and therefore animals transiting between these waters could be behaviourally disturbed across different states. The assessment of the Morgan Generation Assets alone considered the effects on marine mammal populations within relevant MUs which covered, at a minimum, the population within the Irish Sea and therefore in this respect captures the effects at transboundary level. Although, it is noted that these are not closed populations and there is likely to be mixing of individuals between other MUs. The assessment concluded that disturbance could occur intermittently during piling within the two year piling phase and the magnitude for the project alone was considered to be low. Sensitivity of marine mammal IEFs to disturbance was assessed as medium. Therefore, the significance of disturbance from piling at a transboundary level is considered to be minor adverse which is not significant in terms of EIA Regulations.

4.12.1.3 UXO clearance could also lead to large ranges over which elevations in underwater sound occur where there is high order detonation of the largest charge size. For example, injury in the form of PTS was predicted up to 15.3 km (for harbour porpoise) whist a moving away response, using the TTS metric, was predicted up to 34.37 km (for minke whale). Ranges of this extent could therefore affect individuals transiting between transboundary nations. These predictions are, however, highly precautionary since the low order clearance techniques may be used, which would considerably reduce the potential injury and/or disturbance ranges. For injury, also tertiary mitigation measures will be applied to reduce the risk of PTS (see Table 4.17) and with these in place the assessment concluded the magnitude for the project alone for most species, with respect to the relevant MUs, would be negligible. For harbour porpoise, there may be a risk of PTS from high order clearance, and therefore the magnitude was medium for this species only. Marine mammals are considered to be of high sensitivity to PTS and therefore the significance of effects for PTS and TTS for all species (except harbour porpoise) are of minor adverse significance. For harbour porpoise, the significance of effects for PTS was of moderate adverse significance which is significant in EIA terms. Therefore, the significance of both auditory injury and disturbance from UXO clearance at a transboundary level is considered to be minor adverse for all species, except harbour porpoise, which is not significant in terms of EIA Regulations. For harbour porpoise, as there is a potential significant effect from UXO clearance. However, it must be noted that the Applicant has committed to the development of an Underwater sound management strategy (Document Reference J13) to reduce the magnitude of underwater sound levels associated with residual significant potential impacts from the project alone, to a non-significant level, and therefore any potential transboundary level impact will be reduced. Therefore, the significance of injury from UXO clearance at a transboundary level is considered to be minor adverse with the application of tertiary mitigation (Table 4.17, with further detail in the MMMP (Document Reference J17)) and the Outline underwater sound management strategy (Document Reference J13), which is not significant in terms of EIA Regulations.

4.12.1.4 Geophysical and geotechnical surveys, vessel use and other (non-piling) sound producing activities could also lead to large disturbance ranges. For vibro-coring, the range of disturbance could extend out to 8.845 km and for SBP (chirp/pinger) disturbance could extend out to 17.3 km (all species). Individuals transiting between transboundary nations could potentially be disturbed within these ranges. For vessels such as survey and support vessels, crew transfer vessels, and installation vessels the range of disturbance could extend out to 3.6 km and for cable trenching the range of disturbance could extend out to 2.3 km. These predictions are, however, highly precautionary since the modelled ranges represent the distance beyond which no animals would be disturbed. Given that ranges for disturbance for non-impulsive sound sources are presented up to the 120 dB re 1 µPa (SPL_{rms}) threshold, and there is only a single available threshold (120 dB re 1 µPa (SPL_{rms})), (the Level B harassment threshold) (NMFS, 2005), (no distinction between mild and strong disturbance), it can be assumed that not all animals found within those ranges would be disturbed at the same level. Moreover, for those animals disturbed, there is likely to be a proportional response (i.e. not all animals will be disturbed to the same extent). The assessment concluded the magnitude for the project alone, with respect to the relevant MUs, would be low, and the significance of the effect to be of minor adverse significance. Therefore, the significance of disturbance from geophysical and geotechnical surveys at a transboundary level is considered to be minor adverse which is not significant in terms of EIA Regulations.

4.12.1.5 For other potential impacts, including elevated underwater sound from vessel use and other (non-piling) sound producing activities, increased likelihood of injury due to collision with vessels, changes in prey availability and operation related sound emissions, the effects on marine mammals were predicted to be very localised and are therefore considered unlikely to result in significant transboundary effects on marine mammal IEFs.

4.13 Inter-related effects

4.13.1.1 Inter-relationships are considered to be the potential impacts and associated effects of different aspects of the proposal on the same receptor. These are considered to be:

- Project lifetime effects: Assessment of the scope for effects that occur throughout more than one phase of the Morgan Generation Assets (construction, operations and maintenance, and decommissioning), to interact to potentially create a more significant effect on a receptor than if just assessed in isolation in these three phases (e.g. underwater sound effects from piling, operational wind turbines, vessels and decommissioning)
- 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 marine mammals, such as underwater sound from piling, UXO, or vessels, collision risk, changes in prey communities, may interact to produce a different, or greater effect on this receptor than when the

effects are considered in isolation. Receptor-led effects may be short term, temporary or transient effects, or incorporate longer term effects.

4.13.1.2 A description of the likely interactive effects arising from the Morgan Generation Assets on marine mammals is provided in Volume 2, Chapter 15: Inter-related effects of the Environmental Statement.

4.13.1.3 For marine mammals, the following potential impacts have been considered within the inter-related assessment:

- Injury and disturbance from elevated underwater sound during piling
- Injury and disturbance from elevated underwater sound generated from site investigation survey sources
- Injury and disturbance from elevated underwater sound during UXO clearance
- Injury and disturbance from elevated underwater sound due to vessel use and other (non-piling) sound producing activities
- Increased likelihood of injury due to collision with vessels
- Changes in fish and shellfish communities affecting prey availability.

4.14 Summary of impacts, mitigation measures and monitoring

4.14.1.1 Information on marine mammals within the Morgan marine mammal study area was collected through desktop review, site surveys and consultation with the EWG.

4.14.1.2 Table 4.59 presents a summary of the potential impacts, measures adopted as part of the Morgan Generation Assets and residual effects in respect to marine mammals. The impacts assessed include:

- Injury and disturbance from elevated underwater sound during piling
- Injury and disturbance from elevated underwater sound during UXO clearance
- Injury and disturbance from elevated underwater sound due to vessel use and other (non-piling) sound producing activities
- Increased likelihood of injury due to collision with vessels
- Injury and disturbance from elevated underwater sound generated from pre-construction survey sources
- Underwater sound from wind turbine operation
- Changes in fish and shellfish communities affecting prey availability.

4.14.1.3 Overall, for **most potential impacts** it is concluded that there will be **no significant effects** arising from the Morgan Generation Assets during the construction, operations and maintenance or decommissioning phases.

4.14.1.4 However, for harbour porpoise only, a **potential significant impact** was concluded for elevated underwater sound during **UXO clearance** when assessed using high order clearance of a 907 kg UXO (the absolute maximum). Therefore, whilst the assessment is based upon the absolute maximum UXO as per the MDS, it is acknowledged that this is very precautionary. Detailed surveys post-consent will inform the Morgan Generation Assets' understanding of the type and size of UXO that require clearance and consequently the most appropriate method for clearance. There is a general hierarchy of preferred mitigation with regard to UXO: avoid UXO, clear UXO with low order techniques and then clear with high order techniques where low order is not possible (dependent upon the individual situations surrounding each UXO). The Applicant has committed to the development of and adherence to a MMMP (Document Reference J17), which forms an annex to the Underwater sound management strategy (Document Reference J13) and both of which are secured in the deemed marine licences within the draft DCO (Document Reference C1).

4.14.1.5 Specifically, the MMMP (Document Reference J17) will secure the primary and tertiary mitigation measures (e.g. low order clearance, use of ADDs and soft start charges), with an outline MMMP included as part of the application (Document Reference J17). The Outline underwater sound management strategy (Document Reference J13) establishes a process of investigating options to manage underwater sound levels in consultation with the licensing authority and SNCBs and agreeing, prior to construction of those works which would lead to underwater sound impacts, which mitigation measures will be implemented to reduce the magnitude of impacts such that there will be no residual significant effect for the project alone (such as from elevated underwater sound during UXO clearance). Whilst the focus is on harbour porpoise (as a significant effect was concluded for this species from elevated underwater sound during UXO clearance) these measures would also result in a reduction of underwater sound impacts to other marine mammal receptors.

4.14.1.6 Table 4.60 presents a summary of the potential cumulative impacts, mitigation measures and residual effects. The cumulative impacts assessed include:

- Injury and disturbance from elevated underwater sound generated during piling
- Injury and disturbance from elevated underwater sound during UXO clearance
- Injury and disturbance from elevated underwater sound generated from pre-construction survey sources
- Injury and disturbance from elevated underwater sound due to vessel use and other (non-piling) sound producing activities
- Increased likelihood of injury due to collision with vessels
- Changes in fish and shellfish communities affecting prey availability.

4.14.1.7 Overall, it is concluded that **for most impacts** there will be **no significant cumulative effects** from the Morgan Generation Assets alongside other projects/plans, except as a result of **behavioural disturbance during piling** for **bottlenose dolphin** within the Irish Sea MU and **potential injury from UXO clearance for harbour porpoise**, which have a **potential significant cumulative effect**.

4.14.1.8 The potential cumulative impact of piling at projects across the Irish Sea could result in potential reductions to reproductive success during an animals lifetime to some individuals in the Irish Sea MU population, as disturbance in offshore areas during piling could lead to a longer duration over which individuals may be displaced from key feeding areas and therefore there may be a further reduction in the size of declining MU population. The assessment of cumulative effects from other plans and projects is based upon the respective MDSs presented in the Environmental Statements for Tier 1 projects or PEIR for Tier 2 Projects. The assessment does not consider any further mitigation or reduced/refined project design envelopes for other Tier 1 and/or Tier 2 projects that may be implemented post consent. However it is understood that if other projects are consented, they will each implement appropriate measures such that any significant effect is reduced to a non-significant level. Therefore whilst this assessment cannot conclude based upon this assumption, a significant cumulative impact is considered unlikely for this reason.

4.14.1.9 Whilst the project alone assessment determined there is no potential for a significant effect from elevated underwater sound during piling in EIA terms, it is acknowledged the Morgan Generation Assets may contribute to the cumulative impact within the CEA area. As such an Outline underwater sound management strategy (Document Reference J13) has been submitted with the application for consent (alongside the Outline MMMP (Document Reference J17)). The Outline underwater sound management strategy (Document Reference J13) establishes a process for investigating options to manage underwater sound levels in consultation with the MMO and SNCBs and agreeing, prior to construction of those works which would lead to underwater sound impacts, which mitigation measures will be implemented to reduce the magnitude of impacts such that there will be no residual significant effect for the Morgan Generation Assets. The final Underwater sound management strategy (Document Reference J13) will set out the measures agreed with the MMO and SNCBs to reduce sound levels associated with residual significant impacts from the Morgan Generation Assets to a non-significant level, and to minimise the Morgan Generation Asset's contribution to any cumulative effect.

4.14.1.10 As a result of UXO clearance, on the basis of the MDS (absolute maximum 907 kg UXO) high order detonation, there may be some residual effect in-combination with other projects with a small number of animals potentially exposed to sound levels that could elicit PTS. However, the likelihood of UXO clearance being undertaken simultaneously with other projects is considered to be very low.

4.14.1.11 No potential for significant transboundary impacts has been identified in regard to effects of the Morgan Generation Assets.

Table 4.59: Summary of potential environmental effects, mitigation and monitoring.

[a] C=construction, O=operations and maintenance, D=decommissioning

Description of impact	Phase C	O	D	Measures adopted as part of the project	Species	Magnitude of impact	Sensitivity of receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
Injury and disturbance from elevated underwater sound during piling	✓	×	×	Implementation of initiation stage, soft start, ramp up (primary measures); use of MMObs, PAM, ADD (tertiary measures) as set out in the Outline MMMP (Document Reference J17).	Harbour porpoise	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)	None	Minor adverse (injury/disturbance)	None
					Bottlenose dolphin	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Short-beaked common dolphin	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Risso's dolphin	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Minke whale	Low (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Grey seal	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Harbour seal	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	

Description of impact	Phase C	O	D	Measures adopted as part of the project	Species	Magnitude of impact	Sensitivity of receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
Injury and disturbance from elevated underwater sound during UXO clearance	✓	×	×	Inclusion of low order techniques as an option (primary measures); use of MMObs, PAM, ADD and soft start charges (tertiary measures) as set out in the Outline MMMP (Document Reference J17).	Harbour porpoise	Medium (injury)[4] Low (disturbance)	High (injury) Low (disturbance)	Moderate adverse (injury/disturbance)	Further details on UXO requiring clearance will be available post consent. On basis that details are not available at this time the residual effect remains the same, however, with appropriate measures as agreed with the EWG and secured for the DCO via the Underwater sound management strategy (Document Reference J13) it is anticipated that the magnitude of effect would reduce.	Moderate adverse (injury/disturbance)	None
					Bottlenose dolphin	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Short-beaked common dolphin	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Risso's dolphin	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Minke whale	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Grey seal	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Harbour seal	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	

[4] Based on the absolute maximum UXO size of 907 kg, noting that for the most likely maximum UXO size of 130 kg, with project designed-in measures the risk of injury could be mitigated.

Description of impact	Phase C	O	D	Measures adopted as part of the project	Species	Magnitude of impact	Sensitivity of receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
Injury and disturbance from elevated underwater sound due to vessel use and other (non-piling) sound producing activities	✓	✓	✓	Offshore EMP with measures to minimise injury and disturbance to marine mammals from transiting vessels (tertiary measures).	Harbour porpoise	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)	None	Minor adverse (injury/disturbance)	None
					Bottlenose dolphin	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Short-beaked common dolphin	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Risso's dolphin	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Minke whale	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Grey seal	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Harbour seal	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
Increased likelihood of injury of due to collision	✓	✓	✓	Offshore EMP with measures to minimise injury and disturbance to marine mammals from	Harbour porpoise	Low	Medium	Minor adverse	None	Minor adverse	None
					Bottlenose dolphin	Low	Medium	Minor adverse		Minor adverse	
					Short-beaked common dolphin	Low	Medium	Minor adverse		Minor adverse	

Description of impact	Phase C	O	D	Measures adopted as part of the project	Species	Magnitude of impact	Sensitivity of receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
with vessels				transiting vessels (tertiary measures).	Risso's dolphin	Low	Medium	Minor adverse		Minor adverse	
					Minke whale	Low	Medium	Minor adverse		Minor adverse	
					Grey seal	Low	Medium	Minor adverse		Minor adverse	
					Harbour seal	Low	Medium	Minor adverse		Minor adverse	
Injury and disturbance from elevated underwater sound generated from site investigation survey sources	✓			Implementation of soft start and ramp up where possible (primary measures); use of MMObs, PAM, (tertiary measures) as set out in the Outline MMMP.	Harbour porpoise	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)	None	Minor adverse (injury/disturbance)	None
					Bottlenose dolphin	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Short-beaked common dolphin	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Risso's dolphin	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Minke whale	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Grey seal	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Harbour seal	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	

Description of impact	Phase			Measures adopted as part of the project	Species	Magnitude of impact	Sensitivity of receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
	C	O	D								
Underwater sound from wind turbine operation		✓		None	Harbour porpoise	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)	None	Minor adverse (injury/disturbance)	None
					Bottlenose dolphin	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Short-beaked common dolphin	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Risso's dolphin	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Minke whale	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Grey seal	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Harbour seal	Negligible (injury) Low (disturbance)	High (injury) Medium (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
Changes in fish and shellfish communities affecting	✓	✓	✓	None	Harbour porpoise	Low	Low	Minor adverse	None	None	None
					Bottlenose dolphin	Low	Low	Minor adverse		None	
					Short-beaked common dolphin	Low	Low	Minor adverse		None	

Description of impact	Phase C	O	D	Measures adopted as part of the project	Species	Magnitude of impact	Sensitivity of receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
prey availability					Risso's dolphin	Low	Low	Minor adverse		None	
					Minke whale	Low	Medium	Minor adverse		None	
					Grey seal	Low	Low	Minor adverse		None	
					Harbour seal	Low	Low	Minor adverse		None	

Table 4.60: Summary of potential cumulative environmental effects, mitigation and monitoring.

[a] C=construction, O=operations and maintenance, D=decommissioning

Description of impact	Phase C	O	D	Measures adopted as part of the project	Species	Magnitude of impact	Sensitivity of receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
Tier 1											
Injury and disturbance from elevated underwater sound during piling	✓	×	×	Implementation of initiation stage, soft start, ramp up, (primary measures); use of MMObs, PAM, ADD (tertiary measures) as set out in the Outline MMMP.	Harbour porpoise	Low	Medium	Minor adverse	The Underwater sound management strategy (with Outline underwater sound management strategy included as part of the application, Document Reference J13) will reduce the Morgan Generation Assets project alone contributions to the cumulative assessment if required post consent. Requirements for management measures and mitigation will be discussed with the licensing authority and SNCBs.	Minor adverse	None
					Bottlenose dolphin	Medium (Irish Sea MU)	Medium	Moderate Adverse		Moderate Adverse	
					Short-beaked common dolphin	Low	Medium	Minor adverse		Minor adverse	
					Risso's dolphin	Low	Medium	Minor adverse		Minor adverse	
					Minke whale	Low	Medium	Minor adverse		Minor adverse	
					Grey seal	Low	Medium	Minor adverse		Minor adverse	
Injury and disturbance to	✓	×	×	Inclusion of low order	Harbour porpoise	Medium (injury)[5] Low (disturbance)	High (injury)	Moderate adverse (injury)	Further details on UXO requiring	Moderate adverse (injury)	None

[5] For the project alone this is based on the absolute maximum UXO size of 907 kg, noting that for the most likely maximum UXO size of 130 kg, with project designed-in measures the risk of injury could be mitigated. It is assumed that suitable measures will be in place to reduce the risk of injury at all other projects.

Description of impact	Phase C	O	D	Measures adopted as part of the project	Species	Magnitude of impact	Sensitivity of receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
marine mammals from elevated underwater sound during UXO clearance				techniques as an option (primary measures); use of MMObs, PAM, ADD and soft start charges (tertiary measures) as set out in the Outline MMMP.			Low (disturbance)	Minor adverse (disturbance	clearance will be available post consent. On basis that details are not available at this time the residual effect remains the same, however, with appropriate measures as agreed in consultation with the licensing authority and SNCBs and secured for the DCO via the Underwater sound management strategy it is anticipated that the magnitude of effect would reduce for the project alone and therefore reduce the cumulative effect.	Minor adverse (disturbance)	
					Bottlenose dolphin	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse (injury/disturbance)		Minor adverse	
					Short-beaked common dolphin	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse (injury/disturbance)		Minor adverse	
					Risso's dolphin	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse (injury/disturbance)		Minor adverse	
					Minke whale	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse (injury/disturbance)		Minor adverse	
					Grey seal	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse (injury/disturbance)		Minor adverse	
Injury and disturbance from elevated underwater sound due to vessel use and other (non-piling) sound	✓	✓	×	Offshore EMP with measures to minimise injury and disturbance to marine mammals from transiting vessels	Harbour porpoise	Low	Medium	Minor adverse	None	Minor adverse	None
					Bottlenose dolphin	Low	Medium	Minor adverse		Minor adverse	
					Short-beaked common dolphin	Low	Medium	Minor adverse		Minor adverse	

Description of impact	Phase C	Phase O	Phase D	Measures adopted as part of the project	Species	Magnitude of impact	Sensitivity of receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
producing activities				(tertiary measures).	Risso's dolphin	Low	Medium	Minor adverse		Minor adverse	
					Minke whale	Low	Medium	Minor adverse		Minor adverse	
					Grey seal	Low	Medium	Minor adverse		Minor adverse	
					Harbour seal	Low	Medium	Minor adverse		Minor adverse	
Increased likelihood of injury due to collision with vessels	✓	✓	×	Offshore EMP with measures to minimise injury and disturbance to marine mammals from transiting vessels (tertiary measures).	Harbour porpoise	Low	Medium	Minor adverse	None	Minor adverse	None
					Bottlenose dolphin	Low	Medium	Minor adverse		Minor adverse	
					Short-beaked common dolphin	Low	Medium	Minor adverse		Minor adverse	
					Risso's dolphin	Low	Medium	Minor adverse		Minor adverse	
					Minke whale	Low	Medium	Minor adverse		Minor adverse	
					Grey seal	Low	Medium	Minor adverse		Minor adverse	
					Harbour seal	Low	Medium	Minor adverse		Minor adverse	
Changes in fish and shellfish communities	✓	✓	✓	None	Harbour porpoise	Low	Low	Minor adverse	None	Minor adverse	None
					Bottlenose dolphin	Low	Low	Minor adverse		Minor adverse	

Description of impact	Phase C	Phase O	Phase D	Measures adopted as part of the project	Species	Magnitude of impact	Sensitivity of receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
affecting prey availability					Short-beaked common dolphin	Low	Low	Minor adverse		Minor adverse	
					Risso's dolphin	Low	Low	Minor adverse		Minor adverse	
					Minke whale	Low	Medium	Minor adverse		Minor adverse	
					Grey seal	Low	Low	Minor adverse		Minor adverse	
					Harbour seal	Low	Low	Minor adverse		Minor adverse	
Tier 2											
Injury and disturbance from elevated underwater sound during piling	✓	×	×	Implementation of initiation stage, soft start, ramp up, (primary measures); use of MMObs, PAM, ADD (tertiary measures) as set out in the Outline MMMP.	Harbour porpoise	Low	Medium	Minor adverse	The Underwater sound management strategy (with Outline underwater sound management strategy included as part of the application, Document Reference J13) will reduce the Morgan Generation Assets project alone contributions to the cumulative assessment if required post consent. Requirements for management measures and	Minor adverse	None
					Bottlenose dolphin	Medium (IS MU)	Medium	Moderate Adverse		Moderate Adverse	
					Short-beaked common dolphin	Low	Medium	Minor adverse		Minor adverse	
					Risso's dolphin	Low	Medium	Minor adverse		Minor adverse	
					Minke whale	Low	Medium	Minor adverse		Minor adverse	
					Grey seal	Low	Medium	Minor adverse		Minor adverse	
					Harbour seal	Low	Medium	Minor adverse		Minor adverse	

Description of impact	Phase C	Phase O	Phase D	Measures adopted as part of the project	Species	Magnitude of impact	Sensitivity of receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
									mitigation will be discussed with the licensing authority and SNCBs. Further details on UXO requiring clearance will be available post consent. On basis that details are not available at this time the residual effect remains the same, however, with appropriate measures as agreed in consultation with the licensing authority and SNCBs and secured for the DCO via the Underwater sound management strategy it is anticipated that the magnitude of effect would reduce for the project alone and therefore reduce the cumulative effect.		

Description of impact	Phase			Measures adopted as part of the project	Species	Magnitude of impact	Sensitivity of receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
	C	O	D								
Injury and disturbance to marine mammals from elevated underwater sound during UXO clearance	✓	×	×	Inclusion of low order techniques as an option (primary measures); use of MMObs, PAM, ADD and soft start charges (tertiary measures) as set out in the Outline MMMP.	Harbour porpoise	Medium (injury)[6] Low (disturbance)	High (injury) Low (disturbance)	Moderate adverse (injury) Minor adverse (disturbance)	Further details on UXO requiring clearance will be available post consent. On basis that details are not available at this time the residual effect remains the same, however, with appropriate measures as agreed with the EWG and secured for the DCO via the Outline USMS it is anticipated that the magnitude of effect would reduce for the project alone and therefore reducing the cumulative effect.	Moderate adverse (injury) Minor adverse (disturbance)	None
					Bottlenose dolphin	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Short-beaked common dolphin	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Risso's dolphin	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Minke whale	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Grey seal	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
					Harbour seal	Negligible (injury) Low (disturbance)	Medium	Minor adverse (injury/disturbance)		Minor adverse (injury/disturbance)	
Injury and disturbance from	✓	✓	×	Offshore EMP with measures	Harbour porpoise	Low	Medium	Minor adverse	None	Minor adverse	None

[6] For the project alone this is based on the absolute maximum UXO size of 907 kg, noting that for the most likely maximum UXO size of 130 kg, with project designed-in measures the risk of injury could be mitigated. It is assumed that suitable measures will be in place to reduce the risk of injury at all other projects.

Description of impact	Phase C	O	D	Measures adopted as part of the project	Species	Magnitude of impact	Sensitivity of receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
elevated underwater sound due to vessel use and other (non-piling) sound producing activities				to minimise injury and disturbance to marine mammals from transiting vessels (tertiary measures).	Bottlenose dolphin	Low	Medium	Minor adverse		Minor adverse	
					Short-beaked common dolphin	Low	Medium	Minor adverse		Minor adverse	
					Risso's dolphin	Low	Medium	Minor adverse		Minor adverse	
					Minke whale	Low	Medium	Minor adverse		Minor adverse	
					Grey seal	Low	Medium	Minor adverse		Minor adverse	
					Harbour seal	Low	Medium	Minor adverse		Minor adverse	
Increased likelihood of injury due to collision with vessels	✓	✓	✓	Offshore EMP with measures to minimise injury and disturbance to marine mammals from transiting vessels (tertiary measures).	Harbour porpoise	Low	Medium	Minor adverse	None	Minor adverse	None
					Bottlenose dolphin	Low	Medium	Minor adverse		Minor adverse	
					Short-beaked common dolphin	Low	Medium	Minor adverse		Minor adverse	
					Risso's dolphin	Low	Medium	Minor adverse		Minor adverse	
					Minke whale	Low	Medium	Minor adverse		Minor adverse	
					Grey seal	Low	Medium	Minor adverse		Minor adverse	

Description of impact	Phase C	Phase O	Phase D	Measures adopted as part of the project	Species	Magnitude of impact	Sensitivity of receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
					Harbour seal	Low	Medium	Minor adverse		Minor adverse	
Injury and disturbance from pre-construction site-investigation surveys	✓	×	×	Implementation of soft start and ramp up where possible (primary measures); use of MMObs, PAM (tertiary measures) as set out in the Outline MMMP.	Harbour porpoise	Low	Medium	Minor adverse	None	Minor adverse	None
					Bottlenose dolphin	Low	Medium	Minor adverse		Minor adverse	
					Short-beaked common dolphin	Low	Medium	Minor adverse		Minor adverse	
					Risso's dolphin	Low	Medium	Minor adverse		Minor adverse	
					Minke whale	Low	Medium	Minor adverse		Minor adverse	
					Grey seal	Low	Medium	Minor adverse		Minor adverse	
					Harbour seal	Low	Medium	Minor adverse		Minor adverse	
Changes in fish and shellfish communities affecting prey availability	✓	✓	✓	None	Harbour porpoise	Low	Low	Minor adverse	None	Minor adverse	None
					Bottlenose dolphin	Low	Low	Minor adverse		Minor adverse	
					Short-beaked common dolphin	Low	Low	Minor adverse		Minor adverse	
					Risso's dolphin	Low	Low	Minor adverse		Minor adverse	

Description of impact	Phase C	Phase O	Phase D	Measures adopted as part of the project	Species	Magnitude of impact	Sensitivity of receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
					Minke whale	Low	Medium	Minor adverse		Minor adverse	
					Grey seal	Low	Low	Minor adverse		Minor adverse	
					Harbour seal	Low	Low	Minor adverse		Minor adverse	
Tier 3											
Injury and disturbance from elevated underwater sound during piling	✓	×	×	Implementation of initiation stage, soft start, ramp up, (primary measures); use of MMObs, PAM, ADD (tertiary measures) as set out in the Outline MMMP.	Harbour porpoise	Low	Medium	Minor adverse	The Underwater sound management strategy (with Outline underwater sound management strategy included as part of the application, Document Reference J13) will reduce the Morgan Generation Assets project alone contributions to the cumulative assessment if required post consent. Requirements for management measures and mitigation will be discussed with the licensing authority and SNCBs. Further details on UXO requiring clearance will be	Minor adverse	None
					Bottlenose dolphin	Low (wider Irish Sea MU plus Offshore Channel and Southwest England MU)	Medium	Minor adverse		Minor adverse	
						Medium (Irish Sea MU)	Medium	Moderate Adverse		Moderate Adverse	
					Short-beaked common dolphin	Low	Medium	Minor adverse		Minor adverse	
					Risso's dolphin	Low	Medium	Minor adverse		Minor adverse	
					Minke whale	Low	Medium	Minor adverse		Minor adverse	
					Grey seal	Low	Medium	Minor adverse		Minor adverse	
					Harbour seal	Low	Medium	Minor adverse		Minor adverse	

Description of impact	Phase C	Phase O	Phase D	Measures adopted as part of the project	Species	Magnitude of impact	Sensitivity of receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
									available post consent. On basis that details are not available at this time the residual effect remains the same, however, with appropriate measures as agreed in consultation with the licensing authority and SNCBs and secured for the DCO via the Underwater sound management strategy it is anticipated that the magnitude of effect would reduce for the project alone and therefore reduce the cumulative effect.		
Injury and disturbance to marine mammals from elevated underwater	✓	×	×	Inclusion of low order techniques as an option (primary measures); use of MMObs,	Harbour porpoise	Medium (injury)[7]	High (injury)	Moderate adverse	Further details on UXO requiring clearance will be available post consent. On basis that details are not available at this time		None
						Low (disturbance)	Low (disturbance)	Minor adverse			
					Bottlenose dolphin	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse		Minor adverse	

[7] For the project alone this is based on the absolute maximum UXO size of 907 kg, noting that for the most likely maximum UXO size of 130 kg, with project designed-in measures the risk of injury could be mitigated. It is assumed that suitable measures will be in place to reduce the risk of injury at all other projects.

Description of impact	Phase C	O	D	Measures adopted as part of the project	Species	Magnitude of impact	Sensitivity of receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
sound during UXO clearance				PAM, ADD and soft start charges (tertiary measures) as set out in the Outline MMMP.	Short-beaked common dolphin	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse	the residual effect remains the same, however, with appropriate measures as agreed with the EWG and secured for the DCO via the Outline USMS it is anticipated that the magnitude of effect would reduce for the project alone and therefore reducing the cumulative effect.	Minor adverse	
					Risso's dolphin	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse		Minor adverse	
					Minke whale	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse		Minor adverse	
					Grey seal	Negligible (injury) Low (disturbance)	High (injury) Low (disturbance)	Minor adverse		Minor adverse	
					Harbour seal	Negligible (injury) Low (disturbance)	Medium	Minor adverse		Minor adverse	
Injury and disturbance from elevated underwater sound due to vessel use and other (non-piling) sound producing activities	✓	✓	×	Offshore EMP with measures to minimise injury and disturbance to marine mammals from transiting vessels (tertiary measures)					None		None
					Bottlenose dolphin	Low	Medium	Minor adverse		Minor adverse	
					Short-beaked common dolphin	Low	Medium	Minor adverse		Minor adverse	
					Risso's dolphin	Low	Medium	Minor adverse		Minor adverse	
					Minke whale	Low	Medium	Minor adverse		Minor adverse	
					Grey seal	Low	Medium	Minor adverse		Minor adverse	

Description of impact	Phase C	O	D	Measures adopted as part of the project	Species	Magnitude of impact	Sensitivity of receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
					Harbour seal	Low	Medium	Minor adverse		Minor adverse	
Increased likelihood of injury due to collision with vessels	✓	✓	×	Offshore EMP with measures to minimise injury and disturbance to marine mammals from transiting vessels (tertiary measures).	Harbour porpoise	Low	Medium	Minor adverse	None	Minor adverse	None
					Bottlenose dolphin	Low	Medium	Minor adverse		Minor adverse	
					Short-beaked common dolphin	Low	Medium	Minor adverse		Minor adverse	
					Risso's dolphin	Low	Medium	Minor adverse		Minor adverse	
					Minke whale	Low	Medium	Minor adverse		Minor adverse	
					Grey seal	Low	Medium	Minor adverse		Minor adverse	
					Harbour seal	Low	Medium	Minor adverse		Minor adverse	
Changes in fish and shellfish communities affecting prey availability	✓	✓	✓	None	Harbour porpoise	Low	Low	Minor adverse	None	Minor adverse	None
					Bottlenose dolphin	Low	Low	Minor adverse		Minor adverse	
					Short-beaked common dolphin	Low	Low	Minor adverse		Minor adverse	
					Risso's dolphin	Low	Low	Minor adverse		Minor adverse	

Description of impact	Phase C	Phase O	Phase D	Measures adopted as part of the project	Species	Magnitude of impact	Sensitivity of receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
					Minke whale	Low	Medium	Minor adverse		Minor adverse	
					Grey seal	Low	Low	Minor adverse		Minor adverse	
					Harbour seal	Low	Low	Minor adverse		Minor adverse	

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Appendix A: Cumulative effects assessment

A.1 Injury and disturbance from elevated underwater sound during piling

A.1.1.1.1 Parameters of piling for the Morgan Generation Assets; Tier 2 projects (Morgan and Morecambe Offshore Wind Farms: Transmission Assets and Morecambe Generation Assets); and Tier 1 projects (Mona Offshore Wind Project, Awel y Môr Offshore Wind Farm, Project Erebus and White Cross Offshore Wind Farm) are set out in Table A. 1. Table A. 2 (cetaceans) and Table A. 3 (pinnipeds) sets out the numbers of animals predicted to be disturbed as a result of underwater sound during piling for these projects.

Table A. 1: Piling parameters for Morgan Generation Assets; Morgan and Morecambe Offshore Windfarms: Transmission Assets and Morecambe Generation Assets (Tier 2 projects), and Tier 1 projects.

[a] This table includes one OSP (foundation) which is considered under both the Morgan Generation Assets and the Morgan and Morecambe Offshore Windfarms: Transmission Assets; and one OSP (foundation) which is considered under both the Morgan and Morecambe Offshore Wind Farms: Transmission Assets and the Morecambe Generation Assets. This assessment therefore double counts the OSPs and is precautionary.

Project	Reference	Maximum number of piles	Scenario	Piling duration (up to)	Piling phase
Morgan Generation Assets	Section 4.9.1	454	Maximum spatial scenario Pin pile 3,000 kJ/3,000 kJ Concurrent piling	90 days	24 months
		454	Maximum temporal scenario Pin pile 4,400 kJ/3,000 kJ Single piling	114 days	
Tier 1					
Awel y Môr Offshore Wind Farm	RWE (2022)	50	Monopile 5,000 kJ Sequential piling	201 days	12 months
Project Erebus	Blue Gem Wind (2020)	35	Pile 800 kJ	18 days	8 months
Mona Offshore Wind Project	Mona Offshore Wind Ltd. (2023)	454	Pin pile 3,300 kJ Concurrent piling	90 days	24 months

Project	Reference	Maximum number of piles	Scenario	Piling duration (up to)	Piling phase
White Cross Offshore Wind Farm	White Cross Offshore Wind (2023)	48	Wind turbine foundations: pin pile 800 kJ Single piling	5 days	6 months
		4	OSP foundation: pin pile 2,500 kJ Single piling	1 day	
Tier 2					
Morecambe Generation Assets	Morecambe Offshore Windfarm Ltd (2023)	42	Monopile 5,000 kJ Single piling	42 days	24 months
Morgan and Morecambe Offshore Wind Farms: Transmission Assets	Morecambe Offshore Windfarm Ltd and Morgan Offshore Wind Ltd. (2023)	4	Monopile 5,500 kJ/5,000 kJ Concurrent piling	4 days	15 months

Table A. 2: Cumulative assessment for cetacean species – numbers of animals predicted to be disturbed as a result of underwater sound during piling for Tier 1 projects and Tier 2 Projects Morgan and Morecambe Offshore Wind Farms: Transmission Assets and Morecambe Generation Assets.

[a] Based on realistic density of 0.13 animals/km² (JCP Phase III Tool estimate)

[b] White Cross Offshore Wind Farm: number based on TTS as a proxy for disturbance (White Cross Offshore Wind (2023)).

[c] White Cross Offshore Wind Farm: number based on activation of an ADD for 31 minutes (White Cross Offshore Wind (2023)).

[d] White Cross Offshore Wind Farm: number based on activation of an ADD for 62 minutes (White Cross Offshore Wind (2023)).

Project	Harbour porpoise		Bottlenose dolphin		Short-beaked common dolphin		Risso's dolphin		Minke whale	
	Density (animals per km²)	Max no animals disturbed (% CIS MU)	Density (animals per km²)	Max no animals disturbed (% IS MU)	Density (animals per km²)	Max no animals disturbed (% CGNS MU)	Density (animals per km²)	Max no animals disturbed (% CGNS MU)	Density (animals per km²)	Max no animals disturbed (%CGNS MU)
Morgan Generation Assets (maximum spatial scenario)	0.262	1,007 (1.61%)	0.0012	5 (1.57%)	0.0006	3 (0.002%)	0.0313	121 (0.98%)	0.0173	67 (0.33%)
Morgan Generation Assets (maximum temporal scenario)	0.262	858 (1.37%)	0.0012	4 (1.34%)	0.0006	2 (0.002%)	0.0313	103 (0.84%)	0.0173	57 (0.28%)
Mona Offshore Wind Project	0.2773	1,142 (1.83%)	0.0017	7 (2.39%)	0.0006	3 (0.002%)	0.0313	129 (1.05%)	0.0173	72 (0.35%)
Awel y Môr Offshore Wind Farm	1.0 (0.13 animals per km²)[a]	2,112 (275)[a] (3.38%)	0.035 for the 20m depth contour 0.008 offshore	23 (7.9%)	0.0081	17 (0.02%)	0.031	65 (0.53%)	0.0173	36 (0.18%)

Project	Harbour porpoise		Bottlenose dolphin		Short-beaked common dolphin		Risso's dolphin		Minke whale	
	Density (animals per km²)	Max no animals disturbed (% CIS MU)	Density (animals per km²)	Max no animals disturbed (% IS MU)	Density (animals per km²)	Max no animals disturbed (% CGNS MU)	Density (animals per km²)	Max no animals disturbed (% CGNS MU)	Density (animals per km²)	Max no animals disturbed (%CGNS MU)
White Cross Offshore Wind Farm (wind turbines)	0.918	1,652[b] (2.6%)	Not considered under CEA for bottlenose dolphin, as project outside IS MU		5.23	< 1[b] (0.005%)	Project did not consider effects on Risso's dolphin		0.0112	42[c] (0.21%)
White Cross Offshore Wind Farm (OSP)	0.918	2,754[b] (4.4%)			5.23	< 1[b] (0.005%)			0.0112	61[c] (0.30%)
Project Erebus	0.04	1,967 (3.15%)	Not considered under CEA for bottlenose dolphin, as project outside IS MU		1.61 (site specific) 0.3743 (wider area)	2,067 (2.01%)	Project did not consider effects on Risso's dolphin		0.0112	55 (0.30%)
Morgan and Morecambe Offshore Wind Farms: Transmission Assets	0.560	2,465 (3.94%)	0.35	11 (3.7%)	0.047	207 (0.2%)	0.031	125 (1.01%)	0.017	69 (0.34%)
Morecambe Offshore Windfarm Generation Assets	1.394	1,279 (2.0%)	0.0005	<1 (0.000017%)	0.013	<1 (0.0000013%)	0.0002	<1 (0.00000016%)	0.0018	2 (0.0089%)

Table A. 3: Cumulative assessment for pinniped species – numbers of animals predicted to be disturbed as a result of underwater sound during piling for Tier 1 projects and Tier 2 Projects Morgan and Morecambe Offshore Wind Farms: Transmission Assets and Morecambe Generation Assets.

[a] OSPAR Region III was applied as a broader population reference for all projects other than Morecambe Offshore Windfarm Generation Assets. For Morecambe Offshore Windfarm Generation Assets a combined MU of: SCOS MUs, Isle of Man population estimate, east Ireland and southeast Ireland populations was applied.

[b] White Cross Offshore Wind Farm: number based on a 25 km known disturbance range for grey seal for piling (White Cross Offshore Wind (2023)).

Project	Grey seal		Harbour seal	
	Density (animals per km^2)	Max no animals disturbed (% GSRP / % OSPAR Region III)[a]	Density (animals per km^2)	Max no animals disturbed (% HSRP)
Morgan Generation Assets (maximum spatial scenario)	N/A – grid cell specific	61 (0.47%/0.10%)	N/A – grid cell specific	< 1 (0.01%)
Morgan Generation Assets (maximum temporal scenario)		54 (0.41%/0.09%)		< 1 (0.01%)
Mona Offshore Wind Project	N/A – grid cell specific	31 (0.23%/0.05%)	N/A – grid cell specific	< 1 (0.01%)
Awel y Môr Offshore Wind Farm	0.43	81 (1.6%/ 0.1%)	Project did not consider effects on harbour seal	
White Cross Offshore Wind Farm (wind turbines)	0.005	10[b] (0.48% - SW England MU)	Project did not consider effects on harbour seal	
White Cross Offshore Wind Farm (OSP)		10[b] (0.48% - SW England MU)		
Project Erebus	N/A – Grid cell specific	18 (0.3%/ 0.0%)	Project did not consider effects on harbour seal	
Morgan and Morecambe Offshore Wind Farms: Transmission Assets	N/A – Grid cell specific	88 (0.65%/ 0.14%)	N/A – Grid cell specific	<1 (0.01%)
Morecambe Offshore Windfarm Generation Assets	0.084	11 (0.99%/ 0.098%)	0.024	3 (0.19%)

Scenario 1: Morgan Generation Assets together with the Morgan and Morecambe Offshore Wind Farms: Transmission Assets

A.1.1.1.2 The construction of the Morgan Generation Assets, together with the construction of the Morgan and Morecambe Offshore Wind Farms: Transmission Assets (hereafter known as 'Transmission Assets')) may lead to disturbance to marine mammals during piling.

A.1.1.1.3 Given there is a potential for temporal overlap of piling phases at the two projects, animals could be disturbed during piling at both projects simultaneously. Therefore, where cumulative numbers of animals potentially disturbed are presented (e.g. paragraph A.1.1.1.7 for harbour porpoise) the number of animals are summed from both projects. One OSP foundation (therefore 12 pin piles) at the Morgan Generation Assets is considered under both the Morgan Generation Assets and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets applications and therefore the number of days of piling and number of animals to be disturbed on each day of piling is conservative. Cumulative iPCoD modelling was conducted to support the CEA, incorporating numbers of animals disturbed by each project (see paragraph 4.9.2.13 *et seq* for more details on iPCoD modelling), which similarly considers one OSP (foundation) under both projects.

A.1.1.1.4 For Morgan Generation Assets, two scenarios are considered as per the MDS (Table 4.16): a maximum temporal scenario and a maximum spatial scenario. The maximum temporal scenario is up to 114 days of single piling over the piling phase between 2027 and 2028 (3,000 kJ or 4,400 kJ) (Table 4.22). The maximum spatial scenario is 90 days of concurrent piling over the piling phase between 2027 and 2028 (3,000 plus 3,000 kJ) (Table 4.22).

Construction phase

Magnitude of impact

A.1.1.1.5 Based on the Morgan and Morecambe Offshore Wind Farms: Transmission Assets PEIR marine mammal chapter, for concurrent piling (5,500 kJ/5,000 kJ) there will be up to 4 days of piling over the piling phase of 12 months between 2027 and 2028, within the four-year construction phase (Morgan offshore Wind Ltd. and Morecambe Offshore Windfarm Ltd, 2023). Single piling scenarios were also presented for two OSP foundations (5,500 kJ and 5,000 kJ respectively) and a single offshore booster station foundation (5,000 kJ) which would take place over 6 days. The density estimates presented were different across the two OSPs and offshore booster station foundations, as a result of being derived from both the Morgan and Morecambe Offshore Wind Farms: Transmission Assets and the Morecambe Offshore Windfarm Generation Assets PEIR. Therefore, whilst the concurrent piling scenario represented the maximum spatial scenario, for each species this did not necessarily represent the maximum number of animals likely to be disturbed. As such, from a precautionary perspective this assessment has assumed the maximum number of animals per species, regardless of piling scenario, occurring over 6 days as the maximum temporal scenario. It is noted that for some species this may lead to an overestimate of animals, as the maximum number of animals disturbed will be combined with the maximum temporal scenario.

Harbour porpoise

A.1.1.1.6 The maximum number of animals predicted to be disturbed at the Morgan and Morecambe Offshore Wind Farms: Transmission Assets, is up to 2,465 harbour porpoise (Table A. 2) based on a density estimate of 0.560 animals per km^2, derived from Waggitt *et al.* (2020) (Morgan Offshore Wind Ltd. and Morecambe Offshore Windfarm Ltd. (2023)). The impact of the Morgan and Morecambe Offshore Wind Farms: Transmission Assets alone, was assessed as being of low magnitude, based on a dose-response approach.

A.1.1.1.7 It is predicted that during piling at the Morgan Generation Assets, harbour porpoise may experience disturbance over the proportion of the Irish Sea between the Solway Firth and Anglesey to the east of the Irish Sea and Wexford, Ireland, to the south west, albeit only mild (< 135 dB re 1 $\mu Pa^2 s$ SEL_{ss}) where the disturbance contours extend towards the coastal area (section 4.9.2). Cumulatively, up to 3,472 harbour porpoise (5.5% of the CIS MU) could be disturbed at any one time during piling at the Morgan Generation Assets and Morgan and Morecambe Offshore Wind Farms: Transmission Assets. Given the overlap of projects (Figure 4.26) and proximity of piling events, it is expected that animals would be disturbed over a very similar area and a large proportion of disturbance contours are predicted to overlap. Therefore, the number of animals likely to be disturbed is highly precautionary. However, the area of strong disturbance is predicted to be larger compared to the Morgan Generation Assets alone and cumulative piling could result in an increased duration of impact. If there was no overlap in piling individuals may be displaced from key areas (in offshore areas between the mainland coast and the Isle of Man including MNRs) for up to 118 days, compared to the Morgan Generation Assets alone (up to 114 days for piling of pin piles for the temporal MDS) (see Table A. 2).

A.1.1.1.8 Population modelling was carried out for harbour porpoise for the Morgan Generation Assets alongside the Morgan and Morecambe Offshore Wind Farms: Transmission Assets. Results of the cumulative iPCoD modelling for harbour porpoise against the CIS MU showed that the median ratio of impacted to unimpacted population size was 0.9999 at a time point of six years and 25 years after commencement of piling at cumulative projects (Appendix B, Table B. 16) corresponding to a reduction of 40 individuals after 25 years (approximately 0.06% of the CIS MU). Small changes in the impacted population size over time are similar to those predicted for an unimpacted population, as can be seen in Figure A. 1. The impacted population was predicted to be up to 58 individuals smaller than the unimpacted population after five years (corresponding to approximately 0.09% of the CIS MU) with the difference reducing to 40 individuals (approximately 0.06% of the CIS MU) after 25 years. Therefore, given that the difference between impacted and unimpacted populations reduces consistently across the duration of the 25-year simulation (with the difference at the 25 year timepoint 0.06% of the MU), and the unimpacted population itself is believed to exhibit a declining trend (IAMMWG, 2021), it was considered that there is low potential for a long-term cumulative effect on this species.

A.1.1.1.9 Given that harbour porpoise can travel over large distances and there is a potential for overlap of disturbance sound level contours with SACs designated for this species (see paragraph 4.9.2.59 for more information), the cumulative effects on the designated features and conservation objectives of designated sites will be considered in the HRA Stage 2 ISAA (Document Reference E1.1).

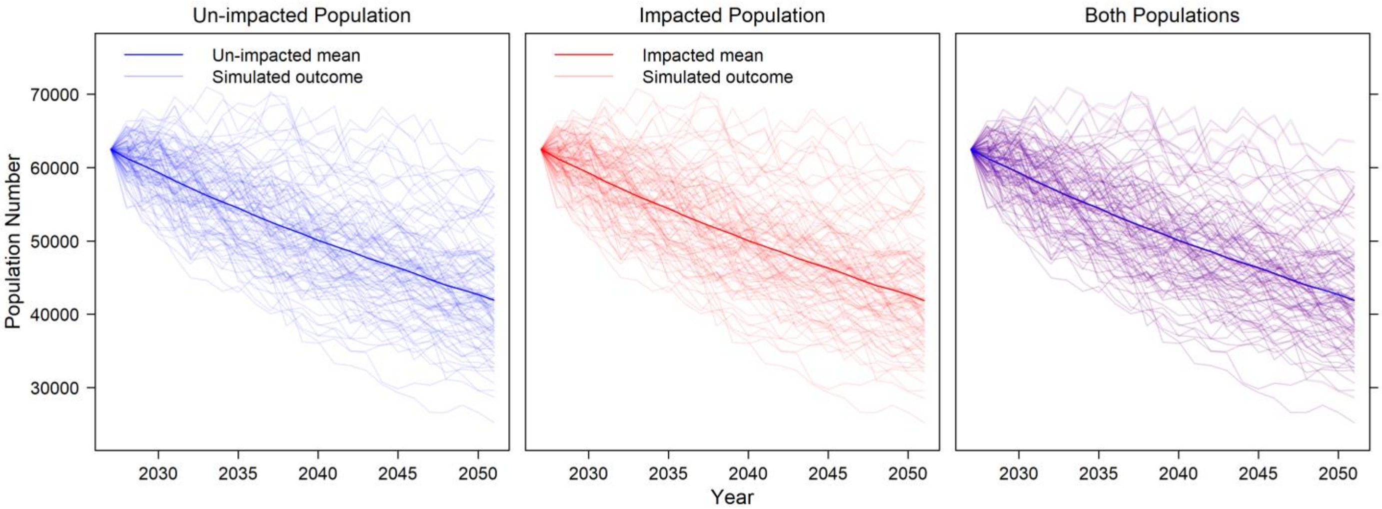

Figure A. 1: Simulated harbour porpoise population sizes for both the baseline (unimpacted) and the impacted populations under the cumulative scenario and no vulnerable subpopulation for Morgan Generation Assets and Morgan and Morecambe Offshore Wind Farms: Transmission Assets.

A.1.1.1.10 The impact (cumulative underwater sound generated from piling) is predicted to be of regional spatial extent, medium term duration and intermittent (only occurs during piling activities). The effect of behavioural disturbance is reversible (with behavioural characteristics returning to baseline levels within hours/days after piling has ceased). It is predicted that the impact will affect the receptor directly. The impact could result in some measurable changes to individuals that are disturbed (i.e. interruption of feeding or breeding and/or displacement to alternative areas), however, in the context of the CIS MU the results of the iPCoD modelling suggest that over the duration of the impact and up to 25 years after the start of piling there would be no significant long-term effects on the harbour porpoise population, as a result of piling. The magnitude is therefore considered to be **low.**

Dolphin species

A.1.1.1.11 The number of bottlenose dolphin, short-beaked common dolphin and Risso's dolphin predicted to be exposed to sound levels that could result in behavioural disturbance at any one time during piling at Morgan and Morecambe Offshore Wind Farms: Transmission Assets (Morgan Offshore Wind Ltd. and Morecambe Offshore Windfarm Ltd, 2023) is set out in Table A. 2 The IS MU was applied as a reference population for bottlenose dolphin, and the CGNS MU was applied for short-beaked common dolphin and Risso's dolphin. The assessment found that 11 bottlenose dolphin (3.7% of the IS MU); 207 short-beaked common dolphin (0.2% of the CGNS MU); and 125 Risso's dolphin (1.01% of the CGNS MU) had the potential to be disturbed.

A.1.1.1.12 It is anticipated that there will be a temporal overlap with piling at the Morgan Generation Assets and Morecambe Offshore Windfarms Transmission Assets. The consequences of potential simultaneous piling (i.e. larger area of strong disturbance and potential for increased duration of impact compared to the Morgan Generation Assets alone) are described in more detail for harbour porpoise in paragraph A.1.1.1.7. Bottlenose dolphin, short-beaked common dolphin and Risso's dolphin may also be affected by strong disturbance over a larger area, however, it is important to note that all three species display seasonal variations in their distributions. Given that animals are not predicted to be present in the Celtic and Irish Seas constantly throughout the year, it can be assumed that these species will not be continuously affected by simultaneous piling if it occurs all year round.

A.1.1.1.13 Cumulatively (see paragraph A.1.1.1.3 for more details), piling at Morgan Generation Assets and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets could potentially affect up to 16 bottlenose dolphin (5.46% of the IS MU), 210 short-beaked common dolphin (0.2% of the CGNS MU) and 246 Risso's dolphin (2.01% of the CGNS MU). However, due to multiple factors, these numbers are likely to be overestimated: highly precautionary densities were used for the respective assessments; the likelihood of sound level contours overlapping due to the proximity of the sites; the consideration of one OSP under both projects; and the combining of maximum spatial scenario and maximum temporal scenario at the Morgan and Morecambe Offshore Wind Farms: Transmission Assets.

A.1.1.1.14 Cardigan Bay, and the Cardigan Bay/Bae Ceredigion SAC in particular, provide important habitats for bottlenose dolphin, with large numbers of animals inhabiting the area in the summer months. As described in more detail in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement, there is an indication that bottlenose dolphin move between Manx waters and Cardigan Bay across the seasons. It has been suggested that Manx waters may provide vital winter habitat, whilst Cardigan Bay for calving. Although there has been no significant trend for Cardigan Bay/Bae Ceredigion SAC between 2001 and 2016, Lohrengel *et al.* (2018) reported that there is 90% certainty that the population in the SAC has declined over the last 10 years (2007 to 2016). Whilst abundance appears to be relatively stable in the IS MU (IAMMWG, 2022; Evans and Waggitt 2023), much of this region has not been well surveyed for population trends and it is difficult to determine an overall trend for the IS MU. Therefore, particular attention needs to be paid to ensure that although individuals may be disturbed in the short to medium term from specific areas of the Irish Sea, it will not have implications on long-term population trajectory. As such, future population dynamics of bottlenose dolphin were investigated using iPCoD modelling as described in paragraph 4.9.2.13.

A.1.1.1.15 Since iPCoD does not facilitate modelling for short-beaked common dolphin and Risso's dolphin, no population modelling was carried out for these species. Population modelling was explored for the cumulative assessment with respect to understanding bottlenose dolphin population level effects for cumulative piling and to provide additional certainty in the predictions of the assessment of potential effects. Population modelling for bottlenose dolphin was carried out for Morgan Generation Assets alongside the Morgan and Morecambe Offshore Wind Farms: Transmission Assets.

A.1.1.1.16 Results of the cumulative iPCoD modelling for bottlenose dolphin against the IS MU population showed that the median ratio of the impacted population to the unimpacted population was 1.0000 at six and 25 years (Appendix B**,** Table B. 24). The corresponding mean ratio was 0.9984 at six years and 0.9986 at 25 years. There was a small difference between the impacted and unimpacted population size over time, with a maximum of one fewer animal in the simulated trajectory (equivalent to 0.34% of the IS MU), and no difference at time point 25. At time point 6, the difference between impacted and unimpacted populations was also zero animals.

A.1.1.1.17 This suggests that after an initial effect of disturbance upon the bottlenose dolphin population from the cumulative projects, beginning approximately three years after the start of piling, the downward population trajectory of the impacted population is expected to stabilise, in line with the population trajectory of the unimpacted population, across the duration of the modelled time series, with occasional differences in the population of one individual. The model outputs suggest that this falls within the natural variation of the population and would not be expected to change the population trajectory (Figure A. 2), although this should be considered against a background of an modelled declining population (based on the conservative demographic parameters provided by NRW). It is important to note that, like most models, the model is sensitive to the demographics chosen, and therefore results should be interpreted with caution. Given the number of animals with the potential to be disturbed by piling sound at the Morgan Generation Assets alongside the Morgan and Morecambe Offshore Wind Farms: Transmission Assets, and the short duration of the impact (up to 16 bottlenose dolphin; 5.46% of the IS MU over 90 days of piling), it is considered that there is low potential for a cumulative effect on this species as a result of cumulative piling for the two projects.

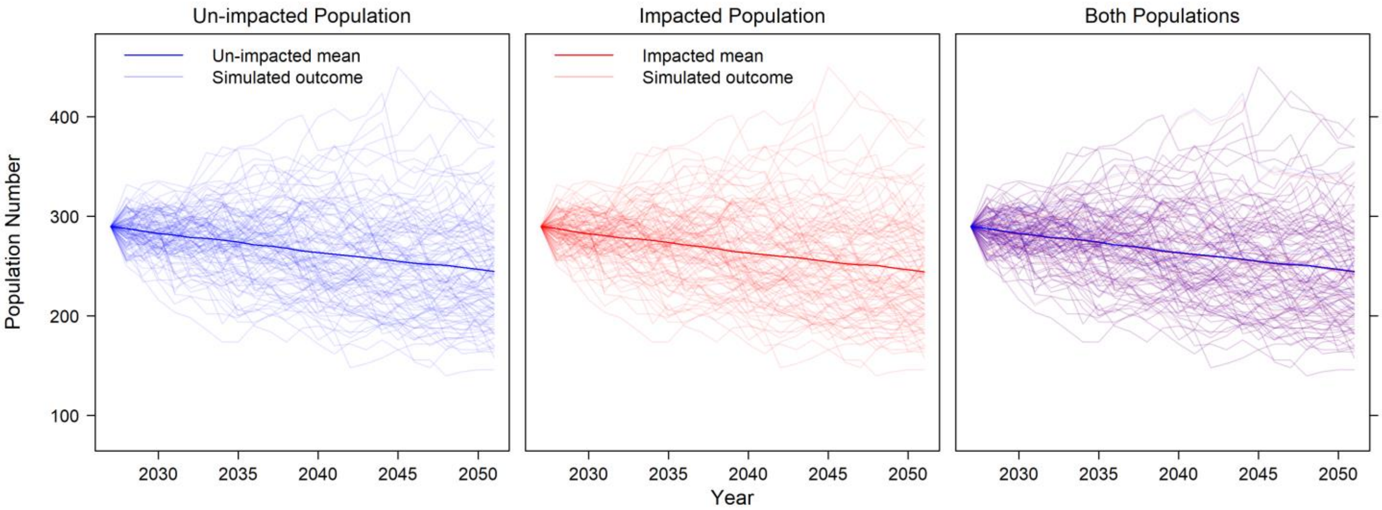

Figure A. 2: Simulated bottlenose dolphin population sizes for both the baseline (unimpacted) and the impacted populations under the cumulative scenario and no vulnerable subpopulation for Morgan Generation Assets alongside the Morgan and Morecambe Offshore Wind Farms: Transmission Assets.

A.1.1.1.18 Given that bottlenose dolphin can travel over large distances, there is a possibility that individuals from SAC populations (see paragraph 4.9.2.68 for more information) may be occasionally present within the disturbance contours. As such the cumulative effects on the designated features and conservation objectives of designated sites will be considered in the HRA Stage 2 ISAA (Document Reference E1.2). In addition, there is potential for overlap of the disturbance contours with a number of MNRs around the Isle of Man designated for bottlenose dolphin including Douglas Bay, Laxey Bay and Baie Ny Carrickey MNRs (although noting that for Morgan Generation Assets the overlap is likely to elicit a mild disturbance response only).

A.1.1.1.19 The impact (cumulative underwater sound generated from piling) is predicted to be of regional spatial extent, medium term duration and intermittent (only occurs during piling activities). The effect of behavioural disturbance is reversible (with behavioural characteristics returning to baseline levels within hours/days after piling has ceased). It is predicted that the impact will affect the receptor directly. For short-beaked common dolphin and Risso's dolphin, the cumulative impact of piling at the Morgan Generation Assets alongside the Morgan and Morecambe Offshore Wind Farms: Transmission Assets is unlikely to lead to population-level consequences as a result of disturbance. The magnitude is therefore conservatively considered to be **low**. For bottlenose dolphin, whilst 5.46% of the IS MU could be affected during piling the results of the iPCoD modelling suggest that over the duration of the impact and up to 25 years after the start of piling there would be no long-term effects on the bottlenose dolphin population. The impact could result in some measurable changes to individuals that are disturbed (i.e. interruption of feeding or breeding and/or displacement to alternative areas), however, there would be no population-level consequences of disturbance. The magnitude is therefore considered to be **low**.

Minke whale

A.1.1.1.20 The number of minke whale predicted to be exposed to sound levels that could result in behavioural disturbance at any one time during piling at the Morgan and Morecambe Offshore Wind Farms: Transmission Assets (Morgan Offshore Wind Ltd. and Morecambe Offshore Windfarm Ltd, 2023) is set out in Table A. 2. The CGNS MU was applied as a reference population. The assessment found that 69 animals had the potential to be affected (0.34% of the CGNS MU).

A.1.1.1.21 The consequences of potential simultaneous piling (i.e. larger area of strong disturbance compared to the Morgan Generation Assets alone) are described in more detail for harbour porpoise in paragraph A.1.1.1.7. As described for dolphin species (paragraph A.1.1.1.12) whilst minke whale may also be affected by strong disturbance over a larger area, this species displays seasonal variations distribution. Given that animals are not predicted to be present in the Celtic and Irish Seas year-round, it can be assumed that minke whale will not be continuously affected by simultaneous piling if it occurs all year round.

A.1.1.1.22 Cumulatively, piling at Morgan Generation Assets alongside the Morgan and Morecambe Offshore Wind Farms: Transmission Assets could affect up to 136 minke whale (0.67% of the CGNS MU). However, this is likely to be an overestimate given highly precautionary densities were used for the respective assessments and that, due to the proximity of the sites, the sound level contours are likely to greatly overlap.

A.1.1.1.23 Population modelling for minke whale was carried out for Morgan Generation Assets alongside the Morgan and Morecambe Offshore Wind Farms: Transmission Assets. Results of this cumulative iPCoD modelling for minke whale against the CGNS MU showed that the median ratio of size of the impacted to unimpacted population at a time point of 25 years after commencement of piling at cumulative projects was 0.9986 (Appendix B, Table B. 30), corresponding to a reduction of 36 individuals (approximately 0.18% of the CGNS MU). Small changes in the impacted population size over time are similar to those predicted for an unimpacted population (36 individuals after 25 years, equivalent to approximately 0.18% of the CGNS MU population estimate), fall within the natural variance of the population and would not be expected to change the population trajectory as can be seen in Figure A. 3. As such, it was considered that there is low potential for a long-term cumulative effect on this species as a result of cumulative piling for all projects considered. Given the number of animals with the potential to be disturbed by piling sound at Morgan Generation Assets alongside the Morgan and Morecambe Offshore Wind Farms: Transmission Assets, and the short duration of the impact (136 minke whale; 0.67% of the CGNS MU over 90 days of piling), it is considered that there is low potential for a long-term cumulative effect on this species as a result of cumulative piling for the two projects (see Figure A. 3 and Table A. 2).

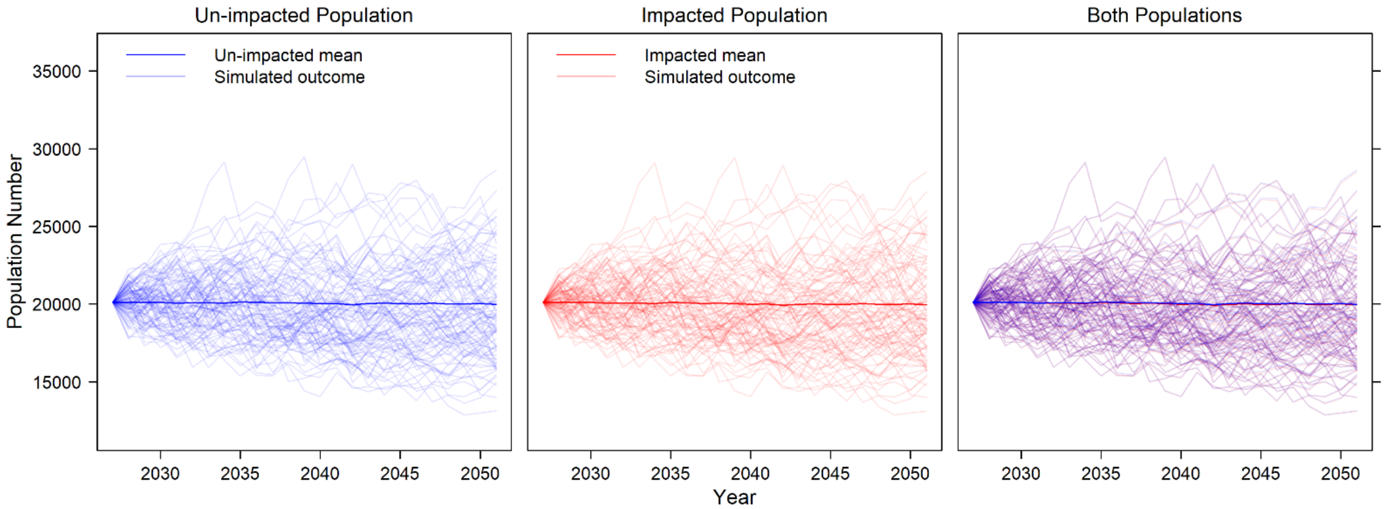

Figure A. 3: Simulated minke whale population sizes for both the baseline (unimpacted) and the impacted populations under the cumulative scenario and no vulnerable subpopulation for Morgan Generation Assets alongside the Morgan and Morecambe Offshore Wind Farms: Transmission Assets.

A.1.1.1.24 The impact (cumulative underwater sound generated from piling) is predicted to be of regional spatial extent, medium term duration and intermittent (only occurs during piling activities). The effect of behavioural disturbance is reversible (with behavioural characteristics returning to baseline levels within hours/days after piling have ceased). It is predicted that the impact will affect the receptor directly. The cumulative impact of piling at the Morgan Generation Assets alongside the Morgan and Morecambe Offshore Wind Farms: Transmission Assets is unlikely to lead to population-level consequences as a result of disturbance and the magnitude is therefore considered to be **low**.

Grey seal

A.1.1.1.25 The number of grey seal predicted to be exposed to sound levels that could result in behavioural disturbance at any one time during piling at Morgan and Morecambe Offshore Wind Farms: Transmission Assets (Morgan Offshore Wind Ltd. and Morecambe Offshore Windfarm Ltd, 2023) is set out in Table A. 3. As presented in the Morgan and Morecambe Offshore Wind Farms: Transmission Assets PEIR, 88 animals had the potential to be affected (0.65% of the GSRP, 0.14% of the OSPAR Region III reference population).

A.1.1.1.26 The consequences of potential simultaneous piling (i.e. larger area of strong disturbance and potential for increased duration of impact compared to the Morgan Generation Assets alone) are described in more detail for harbour porpoise in paragraph A.1.1.1.7. The maximum number of animals predicted to be disturbed, if piling activities at the Morgan Generation Assets coincide with piling at the Morgan and Morecambe Offshore Wind Farms: Transmission Assets, is up to 142 grey seal. This number represents 1.09% of the GSRP or 0.23% of the OSPAR Region III reference population. Although grey seal are present year-round on both the Irish and Welsh coasts, they are known to move between the south east coast of Ireland and the south west coast of Wales. Considering their ability to range over long distances, it is likely that grey seal will be able to find alternative foraging grounds if displaced during simultaneous piling at Morgan and Morecambe Offshore Wind Farms: Transmission Assets.

A.1.1.1.27 Given that there is potential overlap of sound level contours with Lambay Island SAC, designated for grey seal, individuals from SAC populations (see paragraph 4.9.2.97 for more information) may be occasionally present within the disturbance contours. In addition, grey seal telemetry tracks presented in Volume 2, Annex 4.1: Marine mammal technical report of the Environmental Statement demonstrated some connectivity between the Morgan and Morecambe Offshore Wind Farms: Transmission Assets and designated sites (see paragraph 4.9.2.94 for more information). As such the cumulative effects on the designated features and conservation objectives of designated sites will be considered in the HRA Stage 2 ISAA (Document Reference E1.1). In addition, there is potential for overlap of the disturbance contours with a number of MNRs around the Isle of Man designated for grey seal including Langness MNR and Ramsey Bay MNR (although noting that for Morgan Generation Assets the overlap is likely to elicit a mild disturbance response only).

A.1.1.1.28 Population modelling for grey seal was carried out for Morgan Generation Assets alongside the Morgan and Morecambe Offshore Wind Farms: Transmission Assets against the GSRP, as the more precautionary reference population. Results of the cumulative iPCoD modelling for grey seal against the GSRP showed that the median ratio of impacted to unimpacted population size was 1.0000 at a time point of 6 years and 25 years after commencement of piling, at cumulative projects (Appendix B**,** Table B. 36). Small changes in the impacted population size over time are similar to those predicted for an unimpacted population and after 25 years the impacted population is predicted to be no more than one animal smaller than the unimpacted population, as can be seen in Table A. 4. Therefore, it was considered that there is no potential for long-term effects on this species.

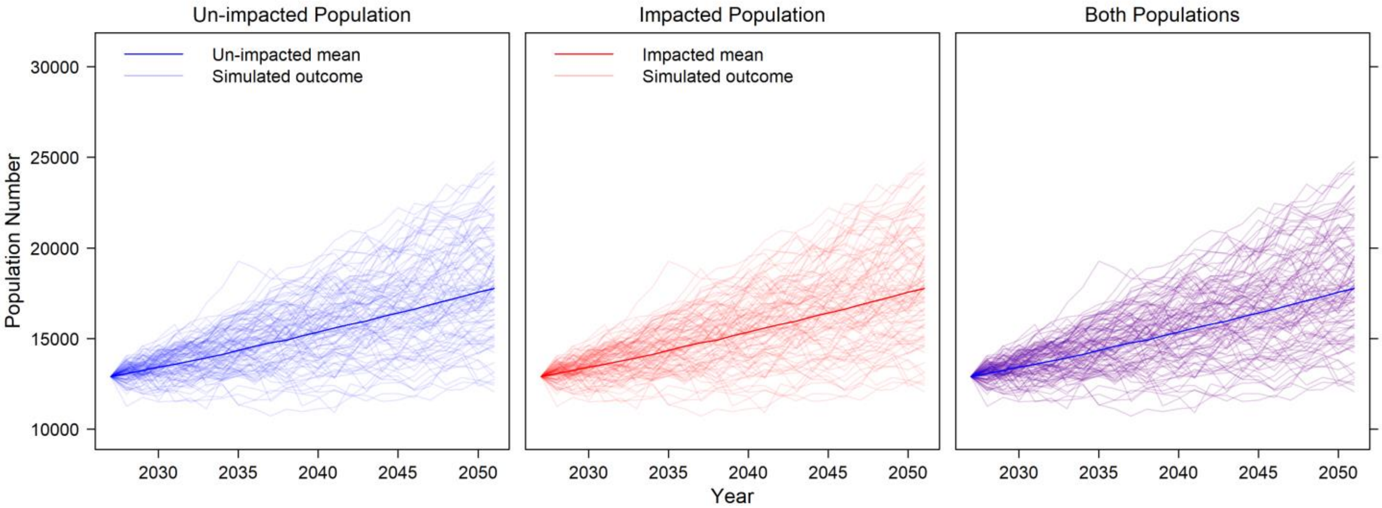

Figure A. 4: Simulated grey seal population sizes for both the baseline (unimpacted) and the impacted populations under the cumulative scenario and no vulnerable subpopulation for Morgan Generation Assets alongside the Morgan and Morecambe Offshore Wind Farms: Transmission Assets.

A.1.1.1.29 The impact (cumulative elevated underwater sound arising during piling) is predicted to be of regional spatial extent, medium term duration and intermittent (only occurs during piling activities). Similarly, the effect of behavioural disturbance is reversible (with animals returning to baseline levels within hours/days after piling have ceased). It is predicted that the impact will affect the receptor directly. The impact could result in some measurable changes to individuals that are disturbed (i.e. interruption of feeding or breeding and/or displacement to alternative areas), however, the results of the iPCoD modelling suggest that over the duration of the impact, up to six and 25 years after the start of piling there would be no long-term effects on the grey seal population in the context of the GSRP. The magnitude is therefore considered to be **low**.

Harbour seal

A.1.1.1.30 The number of harbour seal predicted to be exposed to sound levels that could result in behavioural disturbance at any one time during piling at the Morgan and Morecambe Offshore Wind Farms: Transmission Assets (Morgan Offshore Wind Ltd. and Morecambe Offshore Windfarm Ltd, 2023) is set out in Table A. 3. As presented in the Morgan and Morecambe Offshore Wind Farms: Transmission Assets PEIR, less than one animal had the potential to be affected (0.01% of the HSRP).

A.1.1.1.31 The consequences of potential simultaneous piling (i.e. larger area of strong disturbance and potential for increased duration of impact compared to the Morgan Generation Assets alone) are described in more detail for harbour porpoise in paragraph A.1.1.1.7. Although harbour seal are present year-round animals can travel to other areas to feed during piling. Harbour seal tend to forage within 50 km of the coast and therefore may be restricted in the area of available habitat. Note also that animals would be likely to avoid offshore areas where received levels during piling exceed thresholds for strong disturbance and there may be an energetic cost associated with longer foraging trips and alternative habitat may be sub-optimal in terms of abundance of key prey species.

A.1.1.1.32 Given that there is potential overlap of sound level contours with Lambay Island SAC and Slaney River Valley SAC and Rockabill to Dalkey Island SAC, designated for harbour seal, individuals from SAC populations (see paragraph 4.9.2.109 for more information) may be occasionally present within the disturbance contours. As such the cumulative effects on the designated features and conservation objectives of designated sites will be considered in the HRA Stage 2 ISAA (Document Reference E1.2). In addition, there is potential for overlap of the disturbance contours with a number of MNRs around the Isle of Man designated for grey seal including Langness MNR, Ramsey Bay MNR and West Coast MNR (although noting that for Morgan Generation Assets the overlap is likely to elicit a mild disturbance response only).

A.1.1.1.33 Population modelling was not carried out for harbour seal due to the very small number of animals potentially behaviourally disturbed and therefore very low risk of a population level effect occurring for this species.

A.1.1.1.34 The impact (cumulative underwater sound generated from piling) is predicted to be of regional spatial extent, medium term duration and intermittent (only occurs during piling activities). The effect of behavioural disturbance is reversible (with behavioural characteristics returning to baseline levels within hours/days after piling have ceased). It is predicted that the impact will affect the receptor directly. The cumulative impact of piling at the Morgan Generation Assets and Morgan and Morecambe Offshore Wind Farms: Transmission Assets is unlikely to lead to population-level consequences as a result of disturbance and the magnitude is therefore conservatively considered to be **low**.

Sensitivity of receptor

A.1.1.1.35 The sensitivity of the different marine mammal IEFs to behavioural disturbance from elevated underwater sound due to piling is as described in paragraph 4.9.2.115 for

Morgan Generation Assets alone. Recovery is anticipated to occur between piling events, which will be intermittent for cumulative projects. Baseline levels of activity are anticipated to resume where there are gaps between piling of respective projects.

A.1.1.1.36 It is important to note, however, that the extent to which an animal will be behaviourally affected is context-dependent and varies both inter- and intra-specifically. Behavioural disturbance may lead to the interruption of normal behaviours (such as feeding or breeding) and avoidance and therefore it may lead to displacement from the area and exclusion from potentially critical habitats, making it difficult for an animal to perform its regular functions (Goold, 1996; Weller *et al*., 2002; Castellote *et al*., 2010; 2012). Additionally, some exposures may be loud enough to trigger stress responses, which in turn can lead to a depressed immune function and reduced reproductive success (Anderson *et al*., 2011; De Soto *et al*., 2013).

A.1.1.1.37 All marine mammals are deemed to have some resilience to behavioural disturbance, high recoverability and international value. The sensitivity of the receptor is therefore, considered to be **medium**.

Significance of effect

A.1.1.1.38 Overall, for all marine mammal species, the magnitude of the cumulative impact is **low**, and the sensitivity of the receptor is **medium**. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant.

Scenario 2: Morgan Generation Assets together with the Morecambe Generation Assets and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets

A.1.1.1.39 The construction of the Morgan Generation Assets, together with the construction of the Morgan and Morecambe Offshore Wind Farms: Transmission Assets and the Morecambe Generation Assets may lead to disturbance to marine mammals during piling.

A.1.1.1.40 As per the cumulative assessment of the Morgan Generation Assets and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets (paragraph A.1.1.1.3), given there is a potential for temporal overlap of piling phases at all three projects, animals could be disturbed during piling simultaneously, and therefore the number of animals are summed from all three projects. One OSP foundation at the Morgan Generation Assets is also considered under the Morgan and Morecambe Offshore Wind Farms: Transmission Assets and two OSP foundations at the Morecambe Generation Assets are also considered under the Morgan and Morecambe Offshore Wind Farms: Transmission Assets therefore the number of days of piling and number of animals to be disturbed on each day of piling is highly conservative. Cumulative iPCoD modelling was conducted to support the CEA, incorporating numbers of animals disturbed by each project (see paragraph 4.9.2.13 *et seq* for more details about iPCoD modelling), which considers OSP foundations in line with this CEA.

A.1.1.1.41 As per the cumulative assessment of the Morgan Generation Assets and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets (paragraph A.1.1.1.4), for Morgan Generation Assets, two scenarios are considered as per the MDS (Table 4.16): a maximum temporal scenario and a maximum spatial scenario.

Construction phase

Magnitude of impact

A.1.1.1.42 Based on the MDS presented in the Morecambe Generation Assets PEIR marine mammal chapter, there will be up to 42 days of piling over the piling phase of 24 months between 2027 and 2028, within the 2.5 year construction phase (Morecambe Offshore Windfarm Ltd, 2023).

All marine mammal key receptors

A.1.1.1.43 The maximum number of animals predicted to be disturbed at the Morecambe Generation Assets, is up to 1,279 harbour porpoise (2.04% of the CIS MU); no more than one animal for bottlenose dolphin (0.000017% % of the IS), short-beaked common dolphin (0.0000013%% of the CGNS MU) and Risso's dolphin (0.00000016% of the CGNS MU); 2 minke whale (0.0089% of the CGNS MU); 11 grey seal (0.08% of the GSRP or 0.02% of the OSPAR Region III reference population); and no more than one harbour seal (0.07% of the HSRP). Densities applied to the calculations of the number animals are set out in Table A. 2 and Table A. 3. The magnitude of the impact of the Morgan and Morecambe Offshore Wind Farms: Transmission Assets is set out in paragraph A.1.1.1.5 *et seq*.

A.1.1.1.44 The extent of disturbance for marine mammal key receptors at the Morgan Generation Assets has been described in paragraph A.1.1.1.7. Given the overlap of the Morgan Generation Assets alongside the Morgan and Morecambe Offshore Wind Farms: Transmission Assets and the Morecambe Generation Assets (see Figure 4.26) and proximity of piling events, it is expected that animals would be disturbed over a very similar area and a large proportion of disturbance contours are predicted to overlap. However, the area of strong disturbance is predicted to be larger compared to the Morgan Generation Assets alone and cumulative piling could result in an increased duration of impact. If there was no overlap in piling individuals may be displaced from key areas (in offshore areas between the mainland coast and the Isle of Man including MNRs) for up to 160 days, compared to the Morgan Generation Assets alone (up to 114 days for piling of pin piles for the temporal MDS) (see Table A. 1).

A.1.1.1.45 If simultaneous piling were to occur at all three projects, up to 4,751 harbour porpoise (8.18% of the CIS MU); 17 bottlenose dolphin (5.8% of the IS MU), 211 short-beaked common dolphin (0.21% of the CGNS MU); 247 Risso's dolphin (2.01% of the CGNS MU); 138 minke whale (0.68% of the CGNS MU); 153 grey seal (1.18% of the GSRP; 0.25% of the OSPAR Region III reference population); and up to 5 harbour seal (0.35% of the HSRP) could be disturbed at any one time

A.1.1.1.46 Population modelling was carried out for harbour porpoise, bottlenose dolphin, minke whale and grey seal for the Morgan Generation Assets together with the Morgan and Morecambe Offshore Wind Farms: Transmission Assets and the Morecambe Generation Assets. Population modelling was not carried out for harbour seal due to the very small number of animals potentially behaviourally disturbed and therefore very low risk of a population level effect occurring for this species.

A.1.1.1.47 For harbour porpoise, minke whale and grey seal, small changes in the impacted population size over time are similar to those predicted for an unimpacted population, as can be seen in Figure A. 5**,** Figure A. 6 and Figure A. 7. For harbour porpoise, against the CIS MU, results of the iPCoD modelling showed that the median ratio of impacted to unimpacted population size was 0.9995 at time points of 6 and 25 years after commencement of piling at cumulative projects (Appendix B, Table B. 17). Small changes in the impacted population size over time are similar to those predicted for an unimpacted population, corresponding to a reduction of 96 individuals after 25 years (approximately 0.15% of the CIS MU).

A.1.1.1.48 For minke whale, against the CGNS MU, results of the iPCoD modelling showed that the median ratio of impacted to unimpacted population size at a time point of six years after commencement of piling was 0.9991, and 25 years after commencement of piling at cumulative projects this was 0.9986 (Appendix B, Table B. 31), corresponding to a reduction of 38 individuals after 25 years (approximately 0.19% of the CGNS MU).

A.1.1.1.49 For grey seal, against the GSRP, results of the iPCoD modelling showed that the median ratio of impacted to unimpacted population size was 1.0000 at a time point of six years and 25 years after commencement of piling at cumulative projects (Appendix B, Table B. 37) corresponding to no difference in the size of unimpacted and impacted populations.

A.1.1.1.50 As such, whilst 4,758 harbour porpoise (8.18% of the CIS MU), 138 minke whale (0.68% of the CGNS MU) and 153 grey seal (1.18% of the GSRP; 0.25% of the OSPAR Region III reference population) have the potential to be disturbed, it was considered that there is low potential for a long-term cumulative effect on these species as a result of cumulative piling at the three projects.

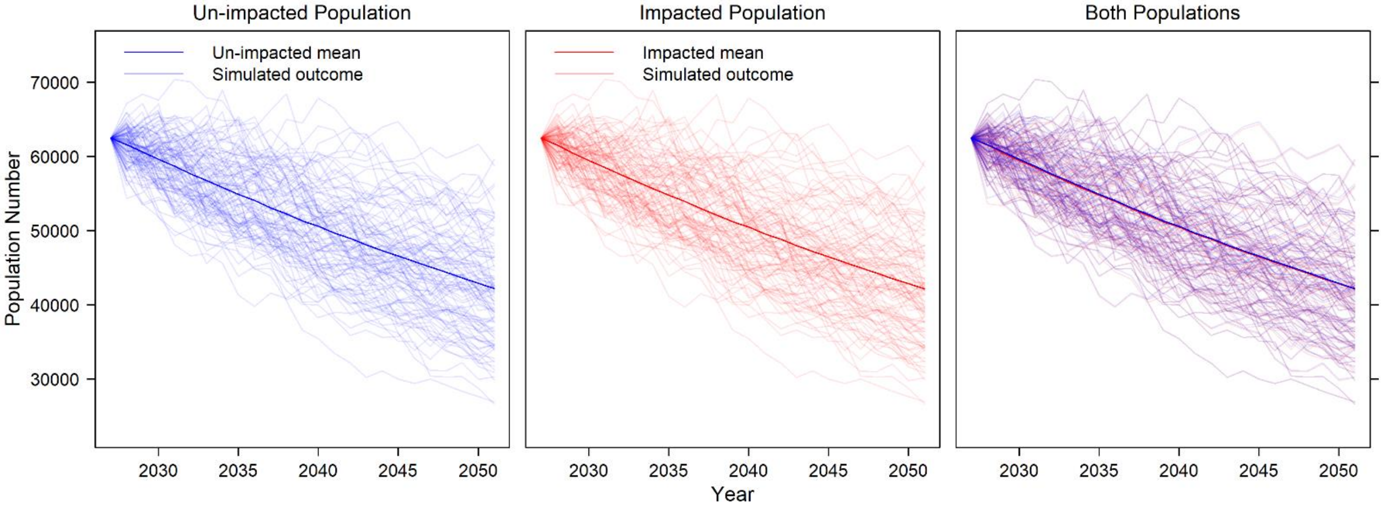

Figure A. 5: Simulated harbour porpoise population sizes for both the baseline (unimpacted) and the impacted populations under the cumulative scenario for Morgan Generation Assets alongside the Morecambe Generation Assets and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets.

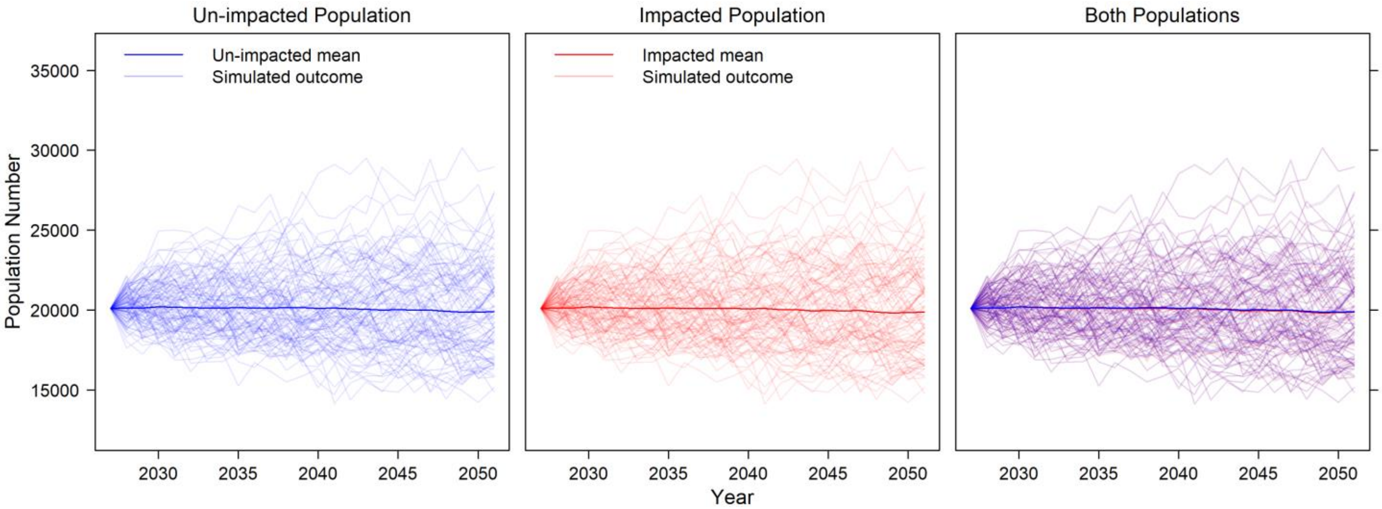

Figure A. 6: Simulated minke whale population sizes for both the baseline (unimpacted) and the impacted populations under the cumulative scenario for Morgan Generation Assets alongside the Morecambe Generation Assets and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets.

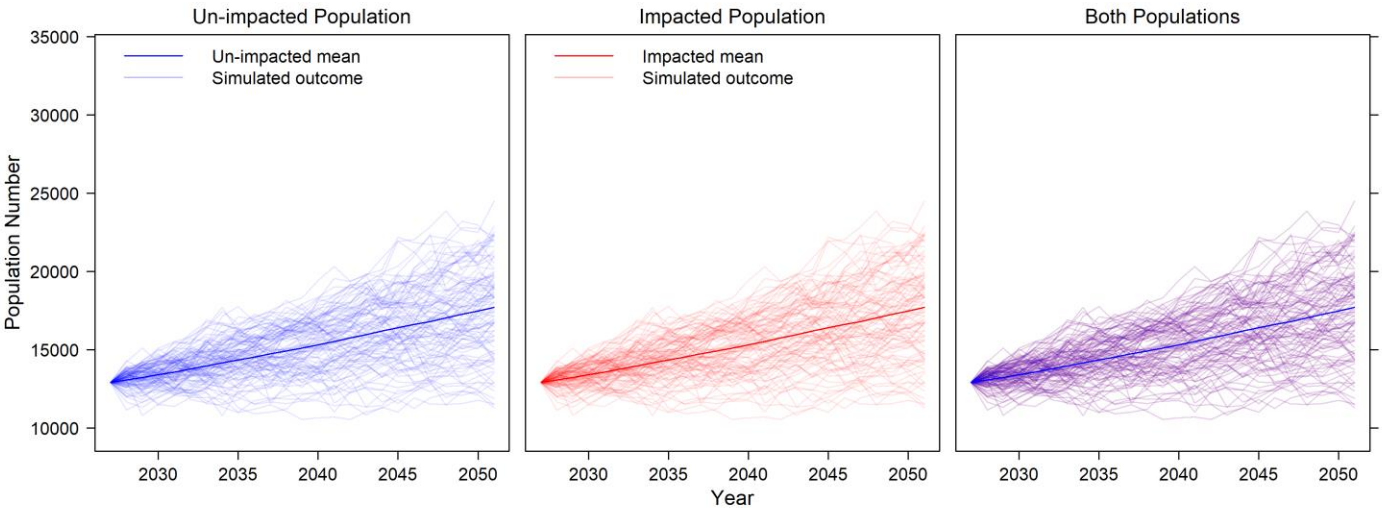

Figure A. 7: Simulated grey seal population sizes for both the baseline (unimpacted) and the impacted populations under the cumulative scenario for Morgan Generation Assets alongside the Morecambe Generation Assets and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets.

A.1.1.1.51 Results of the cumulative iPCoD modelling for bottlenose dolphin against the IS MU population showed that the median ratio of impacted to unimpacted population size at a time point of six years and 25 years after commencement of piling at cumulative projects was 1.0000 (Appendix B, Table B. 25). The corresponding mean ratios were 0.9982 at six years and 0.9984 at 25 years. There was almost no difference between the impacted and unimpacted population size over time, as can be seen in Figure A. 8, with no fewer animals at time point 25 or at time point 6. At ten time points in the simulation the difference between impacted and unimpacted populations was one animal (0.34 % of the IS MU). Therefore, it was considered that there is low potential for long-term cumulative effects for bottlenose dolphin as a result of cumulative piling at the Morgan Generation Assets, together with the Morgan and Morecambe Offshore Wind Farms: Transmission Assets and the Morecambe Generation Assets.

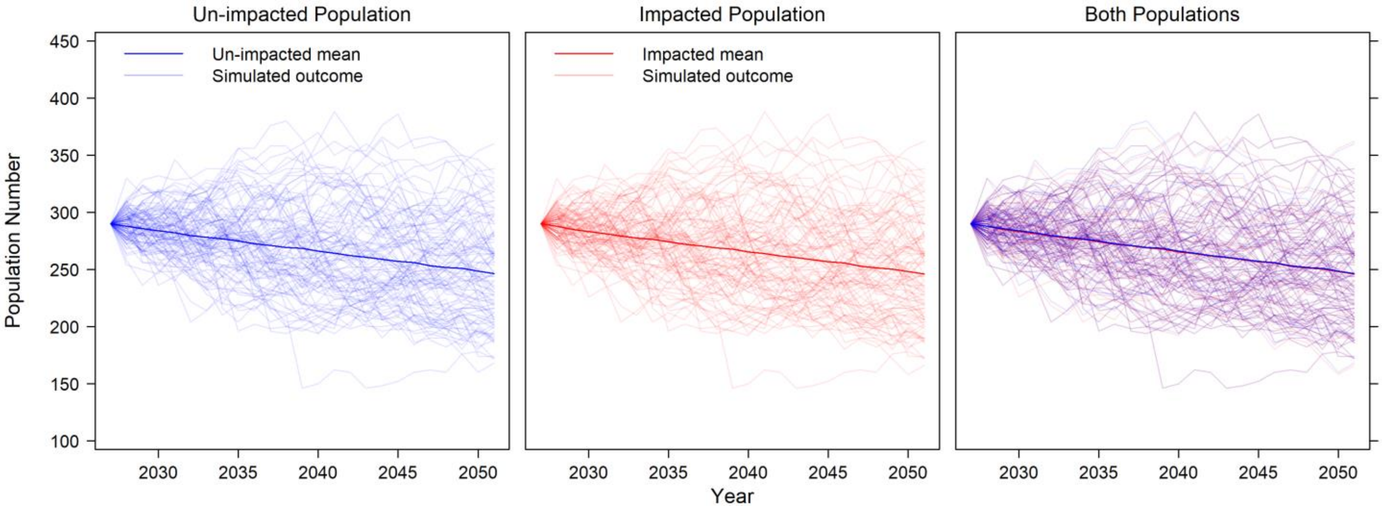

Figure A. 8: Simulated bottlenose dolphin population sizes for both the baseline (unimpacted) and the impacted populations under the cumulative scenario for Morgan Generation Assets alongside the Morecambe Generation Assets and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets.

A.1.1.1.52 Given the low cumulative disturbance levels to short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal as a result of cumulative piling (see paragraph A.1.1.1.45) it is considered that there is low potential for a long-term cumulative effect on any species.

A.1.1.1.53 As per the cumulative assessment of the Morgan Generation Assets and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets, there is the potential for overlap of disturbance sound level contours with designated sites for harbour porpoise, bottlenose dolphin, grey seal and harbour seal (see paragraphs 4.9.2.59, 4.9.2.68, 4.9.2.96 and 4.9.2.109 respectively). As such the cumulative effects on the designated features and conservation objectives of designated sites will be considered in the HRA Stage 2 ISAA (Document Reference E1.1).

A.1.1.1.54 For all marine mammal key receptors the impact (cumulative underwater sound generated from piling) is predicted to be of regional spatial extent, medium term duration and intermittent (only occurs during piling activities). The effect of behavioural disturbance is reversible (with behavioural characteristics returning to baseline levels within hours/days after piling has ceased). It is predicted that the impact will affect the receptor directly. The impact could result in some measurable changes to individuals that are disturbed (i.e. interruption of feeding or breeding and/or displacement to alternative areas), however, in the context of wider populations in the Celtic and Irish Seas for harbour porpoise, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal there is considered to be no long-term effects on populations and the magnitude is therefore considered to be **low.** Whilst the potential disturbance to the bottlenose dolphin IS MU as a result of cumulative piling at all three projects has been predicted as 5.8% of the IS MU, this value is considered to be highly precautionary; given the large overlap of disturbance contours as a result of the overlap of projects, the number of predicted animals is likely to be driven by 'double counting' and the actual number is expected to be considerably lower. The magnitude is therefore realistically considered to be **low.**

Sensitivity of receptor

A.1.1.1.55 The sensitivity of marine mammals to disturbance from underwater sound generated from piling is as described in Scenario 1, paragraph A.1.1.1.35 *et seq* and is not reiterated here.

A.1.1.1.56 All marine mammals are deemed to have some tolerance to behavioural disturbance, exhibit high recoverability and are considered of international value. The sensitivity of the receptor is therefore, **medium**.

Significance of effect

4.15.1.1 For all marine mammal key receptors the magnitude of the cumulative impact is **low**, and the sensitivity of the receptor is **medium**. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant.

Scenario 3: Morgan Generation Assets together with the Morgan and Morecambe Offshore Wind Farms: Transmission Assets and all other relevant projects

Tier 1

Construction phase

A.1.1.1.57 The construction of Morgan Generation Assets, together with construction of Tier 1 projects identified in Table 4.52 may lead to disturbance to marine mammals during piling. Tier 1 projects screened into the assessment within the CEA screening area include Mona Offshore Wind Project, Awel y Môr Offshore Wind Farm, Project Erebus and White Cross Offshore Wind Farm.

A.1.1.1.58 Each of the projects screened into the cumulative assessment have different construction timelines (Table 4.51). The construction phase of the Morgan Generation Assets will temporally overlap with the construction phases of Mona Offshore Wind Project (four years) Awel y Môr Offshore Wind Farm (four years), White Cross Offshore Wind Farm (three years) and Project Erebus. Piling at Project Erebus however is likely to be completed the year before the commencement of piling activities at Morgan Generation Assets. These timelines are, however, indicative and may be subject to change. Piling at each of these projects will occur as a discrete stage within the overall construction phase and therefore the periods of piling may not coincide.

A.1.1.1.59 The assessments provided in the Environmental Statements for Awel y Môr Offshore Wind Farm, Project Erebus and White Cross Offshore Wind Farm did not consider effects on harbour seal, as this species was scoped out. Given, that the cumulative assessment for piling is provided on species-by-species basis, harbour seal will not be considered further for these projects.

A.1.1.1.60 Where cumulative numbers of animals potentially disturbed are presented (e.g. paragraph A.1.1.1.62 for harbour porpoise), the calculations consider the timelines of respective projects. Given that piling will likely be completed at Project Erebus prior to the commencement of piling activities at Morgan Generation Assets, animals are likely to recover from the disturbance between piling events and therefore the numbers of animals potentially disturbed at respective projects are not added together. However, since there is a potential for temporal overlap of piling phase at Morgan Generation Assets with the construction phase at Mona Offshore Wind Project, Awel y Môr Offshore Wind Farm and White Cross Offshore Wind Farm, animals could be disturbed during piling for both projects simultaneously and therefore numbers of animals potentially disturbed during piling are summed. Nevertheless, to ensure the most precautionary approach, cumulative iPCoD modelling incorporates numbers of animals affected by all projects throughout construction phases (see paragraph 4.9.2.13 for more details about iPCoD modelling).

A.1.1.1.61 As per the cumulative assessment of the Morgan Generation Assets and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets (paragraph A.1.1.1.4), for Morgan Generation Assets, two scenarios are considered as per the MDS (Table 4.16): a maximum temporal scenario and a maximum spatial scenario.

Magnitude of impact

Harbour porpoise

A.1.1.1.62 Based on the Mona Offshore Wind Project maximum spatial scenario, as presented in the Mona Offshore Wind Project Environmental Statement marine mammal chapter, there will be up to 90 days of piling over the piling phase of two-year phase between 2027 and 2028 (Mona Offshore Wind Ltd, 2023). The maximum number of harbour porpoise predicted to be disturbed at Mona Offshore Wind Project is up to 1,142 (1.83% of the CIS MU) based on a density estimate of 0.2773, derived from the Welsh Marine Mammal Atlas (Evans and Waggitt, 2023) (Table A. 1)

A.1.1.1.63 Based on the Awel y Môr Offshore Wind Farm MDS presented in the Awel y Môr Environmental Statement marine mammal chapter, there will be up to 201 days of piling over the piling phase of 12 months in 2028, within the four-year construction phase (RWE, 2022). As discussed in the Awel y Môr Offshore Wind Farm Environmental statement marine mammal chapter, the JCP Phase III Tool density estimate for the Awel y Môr Offshore Wind Farm area (0.13 porpoise per km^2) was identified as the most suitable to take forward to impact assessment, alongside a precautionary density estimate obtained from the Sea Watch Foundation (SWF) report (1.0 porpoise per km^2, averaged across coastal and offshore areas) (Evans *et al*. 2021). The maximum number of animals predicted to be disturbed is up to 2,112 (Table A. 2) noting this was based upon the most precautionary (SWF) density estimate. Using JCP densities resulted in an estimate of 275 harbour porpoise with the potential to experience disturbance on each day of pile driving activities (RWE, 2022). The assessment concluded that an absolute maximum of 201 days of piling could temporarily affect fertility rates and probability of calf survival. However, any potential effect was not expected to result in changes in the population trajectory.

A.1.1.1.64 Based on the White Cross Offshore Wind Farm MDS, as presented in the White Cross Offshore Wind Farm marine mammal and marine turtle ecology chapter, there will be up to six days of piling (five days for WTG mooring pin piles and one day for OSP foundation pin piles) over the piling phase of six months between 2026 and 2027 (onshore and offshore construction phase) (Offshore Wind Limited, 2023). The maximum number of animals predicted to be disturbed, at White Cross Offshore Wind Farm is up to 1,652 (2.6% of CIS MU) for wind turbines (800 kJ, mooring pin piles) and 2,754 (4.4% of CIS MU) for OSP foundations (2,500 kJ) (Table A. 1) based on TTS/moving away response as a proxy for disturbance. As such, numbers are likely to be overestimated, as this approach assumes 100% avoidance of all individuals exposed, as opposed to a dose response approach, which assumes a proportional decrease in avoidance at greater distances from the pile driving source (Brandt *et al*., 2011) (see paragraph 4.9.1.11 *et seq*). This was the most precautionary estimate based on the APEM summer density estimate density (0.918 animals per km^2), rather than the lower APEM annual density estimate (0.594 animals per km^2) (see White Cross Offshore Wind Ltd. (2023) for more details about both density estimates and associated caveats). The assessment concluded a magnitude of negligible for the OSP foundation and a magnitude of low for wind turbine foundations.

A.1.1.1.65 The potential for temporal overlap of piling activities between the Morgan Generation Assets alongside Mona Offshore Wind Project, Awel y Môr Offshore Wind Farm and White Cross Offshore Wind Farm is considered likely. As such, simultaneous piling may occur, generating significant levels of underwater sound. It is predicted that during piling at the Morgan Generation Assets, harbour porpoise may experience disturbance over the proportion of Irish Sea between the Solway Firth and Caernarfon Bay, to east Ireland, albeit only low level disturbance (<130 dB re $1\mu Pa^2s$ SEL_{ss}) where the disturbance contours extend towards the coastal area (Figure 4.8). Given the proximity of projects (Figure 4.26) and associated proximity of piling events between the Morgan Generation Assets and Mona Offshore Wind Project, it is expected that animals would be disturbed over a very similar area and a large proportion of disturbance contours are predicted to overlap. Therefore, the cumulative number of animals likely to be disturbed, associated with these two projects, is highly precautionary. In addition, White Cross Offshore Wind Farm is located ~ 320 km from Morgan Generation Assets, and whilst there is potential for simultaneous piling it is unlikely that significant overlap of disturbance contours will occur, and animals are unlikely to be disturbed by both piling events in the same day.

A.1.1.1.66 Cumulatively, up to 4,261 harbour porpoise (6.81% of the CIS MU) could be disturbed at any one time during piling at the Morgan Generation Assets (applying the maximum spatial scenario) alongside Mona Offshore Wind Project and Awel y Môr Offshore Wind Farm. The cumulative number would increase to 5,913 if piling occurred simultaneously with piling of wind turbine foundations (9.46% of the CIS MU) or 7,015 with piling of OSP foundations (11.22% of the CIS MU) at White Cross Offshore Wind Farm. This is likely to be an overestimate given highly precautionary SWF densities (1.0 animals per km^2) used for the assessment at Awel y Môr. If more realistic densities (0.13 animals per km^2, based on JCP Phase III Tool estimate) are taken into account, the cumulative number of harbour porpoise potentially disturbed would be up to 5,178 individuals (8.28% of the CIS MU). In addition, it is expected that animals would be disturbed over a similar area and disturbance contours are likely to overlap to a large extent due to the proximity of the projects. However, the area of strong disturbance may be larger compared to the Morgan Generation Assets alone and cumulative piling will result in longer duration of the impact and subsequently affect animals over longer timescales.

A.1.1.1.67 Project Erebus is a demonstration scale floating offshore wind farm, comprising six to ten wind turbines and a range of foundation options, including pile driven anchors. Piling is planned to take place in 2025 and 2026 with only 18 days over which piling may occur. The number of harbour porpoise predicted to be affected by disturbance is based on densities from site-specific surveys (Blue Gem Wind, 2020; Table A. 1). Since piling activities at Morgan Generation Assets, Mona Offshore Wind Project and Awel y Môr Offshore Wind Farm commence in 2027 and 2028, there is no potential for piling activity at Project Erebus to coincide with piling at these projects and therefore, spatially, there would be no larger cumulative area of disturbance as a result of Project Erebus. There is potential for temporal overlap with White Cross Offshore Wind Farm in 2026. It is, however, important to note that Project Erebus is located in close proximity to the Bristol Channel Approaches/Dynesfeydd Môr Hafren SAC designated for harbour porpoise. Temporally, Project Erebus could contribute to a slightly longer duration of piling within the cumulative marine mammal study area.

A.1.1.1.68 Cumulatively (see paragraph A.1.1.1.3 for more details), there would be piling at Project Erebus in 2025 affecting 1,967 harbour porpoise. In 2026 there would be piling at Project Erebus affecting 1,967 harbour porpoise and piling at White Cross Offshore Wind Farm, affecting up to 2,754 harbour porpoise over five days of piling (wind turbine foundations; maximum hammer energy of 800 kJ) or up to 1,652 harbour porpoise on a single day of piling (OSP foundation; maximum hammer energy of 2,500 kJ). Subsequently, there would be piling in 2027 at Morgan Generation Assets, affecting 1,007 harbour porpoise (maximum spatial scenario); Mona Offshore Wind Project affecting up to 1,142 harbour porpoise; and White Cross Offshore Wind Farm. In 2028, there would be piling at Morgan Generation Assets; Mona Offshore Wind Project; and Awel y Môr Offshore Wind Farm which may coincide and affect up to 4,261 harbour porpoise (if applying the maximum SWF density for Awel y Môr Offshore Wind Farm). It is important to note that piling schedule information available for White Cross Offshore Wind Farm is limited; whilst piling may occur at any point in the construction phase between 2026 and 2027, piling will take place over a maximum of six days, within a six month piling phase. In addition, the higher hammer energy of 2,500 kJ will only occur on a single day, and estimates of number of animals disturbed are based on TTS/moving away response as a proxy for disturbance, and as such numbers are likely to be overestimated (see paragraph A.1.1.1.64). The cumulative total presented is therefore highly precautionary.

A.1.1.1.69 Results of the cumulative iPCoD modelling for harbour porpoise for Tier 1 projects located within the CEA screening area showed that the median ratio of impacted to unimpacted population size at a time point of six years after commencement of piling was 0.9961 and 25 years after commencement of piling was 0.9965 (Appendix B, Table B. 18). Changes in the impacted population size over time, relative to the CIS MU population, are not substantially greater than those predicted for an unimpacted population, as can be seen in Figure A. 9. A maximum difference of 502 individuals (equivalent to 0.80% of the CIS MU) was predicted at a time point of five years following commencement of piling at the cumulative projects, reducing to a difference of 292 individuals (equivalent to 0.47% of the CIS MU) after 25 years. Therefore, given that the difference between impacted and unimpacted populations reduces consistently across the duration of the 25-year simulation (with the difference at the 25 year timepoint of 0.47% of the CIS MU), and the unimpacted population itself is believed to exhibit a declining trend (IAMMWG, 2021), it was considered that there is low potential for long-term cumulative effects on this species as a result of cumulative piling at the Morgan Generation Assets and Tier 1 projects.

A.1.1.1.70 Given that harbour porpoise can travel over large distances and there is a potential for overlap of disturbance sound level contours within SACs designated for this species (see paragraph 4.9.2.59 for more information), the cumulative effects on the designated features and conservation objectives of designated sites will be considered in the HRA Stage 2 ISAA (Document reference E1.2).

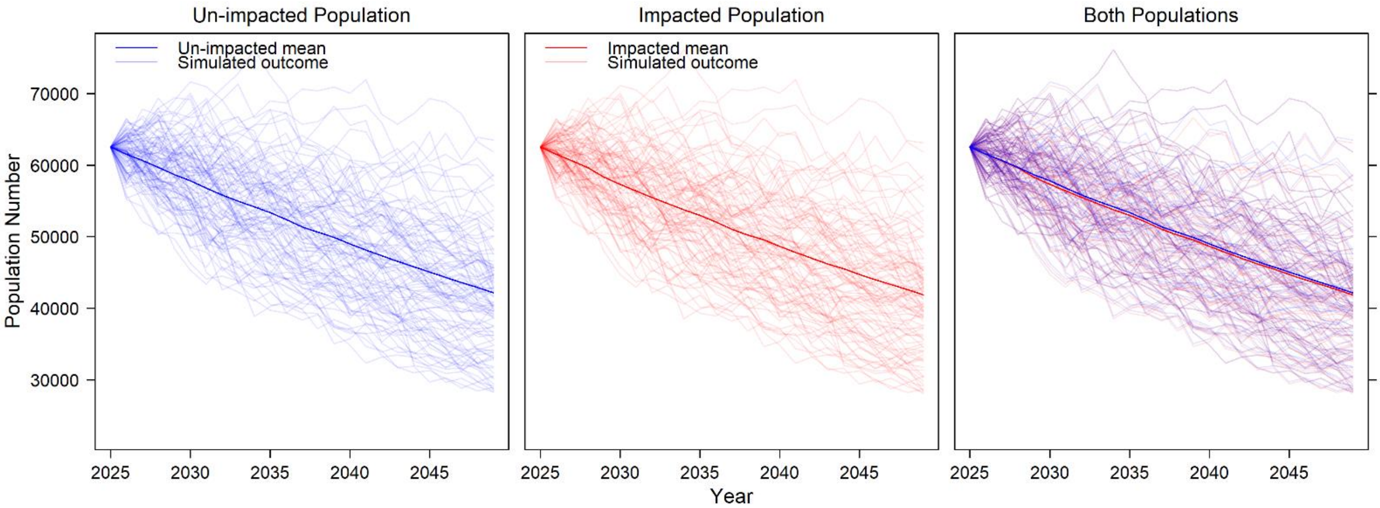

Figure A. 9: Simulated harbour porpoise population sizes for both the baseline (unimpacted) and the impacted populations under the cumulative scenario and no vulnerable subpopulation for Tier 1 projects only.

A.1.1.1.71 The impact (cumulative elevated underwater sound arising during piling) is predicted to be of regional spatial extent, medium term duration and intermittent (only occurs during piling activities). Similarly, the effect of behavioural disturbance is reversible (with animals returning to baseline levels within hours/days after piling have ceased). It is predicted that the impact will affect the receptor directly. The impact could result in some measurable changes to individuals that are disturbed (i.e. interruption of feeding or breeding and/or displacement to alternative areas), however, in the context of the CIS MU the results of the iPCoD modelling suggest that over the duration of the impact and up to six years and 25 years after the start of piling there would be no long-term effects on the harbour porpoise population (see Appendix B). The magnitude is therefore considered to be **low**.

Dolphin species

A.1.1.1.72 As bottlenose dolphin sits within the IS MU, only projects within IS MU will be used for the cumulative effects assessment for bottlenose dolphin, as this MU largely represents the coastal bottlenose dolphin ecotype (of which there are only a few hundred). Therefore Project Erebus, which lies in the Offshore Channel and Southwest England MU (offshore ecotype), is not considered for this species. This approach was agreed with the marine mammal EWG. White Cross Offshore Wind Farm which also lies in the Offshore Channel and Southwest England MU, is also not considered for this species.

A.1.1.1.73 Based on the Mona Offshore Wind Project Environmental Statement marine mammal chapter, the maximum number of bottlenose dolphin, short-beaked common dolphin and Risso's dolphin predicted to be disturbed is up to seven (2.93% of the IS MU); three (0.002% of the CGNS MU); and 129 (1.05% of the CGNS MU) respectively (Table A. 1). Density estimates for bottlenose dolphin and short-beaked common dolphin are derived from Evans and Waggitt, 2023, and for Risso's dolphin is derived from SCANS III, block E (see Table A. 1).

A.1.1.1.74 The number of bottlenose dolphin predicted to be exposed to sound levels that could result in behavioural disturbance at any one time during piling at the Awel y Môr Offshore Wind Farm (RWE, 2022) was based on Lohrengel *et al.* (2018) for the coastal 20 m depth contour and SCANS III data for the offshore densities (Table A. 1). The assessment found that most of the disturbance would occur in offshore waters where densities of bottlenose dolphin were lower. Even so, 23 animals (7.9% of the Irish Sea MU) could be affected by Awel y Môr. iPCoD modelling carried out for the Awel y Môr Offshore Wind Farm however suggested that, whilst there were likely to be some measurable changes in the population during piling, the trajectory of the population is expected to be stable in the long term. The impact of the Awel y Môr Offshore Wind Farm alone was assessed as being of medium magnitude where temporary changes in behaviour and/or distribution of individuals could result in potential reductions to reproductive success during an animal's lifetime to some individuals although not enough to affect the population trajectory over a generational scale.

A.1.1.1.75 The number of short-beaked common dolphin predicted to be exposed to sound levels that could result in a behavioural disturbance at any one time during piling at the Awel y Môr Offshore Wind Farm was assessed using densities from SCANS III density estimates and the CGNS MU as a reference population (RWE, 2022) (Table A. 1). It was assumed that a low proportion (three animals) of the MU population (up to 0.02%) is expected to be repeatedly impacted and any changes to individual vital rates are very unlikely to occur to the extent that the population trajectory would be altered. Awel y Môr Offshore Wind Farm assessed the number of Risso's dolphin predicted to be affected by disturbance based on SCANS III densities and the CGNS MU as the reference population to inform the assessment (RWE, 2022). A small number of animals (n = 65) were likely to be behaviourally disturbed during piling at Awel y Môr but effects were considered to be limited to small spatial and temporal scales. Given that there was very little data on Risso's dolphin in the Project Erebus area, and no density estimate was available, this species was not included in the quantitative impact assessment although the spatial scale of the effects was expected to be similar to that of bottlenose dolphin (Blue Gem Wind, 2020; Table A. 1).

A.1.1.1.76 Project Erebus assessed the number of short-beaked common dolphin predicted to be affected by disturbance, based on densities from site-specific surveys and SCANS III block D (Blue Gem Wind, 2020). Whilst up to 2,067 animals (2.01% of the population) may be behaviourally disturbed, this was not anticipated to lead to changes in the population trajectory due to the short-term nature of the impact.

A.1.1.1.77 Based on the White Cross Offshore Wind Farm MDS, as presented in the White Cross Offshore Wind Farm marine mammal and marine turtle ecology chapter, the maximum number of short-beaked common dolphin predicted to be disturbed is less than one individual for both wind turbine foundations and the OSP foundation (maximum 0.005% of the CCGNS MU) (Table A. 1) based on TTS as a proxy for disturbance. As highlighted for other species, numbers are likely to be overestimated, as this approach assumes 100% avoidance of all individuals exposed, as opposed to a dose response approach, which assumes a proportional decrease in avoidance at greater distances from the pile driving source (Brandt *et al*., 2011) (see paragraph 4.9.1.11 *et seq*). This was the most precautionary estimate based on the APEM winter density estimate density (5.230 animals per km^2), rather than the lower APEM annual density estimate (3.833 animals per km^2) (see Offshore Wind Limited (2023). The assessment concluded a magnitude of negligible for the OSP foundation and a magnitude of low for wind turbine foundations. White Cross Offshore Wind Farm did not assess impacts on Risso's dolphin.

A.1.1.1.78 It is anticipated that there will be a temporal overlap with piling at the Mona Offshore Wind Project, Awel y Môr Offshore Wind Farm and White Cross Offshore Wind Farm with the Morgan Generation Assets. The consequences of potential simultaneous piling in 2028 (i.e. larger area of strong disturbance compared to the Morgan

Generation Assets alone and longer duration of the impact) are described in more detail, for harbour porpoise, in paragraph A.1.1.1.65. Bottlenose dolphin, short-beaked common dolphin and Risso's dolphin may also be affected by strong disturbance over a larger area, however, it is important to note that all three species display seasonal variations in their distributions. Given that animals are not likely to be present in such high densities in the Celtic and Irish Seas constantly throughout the year (though they are present throughout the year (Evans and Waggitt, 2023), it can be assumed that these species will not be continuously affected by simultaneous piling at the same level if it occurs all year round. For example, there is evidence of seasonal and breeding movement between Cardigan Bay and waters around the Isle of Man, and it is not likely to have high densities in both of these areas simultaneously (see Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement for detail).

A.1.1.1.79 Therefore, cumulatively (see paragraph A.1.1.1.3 for more details) for bottlenose dolphin (i.e. IS MU only), there would be piling at Morgan Generation Assets (maximum spatial scenario) and Mona Offshore Wind Project in 2027 affecting 7 bottlenose dolphin (2.93% of the IS MU) and subsequently piling at Morgan Generation Assets (maximum spatial scenario), Mona Offshore Wind Project and Awel y Môr in 2028 which may coincide and affect up to 35 bottlenose dolphin (11.94% of the IS MU).

A.1.1.1.80 For other dolphin species, there would be piling at Project Erebus in 2025 affecting 2,067 short-beaked common dolphin. In 2026 there would be piling at Project Erebus affecting 2,067 short-beaked common dolphin and piling at White Cross Offshore Wind Farm, affecting less than one short-beaked common dolphin on a single day of piling (OSP foundation; maximum hammer energy of 2,500 kJ) or less than one short-beaked common dolphin over 5 days of piling (wind turbine foundations; maximum hammer energy of 800 kJ). Subsequently, piling in 2027 at Morgan Generation Assets would occur, affecting three short-beaked common dolphin and 121 Risso's dolphin; Mona Offshore Wind Project in 2027 affecting three short-beaked common dolphin and 129 Risso's dolphin; and White Cross Offshore Wind Farm affecting less than one short-beaked common dolphin for both wind turbine foundations and OSP foundations. In 2028, there would be piling at Morgan Generation Assets; Mona Offshore Wind Project; and Awel y Môr Offshore Wind Farm which may coincide and affect up to 23 short-beaked common dolphin (0.02% of the CGNS MU) and 186 Risso's dolphin (2.56% CGNS MU). However, this is likely to be an overestimate given that the MDS for each project were used for the respective assessments (which each had levels of precaution within their own assessments) and that, due to the proximity of the sites, the sound level contours are likely to overlap thus reducing the area of ensonification.

A.1.1.1.81 As described above for harbour porpoise (see paragraph A.1.1.1.67), the construction of Project Erebus is planned to take place in 2025 and 2026 with only 18 days over which piling may occur and therefore there is no potential for piling activity to coincide with piling at Morgan Generation Assets, Mona Offshore Wind Project or Awel y Môr Offshore Wind Farm. There is potential for temporal overlap with White Cross Offshore Wind Farm in 2026. Temporally, Project Erebus would contribute to a slightly longer duration of piling within the cumulative study area.

A.1.1.1.82 Cardigan Bay, and the Cardigan Bay/Bae Ceredigion SAC in particular, provide important habitats for bottlenose dolphin, with large numbers of animals inhabiting the area in the summer months. As described in more detail in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement, there is an indication that bottlenose dolphin move between Manx waters and Cardigan Bay across the seasons. It has been suggested that Manx waters may provide vital winter habitat, whilst Cardigan Bay for calving. Although there has been no significant trend for Cardigan Bay/Bae Ceredigion SAC between 2001 and 2016, Lohrengel *et al.* (2018) reported that there is 90% certainty that the population in the SAC has declined over the last 10 years (2007 to 2016). Whilst abundance appears to be relatively stable in the IS MU (IAMMWG, 2022; Evans and Waggitt 2023), much of this region has not been well surveyed for population trends and it is difficult to determine an overall trend for the IS MU. Therefore, particular attention needs to be paid to ensure that although individuals may be disturbed in the short to medium term from specific areas of the Irish Sea, it will not have implications on long-term population trajectory. As such, future population dynamics of bottlenose dolphin were investigated using population modelling, as described in paragraphs 4.9.2.13 to 4.9.2.17.

A.1.1.1.83 Population modelling was carried out for bottlenose dolphin for Tier 1 projects within the IS MU only, namely Mona Offshore Wind Project and Awel y Môr Offshore Wind Farm, alongside Morgan Generation Assets. Results of the cumulative iPCoD modelling for bottlenose dolphin at Morgan Generation Assets, Mona Offshore Wind Project and Awel y Môr Offshore Wind Farm, against the IS MU population showed that the median ratio of the impacted population to the unimpacted population was 1.0000 at 6 and 25 years (Appendix B, Table B. 26), although the corresponding mean ratios do vary: 0.9760 at 6 years and 0.9783 at 25 years. This is reflected in the small difference between the impacted and unimpacted population size over time, with 7 fewer animals at 6 years (corresponding to 2.04% of the IS MU) and 5 fewer animals at time point 25 (corresponding to 1.70% of the IS MU), although the model suggests that this falls within the natural variation of the population and would not be expected to change the population trajectory (Figure A. 10). It should, however, be highlighted that these small differences are predicted against a background of a modelled declining population (based on precautionary demographic parameters recommended by NRW, which uses a 0.22 fertility rate from Arso Civil *et al*., 2017). As discussed in paragraph 4.9.2.17, it is important to highlight that whilst any model is sensitive to input parameters (as evidenced in Appendix B, by modelling with a 0.30 fertility rate from Sinclair *et al.*, 2020 for the Morgan Generation Assets project alone iPCoD modelling), the model chosen represents a conservative assessment of population changes. As discussed in paragraph A.1.1.1.14, the trend for the IS MU is stable (though Cardigan Bay appears to have a declining population), and therefore the interpretation is with respect to the difference between impacted and unimpacted population.

A.1.1.1.84 Additionally, cumulative piling at respective projects could displace animals from important summer and winter habitats intermittently over two years. Given that bottlenose dolphin can travel over large distances, there is a possibility that individuals from SAC populations (see paragraph 4.9.2.68 for more information) may be occasionally present within the disturbance contours. As such the cumulative effects on the designated features and conservation objectives of designated sites will be considered in the HRA Stage 2 ISAA (Document reference E1.1). In addition, there is potential for overlap of the disturbance contours with a number of MNRs around the Isle of Man designated for bottlenose dolphin including Douglas Bay, Laxey Bay and Baie Ny Carrickey MNRs (although noting that for Morgan Generation Assets the overlap is likely to elicit a mild disturbance response only).

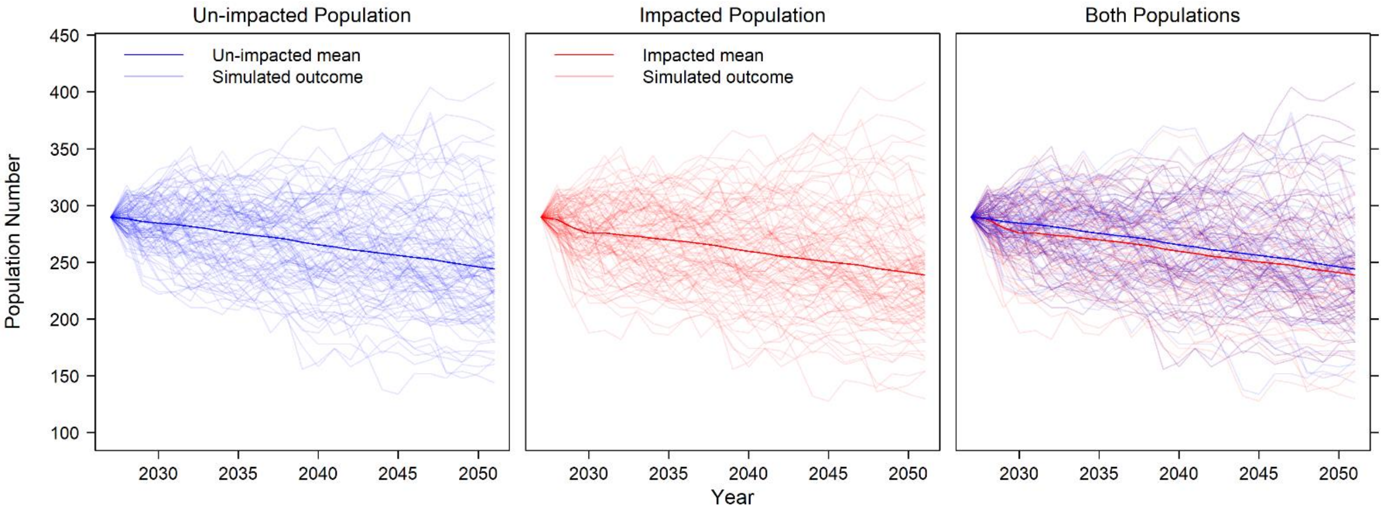

Figure A. 10: Simulated bottlenose dolphin population sizes (Irish Sea MU) for both the baseline (unimpacted) and the impacted populations under the cumulative scenario and no vulnerable subpopulation for Tier 1 projects only (lower fertility rate of 0.22).

A.1.1.1.85 The impact (cumulative elevated underwater sound arising during piling) is predicted to be of regional spatial extent, medium term duration and intermittent (only occurs during piling activities). Similarly, the effect of behavioural disturbance is reversible (with animals returning to baseline levels within hours/days after piling have ceased). It is predicted that the impact will affect the receptor directly. The cumulative impact of piling at projects in the IS MU (Morgan Generation Assets, Mona Offshore Wind Project and Awel y Môr Offshore Wind Farm) could result in potential reductions to reproductive success during an animal’s lifetime to some individuals in the IS MU population as disturbance in offshore areas during piling could lead to a longer duration (up to 405 days if no overlap in piling, based on maximum temporal scenario) over which individuals may be displaced from key areas (in offshore areas between the mainland coast and the Isle of Man including MNRs) compared to the Morgan Generation Assets alone (up to 114 days for piling of pin piles for the maximum temporal scenario). Based on the iPCoD models these changes are not enough to significantly affect the population trajectory over a generational scale (i.e. the trajectory falls within natural variation), however, there may be a small reduction in population size for the impacted population. In the context of possible declining bottlenose dolphin Irish Sea MU population, and the semi-resident population in Cardigan Bay with seasonal movements across to the Isle of Man, the magnitude for bottlenose dolphin is conservatively considered to be **medium**. For short-beaked common dolphin and Risso’s dolphin, the magnitude is considered to be **low**.

Minke whale

A.1.1.1.86 Based on the Mona Offshore Wind Project maximum spatial scenario the maximum number of minke whale predicted to be disturbed is up to 72 (0.35% of the CGNS MU) based on a density estimate of 0.0172, from SCANS-III, block E (Table A. 1) (Mona Offshore Wind Ltd., 2023).

A.1.1.1.87 The maximum number of minke whale predicted to be disturbed at Awel y Môr Offshore Wind Farm is up to 36 (0.18% of the CGNS MU) based on a density estimate of 0.0173, from SCANS III, block E (Table A. 1). The assessment concluded that any changes to individual vital rates are very unlikely to occur to the extent that the population trajectory would be altered (RWE (2022)).

4.15.1.2 The maximum number of animals predicted to be disturbed at White Cross Offshore Wind Farm, is up to 42 minke whale (0.21 % of the CGNS MU) for wind turbine foundations and 61 minke whale (0.30% of the CGNS MU) for an OSP foundation. This was the most precautionary estimate based on the SCANS-III estimate of 0.0112 animals per km^2 (Hammond *et al.,* 2021). The assessment concluded a magnitude of negligible for both wind turbine foundations and the OSP foundation (White Cross Offshore Wind Ltd., 2023).

A.1.1.1.88 It is anticipated that there will be a temporal overlap in piling at Morgan Generation Assets alongside Mona Offshore Wind Project, Awel y Môr Offshore Wind Farm and White Cross Offshore Wind Farm. The consequences of potential simultaneous piling (i.e. larger area of strong disturbance compared to the Morgan Generation Assets alone and longer duration of the impact) are described in more detail, for harbour porpoise, in paragraph A.1.1.1.65. Given that minke whale show high seasonality to the area, with detections mostly over summer months (May to December, see Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement for more details), it can be assumed that individuals will not be continuously affected by simultaneous piling if it occurs throughout the year. The maximum number of animals predicted to be disturbed, if piling activities at Morgan Generation Assets coincide with piling at Mona Offshore Wind Project, Awel y Môr Offshore Wind Farm and White Cross Offshore Wind Farm, is up to 236 minke whale (1.17% of the CGNS MU). However, this is likely to be an overestimate given that the MDS for each project were used for the respective assessments (which each had levels of precaution within their own assessments) and overlap of the sound level contours.

A.1.1.1.89 The maximum number of minke whale predicted to be disturbed at Project Erebus is 55 (0.3% of the CGNS MU) based on a density estimate of 0.0112, from SCANS-III block D (Hammond *et al.,* 2021) (Table A. 1) (Blue Gem Wind, 2020). As described above for harbour porpoise (see paragraph A.1.1.1.67), piling at Project Erebus is planned to take place in 2025 and 2026 with only 18 days over which piling may occur and therefore is no potential for piling activity to coincide with piling at Morgan Generation Assets, Mona Offshore Wind Project or Awel y Môr Offshore Wind Farm. There is potential for temporal overlap with White Cross Offshore Wind Farm in 2025. Temporally, Project Erebus would contribute to a slightly longer duration of piling within the cumulative study area.

A.1.1.1.90 Cumulatively, there would be piling at Project Erebus in 2025 affecting 55 minke whale. In 2026 there would be piling at Project Erebus affecting 55 minke whale and piling at White Cross Offshore Wind Farm, affecting up to 42 minke whale on a single day of piling (OSP foundation; maximum hammer energy of 2,500 kJ) or up to 61 minke whale over 5 days of piling (wind turbine foundations; maximum hammer energy of 800 kJ). Subsequently, there would be piling in 2027 at Morgan Generation Assets, affecting 67 minke whale (maximum spatial scenario); Mona Offshore Wind Project affecting up to 72 minke whale; and White Cross Offshore Wind Farm. In 2028, there would be piling at Morgan Generation Assets; Mona Offshore Wind Project; and Awel y Môr Offshore Wind Farm which may coincide and affect up to 236 minke whale (1.17% of the CGNS MU).

A.1.1.1.91 Population modelling for Tier 1 was carried out to explore the potential of disturbance during piling to affect the population trajectory over time and provide additional certainty in the predictions of the assessment of potential effects. Results of the cumulative iPCoD modelling for minke whale against the CGNS MU showed that the median ratio of impacted population size to unimpacted population size was 0.9994 at 6 years after the commencement of piling and 0.9984 at 25 years after the commencement of piling (Appendix B, Table B. 32). Small differences in the population size over time between the impacted and unimpacted population (40 individuals smaller than the unimpacted population after 25 years, (corresponding to approximately 0.19% of the CGNS MU) fall within the natural variance of the population and would not be expected to change the population trajectory as can be seen in Figure A. 11.

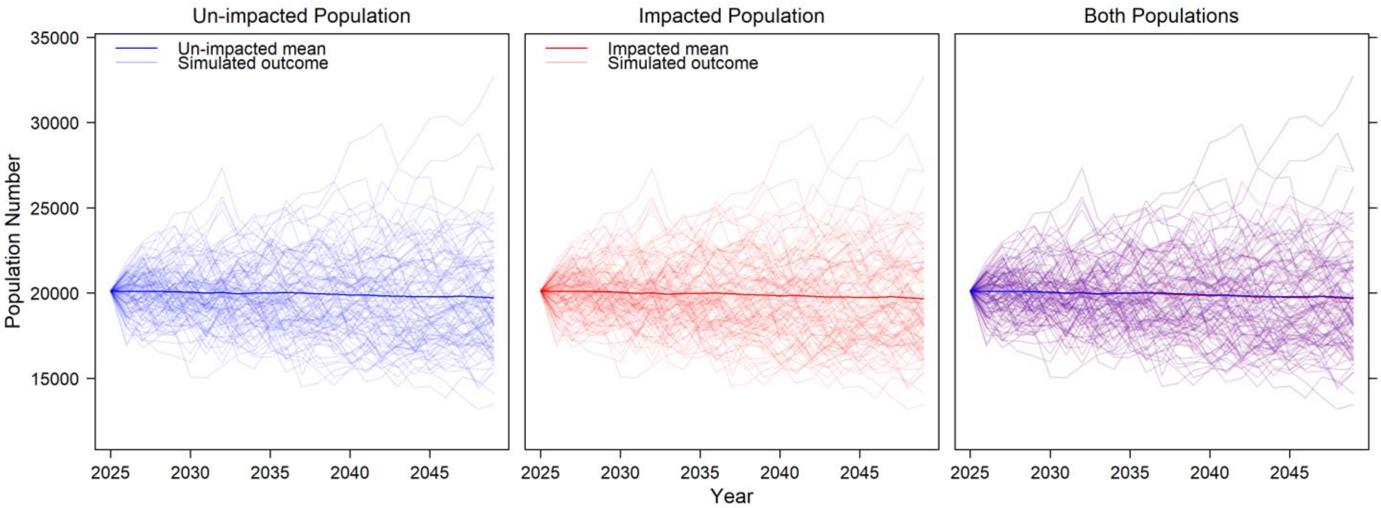

Figure A. 11:Simulated minke whale population sizes for both the baseline (unimpacted) and the impacted populations under the cumulative scenario and no vulnerable subpopulation for Tier 1 Projects.

A.1.1.1.92 The impact (cumulative elevated underwater sound arising during piling) is predicted to be of regional spatial extent, medium term duration and intermittent (only occurs during piling activities). Similarly, the effect of behavioural disturbance is reversible (with animals returning to baseline levels within hours/days after piling have ceased). It is predicted that the impact will affect the receptor directly. The impact could result in some measurable changes to individuals that are disturbed (i.e. interruption of feeding or breeding and/or displacement to alternative areas), however, the results of the iPCoD modelling in the context of the CGNS MU suggest that over the duration of the impact, up to 6 years and 25 years (Appendix B) after the start of piling there would be no long-term effects on the minke whale population. The magnitude is therefore considered to be **low.**

Grey seal

A.1.1.1.93 For grey seal, as discussed in paragraph 4.10.1.5, screening was based on OSPAR Region III following discussions with the EWG. However, all Tier 1 Projects identified through screening lie within the extent of the GSRP and therefore it is appropriate to present quantitative effects against the GSRP, from a precautionary perspective. As such population modelling was carried out against the GSRP (see Appendix B).

A.1.1.1.94 The number of grey seal predicted to be exposed to underwater sound levels that could result in behavioural disturbance at any one time during piling at Mona Offshore Wind Project (Table A. 3) is up to 31 (0.23% of the GSRP), based on grid specific density estimates from Carter *et al.* (2022).

A.1.1.1.95 The number of grey seal predicted to be exposed to underwater sound levels that could result in behavioural disturbance at any one time during piling at Awel y Môr Offshore Wind Farm (Table A. 3) was based on grid specific density estimates from Carter *et al.* (2020). The Wales and NW England MUs population of 5,000 individuals was taken forward as the reference population to inform the assessment for Awel y Môr (RWE, 2022). With up to 81 individuals potentially behaviourally disturbed the assessment concluded that any changes to individual vital rates are very unlikely to occur to the extent that the population trajectory would be altered.

A.1.1.1.96 The maximum number of animals predicted to be disturbed at White Cross Offshore Wind Farm is up to 10 grey seal (0.48% of the SCOS SW England MU), based on grid specific density estimates from Carter *et al.* 2022 and known disturbance ranges for grey seal as a result for piling (25 km; Russel *et al.,* 2016). The assessment concluded a magnitude of negligible for both wind turbine foundations and OSP foundation.

A.1.1.1.97 It is anticipated that there will be a temporal overlap in piling at Morgan Generation Assets alongside Mona Offshore Wind Project, Awel y Môr Offshore Wind Farm and White Cross Offshore Wind Farm. The consequences of potential simultaneous piling, i.e. larger area of strong disturbance compared to the Morgan Generation Assets alone and longer duration of the impact are described for in more detail for harbour porpoise in paragraph A.1.1.1.65. The maximum number of animals predicted to be disturbed, if piling activities at Morgan Generation Assets coincide with piling at Mona Offshore Wind Project, Awel y Môr Offshore Wind Farm and White Cross Offshore Wind Farm, is up to 183 grey seal. This number represents 1.42% of the GSRP or 0.3% of the OSPAR Region III reference population. Although grey seals are present year-round on both the Irish and Welsh coasts, they are known to move between the southeast coast of Ireland and the southwest coast of Wales (see telemetry data in see Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement for more details). Considering their ability to range over long distances, it is likely that grey seals will be able to find alternative foraging grounds if displaced during simultaneous piling.

A.1.1.1.98 Project Erebus assessed the number of grey seals predicted to be affected by disturbance, based on grid specific density estimates from Carter *et al.* (2020) (Table A. 3) (Blue Gem Wind, 2020). The Wales and Southwest England MUs populations of 6,090 individuals were taken forward as the reference population to inform the assessment (Blue Gem Wind, 2020). As described above for harbour porpoise (see paragraph A.1.1.1.67), piling at Project Erebus is planned to take place in 2025 and 2026 with only 18 days over which piling may occur. Since piling at Morgan Generation Assets, Mona Offshore Wind Project and Awel y Môr Offshore Wind Farm commence in 2027 and 2028, there is no potential for piling activity at Project Erebus to coincide with piling at these projects and therefore, spatially, there would be no larger cumulative area of disturbance as a result of Project Erebus. There is potential for temporal overlap with White Cross Offshore Wind Farm in 2026. It is, however, important to note that Project Erebus is in close proximity to the Pembrokeshire Marine/Sir Benfro Forol SAC and Lundy SAC designated for grey seal. Temporally, Project Erebus could contribute to a slightly longer duration of piling within the cumulative study area.

A.1.1.1.99 Cumulatively (see paragraph A.1.1.1.3 for more details), there would be piling at Project Erebus in 2025 affecting 18 grey seal. In 2026 there would be piling at Project Erebus affecting 1, 18 grey seal and piling at White Cross Offshore Wind Farm, affecting up to 10 grey seal on either a single day of piling for the wind turbine foundation (maximum hammer energy of 2,500 kJ) or on a single day of piling for the

OSP foundation (maximum hammer energy of 800 kJ). Subsequently, there would be piling in 2027 at Morgan Generation Assets, affecting up to 61 grey seal (maximum spatial scenario); Mona Offshore Wind Project affecting up to 31 grey seal; and White Cross Offshore Wind Farm. In 2028, there would be piling at Morgan Generation Assets; Mona Offshore Wind Project; and Awel y Môr Offshore Wind Farm which may coincide and affect up to 183 grey seal. This number represents 1.42% of the GSRP or 0.3% of the OSPAR Region III reference population.

A.1.1.1.100 Results of the cumulative population modelling for grey seal showed that the median ratio of impacted population size to the unimpacted population size was 1.0000 at six and 25 years (Appendix B, Table B. 38), and simulated grey seal population sizes for both unimpacted and impacted populations showed no difference (Figure A. 12). Therefore, it was considered that there is no potential for long-term effects on this species.

A.1.1.1.101 Given that grey seal telemetry tracks presented in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement demonstrated some connectivity between the Morgan Generation Assets and designated sites (see paragraph 4.9.2.96 for more information), the cumulative effects on the designated features and conservation objectives of designated sites will be considered in the HRA Stage 2 ISAA (Document reference E1.1).

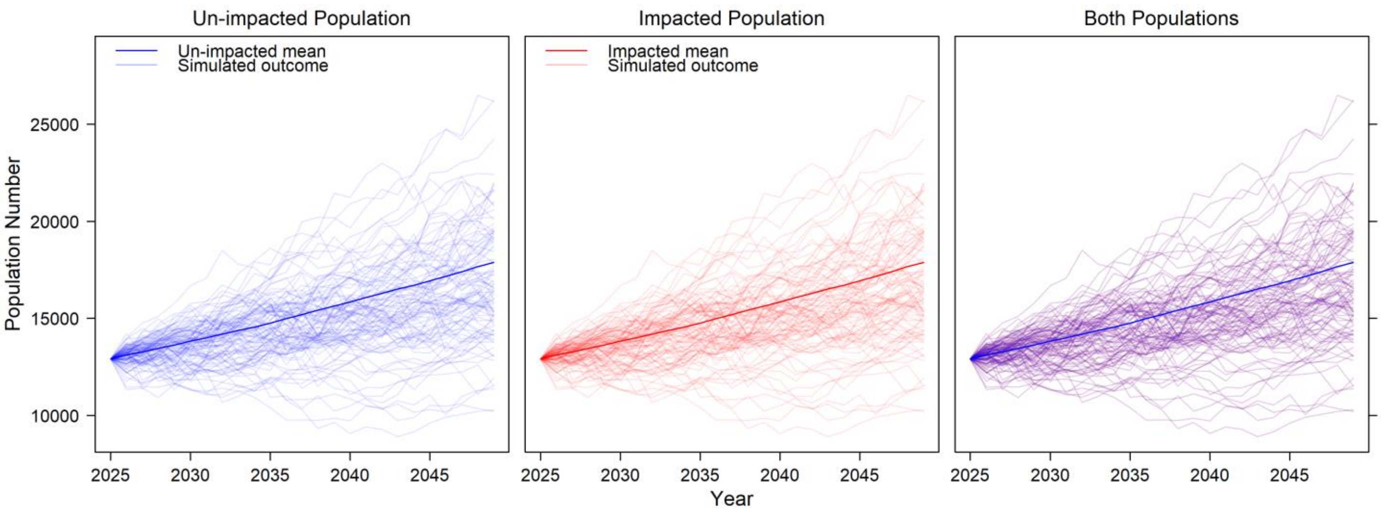

Figure A. 12: Simulated grey seal population sizes for both the baseline and the impacted populations under the cumulative scenario and no vulnerable subpopulation for Tier 1 projects.

A.1.1.1.102 The impact (cumulative elevated underwater sound arising during piling) is predicted to be of regional spatial extent, medium term duration and intermittent (only occurs during piling activities). Similarly, the effect of behavioural disturbance is reversible (with animals returning to baseline levels within hours/days after piling have ceased). It is predicted that the impact will affect the receptor directly. The impact could result in some measurable changes to individuals that are disturbed (i.e. interruption of feeding or breeding and/or displacement to alternative areas), however, the results of the iPCoD modelling suggest that over the duration of the impact, up to six years and 25 years after the start of piling there would be no long-term effects on the grey seal population in the context of the GSRP. The magnitude is therefore considered to be **low** in respect of both populations.

Harbour seal

A.1.1.1.103 The only Tier 1 project that considered effects on harbour seal is Mona Offshore Wind Project. The number of harbour seal predicted to be exposed to underwater sound levels that could result in behavioural disturbance at any one time during piling at Mona Offshore Wind Project (Table A. 3) is less than one (0.01% of the HSRP), based on grid specific density estimates from Carter *et al.* (2022).

A.1.1.1.104 It is anticipated that there will be a temporal overlap in piling at Morgan Generation Assets alongside Mona Offshore Wind Project. The consequences of potential simultaneous piling, i.e. larger area of strong disturbance compared to the Morgan Generation Assets alone and longer duration of the impact are described for in more detail for harbour porpoise in paragraph A.1.1.1.65. The maximum number of animals predicted to be disturbed, if piling activities at Morgan Generation Assets coincide with piling at Mona Offshore Wind Project is less than two harbour seal (0.02% of the HSRP). Although harbour seal are present year-round animals can travel to other areas to feed during piling. Harbour seal tend to forage within 50 km of the coast and therefore may be restricted in the area of available habitat. Note also that animals would be likely to avoid offshore areas where received levels during piling exceed thresholds for strong disturbance and there may be an energetic cost associated with longer foraging trips and alternative habitat may be sub-optimal in terms of abundance of key prey species. Given the proximity of the Morgan Generation Assets and Mona Offshore Wind Project (see Figure 4.26) it is expected that animals would be disturbed over a very similar area and a large proportion of disturbance contours are predicted to overlap. However, the area of strong disturbance is predicted to be larger compared to the Morgan Generation Assets alone and cumulative piling could result in an increased duration of impact. If there was no overlap in piling individuals may be displaced from key areas (in offshore areas between the mainland coast and the Isle of Man including MNRs) for up to 204 days, compared to the Morgan Generation Assets alone (up to 114 days for piling of pin piles for the temporal MDS) (see Table A. 3).

A.1.1.1.105 Given that there is potential overlap of sound level contours with Lambay Island SAC and Slaney River Valley SAC and Rockabill to Dalkey Island SAC, designated for harbour seal, individuals from SAC populations (see paragraph 4.9.2.109 for more information) may be occasionally present within the disturbance contours. As such the cumulative effects on the designated features and conservation objectives of designated sites will be considered in the HRA Stage 2 ISAA (Document Reference E1.1). In addition, there is potential for overlap of the disturbance contours with a number of MNRs around the Isle of Man designated for grey seal including Langness MNR, Ramsey Bay MNR and West Coast MNR (although noting that for Morgan Generation Assets the overlap is likely to elicit a mild disturbance response only).

A.1.1.1.106 Population modelling was not carried out for harbour seal due to the very small number of animals potentially behaviourally disturbed and therefore very low risk of a population level effect occurring for this species.

A.1.1.1.107 The impact (cumulative underwater sound generated from piling) is predicted to be of regional spatial extent, medium term duration and intermittent (only occurs during piling activities). The effect of behavioural disturbance is reversible (with behavioural characteristics returning to baseline levels within hours/days after piling have ceased). It is predicted that the impact will affect the receptor directly. The cumulative impact of piling at the Morgan Generation Assets and Morgan and Morecambe Offshore Wind Farms: Transmission Assets is unlikely to lead to population-level consequences as a result of disturbance and the magnitude is therefore conservatively considered to be **low**.

Sensitivity of receptor

A.1.1.1.108 The sensitivity of marine mammals to disturbance from underwater sound generated from piling is as described in Scenario 1, paragraph A.1.1.1.35 *et seq.* and is not reiterated here.

A.1.1.1.109 All marine mammals are deemed to have some tolerance to behavioural disturbance, exhibit high recoverability and are considered of international value. The sensitivity of the receptor is therefore, **medium**.

Significance of effect

A.1.1.1.110 The significance of effect is presented in A.1.1.1.107 alongside conclusions of magnitude and sensitivity.

A.1.1.1.111 The assessment of potential effects has determined that there are no significant impacts predicted for the Morgan Generation Assets alone, however, recognising the potential for cumulative effects the Applicant will continue to explore options for mitigation of piling sound post-consent, at a time when more detailed information is available (i.e. geotechnical data) and where further refinements to the Morgan Generation Assets have been made on this basis. NAS will be considered as part of the Outline Underwater sound management strategy (Document Reference J13). There will be a stepped strategy post consent which follows the mitigation hierarchy - avoid, reduce, mitigate. Consequently, if NAS is required a detailed exploration of available technologies will be undertaken and information presented to demonstrate how such technology would contribute to the reduction in underwater sound from piling from the Morgan Generation Assets and thus reduce the potential for cumulative effects with other plans or projects.

Further mitigation measures

A.1.1.1.112 The cumulative impact assessment of disturbance from elevated underwater sound from piling concludes a significant effect in EIA terms, for bottlenose dolphin only. The cumulative impact assessment of injury from elevated underwater sound from piling concludes no significant effect in EIA terms, for all marine mammal receptors. Whilst the project alone assessment determined there would be no significant effect in EIA terms, the Morgan Generation Assets may contribute to the cumulative impact in the context of the Irish Sea MU.

A.1.1.1.113 The assessment of cumulative effects from other plans and projects is based upon the respective MDSs presented in the Environmental Statements for Tier 1 projects or PEIR for Tier 2 Projects. The assessment does not consider any further mitigation or reduced/refined project design envelopes for other Tier 1 and/or Tier 2 projects that may be implemented post consent. However it is understood that if other projects are consented, it is reasonable to assume that they will each implement appropriate measures such that any significant effect is reduced to a non-significant level. Although this assessment cannot conclude based upon this assumption, a significant cumulative impact is considered unlikely for this reason.

A.1.1.1.114 Post consent, following a refined Project Design Envelope and programme clarity, the Underwater sound management strategy (Document Reference J13) will investigate options to manage underwater sound levels (such as NAS, temporal and spatial piling restrictions, piling methods, soft start) in order to reduce the magnitude for the project alone, in order to minimise the contribution to any cumulative effect. The Applicant has prepared an Outline underwater sound management strategy (Document Reference J13) which is secured in the deemed marine licences within the draft DCO (Document Reference C1).

A.1.1.1.115 In this case, further mitigation options may be applied to reduce the magnitude for bottlenose dolphin. The Underwater sound management strategy (Document Reference J13) will be developed in consultation with the licensing authority and SNCBs, and agreed, prior to construction, those mitigation measures which may be implemented to reduce the magnitude of impact from the project alone.

Tier 2

Construction phase

A.1.1.1.116 Given the temporal overlap, the construction of the Morgan Generation Assets Project, together with construction of Tier 1 projects and Tier 2 projects: Arklow Bank Wind Park Phase 2, Codling Wind Park Offshore Wind Farm, Dublin Array Offshore Wind Farm, Inis Ealga Marine Energy Park , Llŷr 1, Llŷr 2, North Celtic Sea Offshore Wind Farm, North Channel Wind 1, North Channel Wind 2, North Irish Sea Array Offshore Wind Farm, Oriel Offshore Wind Farm, Project Ilen, Project Valorous, Shelmalere Offshore Wind Farm, Simply Blue Emerald, the Morgan and Morecambe Offshore Wind Farms: Transmission Assets (see paragraph A.1.1.1.2 *et seq* and A.1.1.1.39 for a full assessment, which is not re-iterated here) and Morecambe Generation Assets (see paragraph A.1.1.1.39 *et seq* for a full assessment, which is not re-iterated here) (Table 4.51) may lead to cumulative disturbance to marine mammals from piling.

Magnitude of impact

A.1.1.1.117 The EIA Scoping Reports do not provide detailed information about impacts of underwater sound as a result of piling and therefore it is not possible to undertake a full, quantitative assessment for this impact. As such, a qualitative assessment is provided below.

A.1.1.1.118 The EIA Scoping Reports of all projects screened into the cumulative assessment have identified potential for auditory injury and disturbance as a result of underwater sound during piling as potential impacts (SSE Renewables (2020); Codling Wind Park Limited. (2020); Dublin Array (2020); Inis Ealga Marine Energy Park Ltd. (2022); AECOM (2022); Floventis Energy Ltd. (2022); Orsted (2023); North Celtic Sea Wind Limited (2023); North Channel Wind (2023); North Irish Sea Array Windfarm Ltd (2023); Oriel Wind Farm Ltd. (2019); Western Star Limited (2023a); Blue Gem Wind Ltd (2021); Shelmalere Offshore Wind Farm Ltd. (2022); Emerald Offshore Wind Ltd (2023); Spiorad na Mara Limited (2023)). The indicative timelines suggest that there will be a temporal overlap of construction phase of Morgan Generation Assets with the construction phases of all listed projects. The construction dates are unknown for Arklow Bank Wind Park Phase 2, Codling Wind Park Offshore Wind Farm, North Celtic Sea Offshore Wind Farm, Oriel Offshore Wind Farm and Project Ilen and Simply Blue Emerald, however, conservatively these projects were screened into the cumulative assessment in the event that a temporal overlap occurs. It is noted that the description of the projects provided in the respective EIA Scoping Reports is indicative and may be further refined or changed.

A.1.1.1.119 Most of the Tier 2 projects screened into the cumulative assessment included fixed foundations in their design envelope. Projects such as Arklow Bank Wind Park Phase

2, Codling Wind Offshore Wind Farm, Dublin Array Offshore Wind Farm, North Celtic Sea Offshore Wind Farm, North Irish Sea Array Offshore Wind Farm, Oriel Offshore Wind Farm and Shelmalere Offshore Wind Farm considered various types of wind turbine foundations, including monopiles, jackets, gravity bases or suction bucket foundations. Given that monopiles are characterised by diameters larger than other foundation types and may need to be driven or piled into the seabed, the installation of this foundation type contributes to the greatest amount of underwater sound. Additionally, the foundation installation method depends on the seabed conditions and foundations can be installed using various methods.

A.1.1.1.120 The EIA Scoping Reports for eight of the cumulative projects consists of floating foundation technology for wind turbines: Inis Ealga Energy Park, Llŷr Projects (Llŷr 1/ Llŷr 2), North Channel Wind 1/2, Project Ilen, Project Valorous, and Simply Blue Emerald. However, given that all three projects considered different technologies to ensure that the wind turbines are secured to the seabed (e.g. suction piles, driven piles or drilled and grouted piles), piling is under consideration as a possible anchoring technique. Given turbines are floating they involve piling of much smaller piles compared to the monopiles used during construction of fixed bottom foundations and therefore result in source levels of much smaller magnitude.

A.1.1.1.121 The number of piling days or hammer energies are unknown for most of the projects. However, the number of wind turbines varies from an array consisting of 28 wind turbines (North Channel Wind 2) to up to 140 wind turbines (Codling Wind Park) (Table A. 4) (Morecambe Offshore Wind Farm Generation Assets and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets have been presented here for comparison with other Tier 2 projects).

Table A. 4: Projects screened into the cumulative assessment for underwater sound as a result of piling and number of wind turbines/foundations.

[1] One OSP at the Morgan Generation Assets is considered under both the Morgan Generation Assets and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets.

[2] Two OSPs at the Morecambe Generation Assets considered under both the Morecambe Generation Assets and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets.

Project	Type of foundation	Number of wind turbines/ foundations	Closest distance to Morgan Array Area (km)
Arklow Bank Wind Park Phase 2	Fixed	76	107.6
Codling Wind Park	Fixed	140	141.2
Dublin Array Offshore Wind Farm	Fixed	61	134.4
Inis Ealga Marine Energy Park	Floating	70	327.0
Llŷr Projects (Llŷr 1/ Llŷr 2)	Floating	61	295.0/298.5
Morecambe Offshore Wind Farm Generation Assets	Fixed	40	11.2
Morgan and Morecambe Offshore Wind Farms: Transmission Assets[1]	OSP (fixed)	7	0
North Celtic Sea Offshore Wind Farm	Fixed	60	277.0
North Channel Wind 1	Floating	68	135.0
North Channel Wind 2	Floating	28	107.2

Project	Type of foundation	Number of wind turbines/ foundations	Closest distance to Morgan Array Area (km)
North Irish Sea Array Offshore Wind Farm	Fixed	36	107.6
Oriel Offshore Wind Farm	Fixed	55	119.4
Project Ilen	Floating	90	393.7
Project Valorous	Floating	31	170.5
Shelmalere Offshore Wind Farm	Fixed	67	201.4
Simply Blue Emerald	Floating	87	359.2

A.1.1.1.122 In temporal terms, the first construction phases are anticipated to start in 2025, for North Irish Sea Array Offshore Wind Farm and Llŷr Projects 1 and 2. The construction of some of the cumulative projects will continue until 2029, including Inis Ealga Marine Energy Park, North Channel Wind 1 and 2, and Shelmalere Offshore Wind Farm (Table 4.51). This timescale constitutes a total of six years where construction activities, including piling, will occur across the cumulative marine mammal study area. Piling activities will occur intermittently over the construction phase of respective projects, therefore, whilst this will not result in a continuous risk of disturbance to marine mammals, it may affect multiple breeding seasons for marine mammal species. In the context of the life cycle of respective species (see Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement for more details), the duration of the impact is classified as medium term, as the exposure to elevated sound levels could occur over a meaningful proportion of their lifespan.

A.1.1.1.123 Additionally in spatial terms, depending on the magnitude of impact (i.e. type of foundation, installation technique), piling at each wind farm is likely to affect marine mammals behaviourally over different spatial scales. Due to the proximity of North Irish Sea Array Offshore Wind Farm, Oriel Offshore Wind Farm, Dublin Array Offshore Wind Farm and Codling Wind Park Offshore Wind Farm to the Morgan Generation Assets (Table 4.50) (i.e. within the area of ensonification for Morgan Generation Assets), there is a potential for overlap of sound disturbance contours during piling. Animals may be displaced from an area comparable to piling contours at the Morgan Generation Assets alone (section 4.9.2). However, where there is a potential for simultaneous piling to take place, it is likely to generate considerable levels of underwater sound to the environment and potentially result in larger area of strong disturbance (160 dB re 1µPa SPL_{rms} as discussed in section 4.9.1) compared to piling at the Morgan Generation Assets.

A.1.1.1.124 In the context of the wider habitat available within the cumulative marine mammal study area, it is not anticipated that cumulative piling will result in long-term population-level effects on any of the species, except for bottlenose dolphin. The cumulative piling at North Irish Sea Array Offshore Wind Farm and Oriel Offshore Wind Farm could further contribute to the impacts on bottlenose dolphin within the IS MU, as established in Scenario 1 (paragraph A.1.1.1.16), Scenario 2 (paragraph A.1.1.1.51) and Tier 1 (paragraph A.1.1.1.83), which shows evidence of decline in the Cardigan Bay SAC.

A.1.1.1.125 The cumulative effects on the designated features and conservation objectives of designated sites located in the vicinity of the Morgan Generation Assets will be considered in the HRA Stage 2 ISAA (Document reference E1.1).

A.1.1.1.126 The impact is predicted to be of regional spatial extent, medium term duration, intermittent and high reversibility (the impact itself occurs only during piling). It is predicted that the impact will affect the receptor directly. The effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels within hours/days after piling have ceased). The impact could result in some measurable changes to individuals that are disturbed (i.e. interruption of feeding or breeding and/or displacement to alternative areas). With the exception of the bottlenose dolphin Irish Sea MU, there are no long-term population-level consequences of disturbance anticipated for harbour porpoise, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal.

A.1.1.1.127 Population modelling (iPCoD) was conducted for Tier 1 and Tier 2 projects, Morgan and Morecambe Offshore Wind Farms: Transmission Assets and Morecambe Offshore Wind Farm Generation Assets, combined, for harbour porpoise, bottlenose dolphin, minke whale and grey seal, as per 4.9.2.13 *et seq*. The results of the iPCoD modelling showed for all species modelled that there was no noticeable difference in the iPCoD model outputs with the addition of the Tier 2 projects, compared to Tier 1 projects (see paragraphs A.1.1.1.69, A.1.1.1.83, A.1.1.1.91 and A.1.1.1.100, respectively, for harbour porpoise, bottlenose dolphin, minke whale and grey seal). The results of these models are presented in full, alongside estimates of all population trajectories, in Appendix B (Table B. 19; Table B. 27; Table B. 33; and Table B. 39, respectively). For harbour porpoise, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal the magnitude is considered to be **low**.

A.1.1.1.128 Cumulative piling of Tier 1 plus Tier 2 projects could contribute to a reduction in the IS MU population size for bottlenose dolphin, although it must be noted there was an increase in the difference of only one animal in the iPCoD model with the addition of Tier 2 projects (Morgan and Morecambe Offshore Wind Farms: Transmission Assets and Morecambe Offshore Wind Farm Generation Assets) to the Tier 1 cumulative scenario for Morgan Generation Assets (further described in Appendix B). The median ratio of unimpacted to impacted population size was 1.0000 at six and 25 years following commencement of piling, and the corresponding mean ratio was 0.9749 at six years and 0.9762 at 25 years (Appendix B, Table B. 27) (i.e. a difference of six animals or 2.04% of the IS MU population between the impacted and unimpacted populations at 25 years). Therefore, in the context of a possible declining population, the magnitude is conservatively considered to be **medium** for bottlenose dolphin within the IS MU population.

Sensitivity of receptor

A.1.1.1.129 The sensitivity of marine mammals to disturbance from elevated underwater sound due to piling is as described in Scenario 1, paragraph A.1.1.1.35 *et seq* and is not reiterated here.

A.1.1.1.130 All marine mammals are deemed to have some resilience to behavioural disturbance, high recoverability and international value. The sensitivity of the receptor is therefore, considered to be **medium**.

Significance of effect

A.1.1.1.131 Overall, the magnitude of the impact is deemed to be **low** for harbour porpoise, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal, and **medium** for bottlenose dolphin within the IS MU population. The sensitivity of the receptor is considered to be **medium**.

A.1.1.1.132 The cumulative effects could potentially affect the international value of bottlenose dolphin in the context of the IS MU. The effect on bottlenose dolphin will, therefore, be of **moderate** adverse significance for the bottlenose dolphin IS MU population, which is significant in EIA terms. The applicant will seek to address this potential significant effect on the Irish Sea MU bottlenose dolphin population, via an Underwater sound management strategy (with an Outline underwater sound management strategy submitted as part of the application, Document Reference J13), and is discussed further in paragraphs A.1.1.1.134 to A.1.1.1.137.

A.1.1.1.133 For other species (harbour porpoise, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal, harbour seal), the cumulative effects are unlikely to affect the international value of these species in the context of respective reference populations. The cumulative effect on all marine mammal receptors will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Further mitigation measures

A.1.1.1.134 The cumulative impact assessment of disturbance from elevated underwater sound from piling concludes a significant effect in EIA terms, for bottlenose dolphin only. The cumulative impact assessment of injury from elevated underwater sound from piling concludes no significant effect in EIA terms, for all marine mammal receptors. Whilst the project alone assessment (section 4.9.3) determined there would be no significant effect in EIA terms, the Morgan Generation Assets may contribute to the cumulative impact in the context of the Irish Sea MU and therefore the Applicant has committed to the development of an Underwater sound management strategy (with an Outline underwater sound management strategy submitted as part of the application, Document Reference J13), secured in the deemed marine licences within the draft DCO (Document Reference C1), to reduce the magnitude associated with significant impacts such that there will be no residual significant effect for the project alone.

A.1.1.1.135 As discussed in paragraph A.1.1.1.113, the assessment is based upon the MDSs for other projects presented at application or PEIR stages and therefore does not consider further mitigation for each project, which may be required if a residual significant effect is identified. Therefore, a significant cumulative effect is unlikely.

A.1.1.1.136 The Underwater sound management strategy (with an Outline underwater sound management strategy submitted as part of the application, Document Reference J13) will present a review of relevant mitigation options (such as NAS, temporal and spatial piling restrictions, piling methods, soft start) in order to reduce the magnitude for the project alone, in order to minimise the contribution to any cumulative effect.

A.1.1.1.137 In this case, relevant mitigation options may be applied to reduce the magnitude for bottlenose dolphin. The Underwater sound management strategy (Outline underwater sound management strategy, Document Reference J13) will be developed in consultation with the licensing authority and SNCBs post-consent.

Tier 3

Magnitude

4.15.1.3 The construction of the Morgan Generation Assets, together with construction of Tier 1, Tier 2 and Tier 3 projects (Table 4.50) may lead to cumulative injury and disturbance to marine mammals from underwater sound generated during piling. Tier 3 projects screened into the assessment within the cumulative marine mammal study area are set out in Table 4.52.

A.1.1.1.138 The extended CEA screening area for grey seal (OSPAR Region III) was applied to screen in projects and therefore, of the projects listed in Table 4.52, additional Tier 3 projects included Talisk, Aniar Offshore Array (Floating), Arranmore, Nomadic Offshore Wind, Machair Wind – Hybrid Energy Project, Malin Sea Wind, Haven Offshore Array Wind Farm, and Voyage Offshore Array. However, telemetry data presented in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement suggests connectivity to projects outside of the GSRP is unlikely and there is therefore considered to be no receptor impact pathway.

A.1.1.1.139 As described in paragraph 4.10.1.2 data for Tier 3 projects available at the time of writing is limited. Tier 3 projects were screened in precautionarily based on their location within the CEA screening area, though there is limited/no information on the construction/operation dates or project design with regards to piling. It should be acknowledged that there is a potential for piling activities to be taking place intermittently across the Irish Sea and wider Celtic Sea. As such, although temporal and/or spatial overlap with Tier 3 projects cannot be discounted, at the current time it is not possible to undertake any kind of meaningful assessment. As such the magnitude for Tier 1, Tier 2 and Tier 3 projects combined is concluded to be no different to the magnitude for Tier 1 and Tier 2 projects combined. For harbour porpoise, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal the magnitude is considered to be **low**. For bottlenose dolphin in the context of a possible declining population, the magnitude is conservatively considered to be **medium** within the IS MU population.

Sensitivity of receptor

A.1.1.1.140 The sensitivity of marine mammals to disturbance from elevated underwater sound due to piling is as described in Scenario 1, paragraph A.1.1.1.35 *et seq* and is not reiterated here.

A.1.1.1.141 All marine mammals are deemed to have some resilience to behavioural disturbance, high recoverability and international value. The sensitivity of the receptor is therefore, considered to be **medium**.

Significance of effect

A.1.1.1.142 Overall, the magnitude of the impact is deemed to be **low** for harbour porpoise, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal, and **medium** for bottlenose dolphin within the IS MU population. The sensitivity of the receptor is considered to be **medium**.

A.1.1.1.143 The cumulative effects could potentially affect the international value of bottlenose dolphin in the context of the IS MU. The effect on bottlenose dolphin will, therefore, be of **moderate** adverse significance for the bottlenose dolphin IS MU population, which is significant in EIA terms. The applicant will seek to address this potential significant effect on the Irish Sea MU bottlenose dolphin population as discussed in paragraphs A.1.1.1.134 and A.1.1.1.137.

A.1.1.1.144 For other species (harbour porpoise, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal, harbour seal), the cumulative effects are unlikely to affect the international value of these species in the context of respective reference populations. The cumulative effect on all marine mammal receptors will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

A.1.1.1.145 A summary of the disturbance assessment for underwater sound generated during piling at cumulative projects (Tier 1, Tier 2 and Tier 3) is set out in Table A. 5 below.

Further mitigation measures

A.1.1.1.146 The cumulative impact assessment of disturbance from elevated underwater sound from piling concludes a significant effect in EIA terms, for bottlenose dolphin only. The cumulative impact assessment of injury from elevated underwater sound from piling concludes no significant effect in EIA terms, for all marine mammal receptors. Whilst the project alone assessment (section 4.9.3) determined there would be no significant effect in EIA terms, the Morgan Generation Assets may contribute to the cumulative impact in the context of the Irish Sea MU and therefore the Applicant has committed to the development of an Underwater sound management strategy (with an Outline underwater sound management strategy submitted as part of the application, Document Reference J13), secured in the deemed marine licences within the draft DCO (Document Reference C1), to reduce the magnitude associated with significant impacts such that there will be no residual significant effect for the project alone.

A.1.1.1.147 As discussed in paragraph A.1.1.1.113, the assessment is based upon the MDSs for other projects presented at application or PEIR stages and therefore does not consider further mitigation for each project, which may be required if they have a residual significant effect. Therefore, a significant cumulative effect is unlikely.

A.1.1.1.148 The Underwater sound management strategy (with an Outline underwater sound management strategy submitted as part of the application, Document Reference J13) will present a review of relevant mitigation options (such as NAS, temporal and spatial piling restrictions, piling methods, soft start) in order to reduce the magnitude for the project alone, in order to minimise the contribution to any cumulative effect.

A.1.1.1.149 In this case, relevant mitigation options may be applied to reduce the magnitude for bottlenose dolphin. The Underwater sound management strategy (Outline underwater sound management strategy, Document Reference J13) will be developed in consultation with the licensing authority and SNCBs post-consent.

Table A. 5: Summary of disturbance assessment for underwater sound generated during piling at cumulative projects (Tier 1, Tier 2 and Tier 3 projects).

Species	Magnitude	Sensitivity	Significance	Justification
Harbour porpoise	Low	Medium	Minor adverse	The cumulative effects are unlikely to affect the international value of the species in the context of the CIS MU as there is no long-term decline in the regional population predicted as demonstrated with the cumulative iPCoD modelling assessment.
Bottlenose dolphin	Medium (Irish Sea MU)	Medium	Moderate adverse (Irish Sea MU)	Cumulative effects could potentially affect the international value of the species in the context of the Irish Sea MU.
Risso's dolphin, short-beaked common dolphin	Low	Medium	Minor adverse	The cumulative effects are unlikely to affect the international value of short-beaked common dolphin or Risso's dolphin in the context of the CGNS MU.
Minke whale	Low	Medium	Minor adverse	The cumulative effects are unlikely to affect the international value of the species in the context of the CGNS MU as there is no long-term decline in the regional population predicted as demonstrated with the iPCoD modelling assessment.
Grey seal	Low	Medium	Minor adverse	The cumulative effects are unlikely to affect the international value of the species in the context of

Species	Magnitude	Sensitivity	Significance	Justification
				the GSRP/OSPAR Region III reference population as there is no long-term decline in the regional population predicted as demonstrated with the cumulative iPCoD modelling assessment.
Harbour seal	Low	Medium	Minor adverse	The cumulative effects are unlikely to affect the international value of harbour seal in the context of the HSRP.

A.1.1.2 Injury and disturbance from elevated underwater sound during elevated underwater sound during UXO clearance

Scenario 1: Morgan Generation Assets together with the Morgan and Morecambe Offshore Wind Farms: Transmission Assets

Construction phase

Magnitude of impact

A.1.1.2.1 The Morgan and Morecambe Offshore Wind Farms: Transmission Assets PEIR assumed there may be up to 51 UXOs requiring clearance. This number includes all UXO likely to be found within the Morgan Generation Assets (n = 13), and therefore these UXO are assessed as part of both applications. 38 of the UXO requiring clearance at the Morgan and Morecambe Offshore Wind Farms: Transmission Assets are considered additional to the those assumed to require clearance at the Morgan Generation Assets and therefore an assessment of the cumulative impact of both projects is presented.

A.1.1.2.2 Although the PEIR presents a range of impacts for low order clearance as well as low-yield donor charges, the assessment is based on the high order clearance of the maximum 907 kg. An explosive mass of 907 kg (high order explosion) yielded the largest PTS ranges for all species, with the greatest injury range (15,370 m) seen for harbour porpoise (Table A. 6). With primary measures in place the assessment found that there would be a residual risk of injury over a range of 2,290 m that would require additional tertiary measures and therefore the Morgan and Morecambe Offshore Wind Farms: Transmission Assets will be adopting standard industry practice (JNCC, 2010b) tertiary measures as part of an MMMP, discussed and agreed with consultees post-consent. Behavioural disturbance (using TTS-onset as a proxy) could affect harbour porpoise and minke whale across the largest ranges of up to 28.23 km (SPL_{pk} metric) and 34.36 km (SEL_{cum} metric), respectively (Table A. 6). Construction is expected from 2026 to 2029 and therefore there may be three years of overlap with Morgan Generation Assets, though the exact dates are uncertain at this stage. Impacts including PTS and disturbance are similar to those identified for Morgan Generation Assets and given the overlap of the two projects, there is potential for cumulative effects to occur with Morgan and Morecambe Offshore Wind Farms: Transmission Assets.

A.1.1.2.3 The number of animals predicted to experience PTS as a result of high-order detonation at the Morgan and Morecambe Offshore Wind Farms: Transmission Assets, based on the SPL_{pk} metric is 416 harbour porpoise, less than one individual for dolphin species and harbour seal, and 6 grey seal (Table A. 6). Based on the SEL_{cum} metric, less than one minke whale is predicted to experience PTS. For TTS, based on high-order clearance of 907 kg, large impact ranges were predicted for minke whale (34.36 km), harbour porpoise (28.23 km), and grey seal and harbour seal (6.47 km; SEL_{cum} metric), with the potential to affect up to 65, 1,411, 14 and less than 1 animal, respectively (Table A. 6). This is based on high-order clearance of the MDS of 907 kg, whereas the Morgan and Morecambe Offshore Wind Farms: Transmission Assets PEIR, in line with the Morgan Generation Assets identified that clearance of UXO with an NEQ of 130 kg is considered the more likely (common) scenario. As such, the numbers presented are expected to be highly precautionary. Proposed mitigation measures for UXO clearance include the application of a UXO-specific MMMP, using low order techniques, where possible, as the primary mitigation measure alongside other measures as may be agreed with Natural England and the MMO (such as including the use of MMObs, PAM and ADDs).

Table A. 6: Number of animals with the potential to experience onset PTS and disturbance (using TTS-onset as a proxy) during high-order UXO clearance at Morgan and Morecambe Offshore Wind Farms: Transmission Assets.

Species	Maximum charge size leading to highest impact (kg)	Metric	Maximum range (m)	Estimated number of animals within impact area
PTS				
Harbour porpoise	907	SPL_{pk}	15,370	416
Bottlenose dolphin, short-beaked common dolphin and Risso's dolphin			890	<1
Minke whale		SEL_{cum}	4,215	<1
Grey seal		SPL_{pk}	3,015	4
Harbour seal				<1
Behavioural disturbance (TTS/moving away response as a proxy)				
Harbour porpoise	907	SPL_{pk}	28,230	1,411
Bottlenose dolphin, short-beaked common dolphin and Risso's dolphin			1,635	<1
Minke whale		SEL_{cum}	34,365	65
Grey seal			6,470	14
Harbour seal				<1

A.1.1.2.4 Adopting a precautionary approach, and assuming application of standard industry measures (such as MMObs, PAM and ADDs) measures, the assessment considered the magnitude of impact for a high order detonation.

PTS

A.1.1.2.5 The magnitude of the cumulative impact is predicted to be of local to regional spatial extent, very short-term duration, intermittent and, although the impact itself is reversible (i.e. elevated underwater sound during the detonation event only), the effect of injury on sensitive receptors is permanent. It is predicted that the impact will affect the receptor directly. In line with UXO guidance, assuming standard industry measures applied for each project, it is anticipated that for most species animals would be deterred from the injury zone and therefore the risk of PTS would be removed. The magnitude is therefore considered to be **negligible** for bottlenose dolphin, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal.

A.1.1.2.6 For harbour porpoise the PTS ranges are large (Table A. 6) and there is considered to be a residual risk of PTS to a small number of individuals, even with the application of standard industry measures therefore the magnitude is considered to be **medium** for harbour porpoise.

Behavioural disturbance (using TTS-onset as a proxy)

A.1.1.2.7 The magnitude of cumulative impact (elevated underwater sound due to UXO clearance) resulting from a high order detonation is predicted to be of regional spatial extent, short-term duration, intermittent and both the impact itself (i.e. elevated underwater sound during the detonation event only) and effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low** for all species.

Sensitivity of receptor

A.1.1.2.8 The sensitivity of marine mammals to PTS from elevated underwater sound due to piling is as described in paragraph 4.9.3.25 for Morgan Generation Assets alone, whilst behavioural disturbance (using TTS-onset as a proxy) is described in paragraph 4.9.3.31.

A.1.1.2.9 For a given marine mammal hearing group, exceedance of the threshold for the onset of PTS may result in a permanent hearing loss which in turn could inhibit ecological functioning, such as communication, foraging, navigation and predator avoidance. The inability to continue with these important activities could eventually lead to a decline in vital rates of an individual, including growth, reproduction and subsequently survival. Depending on the type of detonation and size of UXO, UXO clearance activities may have residual effects in respect to marine mammals and PTS injury.

A.1.1.2.10 Species-specific behavioural responses must also be taken into account. For example, it is likely that harbour porpoise would move away from the area upon hearing vessel sound and thus be further from the UXO source before any detonation has begun. Further mitigation measures such as ADD are designed to emit sound levels that cause marine mammals to move away and thus reduce the potential for a PTS to occur due to UXO clearance.

PTS

A.1.1.2.11 As a result of UXO clearance, all marine mammals are deemed to have limited resilience, low recoverability and international value. The sensitivity of the receptors to PTS is therefore, considered to be **high.**

Behavioural disturbance (using TTS-onset as a proxy)

A.1.1.2.12 As a result of UXO clearance, all marine mammals are deemed to have some resilience, high recoverability and international value. The sensitivity of the receptor to TTS is therefore, considered to be **low.**

Significance of effect

PTS

A.1.1.2.13 with standard industry measures applied, for bottlenose dolphin, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal the magnitude of the cumulative impact is deemed to be **negligible** and the sensitivity of the receptors is considered to be **high**. There is not anticipated to be any effect on the international value of these species. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

A.1.1.2.14 For harbour porpoise, with tertiary mitigation applied, the magnitude of the cumulative impact is deemed to be **medium,** and the sensitivity of the receptors is considered to be **high**. On the basis of high order detonation, there may be some residual effect with a small number of animals potentially exposed to sound levels that could elicit PTS. The cumulative effect will, therefore, be of **moderate adverse** significance, which is significant in EIA terms.

Behavioural disturbance (using TTS-onset as a proxy)

A.1.1.2.15 In terms of TTS, with standard industry measures applied, the magnitude of the cumulative impact for all species is deemed to be **low** and the sensitivity of the receptor is considered to be **low**. There is not anticipated to be any effect on the international value of any marine mammal species. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Further mitigation measures

A.1.1.2.16 The cumulative impact assessment of injury from elevated underwater sound from UXO clearance concludes a significant effect in EIA terms, for harbour porpoise only. The cumulative impact assessment of disturbance from elevated underwater sound from piling concludes no significant effect in EIA terms, for all marine mammal receptors. As the project alone assessment determined there would be a significant effect in EIA terms, the Morgan Generation Assets may contribute to the cumulative impact in the context of the CIS MU, and therefore the Applicant has committed to the development of an Underwater sound management strategy (with an Outline underwater sound management strategy included as part of the application Document Reference J13) secured in the deemed marine licences within the draft DCO (Document Reference C1), to reduce the magnitude of impacts, such that there will be no residual significant effect for the project alone and therefore no contribution to cumulative effects.

A.1.1.2.17 Development of the final Underwater sound management strategy post consent (in consultation with the licensing authority and SNCBs) will present options for relevant mitigation measures (such as NAS, temporal and spatial restrictions, low order clearance methods, soft start) in order to reduce the magnitude for the project alone. Further details on the numbers and type of UXO requiring clearance will be available post consent. In this case, if required, further mitigation measures would be applied to reduce potential underwater sound impacts to a level whereby a non-significant effect for harbour porpoise could be concluded. These mitigation measures would also result in a reduction of potential underwater sound impacts to other marine mammal receptors.

Scenario 2: Morgan Generation Assets together with the Morgan and Morecambe Offshore Wind Farms: Transmission Assets and all other relevant projects

Tier 1

Construction phase

A.1.1.2.18 The construction of the Morgan Generation Assets, together with construction of Tier 1 projects identified in Table 4.50 may lead to injury and/or disturbance to marine mammals during UXO clearance. Tier 1 projects screened into the assessment within the cumulative marine mammal study area include Mona Offshore Wind Project, Awel y Môr Offshore Wind Farm, White Cross Offshore Wind Farm and Project Erebus.

Magnitude of impact

A.1.1.2.19 Based on the Mona Offshore Wind Project maximum spatial scenario, as presented in the Mona Offshore Wind Project Environmental Statement anticipated 22 UXOs requiring clearance. Although the Environmental Statement presents a range of impacts for low order clearance as well as low-yield donor charges, the assessment is based on the high order clearance of the maximum UXO size of 907 kg. An explosive mass of 907 kg (high order explosion) yielded the largest PTS ranges for all species, with the greatest injury range (15,370 m) seen for harbour porpoise. With primary measures in place the assessment found that there would be a residual risk of injury over a range of 2,290 m that would require additional tertiary measures and therefore the Mona Offshore Wind Project will be adopting standard industry practice (JNCC, 2010b) tertiary measures as part of an MMMP, discussed and agreed with consultees post-consent. Behavioural disturbance (using TTS-onset as a proxy) could affect harbour porpoise and minke whale across the largest ranges of up to 28.23 km (SPL_{pk} metric) and 34.36 km (SEL_{cum} metric), respectively.) (Table A. 7). Construction is expected from 2026 to 2029 and therefore there may be three years of overlap with Morgan Generation Assets, though the exact dates are uncertain at this stage. Impacts including PTS and disturbance are similar to those identified for Morgan Generation Assets and given the proximity of the two projects, there is potential for cumulative effects to occur with Mona Offshore Wind Project.

A.1.1.2.20 The number of animals predicted to experience PTS as a result of high-order detonation at the Mona Offshore Wind Project, based on the SPL_{pk} metric is 206 harbour porpoise, less than one individual for dolphin species, 6 grey seal and less than one harbour seal. Based on the SEL_{cum} metric, one minke whale is predicted to experience PTS. For TTS, based on high-order clearance of 907 kg, large impact ranges were predicted for minke whale (34.36 km), harbour porpoise (28.23 km), and grey seal and harbour seal (6.47 km; SEL_{cum} metric), with the potential to affect up to 65, 245, 26 and less than 1 animal, respectively (Table A. 8). This is based on high-order clearance of the MDS of 907 kg NEQ, whereas the Mona Offshore Wind Project Environmental Statement identified that clearance of UXO with an NEQ of 130 kg is considered the more likely (common) scenario. As such, the numbers presented are expected to be highly precautionary. Proposed mitigation measures for UXO clearance include the application of a UXO-specific MMMP, using low order techniques, where possible, as the primary mitigation measure alongside other measures as may be agreed with Natural England and the MMO (such as including the use of MMObs, PAM and ADDs).

A.1.1.2.21 Awel y Môr Offshore Wind Farm is located 46.8 km from the Morgan Array Area. The MDS for Awel y Môr Offshore Wind Farm anticipated 10 UXOs requiring clearance, with two clearance events every 24 hours but up to 10 detonations in 10 days. The assessed clearance method was high-order detonation, though low-order is more likely. The Environmental Statement for Awel y Môr Offshore Wind Farm assessed both PTS and behavioural disturbance as a result of UXO clearance. Awel y Môr used both the EDR approach and TTS-onset thresholds for assessing disturbance, basing the use of the TTS onset threshold on Southall *et al*. (2007) which states *'in the absence of empirical data on responses, the use of the TTS onset threshold may be appropriate for single pulses*'. TTS-onset thresholds were taken as those proposed for different functional hearing groups by Southall *et al.* (2019).

A.1.1.2.22 However, the Awel y Môr Offshore Wind Farm Environmental Statement does highlight that there is a lack of empirical evidence from UXO detonations using the TTS metric, in particular the range-dependent characteristics of the peak sounds, and consequently challenges whether current propagation models can accurately predict the range at which these thresholds are reached (RWE, 2023). An estimation of the source level and predicted PTS ranges were modelled for a range of expected UXO sizes (5 kg TNT NEQ, 15 kg TNT NEQ and 164 kg TNT NEQ). The source level of each UXO charge weight was calculated in accordance with Soloway and Dahl (2014), Arons (1954) and Barett (1996), using conservative calculation parameters that result in the upper estimate of the source level for each charge size.

A.1.1.2.23 The charge sizes modelled for the Awel y Môr assessment are lower than the maximum modelled for Morgan Generation Assets, and injury ranges are smaller. For the most sensitive species (harbour porpoise) Awel y Môr Offshore Wind Farm assessed the effects using two densities (JCP 0.13 per km^2 and SWF 1.0 per km^2), and the maximum number of animals estimated within the ZoI presented was considered to be highly conservative. PTS is a permanent change in hearing threshold and is not recoverable, but the magnitude of this impact was considered to be negligible adverse in the EIA, due to the commitment to implement a UXO-specific MMMP to reduce the risk of PTS to negligible. Maximum injury ranges from UXO and numbers of animals predicted to be injured as a result of underwater sound from UXO clearance for Tier 1 projects including Awel y Môr Offshore Wind Farm is presented in Table A. 7 and Table A. 8. The exact mitigation measures contained with the UXO-specific MMMP for Awel y Môr Offshore Wind Farm are yet to be determined and agreed with NRW. Residual impacts for PTS from UXO were therefore considered unlikely for harbour porpoise, minke whale, grey seal and minor adverse significance for bottlenose dolphin, short-beaked common dolphin and Risso's dolphin (RWE, 2022).

A.1.1.2.24 In the absence of agreed thresholds to assess the potential for behavioural disturbance in marine mammals from UXO detonations, the Awel y Môr assessment presented results for various disturbance thresholds, including 26 km EDR for high order detonations, 5 km EDR for low order and TTS-onset thresholds for high-order detonations. JNCC advised that an EDR of 26 km around the source location should be used to determine the ensonified area from UXO clearance with respect to disturbance of harbour porpoise in SACs, but this is applied for all species and should be viewed with caution as there is a lack of evidence to support this range (as per latest guidance (JNCC, Natural England, DAERA, 2020)). As such Awel y Môr suggested limited confidence for using this approach. Furthermore, Awel y Môr suggested that there is no evidence of a 5 km EDR being suitable for any species of marine mammal for the low order detonation, and therefore should be treated with caution. As such Awel y Môr used TTS-onset as a proxy for disturbance but caveated that this is likely to over-estimate true behavioural responses due to UXO comprising a single pulse source sound and not lasting a full diel cycle. Large disturbance (using TTS-onset as a proxy) ranges were predicted for harbour porpoise (16 km using SPL_{pk}) and minke whale (65 km using SEL_{cum}) for a UXO charge size of 164 kg. As highlighted in the Awel y Môr Environmental Statement, these ranges may be highly over-precautionary as these do not account for an impulsive sound losing impulsive characteristics and becoming non-impulsive as it propagates from the source (RWE, 2023). Based on the predicted disturbance ranges and numbers of animals affected Awel y Môr concluded that the magnitude of the effects of behavioural disturbance (using TTS-onset as a proxy) would be low for all species (Table A. 8).

A.1.1.2.25 White Cross Offshore Wind Farm is located 319.6 km from the Morgan Array Area. The number of UXO requiring clearance and duration of UXO clearance operations at White Cross Offshore Wind Farm was unknown at the time of publication of the Environmental Statement. A UXO Risk Assessment identified different types of UX that may pose a threat to the study site, with a range NEQs (ranging from 0.06 kg to 309.4 kg). The assessed clearance method modelled was high-order detonation (up to 309 kg NEQ) and low-order clearance (2 kg). The Environmental Statement for White Cross Offshore Wind Farm assessed PTS and TTS/ fleeing response as a proxy for behavioural disturbance, as well as applying a 26 km EDR for harbour porpoise, based on current SNCB guidance.

A.1.1.2.26 The charge sizes modelled for the White Cross Offshore Wind Farm assessment are lower than the maximum modelled for Morgan Generation Assets, and injury ranges are smaller. With the implementation of an MMMP the significance of effect for all species was considered to be minor adverse for all species for PTS from high-order and low-order detonation. For TTS (and behavioural disturbance), from high-order detonation the significance of effect for harbour porpoise, minke whale and grey seal was considered to be minor adverse, and for HF species was considered to be negligible. For TTS (and behavioural disturbance) from low-order detonation the significance of effect for harbour porpoise was considered to be minor adverse, and for all other species was considered to be negligible. Maximum PTS ranges from UXO and numbers of animals predicted to be injured as a result of underwater sound from UXO clearance for Tier 1 projects including White Cross Offshore Wind Farm is presented in Table A. 7, and for TTS is presented in Table A. 8. The numbers presented for harbour porpoise are based on the higher APEM summer density estimate, and for short-beaked common dolphin are based on the higher APEM winter density estimate.

A.1.1.2.27 The number of animals predicted to experience PTS as a result of high-order detonation is 349 harbour porpoise, less than one bottlenose dolphin and up to two individuals for both minke whale and grey seal. For low-order detonation up to 11 harbour porpoise, and less than one individual for all other species, were predicted to experience PTS. For TTS, large impact ranges were predicted for minke whale, at 85 km and grey seal at 16 km, with the potential to affect up to 255 and 96 individuals, respectively. For harbour porpoise, for a 20 km disturbance range, up to 1,154 individuals were predicted to be disturbed (see Table A. 8). This is based on high-order detonation of the largest UXO size of 309 kg NEQ, whereas the White Cross Offshore Wind Farm Environmental Statement identified that UXO likely to be found in the site would range from 0.06 kg to 309.4 kg. Proposed mitigation measures for UXO clearance include the use of low-order clearance techniques, such as deflagration; high order clearance would only be undertaken in the event that all other options are not possible, following the identified hierarchy. As such, the numbers presented are expected to be highly precautionary.

A.1.1.2.28 Project Erebus anticipated one UXO detonation via low-order deflagration but included assessment for high-order detonations for completeness, highlighting this was not deemed realistic as ‘the Project intends to employ deflagration (low-order) as the clearance method’ (Blue Gem Wind, 2020). For PTS, Southall *et al.* (2019) was used to assess impacts. Project Erebus assessed the number of harbour porpoise predicted to be affected by injury or disturbance based on densities from site-specific surveys (0.04 animals per km^2). Bottlenose dolphin was based on 0.063 animals per km^2 presented by Lohrengel *et al*. (2018), minke whale was based on SCANS-III block D (Hammond *et al.,* 2021) and grey seal was based on habitat preference map grid cells from Carter *et al.* (2022).

A.1.1.2.29 The number of marine mammals expected to experience PTS-onset as a result of low-order detonation was <1 for all species and charge sizes, apart from 0.5 kg and 2 kg NEQ, which could result in PTS in up to two and five harbour porpoises, respectively. For high-order detonation, which is not in the project design for Project Erebus, up to 212 harbour porpoises could be affected by PTS (Table A. 7). The Environmental Statement for Project Erebus highlighted that for UXO clearance there are no dose-response functions available that describe the magnitude and transient nature of the behavioural effect of UXO detonation on marine mammals and no guidance on thresholds to be used to assess disturbance, therefore they used an EDR of 5 km for low order clearance and 26 km for high-order clearance. Project Erebus also used TTS-onset as a proxy for disturbance, and the maximum predicted disturbance range is 103 km for minke whale. It has been suggested in the Erebus Environmental Statement that TTS-onset as a proxy for disturbance is expected to over-estimate the actual biological consequences (Blue Gem Wind, 2020). This is supported by Southall *et al.* (2007) which 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*”. For disturbance (assessed using TTS-onset as a proxy) from either low-order or high-order UXO detonation, Project Erebus concluded that the impact was unlikely to significantly affect marine mammal receptors (Blue Gem Wind, 2020).

A.1.1.2.30 A spatial MDS would occur where UXO clearance activities coincide at the respective projects considered in the CEA. This is, however, highly unlikely, as due to safety reasons UXO clearance activities would take place before other construction activities commence. Sequential UXO clearance is therefore more likely for Tier 1 projects noting, however, that there may be some overlap in pre-construction activities of Mona Offshore Wind Project and Awel y Môr Offshore Wind Farm with Morgan Generation Assets, based on indicative construction timelines (Table 4.51). These timelines are, however, indicative and subject to change. UXO clearance at each of these projects will occur as a discrete stage within the overall construction phase and therefore will not coincide continuously over the duration of temporal overlap. Furthermore, each clearance event results in a very short duration of sound emission (seconds) (as mentioned in paragraph 4.9.3.4) and therefore the impact will be short in duration and unlikely to overlap. Construction of Project Erebus is likely to be completed the year before the commencement of construction activities at Morgan Generation Assets and therefore is not likely to overlap with associated UXO clearance. Given the project design for use of low-order UXO clearance techniques only for Project Erebus, cumulative impacts are considered unlikely.

A.1.1.2.31 The assessments provided in the Environmental Statements for the Awel y Môr Offshore Wind Farm, White Cross Offshore Wind Farm and Project Erebus did not consider effects on harbour seal, as this was not included as a key species in these assessments. Therefore, cumulatively, harbour seal has only been considered for Morgan Generation Assets alongside Mona Offshore Wind Project.

A.1.1.2.32 The maximum cumulative number of animals potentially affected by PTS (harbour porpoise) in the regional marine mammal study area is 1,194 animals, however this is using modelled high-order UXO clearance for Project Erebus which is very unlikely to occur in practice (the maximum UXO charge weight expected in the area is 331 kg, and the project is seeking consent for one low-order detonation with a maximum of 2 kg NEQ) and based upon high-order clearance for Mona Offshore Wind Project. Therefore, with measures applied at cumulative projects (i.e. use of low order clearance only for Project Erebus and MMMP for Awel y Môr) the residual risk of injury is likely to be very small.

Table A. 7: Maximum number of animals with the potential to experience PTS during high-order UXO clearance at cumulative Tier 1 projects.

Project	Species	Maximum charge size (kg)	Metric	Maximum PTS range (m)	Estimated number within PTS range	Mitigation included in EIA
Morgan Generation Assets	Harbour porpoise	907	SPL_{pk}	15,370	195	Measures adopted (Table 4.17) (including Outline MMMP (Document Reference J17) and Outline Underwater sound management strategy (Document Reference J13).
	Bottlenose dolphin, short-beaked common dolphin and Risso's dolphin			890	<1	
	Minke whale		SEL_{cum}	4,215	1	
	Grey seal		SPL_{pk}	3,015	2	
	Harbour seal			3,015	<1	
Mona Offshore Wind Project	Harbour porpoise	907	SPL_{pk}	15,370	206	MMMP and UWSMS.
	Bottlenose dolphin, short-beaked common dolphin and Risso's dolphin			890	<1	
	Minke whale		SEL_{cum}	4,215	1	
	Grey seal		SPL_{pk}	3,015	6	
	Harbour seal			3,015	<1	
Awel y Môr Offshore Wind Farm	Harbour porpoise	164	SPL_{pk}	8,600	232	UXO-specific MMMP
	Bottlenose dolphin, short-beaked common dolphin and Risso's dolphin			500	<1	
	Minke whale		SEL_{cum}	5,400	2	
	Grey seal		SPL_{pk}	1,600	3	
White Cross Offshore	Harbour porpoise	309	SPL_{pk}	11,000	349	MMMP (including low-
	Bottlenose dolphin			610	< 1	

Project	Species	Maximum charge size (kg)	Metric	Maximum PTS range (m)	Estimated number within PTS range	Mitigation included in EIA
Wind Farm	Short-beaked common dolphin			610	7	order detonation and ADD)
	Minke whale			7,400	2	
	Grey seal			2,000	2	
Project Erebus	Harbour porpoise	525	SPLpk	13,000	212	Low-order deflagration
	Bottlenose dolphin, short-beaked common dolphin and Risso's dolphin			730	3 (short-beaked common dolphin) <1 (bottlenose dolphin)	
	Minke whale		SELcum	9,500	3	
	Grey seal		SPLpk	2,500	1	

A.1.1.2.33 Production of underwater sound during detonation of UXOs as a part of Tier 1 projects as well as the Morgan Generation Assets have the potential to cause behavioural disturbance (using TTS-onset as a proxy) in marine mammal receptors, however, this effect will be short-lived and reversible. Since behavioural disturbance is a recoverable and the duration of impact will be very short, the potential for cumulative impact is considered to be limited, even for multiple Tier 1 projects within the regional marine mammal study area (Table A. 8). It is assumed whilst some ecological functions could be inhibited in the short-term due to behavioural disturbance (e.g. cessation of feeding), these are reversible on recovery of the animal's hearing and therefore not considered likely to lead to any long-term effects on the individual.

Table A. 8: Maximum number of animals with the potential to experience behavioural disturbance (using TTS-onset as a proxy) during high-order UXO clearance at cumulative Tier 1 projects.

Project	Species	Maximum charge size (kg)	Metric	Maximum range (m)	Estimated number within the range
Morgan Generation Assets	Harbour porpoise	907	SPLpk	28,230	661
	Bottlenose dolphin, short-beaked common dolphin and Risso's dolphin			1,635	<1
	Minke whale		SELcum	34,365	65
	Grey seal		SPLpk	6,470	6
	Harbour seal		SPLpk	6,470	<1
	Harbour porpoise	907	SPLpk	28,230	245

Project	Species	Maximum charge size (kg)	Metric	Maximum range (m)	Estimated number within the range
Mona Offshore Wind Project	Bottlenose dolphin, short-beaked common dolphin and Risso's dolphin			1,635	<1
	Minke whale		SEL_{cum}	34,365	65
	Grey seal		SEL_{cum}	6,470	26
	Harbour seal		SEL_{cum}	6,470	<1
Awel y Môr Offshore Wind Farm	Harbour porpoise	164	SPL_{pk}	16,000	804
	Bottlenose dolphin, short-beaked common dolphin and Risso's dolphin			920	<1
	Minke whale		SEL_{cum}	64,000	226
	Grey seal		SPL_{pk}	310	13
White Cross Offshore Wind Farm	Harbour porpoise	309	SPL_{pk}	20,000	1,154
	Bottlenose dolphin			1,100	<1
	Short-beaked common dolphin			1,100	20
	Minke whale			85,000	255
	Grey seal			16,000	96
Project Erebus	Harbour porpoise	525	SPL_{pk}	23,000	665
	Bottlenose dolphin, short-beaked common dolphin and Risso's dolphin			1,300	9 (common dolphin) <1 (bottlenose dolphin)
	Minke whale		SEL_{cum}	103,000	373
	Grey seal			20,000	52

A.1.1.2.34 Adopting a precautionary approach, and assuming application of standard industry measures (such as MMObs, PAM and ADDs), the assessment considered the magnitude of impact for a high order detonation.

PTS

A.1.1.2.35 The magnitude of cumulative impact (elevated underwater sound due to UXO clearance) is predicted to be of local to regional spatial extent, very short-term duration, intermittent and, although the impact itself is reversible (i.e. during the detonation event only), the effect of injury on sensitive receptors (PTS) is permanent. It is predicted that the impact will affect the receptor directly. In line with UXO guidance, assuming standard industry measures applied for each project, it is anticipated that for most species animals would be deterred from the injury zone and therefore the risk of PTS would be reduced. The magnitude is therefore considered to be **negligible** (for bottlenose dolphin, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal). For harbour porpoise the injury ranges are large (Table A. 7) and there is considered to be a residual risk of PTS to a small number of individuals, even with the application of standard industry measures. The magnitude is therefore considered to be **medium** for harbour porpoise.

Behavioural disturbance (using TTS-onset as a proxy)

A.1.1.2.36 The magnitude of cumulative impact (elevated underwater sound due to UXO clearance) resulting from a high order detonation is predicted to be of regional spatial extent, short-term duration, intermittent and both the impact itself (i.e. during the detonation event) and effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low** for all species.

Sensitivity of receptor

A.1.1.2.37 The sensitivity of marine mammals to UXO clearance was as described in paragraph A.1.1.2.8.

PTS

A.1.1.2.38 As a result of UXO clearance, all marine mammals are deemed to be of limited tolerance, low recoverability and international value. The sensitivity of the receptors to PTS is therefore, considered to be **high.**

Behavioural disturbance (using TTS-onset as a proxy)

A.1.1.2.39 As a result of UXO clearance, all marine mammals are deemed to be of some tolerance, high recoverability and international value. The sensitivity of the receptor to TTS is therefore, considered to be **low.**

Significance of effect

PTS

A.1.1.2.40 With tertiary mitigation applied, for bottlenose dolphin, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal, the magnitude of the cumulative impact is deemed to be **negligible**, and the sensitivity of the receptors is considered to be **high**. There is not anticipated to be any effect on the international value of these species. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

A.1.1.2.41 For harbour porpoise, with tertiary mitigation applied, the magnitude of the cumulative impact is deemed to be **medium,** and the sensitivity of the receptors is considered to be **high**. On the basis of high order detonation, there may be some residual effect with a small number of animals potentially exposed to sound levels that could elicit PTS. The cumulative effect will, therefore, be of **moderate adverse** significance, which is significant in EIA terms. As discussed in A.1.1.2.16, mitigation measures will be adopted via the Outline MMMP (Document Reference J17), an annex to the Outline Underwater sound management strategy (Document Reference J13) to reduce any residual risk of injury to harbour porpoise from Mona Offshore Wind Project.

Behavioural disturbance (using TTS-onset as a proxy)

A.1.1.2.42 With standard industry measures applied, the magnitude of the cumulative impact for all species is deemed to be **low** and the sensitivity of the receptor is considered to be

low. There is not anticipated to be any effect on the international value of any marine mammal species. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Tier 2

A.1.1.2.43 The construction of Morgan Generation Assets, together with construction of Tier 1 and Tier 2 projects identified in Table 4.50 may lead to injury and/or disturbance to marine mammals during UXO clearance. Tier 2 projects screened into the assessment within the regional marine mammal study area include: Codling Wind Park, Inis Ealga Marine Energy Park, Llŷr 2, Llŷr 1, North Celtic Sea Offshore Wind Farm, North Channel Wind 1 and North Channel Wind 2, Project Ilen, Project Valorous, Shelmalere Offshore Wind Farm, Simply Blue Emerald and Morgan and Morecambe Offshore Wind Farms: Transmission Assets (see paragraph A.1.1.2.1 *et seq* for a full assessment, which is not re-iterated here). As stated in paragraph 4.11.2.2 the cumulative assessment has not considered Morgan Generation Assets alongside both the Morgan and Morecambe Offshore Wind Farms: Transmission Assets and Morecambe Generation Assets on the basis that this would represent duplication.

Construction phase

A.1.1.2.44 Potential effects of underwater sound from UXO detonations on marine mammals include mortality, physical injury or auditory injury. The risk of injury in terms of PTS to marine mammal receptors as a result of underwater sound during UXO clearance would be expected to be localised to the vicinity around the boundaries of the respective projects. The potential for a residual risk of injury was investigated based on assuming high-order UXO clearance technique. As previously presented for the Morgan Generation Assets alone in paragraph 4.9.3.4, the duration of impact for each UXO detonation is very short (seconds) and therefore behavioural effects are considered to be negligible in this context. However, behavioural disturbance is presented in this section using TTS-onset as a proxy.

Magnitude of impact

A.1.1.2.45 Projects screened in for this cumulative assessment are expected to involve similar construction activities to those described for the Morgan Generation Assets alone, including UXO clearance activities. It is anticipated that, for all projects, impacts associated with this activity will require additional assessment under EPS licensing or marine licenses, however such applications are not yet available in the public domain.

A.1.1.2.46 For Tier 2 projects, except Morgan and Morecambe Offshore Wind Farms: Transmission Assets (which is assessed in Scenario 1), beyond the EIA Scoping Report there was not sufficient information to conduct a quantitative assessment. The EIA Scoping Reports do not provide detailed information about the impact of sound from UXO clearance. These projects are likely to have effects similar to the Morgan Generation Assets and will likely have similar mitigation (e.g. MMMPs or separate marine licenses) to avoid injury; but at this stage a more detailed assessment cannot be presented. Dublin Array Offshore Wind Farm, North Irish Sea Array Offshore Wind Farm, Oriel Offshore Wind Farm and Arklow Bank Wind Park Phase 2 scoped out UXO in their respective scoping reports.

A.1.1.2.47 The EIA Scoping Report for Inis Ealga Marine Energy Park proposed that UXO is scoped into the EIA, and the assessment of potential underwater sound produced by UXO detonation will be based upon a range of potential charge weights (until detailed data on the UXOs detected on site becomes available) (REF). Construction is planned in 2028, therefore it is unlikely there will be overlap in UXO clearance with the Morgan

Generation Assets as it will be carried out after the Morgan Generation Assets construction period. This, in combination with the distance from the Morgan Generation Assets (approximately 327 km; Table 4.50) means that minimal spatial overlap in UXO PTS and behavioural disturbance ranges and limited potential for cumulative effects are unlikely.

A.1.1.2.48 The Llŷr Projects (Llŷr 1/Llŷr 2) EIA Scoping Report confirms UXO surveys will be undertaken before construction and suggested the potential for UXO clearance will be high due to the proximity of the inshore part of the study area to Castlemartin Range (REF). The Llŷr 1 and Llŷr 2 construction period is planned from 2024 to 2025 and therefore it is unlikely there will be overlap in UXO clearance with the Morgan Generation Assets. This, in combination with the distance from the Morgan Generation Assets (approximately 295 km and 298.5 km; Table 4.50) mean minimal spatial overlap in UXO PTS and behavioural disturbance ranges, and limited potential for cumulative effects.

A.1.1.2.49 The North Celtic Sea Offshore Wind Farm EIA Scoping Report assumes that UXO clearance may result in injury and/or disturbance to marine mammals from underwater sound (North Celtic Sea Wind Limited, 2023). However, the timeline for the construction phase of the North Celtic Sea Offshore Wind Farm is unknown and therefore the temporal overlap with the Morgan Generation Assets UXO clearance is not possible to assess. However, given that the North Celtic Sea Offshore Wind Farm will be located approximately 277 km (Table 4.50) from the Morgan Generation Assets, the spatial overlap of sound contours and therefore cumulative impacts are unlikely.

A.1.1.2.50 Injury and disturbance due to UXO clearance has also been scoped in for further consideration as a potential impact to marine mammals in North Channel Wind 1 and 2 Projects EIA Scoping Report (North Channel Wind Limited, 2023). The use of low order clearance techniques (deflagration) was acknowledged as preferred approach and the project committed to appropriate mitigation measures, e.g., ADDs and soft starts (North Channel Wind Limited, 2023). The construction of North Channel Wind 1 and 2 Projects is planned to take place in 2029 and since UXO clearance is assumed to take place at the onset of the construction phase (commencing in 2026 at Morgan Generation Assets), temporal overlap and therefore cumulative impacts are unlikely.

A.1.1.2.51 The Project Ilen EIA Scoping Report identified that underwater sound due to clearance of UXO detonation may have detrimental effects on marine mammals, including physical or auditory injury as well as short-term behavioural effects (Western Star Wind Ltd, 2023). The use of low order clearance techniques (deflagration) was acknowledged as preferred approach and the project committed to appropriate mitigation measures, e.g. ADDs and soft starts. However, as for Simply Blue Emerald, the timeline for the construction phase of the Project Ilen is unknown and therefore the temporal overlap with the Morgan Generation Assets UXO clearance is not possible to assess. However, considering that Project Ilen is located to the west of Ireland and approximately 393.7 km (Table 4.50) from the Morgan Generation Assets, spatial overlap of sound contours and therefore cumulative impacts are unlikely.

A.1.1.2.52 The Project Valorous EIA Scoping Report assumes that given the proximity to the Castlemartin firing range, there is potential for UXOs to be present in the area and that their controlled detonation can cause injury to marine mammals (Blue Gem Wind, 2020). Though it is not certain that UXOs will be discovered at the scoping stage, the impact has been scoped in due to its potential severity (Blue Gen Wind, 2020). It has been acknowledged that Project Valorous would follow best practice measures to limit the impacts of underwater sound on sensitive receptors, such as adhering to the JNCC's guidelines on mitigation measures UXO detonation (JNCC, 2010b). The construction of Project Valorous is planned to take place in 2029 and since the UXO clearance usually takes place at the beginning of its construction phase (commencing in 2026 at Morgan Generation Assets), the temporal overlap and therefore cumulative impacts are unlikely.

A.1.1.2.53 The EIA Scoping Report for Shelmalere Offshore Wind Farm concluded that a detailed UXO survey would be undertaken post-consent, ahead of construction activities (planned for 2023), and therefore UXO clearance activities will not overlap with the Morgan Generation Assets. No further information on UXO clearance method was given. Construction activities are planned from 2028, therefore it is unlikely there will be overlap in UXO clearance with the Morgan Generation Assets. This, in combination with the distance from the Morgan Generation Assets (approximately 201.4 km; Table 4.50) means minimal spatial overlap in UXO PTS and behavioural disturbance ranges and limited potential for cumulative effects.

A.1.1.2.54 The Simply Blue Emerald EIA Scoping Report assumes that if UXO clearance will be required, disposal could be a significant source of underwater sound depending on the selected disposal methods and this impact has been scoped in for further consideration in the EIA process (Emerald Floating Wind, 2023). The EIA Scoping Report anticipated that a number of mitigation measures could be applied, including methods to reduce underwater sound from the project, such as the use of low order detonation for UXO disposal. Nevertheless, the timeline for the construction phase of the Simply Blue Emerald project is unknown and therefore temporal overlap with the Morgan Generation Assets UXO clearance is not possible to assess. However, considering that Simply Blue Emerald will be located approximately 359.2 km (Table 4.50) from the Morgan Generation Assets, spatial overlap of sound contours and therefore cumulative impacts are unlikely.

A.1.1.2.55 Codling Wind Park EIA Scoping Report does not explicitly scope in sound from UXO clearance but does identify that an MMMP will be considered for any potential UXO clearance work (REF) The construction phase is planned to be complete by 2027 and therefore some temporal overlap with Morgan Generation Assets construction is possible. Despite the lack of information, the smaller proposed extent (fewer UXOs within the area) and location to the east of Ireland (approximately 141.2 km from the Morgan Generation Assets) means there is limited potential for spatial overlap of sound contours and therefore cumulative effects with Codling Wind Park.

A.1.1.2.56 Adopting a precautionary approach, and assuming application of standard industry measures (such as MMObs, PAM and ADDs) measures, the assessment considered the magnitude of impact for a high order detonation.

PTS

A.1.1.2.57 The magnitude of the cumulative impact is predicted to be of local to regional spatial extent, very short-term duration, intermittent and, although the impact itself is reversible (i.e. elevated underwater sound during the detonation event only), the effect of injury on sensitive receptors is permanent. It is predicted that the impact will affect the receptor directly. In line with UXO guidance, assuming standard industry measures applied for each project, it is anticipated that for most species animals would be deterred from respective injury zones and therefore the risk of PTS would be reduced. The magnitude is therefore considered to be **negligible** (for bottlenose dolphin, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal).

A.1.1.2.58 For harbour porpoise, for Tier 1 and Tier 2 projects, the PTS ranges are large (Table A. 7 and Table A. 6, respectively) and there is considered to be a residual risk of PTS to a small number of individuals. Whilst PTS ranges have not been presented for other Tier 2 projects, these are expected to be of a similar magnitude for VHF species. The magnitude is therefore considered to be **medium** for harbour porpoise.

Behavioural disturbance (using TTS-onset as a proxy),

A.1.1.2.59 The magnitude of the cumulative impact is predicted to be of regional spatial extent, short-term duration, intermittent and both the impact itself (i.e. elevated underwater sound during the detonation event only) and the effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low** for all species.

Sensitivity of receptor

A.1.1.2.60 The sensitivity of marine mammals to UXO clearance was as described in paragraph A.1.1.2.8.

PTS

A.1.1.2.61 In terms of PTS as a result of UXO clearance, all marine mammals are deemed to be of limited tolerance, low recoverability and international value. The sensitivity of the receptors to PTS is therefore, considered to be **high.**

Behavioural disturbance (using TTS-onset as a proxy)

A.1.1.2.62 In terms of TTS as a result of UXO clearance, all marine mammals are deemed to be of some tolerance, high recoverability and international value. The sensitivity of the receptor to TTS is therefore, considered to be **low.**

Significance of effect

PTS

A.1.1.2.63 With standard industry measures applied, for bottlenose dolphin, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal the magnitude of the cumulative impact is deemed to be **negligible** and the sensitivity of the receptors is considered to be **high**. There is not anticipated to be any effect on the international value of these species. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

A.1.1.2.64 For harbour porpoise, with tertiary mitigation applied, the magnitude of the cumulative impact is deemed to be **medium,** and the sensitivity of the receptors is considered to be **high**. On the basis of high order detonation, there may be some residual effect with a small number of animals potentially exposed to sound levels that could elicit PTS. The cumulative effect will, therefore, be of **moderate adverse** significance, which is significant in EIA terms. As discussed in A.1.1.2.16, mitigation measures will be adopted via the Outline MMMP (Document Reference J17) an annex to the Outline Underwater sound management strategy (Document Reference J13) to reduce any residual risk of injury to harbour porpoise as a result of Morgan Generation Assets.

Behavioural disturbance (using TTS-onset as a proxy)

A.1.1.2.65 In terms of TTS, with standard industry measures applied, the magnitude of the cumulative impact for all species is deemed to be **low** and the sensitivity of the receptor is considered to be **low**. There is not anticipated to be any effect on the international value of any marine mammal species. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Further mitigation measures

A.1.1.2.66 The cumulative impact assessment of injury from elevated underwater sound from UXO clearance concludes a significant effect in EIA terms, for harbour porpoise only. The cumulative impact assessment of disturbance from elevated underwater sound from piling concludes no significant effect in EIA terms, for all marine mammal receptors. As the project alone assessment determined there would be a significant effect in EIA terms, the Morgan Generation Assets may contribute to the cumulative impact in the context of the CIS MU, and therefore the Applicant has committed to the development of an Underwater sound management strategy (with an Outline underwater sound management strategy included as part of the application Document Reference J13) secured in the deemed marine licences within the Draft DCO (Document Reference C1), to reduce the magnitude of impacts, such that there will be no residual significant effect for the project alone and therefore no contribution to cumulative effects..

A.1.1.2.67 Development of the final Underwater sound management strategy post consent (in consultation with the licensing authority and SNCBs) will present options for relevant mitigation measures (such as NAS, temporal and spatial restrictions, low order clearance methods, soft start) in order to reduce the magnitude for the project alone. Further details on the numbers and type of UXO requiring clearance will be available post consent. In this case, if required, further mitigation measures would be applied to reduce potential underwater sound impacts to a level whereby a non-significant effect for harbour porpoise could be concluded. These mitigation measures would also result in a reduction of potential underwater sound impacts to other marine mammal receptors (Document Reference J13).

Tier 3

A.1.1.2.68 The construction of the Morgan Generation Assets, together with construction phase of Tier 1, Tier 2 and Tier 3 projects (Table A. 4) may lead to cumulative injury and disturbance to marine mammals from underwater sound generated during UXO clearance. Tier 3 projects screened into the assessment within the cumulative marine mammal study area are set out in Table 4.52.

Magnitude of impact

A.1.1.2.69 As described in paragraph 4.10.1.2 data for Tier 3 projects available at the time of writing is limited. Tier 3 projects were screened in precautionarily based on their location within the CEA screening area, though there is limited/no information on the construction/operation dates or whether UXO clearance will be considered in respective EIA assessments. It should be acknowledged that there is a potential for UXO clearance activities to be taking place intermittently across the Irish Sea and wider Celtic Sea, however, the impacts are anticipated to be of very short duration (i.e. elevated underwater sound during the detonation event only). As such, although temporal and/or spatial overlap with Tier 3 projects cannot be discounted, at the current time it is not possible to undertake any kind of meaningful assessment. As such the magnitude for Tier 1, Tier 2 and Tier 3 projects combined is concluded to be no different to the magnitude for Tier 1 and Tier 2 projects combined.

A.1.1.2.70 Adopting a precautionary approach, and assuming application of standard industry measures (such as MMObs, PAM and ADDs) measures, the assessment considered the magnitude of impact for a high order detonation.

PTS

A.1.1.2.71 The magnitude of the cumulative impact is predicted to be of local to regional spatial extent, very short-term duration, intermittent and, although the impact itself is reversible (i.e. elevated underwater sound during the detonation event only), the effect of injury on sensitive receptors is permanent. It is predicted that the impact will affect the receptor directly. In line with UXO guidance, assuming standard industry measures applied for each project, it is anticipated that for most species animals would be deterred from respective injury zones and therefore the risk of PTS would be reduced. The magnitude is therefore considered to be **negligible** (for bottlenose dolphin, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal). The magnitude is considered to be **medium** for harbour porpoise.

Behavioural disturbance (using TTS-onset as a proxy),

A.1.1.2.72 The magnitude of the cumulative impact is predicted to be of regional spatial extent, short-term duration, intermittent and both the impact itself (i.e. elevated underwater sound during the detonation event only) and the effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low** for all species.

Sensitivity of receptor

A.1.1.2.73 The sensitivity of marine mammals to UXO clearance was as described in paragraph A.1.1.2.8.

PTS

A.1.1.2.74 In terms of PTS as a result of UXO clearance, all marine mammals are deemed to be of limited tolerance, low recoverability and international value. The sensitivity of the receptors to PTS is therefore, considered to be **high.**

Behavioural disturbance (using TTS-onset as a proxy)

A.1.1.2.75 In terms of TTS as a result of UXO clearance, all marine mammals are deemed to be of some tolerance, high recoverability and international value. The sensitivity of the receptor to TTS is therefore, considered to be **low.**

Significance of effect

PTS

A.1.1.2.76 With standard industry measures applied, for bottlenose dolphin, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal the magnitude of the cumulative impact is deemed to be **negligible** and the sensitivity of the receptors is considered to be **high**. There is not anticipated to be any effect on the international value of these species. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

A.1.1.2.77 For harbour porpoise, with tertiary mitigation applied, the magnitude of the cumulative impact is deemed to be **medium,** and the sensitivity of the receptors is considered to be **high**. On the basis of high order detonation, there may be some residual effect with a small number of animals potentially exposed to sound levels that could elicit PTS. The cumulative effect will, therefore, be of **moderate adverse** significance, which is significant in EIA terms. As discussed in A.1.1.2.16, mitigation measures will be adopted via the Outline MMMP (Document Reference J17) an annex to the Outline Underwater sound management strategy (Document Reference J13) to reduce any residual risk of injury to harbour porpoise as a result of Morgan Generation Assets.

Behavioural disturbance (using TTS-onset as a proxy)

A.1.1.2.78 In terms of TTS, with standard industry measures applied, the magnitude of the cumulative impact for all species is deemed to be **low** and the sensitivity of the receptor is considered to be **low**. There is not anticipated to be any effect on the international value of any marine mammal species. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Further mitigation measures

A.1.1.2.79 The cumulative impact assessment of injury from elevated underwater sound from UXO clearance concludes a significant effect in EIA terms, for harbour porpoise only. The cumulative impact assessment of disturbance from elevated underwater sound from piling concludes no significant effect in EIA terms, for all marine mammal receptors. As the project alone assessment determined there would be a significant effect in EIA terms, the Morgan Generation Assets may contribute to the cumulative impact in the context of the CIS MU, and therefore the Applicant has committed to the development of an Underwater sound management strategy (with an Outline underwater sound management strategy included as part of the application Document Reference J13) secured in the deemed marine licences within the draft DCO (Document Reference C1), to reduce the magnitude of impacts, such that there will be no residual significant effect for the project alone and therefore no contribution to cumulative effects..

A.1.1.2.80 Development of the final Underwater sound management strategy post consent (in consultation with the licensing authority and SNCBs) will present options for relevant mitigation measures (such as NAS, temporal and spatial restrictions, low order clearance methods, soft start) in order to reduce the magnitude for the project alone. Further details on the numbers and type of UXO requiring clearance will be available post consent. In this case, if required, further mitigation measures would be applied to reduce potential underwater sound impacts to a level whereby a non-significant effect for harbour porpoise could be concluded. These mitigation measures would also result in a reduction of potential underwater sound impacts to other marine mammal receptors.

Appendix B: Marine mammal population modelling report

B.1. Introduction

B.1.1 Overview

B.1.1.1.1 An EIA has been carried out to determine the potential effects of the Morgan Generation Assets, on sensitive marine mammal receptors from a range of different impacts. A key impact assessed is the potential for elevations in underwater sound during piling to lead to injury and behavioural/or disturbance to individual marine mammals.

B.1.1.1.2 Underwater sound modelling was undertaken to predict the potential spatial scale of the impact for piling associated with the installation of three foundation types for up to 74 wind turbines (comprising up to 64 jacket foundations and up to 10 GBFs with ground strengthening pin piles) and up to four OSPs, (see Volume 1, Chapter 3: Project description of the Environmental Statement).

B.1.1.1.3 Across the three foundation types (jacket foundations for wind turbines, jacket foundations for OSPs and gravity base foundations (with ground strengthening pin piles) for wind turbines), one pile type – pin piles – has been assessed in the EIA, with two piling scenarios considered across the Morgan Generation Assets (Table 4.16): a single vessel piling four piles sequentially and concurrent piling where two vessels pile at the same time (i.e. up to two piles installed simultaneously). The impact of consecutive piling is expected to occur over the greatest temporal scale, and the impact of concurrent piling is expected to occur over the greatest spatial scale. The piling scenarios are hereafter referred to as the 'maximum temporal scenario' and the 'maximum spatial scenario', respectively. For both scenarios a maximum of 454 pin piles are expected to be installed (section B.2.1.1).

B.1.1.1.4 Population modelling was carried out to determine the potential for a short to medium term exposure to piling, which could occur intermittently within a 24-month piling period, during the four-year offshore construction timeframe (expected to occur between 2026 and 2029, inclusive), to result in long term population level effects on any marine mammal species for which population modelling is possible within the interim Population Consequences of Disturbance (iPCoD) framework.

B.1.1.1.5 The iPCoD model (developed by SMRU with a team of researchers at the University of St Andrews), was adopted to simulate the potential changes in the population over time and is described within this appendix.

B.1.2 Interim Population Consequences of Disturbance modelling

B.1.2.1.1 The iPCoD model simulates the potential changes in a population over time, for both a disturbed and an undisturbed population. This provides a comparison of the type of changes that may result from natural environmental variation, demographic stochasticity (i.e. variability in population growth rates) and anthropogenic disturbance (Harwood *et al*., 2014; King *et al*., 2015). This approach has been used in previous offshore wind applications, and consented projects (e.g. Awel y Môr Offshore Wind Farm (RWE, 2023), Hornsea Four Offshore Wind Project (Ørsted Hornsea Project Four Ltd, 2021) and Hornsea Project Three Offshore Wind Farm (Ørsted Hornsea Project Three Ltd, 2018)).

B.1.2.1.2 The iPCoD model is based on expert elicitation, a widely accepted process in conservation science whereby the opinions of many experts are combined when there is an urgent need for decisions to be made but a lack of empirical data with which to inform them (Donovan et al., 2016). In the case of the iPCoD model, the marine mammal experts (detailed in Sinclair *et al*. 2020) were asked for their opinion on how changes in hearing resulting from PTS and behavioural disturbance (equivalent to a score of 5* or higher on the 'behavioural severity scale' described by Southall *et al*. (2007)) associated with offshore renewable energy developments affect calf and juvenile survival, and the probability of giving birth (Harwood *et al*., 2014). Experts were asked to estimate values for two parameters which determine the shape of the relationships between the number of days of disturbance experienced by an individual and its vital rates, thus providing parameter values for functions that form part of the iPCoD model (Harwood et al., 2014).

B.1.2.1.3 The relationship between disturbance and survival/reproduction assumes that individual animals would have a limited ability to alter their activity budget to compensate for a reduction in, for example, time spent feeding (Houston *et al*., 2012; King *et al*., 2015). The individual's ability to provision/care for young, evade predation or resist disease would likely be affected, and it is expected that effects would be reflected in changes to vital rates. It is important to note, however, that this relationship is highly simplified (Harwood *et al*., 2014), and an individual's response to disturbance will depend on factors including the context of the disturbance, the individual's existing condition and its exposure history (Ellison *et al*. 2011). The iPCoD framework applies simulated changes in vital rates to infer the number of animals that may be affected by disturbance as a means to iteratively project the size of the population.

B.1.2.1.4 Following the initial development of the iPCoD model a study was undertaken to update the transfer functions on the effects of PTS and disturbance on the probability of survival and giving birth to viable young for harbour porpoise, harbour seal and grey seal (again via expert elicitation) (Booth and Heinis, 2018; Booth *et al*., 2019). The iPCoD model has been updated in light of additional work undertaken since it was originally launched in February 2014 (version 1) and iPCoD version 5.2 was used in the modelling for this report (Sinclair *et al*., 2019).

B.1.2.1.5 A potential limitation of the iPCoD model is that no form of density dependence has been incorporated into the model due to the uncertainties as to how to estimate carrying capacity or how to model the mechanism of density dependence. As discussed in Harwood *et al*. (2014), the concept of density dependence is fundamental to understanding how animal populations respond to a reduction in population size. Density-dependent factors, such as resource availability or competition for space, can limit population growth. If the population declines, these factors no longer become limiting and therefore, for the remaining individuals in a population, there is likely to be an increase in survival rate and reproduction. This then allows the population to expand back to previous levels at which density-dependent factors become limiting again (i.e. population remains at carrying capacity).

B.1.2.1.6 The limitations for assuming a simple linear ratio between the maximum net productivity level and carrying capacity have been highlighted by Taylor and DeMaster (1993) as simple models demonstrate that density dependence is likely to involve several biological parameters which themselves have biological limits (e.g. fecundity and survival). For UK populations of harbour porpoise (and other marine mammal species) however, there is no published evidence for density dependence and, therefore, density dependence assumptions are not currently included within the iPCoD protocol.

B.2. Methodology

B.2.1 Piling parameters

B.2.1.1 Maximum design scenario

B.2.1.1.1 The maximum design scenario for piling at the Morgan Generation Assets has been developed on the basis that pile driving operations would be required for the installation of up to 454 piles across:

- up to 48 wind turbine jacket foundations with hammer energy up to 3,000 kJ
- up to 16 wind turbine jacket foundations with hammer energy up to 4,400 kJ
- up to four OSP foundations with hammer energy up to 4,400 kJ
- Ground-strengthening pin piles for up to 10 wind turbine gravity base foundations with hammer energy up to 3,000 kJ.

B.2.1.1.2 The maximum temporal scenario is represented by piling occurring over the greatest number of days, resulting from piling at only one location at a time. Sound introduced into the marine environment over a longer period may increase the risk for disturbance to marine mammals, with potential effects during multiple stages of a species' annual cycle.

B.2.1.1.3 The maximum temporal scenario was assessed on the number of piles that could be installed within one 24-hour period. For pin piles, a maximum of four piles could be installed in a single location, in a single day, equating to 113.5 days for the installation of 454 piles.

B.2.1.1.4 A summary of the maximum temporal scenario for the Morgan Generation Assets is presented in Table B. 1

Table B. 1: Summary of the maximum temporal scenario for piling of offshore foundations at the Morgan Generation Assets.

Structure	Number of piled locations	Number of legs	Piles per leg	Number of piles (up to)	Max hammer energy (kJ)	Max piles per day	Number of vessels	Max piling days
Wind turbine (jacket foundation)	48	4	1	192	3,000	4	1	48
Wind turbine (jacket foundation)	16	4	1	64	4,400	4	1	16
OSP (jacket foundation)	4	4	3	48	4,400	4	1	12
Wind turbine (gravity base foundation)	10	1	15	150	3,000	4	1	37.5
Total	**78**	**-**	**-**	**454**	**-**	**-**	**-**	**113.5**

B.2.1.1.5 For the maximum spatial scenario the largest hammer energy and maximum spacing between concurrent piling events would reduce the time required for piling operations but would lead to the largest spatial extent of ensonification at any one time. Minimum spacing between concurrent piling represents the highest risk of injury to marine mammals as sound from adjacent foundations could combine to produce a greater radius of effect compared to a single piling event.

B.2.1.1.6 Concurrent piling for wind turbine foundations (i.e. at two wind turbines on the same day) with a maximum hammer energy of 3,000 kJ would occur over 24 days. The 26 foundations that will not be piled concurrently (16 jacket foundations piled a maximum hammer energy of 4,400 kJ and ground-strengthening pin piles for up to 10 GBFs installed at a maximum hammer energy of 3,000 kJ) would be installed, one location at a time, over 53.5 days. The maximum duration of piling for the maximum spatial scenario would be 89.5 days.

B.2.1.1.7 A summary of the maximum spatial scenario for the Morgan Generation Assets is presented in Table B. 2.

Table B. 2: Summary of the maximum spatial scenario for piling of offshore foundations at the Morgan Generation Assets.

Structure	Number of piled locations	Number of legs	Piles per leg	Number of piles (up to)	Maximum hammer energy (kJ)	Max piles per day	Number of vessels	Max piling days
Wind turbine (jacket foundation)	48	4	1	192	3,000	4	2	24.0
Wind turbine (jacket foundation)	16	4	1	64	4,400	4	1	16.0
OSP (jacket foundation)	10	4	3	48	4,400	4	1	12.0
Wind turbine (gravity base foundation)	4	1	15	150	3,000	4	1	37.5
Total	**78**	**-**	**-**	**454**	**-**	**-**	**-**	**89.5**

B.2.1.1.8 It is estimated that piling activity at Morgan Generation Assets will take place within a two-year timeframe (2027 and 2028) during the four-year construction phase (see paragraph B.1.1.1.4). Piling could potentially take place at any point within the foundation installation phase, however, for the purposes of developing the piling schedule for iPCoD (a requirement of the model) an indicative programme has been developed based on a realistic installation approach with piling spread across the two years, discussed in section B.3.7.

B.3. Model inputs

B.3.1 Key species

B.3.1.1.1 Species for inclusion in iPCoD modelling were determined in consultation with the marine mammal EWG, and were selected on the basis of their distribution, abundance and conservation status within the regional marine mammal study area. These species are:

- Harbour porpoise *Phocoena phocoena*
- Bottlenose dolphin *Tursiops truncatus*
- Minke whale *Balaenoptera acutorostrata*
- Grey seal *Halichoerus grypus*.

B.3.1.1.2 It is also possible for iPCoD to model potential effects of piling upon harbour seal *Phoca vitulina*, however this species does not occur in the region in numbers considered high enough to be at risk of a population-level effect and has therefore not been included for analysis.

B.3.2 Demographic parameters

B.3.2.1.1 The iPCoD model v5.2 (Harwood *et al.*, 2014) was set up using the program R v4.3.0 (R Core Team, 2023) with RStudio v 2023.6.2.561 (Posit team, 2023) as the user interface. To enable the iPCoD model to be run, the following data were provided:

- Demographic parameters for the key species
- User specified input parameters:
  - Vulnerable subpopulations
  - Residual days of disturbance
- Number of animals predicted to experience PTS and/or disturbance during piling
- Estimated piling schedule during the proposed construction programme.

B.3.2.1.2 Demographic parameters for the key species in the population model are presented in Table B. 3, and were chosen from Sinclair *et al*. (2020) and using parameters from sources as recommended by Natural Resources Wales (NRW) following consultation (NRW, *pers. comm.* 21.10.22), with parameters from additional sources to build in a more conservative, precautionary approach. Additionally-sourced parameter values included survival and reproductive rates for harbour porpoise (Murphy *et al*., 2015; 2020), calf survival (Pesante *et al*., 2008; Feingold and Evans, 2012) and fertility rate (Arso Civil *et al*., 2017) for bottlenose dolphin. Parameters adopted in the modelling were discussed and agreed with all relevant stakeholders via the marine mammal expert working group (EWG).

B.3.2.1.3 Whilst the importance of iPCoD modelling is to look at unimpacted versus impacted populations, it must be highlighted that the model is very sensitive to the parameters the user inputs and with small alterations to parameters leading to large changes in population trajectories (e.g. populations increasing or decreasing). For instance, small changes in fertility rates or stage-specific survival rates can change the population trajectories for both unimpacted and impacted populations. In the case of the bottlenose dolphin population modelled here, using a fertility rate parameter of 0.22 (Arso Civil *et al*., 2017), the population appears to decline in the unimpacted scenario (as well as the impacted scenario), however if a higher parameter for fertility rate (0.30: Sinclair *et al*., 2020) is used, the population trajectory is stable.

Table B. 3: Marine mammal management units, population estimates, and vital rates used to parameterise iPCoD models. Note that growth rate is not an input parameter, but is derived as a model output, and is included for information.

[1] Higher fertility rate of 0.30 recommended by NRW for inclusion in modelling (NRW, *pers. comm*. 21.10.22).

[2] Population estimates for GSRP are taken from Sinclair *et al*. (2022), Ireland regions from Duck and Morris (2019) and Isle of Man population from Howe (2018).

Species	Management Unit/ Seal Management Unit	Population estimate	Calf/ pup survival	Juvenile survival	Adult survival	Fertility	Age of independence	Age of first birth	Growth rate
Harbour porpoise	Celtic and Irish Seas (CIS)	62,517	0.60	0.85	0.90	0.50	1	5	0.98
Bottlenose dolphin	Irish Sea (IS)	293	0.87	0.93	0.94	0.22	2	9	0.99
						0.30[1]			1.01
Minke whale	Celtic and Greater North Sea (CGNS)	20,118	0.70	0.77a	0.96a	0.91	1	9	1.00
Grey seal	"Grey Seal Reference population" (GSRP)[2]	12,910	0.22	0.94a	0.94a	0.90	1	9	1.01

B.3.3 Reference populations

B.3.3.1.1 Populations based upon MUs were specified in the iPCoD models as the reference populations against which the effects (i.e. number of animals experiencing disturbance or PTS) were assessed.

B.3.3.1.2 The relevant MUs were determined by their coincidence with the location of the Morgan Generation Assets in the east Irish Sea and were agreed during the Marine Mammals Expert Working Group process (EWG Meeting 02, Table 4.5). Table B. 4 summarises the reference populations used in the iPCoD models.

B.3.3.1.3 The boundaries of the grey seal SMUs only extend to UK waters, but in southwest Britain photo-ID data and recent telemetry studies demonstrate movements of seals not only around the Irish Sea, but also encompassing southwest England, northwest France and Ireland (Vincent *et al*., 2017, Russell *et al*., 2019, Carter *et al*., 2020, Langley *et al*., 2020; Luck *et al*., 2020). Therefore, iPCoD modelling has been undertaken for the four SMUs which cover the Irish Sea (12: Wales, 13: NW England, 14: Northern Ireland, 1: SW Scotland) plus the 'Southeast of Ireland' and 'East of Ireland' survey regions in the Republic of Ireland which border the Irish Sea, and the Isle of Man population. This combined reference population is hereafter referred to as the 'Grey Seal Reference Population' (GSRP).

Table B. 4: Reference populations used in the iPCoD modelling.

Species	Management Unit/ Seal Management Unit	Population estimate	Reference
Harbour porpoise	Celtic and Irish Seas (CIS)	62,517	IAMMWG (2015; 2021)
Bottlenose dolphin	Irish Sea MU (IAMMWG, 2021)	293	SCANS-III estimate from IAMMWG (2021)
Minke whale	Celtic and Greater North Seas MU	20,118	IAMMWG (2021)
Grey seal	Grey Seal Reference Population (GSRP) consisting of four UK SMUs, IoM and RoI estimates:		
	SMU 12: Wales	3,579	Four SMU estimates from SCOS (2021), reported in Sinclair *et al*. (2022).
	SMU 13: NW England	994	
	SMU 14: Northern Ireland	2,008	
	SMU 1: SW Scotland	2,056	
	Isle of Man estimate	400	IoM estimate from Howe (2018)
	East of Ireland	1,662	RoI estimates from Duck and Morris (2019)
	Southeast of Ireland	2,211	
	GSRP total	**12,910**	

B.3.4 Residual days disturbance

B.3.4.1.1 Empirical evidence from the constructed Beatrice and Horns Rev 2 offshore wind farms (Graham *et al*., 2019; Brandt *et al*., 2011) suggests that the detection of animals returns to baseline levels in the hours following a disturbance from piling and therefore, for the most part, it can be assumed that the disturbance occurs only on the day (24 hours) that piling takes place.

B.3.4.1.2 Due to the potential duration of piling occurring at the Morgan Generation Assets (e.g. up to 4.5 hours each for up to four pin piles per day, associated with jacket foundations required for wind turbines and OSPs), piling could occur for up to 18 hours in a 24 hour period. Therefore, the number of residual days of disturbance has, conservatively, been selected as one, meaning that the model assumes that disturbance occurs on the day of piling and persists for a period of 24 hours after piling has ceased.

B.3.5 Years of simulation

B.3.5.1.1 Whilst the operational lifetime of the Morgan Generation Assets is 35 years, technical documentation for the iPCoD model (Sinclair *et al*., 2019) highlights that the predictions of the model become increasingly uncertain as the number of years to be simulated is increased and suggests that values in excess of 25 years are not usually recommended. This iPCoD parameter (‘years’) was therefore set at 25 years in all iPCoD models.

B.3.6 Number of animals (PTS/disturbance)

B.3.6.1.1 The number of animals predicted to experience disturbance or PTS was based on the density values provided as part of the baseline assessment in Volume 4, Annex 4.1: Marine mammal technical report of the Environmental Statement.

B.3.6.1.2 For the assessment of PTS an average density value was applied to the area of effect; calculated from the range out to which the injury threshold would be exceeded for each marine mammal hearing group. Where a range has been used for densities, maximum values were taken forward to the assessment in a conservative approach. For harbour porpoise and bottlenose dolphin, the maximum density is based upon estimates derived from Evans and Waggitt (2023). Minke whale density was estimated from SCANS III surveys of Block E (since no minke whale were identified in the adjacent Block F, which coincides with the location of the Morgan Generation Assets), and for grey seal, the inshore densities derived from Carter *et al*. (2022) maps were used to represent the maximum.

B.3.6.1.3 To estimate the number of animals potentially disturbed, the sound contours were mapped, and a dose response approach applied to calculate the number of animals within each 5 dB isopleth using the density values as described above. For grey seal, however, the quantitative assessment was undertaken by overlaying the unweighted SEL_{ss} contours on at-sea density maps produced by Carter *et al*. (2022). The number of animals in each 5x5 km grid cell was summed for each isopleth and corrected using the proportional response as per Whyte *et al*. (2020).

B.3.6.1.4 For all scenarios, primary mitigation was applied (section 4.8). The piling campaign was developed with the lowest achievable hammer energy, slow initiation phase, followed by a soft start and ramp up to reduce the potential risk of injury (see Volume 3, Annex 3.1: Underwater sound technical report of the Environmental Statement).

B.3.6.1.5 With these primary measures in place, the residual number of individuals potentially affected by PTS was taken forward for the iPCoD model. This is a conservative approach since tertiary mitigation (i.e. application of a marine mammal mitigation protocol (MMMP)) will reduce the risk of PTS further. However, the large injury ranges predicted for some species (section 4.9.1) requires that a conservative approach is taken in parameterising iPCoD models.

B.3.6.1.6 Currently the models for the Morgan Generation Assets alone assume one animal experiencing PTS for minke whale only. Maximum numbers of animals disturbed and injured (PTS) for the maximum temporal scenario is presented in Table B. 5 and maximum numbers of animals disturbed and injured (PTS) for the maximum spatial scenario is presented in Table B. 6.

Table B. 5: Estimated number of animals predicted to be disturbed or injured (PTS) at any one time during piling for the maximum temporal scenario.

Species	Operation	Number of animals disturbed	Number of animals injured (PTS)
Harbour porpoise	Wind turbine (jacket foundation: 3,000 kJ)	713	0
	Wind turbine (jacket foundation: 4,400 kJ)	858	0
	OSP (jacket foundations: 4,400 kJ)	858	0
	Wind turbine (gravity base foundation: 3,000 kJ)	713	0
Bottlenose dolphin	Wind turbine (jacket foundation: 3,000 kJ)	4	0
	Wind turbine (jacket foundation: 4,400 kJ)	4	0
	OSP (jacket foundations: 4,400 kJ)	4	0
	Wind turbine (gravity base foundation: 3,000 kJ)	4	0
Minke whale	Wind turbine (jacket foundation: 3,000 kJ)	48	0
	Wind turbine (jacket foundation: 4,400 kJ)	57	1
	OSP (jacket foundations: 4,400 kJ)	57	1
	Wind turbine (gravity base foundation: 3,000 kJ)	48	0
Grey seal	Wind turbine (jacket foundation: 3,000 kJ)	41	0
	Wind turbine (jacket foundation: 4,400 kJ)	54	0
	OSP (jacket foundations: 4,400 kJ)	54	0
	Wind turbine (gravity base foundation: 3,000 kJ)	41	0

Table B. 6: Estimated number of animals predicted to be disturbed or injured (PTS) at any one time during piling for the maximum spatial scenario.

Species	Operation	Number of animals disturbed	Number of animals injured (PTS)
Harbour porpoise	Wind turbine (jacket foundation: 3,000 kJ, concurrent)	1,007	0
	Wind turbine (jacket foundation: 4,400 kJ)	858	0
	OSP (jacket foundations: 4,400 kJ)	858	0
	Wind turbine (gravity base foundation: 3,000 kJ)	713	0
Bottlenose dolphin	Wind turbine (jacket foundation: 3,000 kJ, concurrent)	5	0

Species	Operation	Number of animals disturbed	Number of animals injured (PTS)
	Wind turbine (jacket foundation: 4,400 kJ)	4	0
	OSP (jacket foundations: 4,400 kJ)	4	0
	Wind turbine (gravity base foundation: 3,000 kJ)	4	0
fMinke whale	Wind turbine (jacket foundation: 3,000 kJ, concurrent)	67	1
	Wind turbine (jacket foundation: 4,400 kJ)	57	1
	OSP (jacket foundations: 4,400 kJ)	57	1
	Wind turbine (gravity base foundation: 3,000 kJ)	48	0
Grey seal	Wind turbine (jacket foundation: 3,000 kJ, concurrent)	61	0
	Wind turbine (jacket foundation: 4,400 kJ)	54	0
	OSP (jacket foundations: 4,400 kJ)	54	0
	Wind turbine (gravity base foundation: 3,000 kJ)	41	0

B.3.7 Piling schedule

B.3.7.1.1 The piling schedule used in the iPCoD modelling was developed from the Project Design Envelope (PDE). This provides an estimate of the maximum number of days of piling required for the foundations of the wind turbines and OSPs, within a defined piling window.

B.3.7.1.2 The piling phase for the Morgan Generation Assets is expected to occur across the 24-month period in years two and three of the four-year construction phase (i.e. in 2027 and 2028).

B.3.7.1.3 For the purposes of developing the piling schedule for iPCoD (a required input for all models) an indicative programme has been developed for each scenario, based on a realistic installation approach, with piling spread across the two years.

B.3.7.1.4 For the maximum temporal scenario, piling was scheduled to occur over the greatest time frame. The 113.5 piling days (Table B. 1) have been rounded up to 114 days for the purposes of modelling, and have been spread as evenly as practicable across the two-year construction period, with an interval of approximately eight days between piling days.

B.3.7.1.5 For the maximum spatial scenario, concurrent piling has been assumed at the 48 wind turbine jacket foundations for which the maximum hammer energy will be 3,000 kJ. Subsequently, all piling at these locations has been assumed to occur across 24 days (i.e. two locations piled on the same day). Piling for the remaining structures has been assumed to be identical to that for the maximum temporal scenario, so the maximum number of days of piling for the maximum spatial scenario is 89.5 days. For the purposes of modelling this has been rounded to 90 days.

B.3.7.1.6 Details of the piling schedules for the maximum temporal scenario and maximum spatial scenario are presented in Table B. 7, and the time points selected from the iPCoD model outputs to coincide with key periods in the piling schedule, and with statutory reporting periods for Special Areas of Conservation (SAC), are summarised in Table B. 8.

Table B. 7: Indicative two-year piling programme for each piling scenario in the Morgan Generation Assets within the four-year offshore construction phase.

Year	Month	Days piling per month	
		Maximum temporal scenario	Maximum spatial scenario
2026	No piling		
2027	January	5	4
	February	5	4
	March	4	3
	April	5	4
	May	5	4
	June	5	4
	July	4	3
	August	5	4
	September	5	4
	October	5	4
	November	4	3
	December	5	4
2028	January	5	4
	February	4	3
	March	5	4
	April	5	4
	May	5	4
	June	4	3
	July	5	4
	August	5	4
	September	4	3
	October	5	4
	November	5	4
	December	5	4
2029	No piling		

Year	Month	Days piling per month	
		Maximum temporal scenario	Maximum spatial scenario
Total piling days		**114**	**90**

Table B. 8: Selected time points from simulation output, corresponding years, and corresponding events.

Time point	Year	Corresponding event
1	2027	Start of piling phase
2	2028	End of first year of piling phase
3	2029	**End of two-year piling phase**
7	2033	Six-year Habitats Directive reporting period (start of piling)
9	2035	Six-year Habitats Directive reporting period (end of piling)
11	2037	Ten years after start of piling
13	2039	Ten years after end of piling
21	2047	Twenty years after start of piling
26	2052	**Twenty-five years after start of piling phase** Maximum capacity of iPCoD model predictions

B.3.8 Cumulative projects

B.3.8.1.1 Cumulative projects for marine mammal species were considered across the regional marine mammal study area, which encompasses the Irish Sea and Celtic Seas, and those projects for which quantitative information was available were included in iPCoD models. A summary of indicative offshore piling scenarios and schedules is provided in Table B. 9.

Table B. 9: Indicative offshore piling programmes and schedules for cumulative projects. Green shading indicates construction phases, and blue shading indicates the anticipated start of respective operation and maintenance phases.

Project		Tier	Max piles	Max piling duration (days)	2025	2026	2027	2028	2029	2030 onward
Morgan Generation Assets		n/a	454	114			Piling	Piling		
Mona Offshore Wind Project		1	454	90			Piling	Piling		
Awel y Môr		1	50	201				Piling		
Project Erebus		1	35	18	Piling	Piling				
White Cross Offshore Wind Farm	Wind turbines	1	64	5		Piling	Piling			
	OSP	1	4	1		Piling	Piling			
Morecambe Generation Assets		2	42	42			Piling			
Morgan and Morecambe Offshore Wind Farms: Transmission Assets	Morgan OSP	2	2	2			Piling	Piling		
	Morecambe OSP		2	2			Piling	Piling		
	Morgan booster station		2	2			Piling	Piling		

B.3.8.1.2 The Morgan Generation Assets piling scenario carried forward to the cumulative assessment was the maximum spatial scenario as this represented the highest number of animals potentially disturbed in a 24-hour period.

B.3.8.1.3 There is no potential for significant cumulative impacts for injury (PTS) from elevated underwater sound during piling for the cumulative projects presented in Table B. 9 as iPCoD simulations for these projects have modelled zero animals experiencing PTS.

B.3.8.1.4 The iPCoD models were set up as described in sections B.3.2 and B.3.3 for demographic parameters and reference populations, respectively, and with the same days of residual disturbance specified in section B.3.6.

B.3.8.1.5 Cumulative models were run in two stages: one set of models incorporating the Morgan Generation Assets and only Tier 1 projects in the regional marine mammal study area, and one set incorporating all Tier 1 and Tier 2 projects. Cumulative projects were only included in species' models if they overlap spatially with the species-specific management units described in Table B. 3.

B.3.8.1.6 The SMUs comprising the GSRP (see paragraph B.3.3.1.3) do not overlap spatially with White Cross Offshore Wind Farm, however this project is located approximately 7.8 km from the boundary of the Wales SMU (a constituent part of the GSRP), and underwater sound contours reported by the White Cross Offshore Wind Farm (White Cross Offshore Wind, 2023) are expected to overlap with the Wales MU.

B.3.8.1.7 Since the IS MU for bottlenose dolphin does not spatially overlap with Project Erebus or the White Cross Offshore Wind Farm these projects were not included in the cumulative iPCoD models for bottlenose dolphin.

B.3.8.1.8 The number of animals affected for each of the key species and number of days on which piling occurred was taken from the MDS for each of the cumulative projects. A summary of the number of animals for each species affected and number of piling days for each of cumulative projects is provided in Table B. 10

B.3.8.1.9 In cases for which less than one animal was expected to experience disturbance, this was rounded up to one animal for the relevant models.

Table B. 10: Summary of number of animals estimated to experience disturbance for cumulative iPCoD models.

Project		Piling days (up to)	Maximum number of animals disturbed			
			Harbour porpoise	Bottlenose dolphin	Minke whale	Grey seal
Morgan Generation Assets	Wind turbine (3,000 kJ, concurrent)	24	1,007	5	67	61
	Wind turbine (4,400 kJ)	16	858	4	57	54
	OSP (4,400 kJ)	12	858	4	57	54
	Wind turbine (gravity base foundation: 3,000 kJ)	38	713	4	48	41
Tier 1 projects						
Mona Offshore Wind Project	Wind turbine (3,000 kJ, concurrent)	24	1,142	7	72	31
	Wind turbine (4,400 kJ)	16	971	6	61	27
	OSP (4,400 kJ)	12	971	6	61	27
	Wind turbine (gravity base foundation: 3,000 kJ)	38	803	5	51	17
Awel y Môr		201	2,112	23	36	81
Project Erebus		18	1,967	n/a	55	18
White Cross Offshore Wind Farm	Wind turbines	5	1,652	n/a	42	10
	OSP	1	2,754	n/a	61	10
Tier 2 projects						
Morecambe Generation Assets		42	2,961	<1	2	<1
Morgan and Morecambe Offshore Wind Farms: Transmission Assets	Morgan OSP	2	2,465	11	69	88
	Morecambe OSP	2	2,465	<1	2	88
	Morgan booster station	2	1,793	4	17	28

B.3.8.1.10 As precise piling schedules for the Morgan Generation Assets were unknown, the piling days were distributed as discussed in section B.3.7, and those for cumulative projects were spread evenly throughout the offshore construction phases shown in Table B. 9, with care taken to ensure that piling days for each project did not coincide.

B.3.8.1.11 The starting year for all cumulative models except those for bottlenose dolphin (see paragraph B.3.8.1.7) was 2026 as this is the anticipated start of piling at Project Erebus. For bottlenose dolphin all cumulative models started in 2027.

B.3.8.1.12 The time points selected from the iPCoD model outputs for cumulative projects were chosen to coincide with key periods in the piling programmes, and with statutory reporting periods for SACs, and are summarised in Table B. 11 and Table B. 12.

Table B. 11: Selected time points from simulation output, and corresponding events, for cumulative projects for harbour porpoise, minke whale and grey seal.

Time point	Year	Corresponding event/s
1	2025	Start of piling for Project Erebus
2	2026	End of piling for Project Erebus Start of piling for White Cross Offshore Wind Farm
3	2027	Start of piling for Morgan Generation Assets Start of piling for Mona Offshore Wind Project Start and end of piling for Morecambe Generation Assets Start of piling for Morgan and Morecambe Offshore Wind Farms: Transmission Assets
4	2028	Start of piling for Awel y Môr Second year piling for Morgan Generation Assets Second year piling for Mona Offshore Wind Project Second year piling for Morgan and Morecambe Offshore Wind Farms: Transmission Assets
5	2029	**End of piling phase at all cumulative projects**
7	2031	Six years after start of piling for Project Erebus
8	2032	Six years after start of piling for White Cross Offshore Wind Farm
9	2033	Six years after start of piling for Morgan Generation Assets Six years after start of piling for Mona Offshore Wind Project Six years after start of piling for Morecambe Generation Assets Six years after start of piling for Morgan and Morecambe Offshore Wind Farms: Transmission Assets.
10	2034	Six years after start of piling for Awel y Môr
11	2035	Ten years after start of piling for Project Erebus Six years after end of piling for Morgan Generation Assets Six years after end of piling for Mona Offshore Wind Project Six years after end of piling for Morecambe Generation Assets Six years after end of piling for Morgan and Morecambe Offshore Wind Farms: Transmission Assets
12	2036	Ten years after start of piling for White Cross Offshore Wind Farm
13	2037	Ten years after start of piling for Morgan Generation Assets Ten years after start of piling for Mona Offshore Wind Project Ten years after start of piling for Morecambe Generation Assets Ten years after start of piling for Morgan and Morecambe Offshore Wind Farms: Transmission Assets
15	2039	**Ten years after end of piling phase at all cumulative projects**

Time point	Year	Corresponding event/s
23	2047	Twenty years after start of piling for Morgan Generation Assets Twenty years after start of piling for Mona Offshore Wind Project Twenty years after start of piling for Morecambe Generation Assets Twenty years after start of piling for Morgan and Morecambe Offshore Wind Farms: Transmission Assets
26	2050	Twenty-five years after start of piling for Project Erebus **Maximum capacity of iPCoD model predictions**

Table B. 12: Selected time points from simulation output, and corresponding events, for cumulative projects for bottlenose dolphin.

Time point	Year	Corresponding event/s
1	2027	Start of piling for Morgan Generation Assets Start of piling for Mona Offshore Wind Project Start and end of piling for Morecambe Generation Assets Start of piling for Morgan and Morecambe Offshore Wind Farms: Transmission Assets
2	2028	Start of piling for Awel y Môr Second year piling for Morgan Generation Assets Second year piling for Mona Offshore Wind Project Second year piling for Morgan and Morecambe Offshore Wind Farms: Transmission Assets
3	2029	**End of piling phase at all cumulative projects**
7	2033	Six years after start of piling for Morgan Generation Assets Six years after start of piling for Mona Offshore Wind Project Six years after start of piling for Morecambe Generation Assets Six years after start of piling for Morgan and Morecambe Offshore Wind Farms: Transmission Assets.
8	2034	Six years after start of piling for Awel y Môr
9	2035	Six years after end of piling for Morgan Generation Assets Six years after end of piling for Mona Offshore Wind Project Six years after end of piling for Morecambe Generation Assets Six years after end of piling for Morgan and Morecambe Offshore Wind Farms: Transmission Assets
11	2037	Ten years after start of piling for Morgan Generation Assets Ten years after start of piling for Mona Offshore Wind Project Ten years after start of piling for Morecambe Generation Assets Ten years after start of piling for Morgan and Morecambe Offshore Wind Farms: Transmission Assets
13	2039	**Ten years after end of piling phase at all cumulative projects**

Time point	Year	Corresponding event/s
21	2047	Twenty years after start of piling for Morgan Generation Assets Twenty years after start of piling for Mona Offshore Wind Project Twenty years after start of piling for Morecambe Generation Assets Twenty years after start of piling for Morgan and Morecambe Offshore Wind Farms: Transmission Assets
26	2052	Twenty-five years after start of piling for Morgan Generation Assets Twenty-five years after start of piling for Mona Offshore Wind Project Twenty-five years after start of piling for Morecambe Generation Assets Twenty-five years after start of piling for Morgan and Morecambe Offshore Wind Farms: Transmission Assets **Maximum capacity of iPCoD model predictions**

B.3.9 Summary of iPCoD scenarios.

B.3.9.1.1 A total of 26 iPCoD modelling scenarios were run for the Morgan Generation Assets and relevant cumulative projects, and these are summarised in Table B. 13 for each of the four key species.

Table B. 13: Summary of iPCoD scenarios modelled for key species associated with the Morgan Generation Assets and relevant cumulative projects.

[1] White Cross Offshore Wind Farm has been included in grey seal cumulative models due to proximity of boundary with the Wales SMU, a constituent of the GSRP.

Scenario		Population unit	Population estimate	Calf survival	Juvenile survival	Adult survival	Fertility	Age at independence	Age at first offspring
Harbour porpoise									
HP-01	Maximum temporal scenario	CIS	62,517	0.60	0.85	0.90	0.50	1	5
HP-02	Maximum spatial scenario	CIS	62,517	0.60	0.85	0.90	0.50	1	5
HP-CT	Cumulative scenario: Morgan and Morecambe Offshore Wind Farms: Transmission Assets only	CIS	62,517	0.60	0.85	0.90	0.50	1	5
HP-CTM	Cumulative scenario: Morgan and Morecambe Offshore Wind Farms: Transmission Assets and Morecambe Generation Assets	CIS	62,517	0.60	0.85	0.90	0.50	1	5
HP-C1	Cumulative scenario: Tier 1 projects within boundary of CIS MU	CIS	62,517	0.60	0.85	0.90	0.50	1	5
HP-C2	Cumulative scenario: Tier 1 and Tier 2 projects within boundary of CIS MU	CIS	62,517	0.60	0.85	0.90	0.50	1	5
Bottlenose dolphin									
BND-01a	Maximum temporal scenario	IS	293	0.87	0.93	0.94	0.22	2	9
BND-01b	Maximum temporal scenario, with higher 0.30 fertility rate.	IS	293	0.87	0.93	0.94	0.30	2	9
BND-02a	Maximum spatial scenario	IS	293	0.87	0.93	0.94	0.22	2	9
BND-02b	Maximum spatial scenario, with higher 0.30 fertility rate.	IS	293	0.87	0.93	0.94	0.30	2	9
BND-CT	Cumulative scenario: Morgan and Morecambe Offshore Wind Farms: Transmission Assets only	IS	293	0.87	0.93	0.94	0.22	2	9

Scenario		Population unit	Population estimate	Calf survival	Juvenile survival	Adult survival	Fertility	Age at independence	Age at first offspring
BND-CTM	Cumulative scenario: Morgan and Morecambe Offshore Wind Farms: Transmission Assets and Morecambe Generation Assets	IS	293	0.87	0.93	0.94	0.30	2	9
BND-C1	Cumulative scenario: Tier 1 projects within boundary of IS MU.	IS	293	0.87	0.93	0.94	0.22	2	9
BND-C2	Cumulative scenario: Tier 1 and Tier 2 projects within boundary of IS MU.	IS	293	0.87	0.93	0.94	0.30	2	9
Minke whale									
MW-01	Maximum temporal scenario	CGNS	20,118	0.70	0.77	0.96	0.91	1	9
MW-02	Maximum spatial scenario	CGNS	20,118	0.70	0.77	0.96	0.91	1	9
MW-CT	Cumulative scenario: Morgan and Morecambe Offshore Wind Farms: Transmission Assets only	CGNS	20,118	0.70	0.77	0.96	0.91	1	9
MW-CTM	Cumulative scenario: Morgan and Morecambe Offshore Wind Farms: Transmission Assets and Morecambe Generation Assets	CGNS	20,118	0.70	0.77	0.96	0.91	1	9
MW-C1	Cumulative scenario: Tier 1 projects within boundary of CIS MU	CGNS	20,118	0.70	0.77	0.96	0.91	1	9
MW-C2	Cumulative scenario: Tier 1 and Tier 2 projects within boundary of CIS MU	CGNS	20,118	0.70	0.77	0.96	0.91	1	9
Grey seal									
GS-01	Maximum temporal scenario	GSRP	12,910	0.94	0.94	0.90	0.22	1	5
GS-02	Maximum spatial scenario	GSRP	12,910	0.94	0.94	0.90	0.22	1	5
GS-CT	Cumulative scenario: Morgan and Morecambe Offshore Wind Farms: Transmission Assets only	GSRP	60,780	0.94	0.94	0.90	0.22	1	5

Scenario		Population unit	Population estimate	Calf survival	Juvenile survival	Adult survival	Fertility	Age at independence	Age at first offspring
GS-CTM	Cumulative scenario: Morgan and Morecambe Offshore Wind Farms: Transmission Assets and Morecambe Generation Assets	GSRP	12,910	0.94	0.94	0.90	0.22	1	5
GS-C1	Cumulative scenario: Tier 1 projects within boundary of MUs corresponding to GSRP[1]	GSRP	60,780	0.94	0.94	0.90	0.22	1	5
GS-C2	Cumulative scenario: Tier 1 and Tier 2 projects within boundary of MUs corresponding to GSRP[1]	GSRP	12,910	0.94	0.94	0.90	0.22	1	5

B.3.10 Model outputs

B.3.10.1.1 The outputs of the iPCoD models are focussed on describing the potential impact to a given marine mammal population under the relevant development scenario, relative to the population in the absence of the development. An estimate is provided for every time step in the scenario (here given as 25 years after commencement of piling), for each simulation (n = 1,000) and is presented in Figure B. 1 to Figure B. 26. The ratio of the impacted to the unimpacted population sizes can then be expressed as a ratio, termed the counterfactual of population size.

B.3.10.1.2 The mean estimate (plus 95% confidence interval) of impacted and unimpacted population sizes across all simulations, and the corresponding counterfactuals, are reported for each species, and each scenario (Table B. 14 to Table B. 39). The median counterfactual is also presented since this measure can be less sensitive to outliers. However, it is important to note that the median counterfactual may not always be representative of overall projections, and should be interpreted with caution, since this is calculated simply as the central value in the ordered set of counterfactuals from all simulations.

B.4. Results

B.4.1 Harbour porpoise

B.4.1.1 Project alone

B.4.1.1.1 Results of the iPCoD modelling at the time points described in Table B. 8 for harbour porpoise under the maximum temporal and maximum spatial scenarios are presented in Table B. 14 and Table B. 15, and illustrated in Figure B. 1 and Figure B. 2, respectively.

B.4.1.1.2 Both unimpacted and impacted populations of harbour porpoise appear to be reducing in size, and there has been a suggested 4% per annum declining trend in the CIS MU (IAMMWG, 2021) and thus this is not unexpected. However, iPCoD models can be very sensitive to the parameters chosen, and since conservative parameters were selected this may be reflected in simulated population trajectories.

Scenario HP-01: maximum temporal scenario

B.4.1.1.3 For the maximum temporal scenario the results indicate a very small difference in the growth trajectory of harbour porpoise between the unimpacted population and impacted population (Table B. 14). At all time points there was very little difference in the mean size of the impacted and unimpacted populations (Figure B. 1).

B.4.1.1.4 For example, at time point 3, which represents the end of the two-year piling phase, the impacted population was predicted to be 48 animals smaller than the unimpacted population. At time point 7, representing six years following the start of piling, and corresponding to the six-year reporting period formerly required under the Habitats Directive, the difference between impacted and unimpacted populations is 44 animals.

Table B. 14: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for harbour porpoise under the maximum temporal scenario.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	62,514	**62,514**	62,514	62,514	**62,514**	62,514	1.0000	1.0000
2	56,137	**61,537**	65,900	56,137	**61,524**	65,900	0.9998	1.0000
3	53,989	**60,544**	66,297	53,862	**60,496**	66,295	0.9992	0.9999
7	47,082	**56,819**	66,688	47,082	**56,775**	66,504	0.9992	0.9999
9	44,552	**54,942**	66,961	44,546	**54,896**	66,855	0.9992	0.9999
11	42,422	**53,281**	66,446	42,422	**53,236**	66,356	0.9992	0.9999
13	40,519	**51,543**	65,147	40,517	**51,500**	65,139	0.9992	0.9999
21	33,454	**45,162**	61,417	33,434	**45,124**	61,417	0.9992	1.0000
26	29,458	**41,534**	56,758	29,458	**41,499**	56,754	0.9992	1.0000

B.4.1.1.5 At time point 26, which represents the population at the end point of the iPCoD modelling, 25 years after the start of piling (and 23 years after the cessation of piling), this difference has reduced to 35 animals, corresponding to approximately 0.056% of the reference population (Table B. 14). This suggests that there would not be a long-term increase in any potential effect from piling upon the harbour porpoise population within the CIS MU.

B.4.1.1.6 The median counterfactual for scenario HP-01 fluctuated between 1.0000 and 0.9999 through the 26-year simulation, whereas the mean counterfactual reduced to 0.9992 by the end of the simulation. Therefore, given that the differences in disturbed to un-disturbed populations approaches a ratio of 1 there is not considered to be a potential for a long-term effect from this piling scenario upon harbour porpoise.

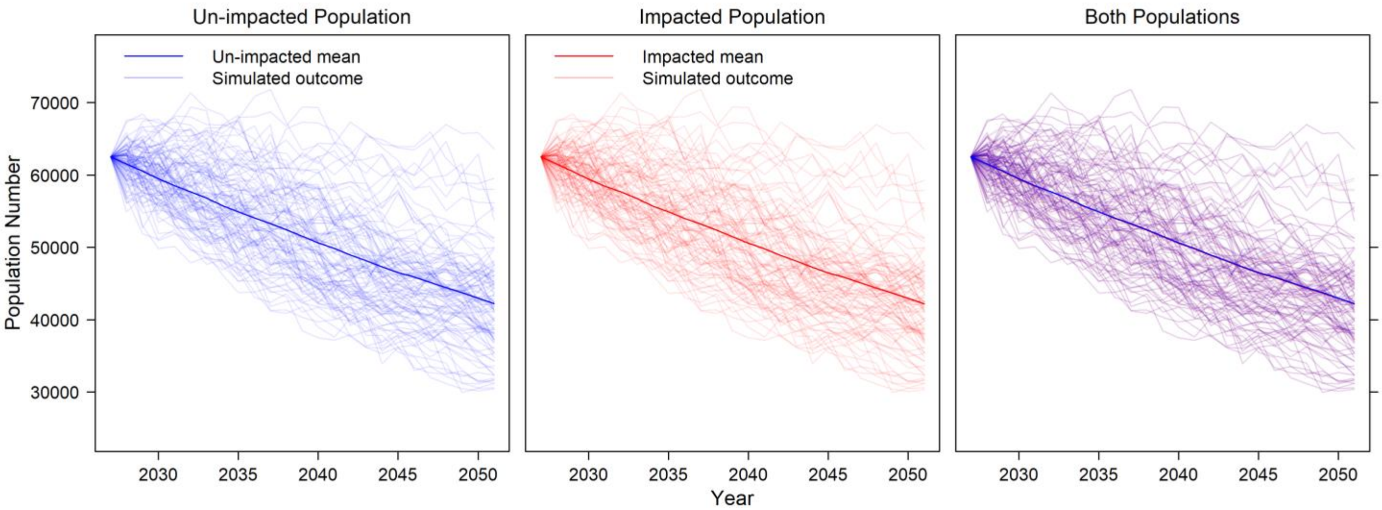

Figure B. 1: Simulated harbour porpoise population trajectories in an unimpacted versus impacted population, for the maximum temporal scenario.

Scenario HP-02: maximum spatial scenario

B.4.1.1.7 For the maximum spatial scenario the results indicate a very small difference in the population trajectory of harbour porpoise between the unimpacted population and impacted population (Table B. 15 and Figure B. 2).

B.4.1.1.8 At all time points there was very little difference in the mean size of the impacted and unimpacted populations. For example at time point 3, corresponding to the end of the two-year piling phase, the impacted population was predicted to be 34 fewer than the unimpacted population, corresponding to approximately 0.054% of the reference population. At time point 7, representing six years following the start of piling, and corresponding to the six-year reporting period formerly required under the Habitats Directive, the difference between impacted and unimpacted populations was 29 animals (equivalent to 0.046% of the reference population).

B.4.1.1.9 At time point 26, which represents the population at the end point of the iPCoD modelling, 25 years after the start of piling (and 23 years after the cessation of piling), this difference was 22 animals (Table B. 15), equivalent to approximately 0.035% of the reference population. This suggests that there would not be a long-term increase in any potential effect from piling upon the harbour porpoise population within the CIS management unit. Indeed, the effect appears to have reduced in magnitude over the modelled time series.

Table B. 15: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for harbour porpoise under the maximum spatial scenario.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	62,514	**62,514**	62,514	62,514	**62,514**	62,514	1.0000	1.0000
2	55,926	**61,477**	65,598	55,926	**61,468**	65,598	0.9999	1.0000
3	54,071	**60,427**	66,227	54,071	**60,393**	66,175	0.9994	1.0000
7	47,755	**56,405**	66,192	47,751	**56,376**	66,178	0.9995	1.0000
9	45,032	**54,690**	65,578	45,028	**54,661**	65,547	0.9995	1.0000
11	42,296	**52,865**	63,918	42,175	**52,837**	63,906	0.9995	1.0000
13	39,554	**51,153**	63,196	39,553	**51,126**	63,195	0.9995	1.0000
21	32,797	**44,812**	59,086	32,797	**44,788**	59,004	0.9995	1.0000
26	29,124	**41,226**	56,474	29,123	**41,204**	56,473	0.9995	1.0000

B.4.1.1.10 The median counterfactual of population size for scenario HP-02 was 1.0000 throughout the 26-year simulation, whereas the mean counterfactual ratio at time point 26 had reduced from 1.0000 to 0.9995. Therefore, given that the differences in disturbed to undisturbed populations approaches a ratio of 1 there is not considered to be a potential for a long-term effect from this piling scenario upon harbour porpoise.

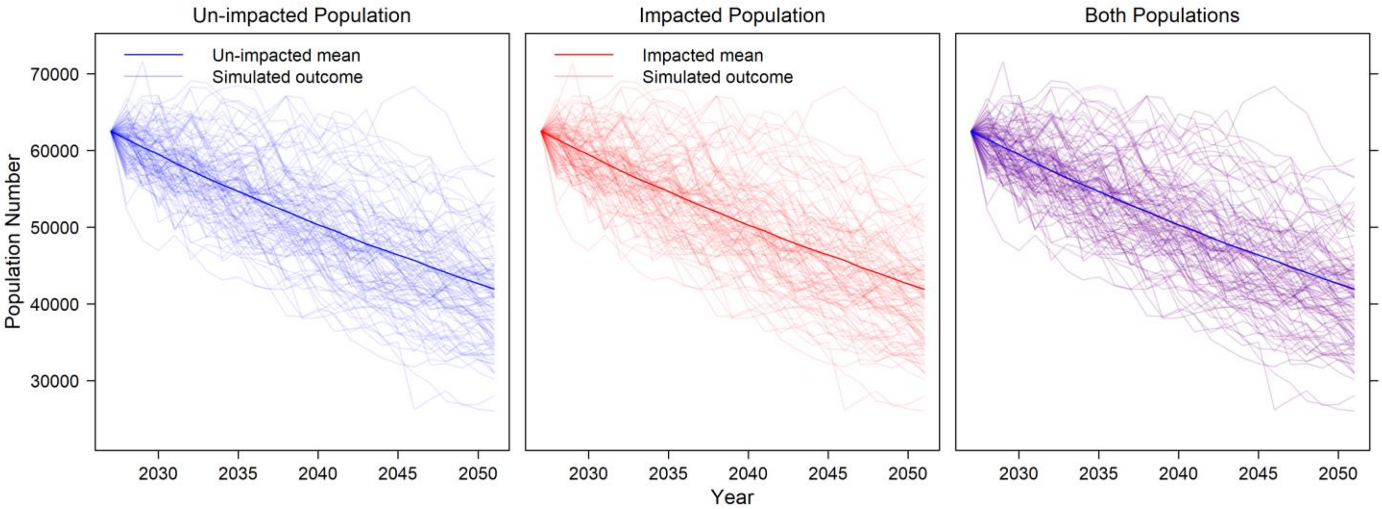

Figure B. 2: Simulated harbour porpoise population trajectories in an unimpacted versus impacted population, for the maximum spatial scenario.

B.4.1.2 Cumulative projects

B.4.1.2.1 Results of the iPCoD modelling at the time points described in Table B. 11 for harbour porpoise using the maximum spatial cumulative scenarios are presented in Table B. 16 to Table B. 19 and illustrated in Figure B. 3 to Figure B. 6, respectively.

B.4.1.2.2 As for the two scenarios for the Morgan Generation Assets alone, there appears to be a decline in both impacted and unimpacted populations for harbour porpoise (see section B.4.1.1). However, when compared directly, a slightly lower population trajectory is visible in the third panel of Figure B. 3 to Figure B. 6 for the impacted population in HP-CT, HP-CTM, HP-C1 and HP-C2 cumulative scenarios.

Scenario HP-CT: Morgan and Morecambe Offshore Wind Farms: Transmission Assets

B.4.1.2.3 For scenario HP-CT, in which a total of 90 days of piling occur at the Morgan Generation Assets alongside a total of four piling days at the Morgan and Morecambe Offshore Wind Farms: Transmission Assets, these results indicate a difference of 40 fewer animals in the impacted population at time point 26, compared to the unimpacted population (Table B. 16).

B.4.1.2.4 At time point 7, which corresponds to the six-year reporting period formerly required under the Habitats Directive, the difference between impacted and unimpacted populations is 53 animals (0.085% of the reference population). When compared to the equivalent time point from scenario HP-02 (maximum spatial scenario for the Morgan Generation Assets alone: n = 29), this is a difference of 24 animals.

B.4.1.2.5 The median counterfactual of population size for scenario HP-CT was 0.9999 at the end of the 26-year simulation, while the mean counterfactual was 0.9990 (Table B. 18). Therefore, given that the differences in disturbed to undisturbed populations approaches a ratio of 1 there is not considered to be a potential for a long-term MU population-level effect from this cumulative piling scenario upon harbour porpoise.

Table B. 16: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for harbour porpoise for cumulative scenario HP-CT.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	62,514	**62,514**	62,514	62,514	**62,514**	62,514	1.0000	1.0000
2	55,958	**61,287**	65,674	55,958	**61,273**	65,674	0.9998	1.0000
3	53,841	**60,327**	66,055	53,781	**60,269**	65,962	0.9990	0.9998
7	47,461	**56,219**	65,506	47,461	**56,166**	65,504	0.9991	0.9999
9	43,910	**54,477**	65,012	43,877	**54,422**	65,012	0.9990	0.9999
11	41,438	**52,598**	64,204	41,436	**52,545**	64,014	0.9990	0.9999
13	39,903	**50,991**	63,854	39,873	**50,940**	63,815	0.9990	0.9999
21	33,188	**44,764**	59,460	33,126	**44,719**	59,460	0.9990	0.9999
26	28,727	**41,214**	57,703	28,727	**41,174**	57,559	0.9990	0.9999

B.4.1.2.6 This suggests that after an initial effect of disturbance upon the harbour porpoise population from the cumulative projects, peaking approximately five years after the start of piling, this effect is expected to stabilise across the duration of the modelled time series (i.e. the counterfactual of population size is not expected to reduce below the ratio predicted at six years).

B.4.1.2.7 As for scenarios HP-01 and HP-02 for the Morgan Generation Assets alone, there appears to be a decline in both impacted and unimpacted populations for harbour porpoise (see section B.4.1.1). However, when compared directly, a slightly lower population trajectory is visible in the third panel of Figure B. 3 for the impacted population for cumulative scenario HP-C1.

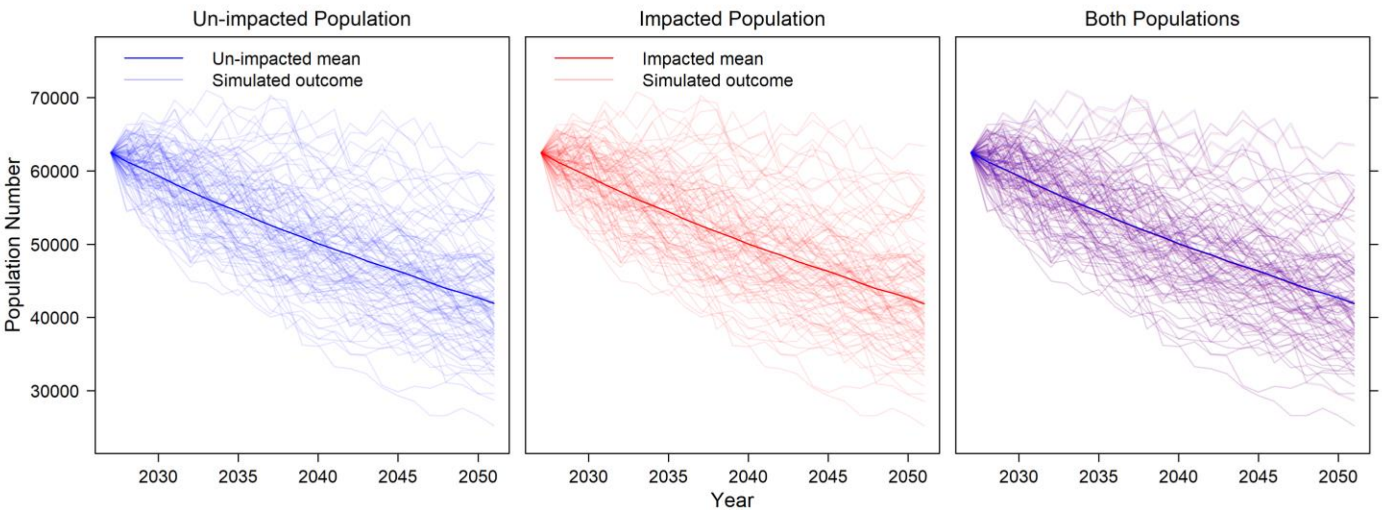

Figure B. 3: Simulated harbour porpoise population trajectories in an unimpacted versus impacted population, for cumulative scenario HP-CT (Morgan and Morecambe Offshore Wind Farms: Transmission Assets only).

Scenario HP-CTM: Morgan and Morecambe Offshore Wind Farms: Transmission Assets and Morecambe Generation Assets

B.4.1.2.8 For scenario HP-CTM, in which a total of 90 days of piling occur at the Morgan Generation Assets alongside a total of four piling days at the Morgan and Morecambe Offshore Wind Farms: Transmission Assets and 42 at Morecambe Generation Assets, these results indicate a difference of 96 fewer animals in the impacted population at time point 26, compared to the unimpacted population (Table B. 17).

B.4.1.2.9 At time point 7, which corresponds to the six-year reporting period formerly required under the Habitats Directive, the difference between impacted and unimpacted populations is 128 animals (0.205% of the reference population). When compared to the equivalent time point from scenario HP-02 (maximum spatial scenario for the Morgan Generation Assets alone: n = 29), this is a difference of 99 animals.

B.4.1.2.10 The median counterfactual of population size for scenario HP-CTM was 0.9995 at the end of the 26-year simulation, while the mean counterfactual was 0.9977 (Table B. 17). Therefore, given that the differences in disturbed to undisturbed populations approaches a ratio of 1 there is not considered to be a potential for a long-term MU population-level effect from this cumulative piling scenario upon harbour porpoise.

Table B. 17: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for harbour porpoise for cumulative scenario HP-CTM.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	62,514	**62,514**	62,514	62,514	**62,514**	62,514	1.0000	1.0000
2	56,271	**61,617**	65,942	56,270	**61,562**	65,910	0.9991	0.9999
3	53,720	**60,603**	66,532	53,695	**60,447**	66,446	0.9974	0.9993
7	47,468	**56,752**	66,603	47,459	**56,624**	66,584	0.9978	0.9995
9	44,636	**54,909**	65,363	44,636	**54,779**	65,317	0.9976	0.9994
11	42,903	**53,105**	63,879	42,826	**52,980**	63,728	0.9977	0.9994
13	40,320	**51,347**	63,206	40,088	**51,227**	63,202	0.9977	0.9995
21	33,178	**45,111**	58,478	33,167	**45,006**	58,284	0.9977	0.9995
26	29,380	**41,516**	56,618	29,332	**41,420**	56,421	0.9977	0.9995

B.4.1.2.11 This suggests that after an initial effect of disturbance upon the harbour porpoise population from the cumulative projects, peaking approximately three years after the start of piling, this effect is expected to stabilise across the duration of the modelled time series (i.e. the counterfactual of population size is not expected to reduce below the ratio predicted at six years).

B.4.1.2.12 As for scenarios HP-01 and HP-02 for the Morgan Generation Assets alone and HP-CT for the addition of the Morgan and Morecambe Offshore Wind Farms: Transmission Assets, there appears to be a decline in both impacted and unimpacted populations for harbour porpoise (see section B.4.1.1). However, when compared directly, a slightly lower population trajectory is visible in the third panel of Figure B. 4 for the impacted population for cumulative scenario HP-C1.

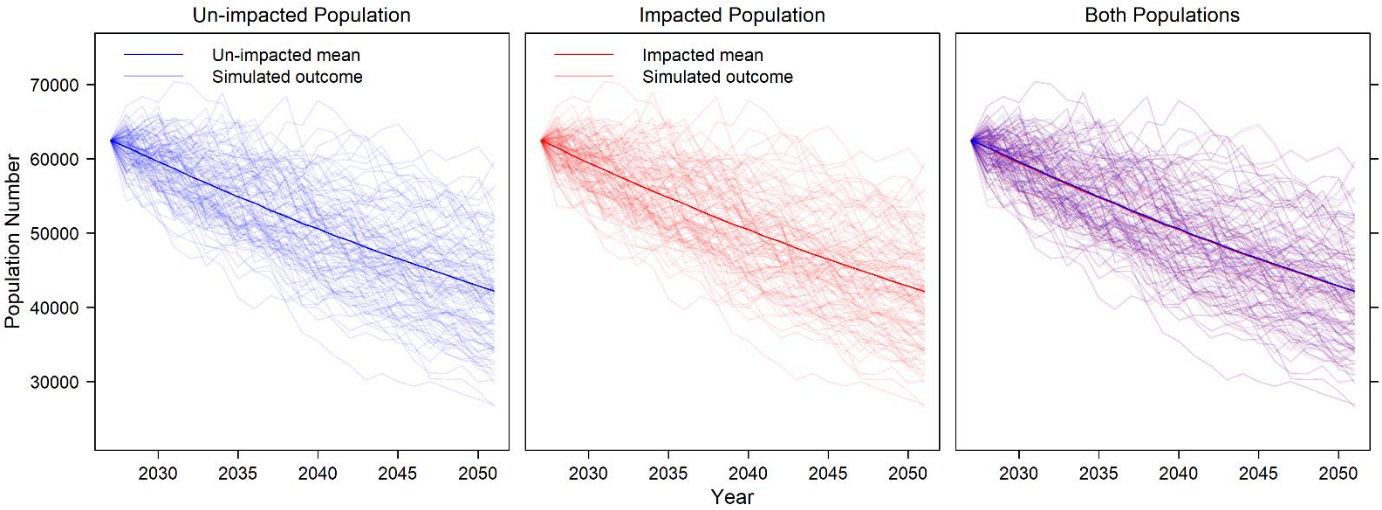

Figure B. 4: Simulated harbour porpoise population trajectories in an unimpacted versus impacted population, for cumulative scenario HP-CTM (Morgan and Morecambe Offshore Wind Farms: Transmission Assets and Morecambe Generation Assets).

Scenario HP-C1: Tier 1 projects

B.4.1.2.13 For scenario HP-C1, in which a total of up to 90 days of piling occur at the Morgan Generation Assets alongside a total of 315 piling days across Tier 1 cumulative projects (90 days at Mona Offshore Wind Project, 18 days at Project Erebus, six days at White Cross Offshore Wind Farm and 201 days at Awel y Môr), these results indicate a difference of 292 fewer animals in the impacted population at time point 26, compared to the unimpacted population (Table B. 18).

B.4.1.2.14 At time point 7, which corresponds to the six-year reporting period formerly required under the Habitats Directive, the difference between impacted and unimpacted populations is 430 animals (0.688% of the reference population). When compared to the equivalent time point from scenario HP-02 (maximum spatial scenario for the Morgan Generation Assets alone: n = 29), this is a difference of 401 animals.

B.4.1.2.15 The median counterfactual of population size for scenario HP-C1 was 0.9965 at the end of the 26-year simulation, while the mean counterfactual was 0.9939 (Table B. 18). Therefore, given that the differences in disturbed to undisturbed populations approaches a ratio of 1 there is not considered to be a potential for a long-term MU population-level effect from this cumulative piling scenario upon harbour porpoise.

B.4.1.2.16 This suggests that after an initial effect of disturbance upon the harbour porpoise population from the cumulative projects, peaking approximately five years after the start of piling, this effect is expected to stabilise across the duration of the modelled time series (i.e. the counterfactual of population size is not expected to reduce below the ratio predicted at six years).

Table B. 18: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for harbour porpoise for cumulative piling scenario HP-C1.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	62,514	**62,514**	62,514	62,514	**62,514**	62,514	1.0000	1.0000
3	53,426	**60,637**	66,429	53,426	**60,626**	66,425	0.9997	1.0000
4	51,448	**59,692**	66,891	51,448	**59,635**	66,749	0.9992	0.9999
5	50,764	**58,639**	66,604	50,549	**58,325**	66,385	0.9953	0.9973
7	47,382	**56,805**	66,548	47,187	**56,375**	65,972	0.9933	0.9961
9	44,177	**54,988**	65,311	43,943	**54,629**	64,942	0.9943	0.9968
10	43,258	**54,175**	65,365	43,163	**53,804**	64,653	0.9940	0.9966
11	42,318	**53,362**	65,108	42,214	**52,988**	64,506	0.9939	0.9966
13	40,868	**51,408**	63,514	40,471	**51,046**	63,158	0.9939	0.9965
15	38,543	**49,894**	62,236	38,534	**49,544**	61,604	0.9939	0.9966
23	31,514	**43,619**	58,385	31,330	**43,315**	58,265	0.9939	0.9964
26	29,267	**41,602**	56,073	29,172	**41,310**	55,401	0.9939	0.9965

B.4.1.2.17 As for scenarios HP-01 and HP-02 for the Morgan Generation Assets alone, there appears to be a decline in both impacted and unimpacted populations for harbour porpoise (see section B.4.1.1). However, when compared directly, a slightly lower population trajectory is visible in the third panel of Figure B. 5 for the impacted population for cumulative scenario HP-C1.

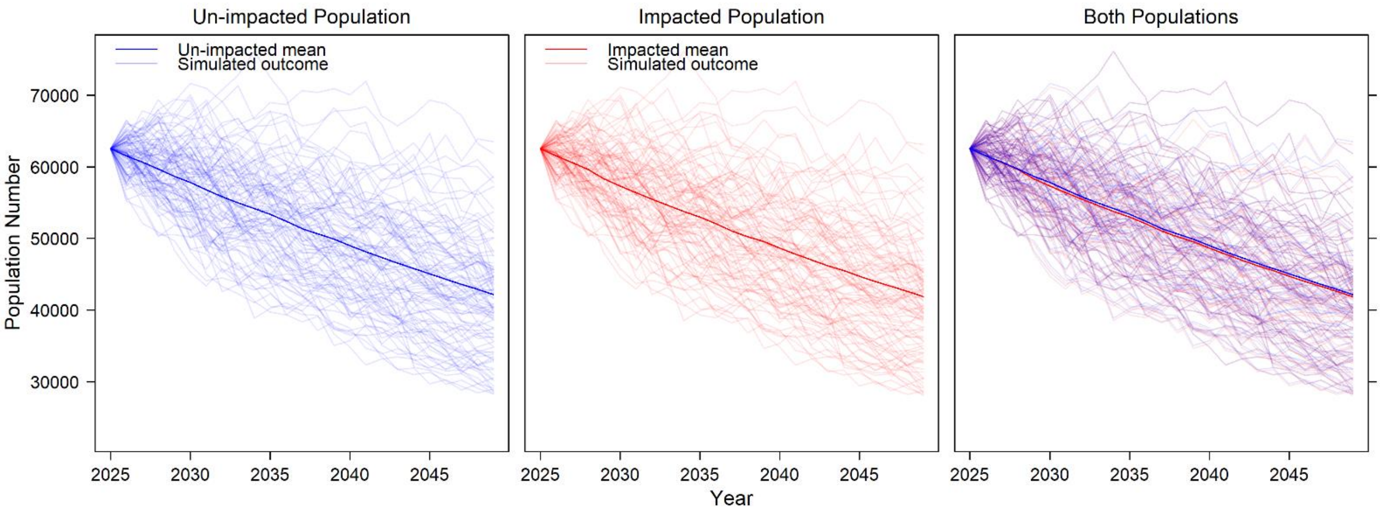

Figure B. 5: Simulated harbour porpoise population trajectories in an unimpacted versus impacted population, for cumulative scenario HP-C1 (Tier 1 projects only).

Scenario HP-C2: Tier 1 and Tier 2 projects

B.4.1.2.18 The results for scenario HP-C2 (i.e. 90 days of piling for the Morgan Generation Assets alongside up to 451 piling days from Tier 1 and Tier 2 cumulative projects) indicate a similar pattern in the population trajectory as scenario HP-C1 (Table B. 19), although the magnitude of effect appears to be lower.

B.4.1.2.19 The impacted population size at time point 26 is estimated to be 392 animals fewer than the unimpacted population (0.627% of the reference population), and for time point 7, this is 577 animals fewer than the unimpacted population. As for scenario HP-C1, an initial peak in the effect after six years appears to reduce and stabilise over the longer term (Figure B. 6).

Table B. 19: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for harbour porpoise for cumulative piling scenario HP-C2.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	62,514	**62,514**	62,514	62,514	**62,514**	62,514	1.0000	1.0000
3	54,088	**60,543**	66,558	54,027	**60,531**	66,554	0.9996	1.0000
4	52,122	**59,487**	66,861	52,108	**59,390**	66,700	0.9984	0.9995
5	50,956	**58,721**	66,725	50,671	**58,268**	66,282	0.9921	0.9948
7	47,768	**56,825**	66,416	47,156	**56,248**	65,790	0.9895	0.9930
9	45,234	**55,059**	65,521	44,618	**54,571**	64,534	0.9909	0.9942
10	44,125	**54,152**	65,655	43,870	**53,648**	64,792	0.9904	0.9939
11	43,390	**53,330**	65,323	42,541	**52,821**	64,796	0.9902	0.9938
13	39,939	**51,482**	64,183	39,780	**50,991**	63,196	0.9902	0.9938
15	37,770	**49,780**	63,426	37,487	**49,308**	63,173	0.9903	0.9938
23	31,032	**43,484**	58,285	30,743	**43,073**	57,917	0.9903	0.9938
26	29,116	**41,470**	55,764	28,770	**41,078**	55,274	0.9903	0.9937

B.4.1.2.20 The median counterfactual of population size for scenario HP-C2 was 0.9937 at the end of the 26-year simulation, while the mean counterfactual at the same time point was 0.9903. Therefore, given that the differences in disturbed to undisturbed populations approaches a ratio of 1 there is not considered to be a potential for a long-term MU population-level effect from this cumulative piling scenario upon harbour porpoise.

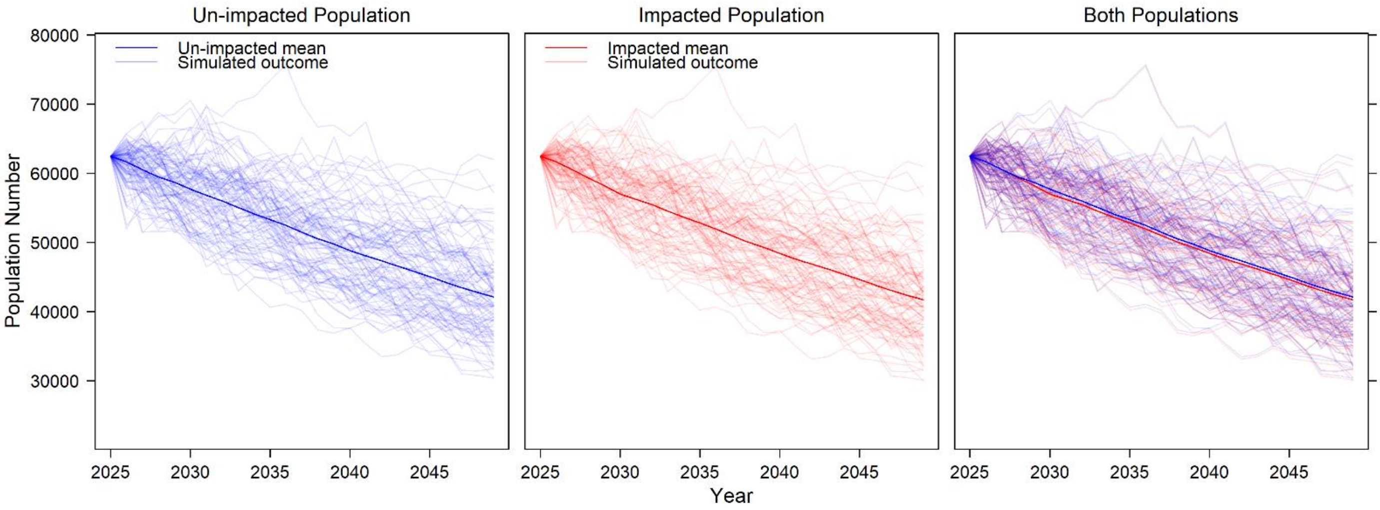

Figure B. 6: Simulated harbour porpoise population trajectories in unimpacted versus impacted populations, for cumulative scenario HP-C2 (Tier 1 and Tier 2 projects).

B.4.2 Bottlenose dolphin

B.4.2.1 Project alone

B.4.2.1.1 Results of the iPCoD modelling at the time points described in Table B. 8 for bottlenose dolphin under the maximum temporal and maximum spatial piling scenarios are presented in Table B. 20 and Table B. 21 and illustrated in Figure B. 7 and Figure B. 8.

B.4.2.1.2 As for harbour porpoise, there appears to be a decline in both impacted and unimpacted populations for bottlenose dolphin across the modelled time series, when the fertility rate is set at 0.22 (scenarios BND-01a and BND-02a, after Arso Civil *et al*., 2017). Reported estimates of bottlenose dolphin abundance in the IS MU suggest an existing decline in the population, from 379 individuals in 2012 (Evans, 2012 in IAMMWG, 2021) to approximately 293 individuals in 2018 (Rogan et al., 2018; Hammond et al., 2021 in IAMMWG, 2021), representing declining trend of 4.2% per annum in the IS MU.

B.4.2.1.3 However, when the fertility parameter is set to 0.30 (scenarios BND-01b and BND-02b, after Sinclair *et al*., 2020), the decline is reversed, and the population appears to be modestly increasing in size.

Scenario BND-01a: maximum temporal scenario, 0.22 fertility rate

B.4.2.1.4 For the maximum temporal scenario applying a fertility rate of 0.22, the results of iPCoD modelling indicate a very small difference in the population trajectory of bottlenose dolphin between the unimpacted population and impacted population (Table B. 20 and Figure B. 7). At all time points there was a maximum difference of one animal in the mean size of the impacted and unimpacted populations.

B.4.2.1.5 For example, at time point 2, which represents the end of the first year of piling for the Morgan Generation Assets, the impacted population was predicted to be the same size as the unimpacted population (n = 288). At time point 7, representing six years following the start of piling, and corresponding to the six-year reporting period formerly required under the Habitats Directive, the difference was predicted to be 278 animals in the impacted population, compared to 279 animals in the unimpacted population (Table B. 20).

B.4.2.1.6 At time point 26, which represents the population at the end point of the iPCoD modelling, 25 years after the start of the two-year piling phase (and 23 years after the cessation of piling), this difference was also one animal (approximately 0.341% of the reference population). This suggests that there would not be a short- or long-term effect from piling at the Morgan Generation Assets upon the bottlenose dolphin population within the IS management unit.

Table B. 20: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for bottlenose dolphin under the maximum temporal scenario, with fertility rate of 0.22.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	290	**290**	290	290	**290**	290	1.0000	1.0000
2	254	**288**	316	254	**288**	316	0.9996	1.0000
3	246	**286**	322	246	**285**	320	0.9980	1.0000
7	216	**279**	344	216	**278**	342	0.9981	1.0000
9	212	**275**	344	210	**275**	342	0.9982	1.0000
11	200	**270**	348	200	**270**	346	0.9982	1.0000
13	196	**267**	350	196	**266**	348	0.9981	1.0000
21	162	**252**	358	162	**252**	358	0.9980	1.0000
26	148	**243**	364	148	**242**	364	0.9980	1.0000

B.4.2.1.7 The median counterfactual of population size for scenario BND-01a was 1.0000 throughout the 26-year simulation, whereas the mean counterfactual ratio at time point 26 was 0.9980. Therefore, given that the differences in impacted to unimpacted populations approaches a ratio of 1 there is not considered to be a potential for an effect from this piling scenario upon bottlenose dolphin.

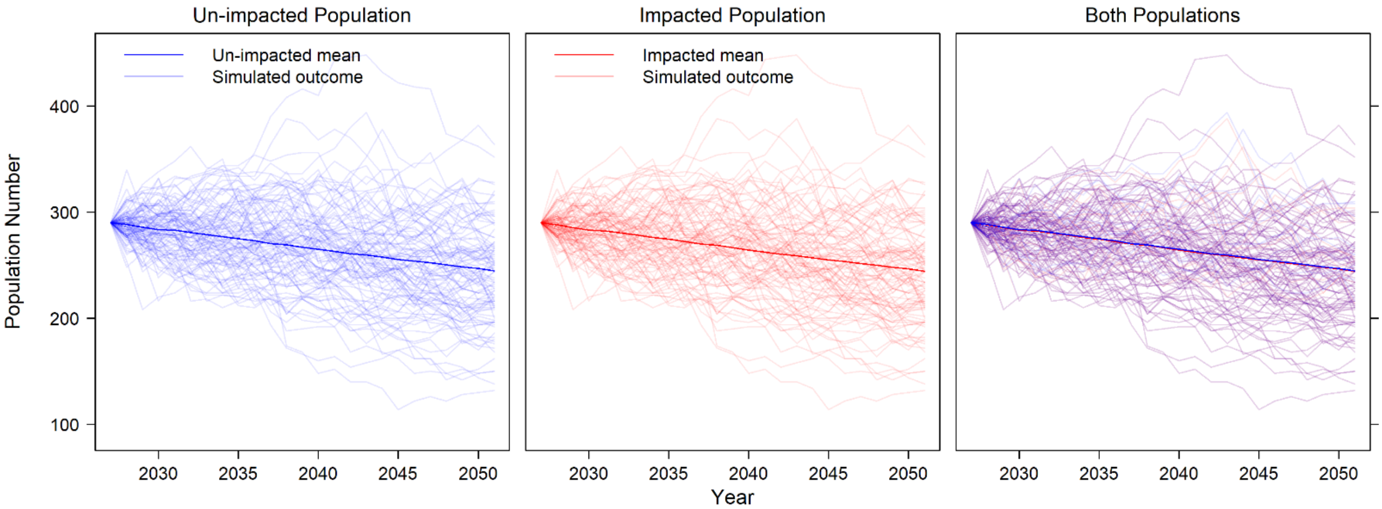

Figure B. 7: Simulated bottlenose dolphin population trajectories (fertility rate = 0.22) in an unimpacted versus impacted population, for the maximum temporal scenario.

Scenario BND-01b: maximum temporal scenario, 0.30 fertility rate

B.4.2.1.8 For the maximum temporal scenario applying a fertility rate of 0.30, the results of iPCoD modelling again indicate a very small difference in the population trajectory of bottlenose dolphin between the unimpacted population and impacted population (Table B. 21 and Figure B. 8). At all time points there was a maximum difference of one animal in the mean size of the impacted and unimpacted populations, and like scenario BND-01a, there was no difference at some time points.

Table B. 21: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for bottlenose dolphin under the maximum temporal scenario, with fertility rate of 0.30.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	290	**290**	290	290	**290**	290	1.0000	1.0000
2	258	**292**	318	258	**292**	318	0.9995	1.0000
3	244	**294**	330	244	**293**	330	0.9980	1.0000
7	228	**299**	370	228	**298**	370	0.9981	1.0000
9	224	**303**	382	222	**302**	382	0.9984	1.0000
11	226	**306**	396	226	**305**	396	0.9984	1.0000
13	218	**310**	410	218	**309**	410	0.9983	1.0000
21	200	**323**	454	200	**323**	454	0.9982	1.0000
26	202	**333**	486	202	**332**	486	0.9982	1.0000

B.4.2.1.9 At time point 2, which represents the end of the first year of piling for the Morgan Generation Assets, the impacted population was predicted to be the same size as the unimpacted population (n = 292). At time point 7, representing six years following the start of piling, and corresponding to the six-year reporting period formerly required under the Habitats Directive, the difference was predicted to be 298 animals in the impacted population, compared to 299 animals in the unimpacted population (Table B. 21).

B.4.2.1.10 At time point 26, which represents the population at the end point of the iPCoD modelling, 25 years after the start of the two-year piling phase (and 23 years after the cessation of piling), this difference was also one animal. This suggests that there would not be a short- or long-term effect from piling at the Morgan Generation Assets upon the bottlenose dolphin population within the IS management unit.

B.4.2.1.11 The median counterfactual of population size for scenario BND-01b was 1.0000 throughout the 26-year simulation, whereas the mean counterfactual ratio at time point 26 was 0.9982: marginally higher than for scenario BND-01a. Therefore, given that the differences in impacted to unimpacted populations approaches a ratio of 1 there is not considered to be a potential for an effect from this piling scenario upon bottlenose dolphin.

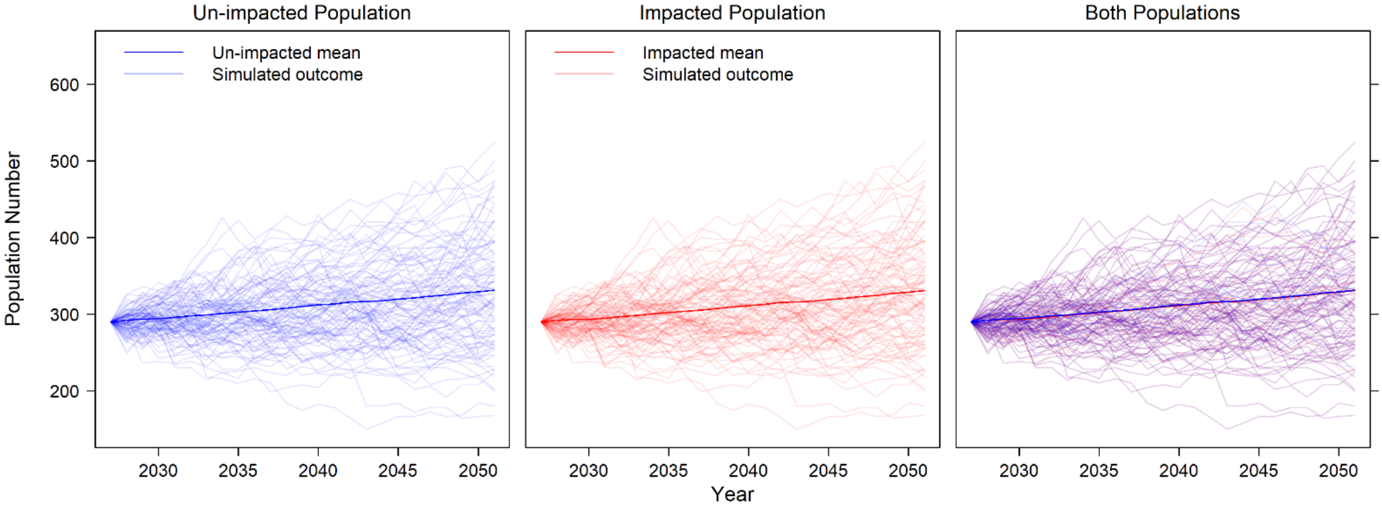

Figure B. 8: Simulated bottlenose dolphin population trajectories (fertility rate = 0.30) in an unimpacted versus impacted population, for the maximum temporal scenario.

Scenario BND-02a: maximum spatial scenario, 0.22 fertility rate

B.4.2.1.12 For the maximum spatial scenario applying a fertility rate of 0.22, the results of iPCoD modelling indicate a similarly small difference in the population trajectory of bottlenose dolphin between the unimpacted population and impacted population as for scenario BND-01a (Table B. 22 and Figure B. 9). At all time points there was a maximum difference of one animal in the mean size of the impacted and unimpacted populations.

Table B. 22: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for bottlenose dolphin under the maximum spatial scenario, with fertility rate of 0.22.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	290	**290**	290	290	**290**	290	1.0000	1.0000

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
2	256	**289**	314	256	**289**	314	0.9996	1.0000
3	246	**287**	324	246	**287**	324	0.9986	1.0000
7	216	**279**	340	216	**278**	340	0.9986	1.0000
9	210	**275**	342	210	**274**	342	0.9988	1.0000
11	204	**270**	344	202	**270**	344	0.9989	1.0000
13	194	**266**	344	192	**266**	342	0.9988	1.0000
21	168	**253**	352	166	**253**	352	0.9988	1.0000
26	154	**245**	352	154	**244**	352	0.9988	1.0000

B.4.2.1.13 At time point 3, corresponding to the end of the two-year piling phase for the Morgan Generation Assets, the impacted population was predicted to be the same size as the unimpacted population (n = 287). At time point 7, representing six years following the start of piling, and corresponding to the six-year reporting period formerly required under the Habitats Directive, the difference was predicted to be 278 animals in the impacted population, compared to 279 animals in the unimpacted population (Table B. 22).

B.4.2.1.14 At time point 26, which represents the population at the end point of the iPCoD modelling, 25 years after the start of the two-year piling phase (and 23 years after the cessation of piling), the difference between the impacted population (n = 244) compared to the unimpacted population (n = 245) was also one animal (equivalent to approximately 0.341% of the reference population). This suggests that there would not be a short- or long-term effect from piling at the Morgan Generation Assets upon the bottlenose dolphin population within the IS management unit.

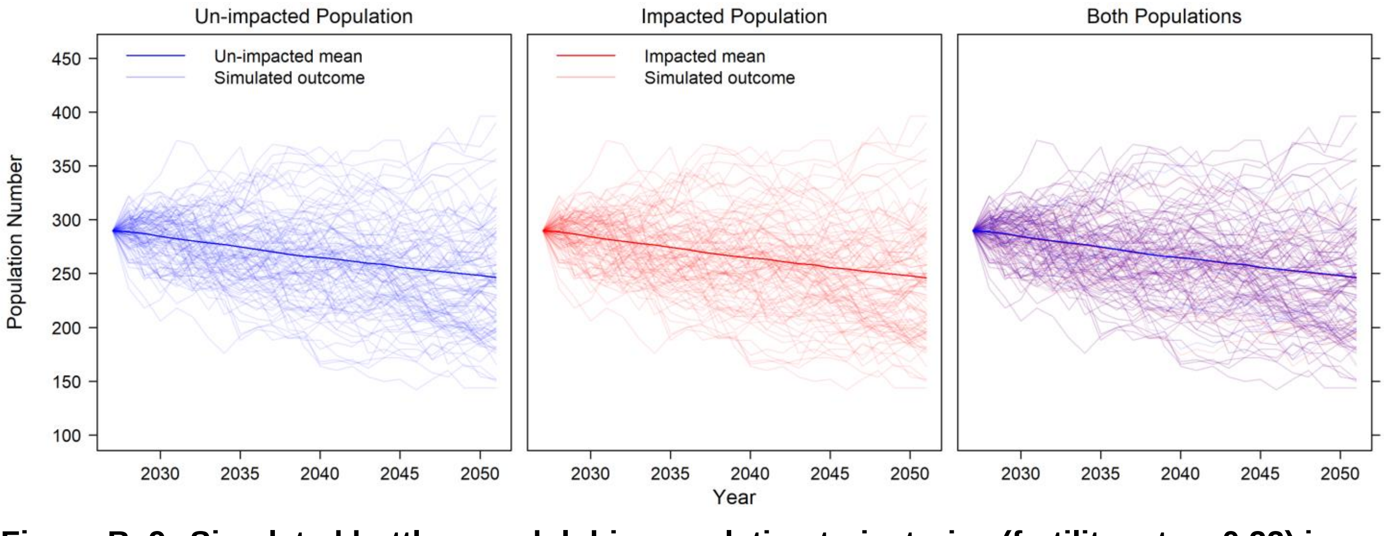

Figure B. 9: Simulated bottlenose dolphin population trajectories (fertility rate = 0.22) in an unimpacted versus impacted population, for the maximum spatial scenario.

B.4.2.1.15 The median counterfactual of population size for scenario BND-02a was 1.0000 throughout the 26-year simulation, whereas the mean counterfactual ratio at time point 26 was 0.9988. Therefore, given that the differences in impacted to unimpacted populations approaches a ratio of 1 there is not considered to be a potential for an effect from this piling scenario upon bottlenose dolphin.

Scenario BND-02b: maximum spatial scenario, 0.30 fertility rate

B.4.2.1.16 For the maximum temporal scenario applying a fertility rate of 0.30, the results of iPCoD modelling again indicate a very small difference in the population trajectory of bottlenose dolphin between the unimpacted population and impacted population (Table B. 23 and Figure B. 10). At all time points there was a maximum difference of one animal in the mean size of the impacted and unimpacted populations, with no difference in simulated population size at the first two time points.

B.4.2.1.17 At time point 3, which represents the end of the two-year piling phase for the Morgan Generation Assets, the impacted population was predicted to be the one individual smaller the unimpacted population (n = 292). At time point 7, representing six years following the start of piling, and corresponding to the six-year reporting period formerly required under the Habitats Directive, the difference was predicted to be 300 animals in the impacted population, compared to 301 animals in the unimpacted population (Table B. 23).

Table B. 23: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for bottlenose dolphin under the maximum spatial scenario, with fertility rate of 0.30.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	290	290	290	290	290	290	1.0000	1.0000
2	258	292	316	258	291	316	0.9995	1.0000
3	246	293	330	246	292	328	0.9980	1.0000
7	230	301	366	230	300	366	0.9981	1.0000
9	230	304	384	230	303	382	0.9983	1.0000
11	228	307	392	226	307	392	0.9983	1.0000
13	222	312	404	222	311	404	0.9982	1.0000
21	206	326	452	210	325	452	0.9982	1.0000
26	210	335	492	210	334	492	0.9981	1.0000

B.4.2.1.18 At time point 26, which represents the population at the end point of the iPCoD modelling, 25 years after the start of the two-year piling phase (and 23 years after the cessation of piling), the difference between the impacted population (n = 334) compared to the unimpacted population (n = 335) was also one animal (equivalent to approximately 0.341% of the reference population). This suggests that there would not be a short- or long-term effect from piling at the Morgan Generation Assets upon the bottlenose dolphin population within the IS management unit.

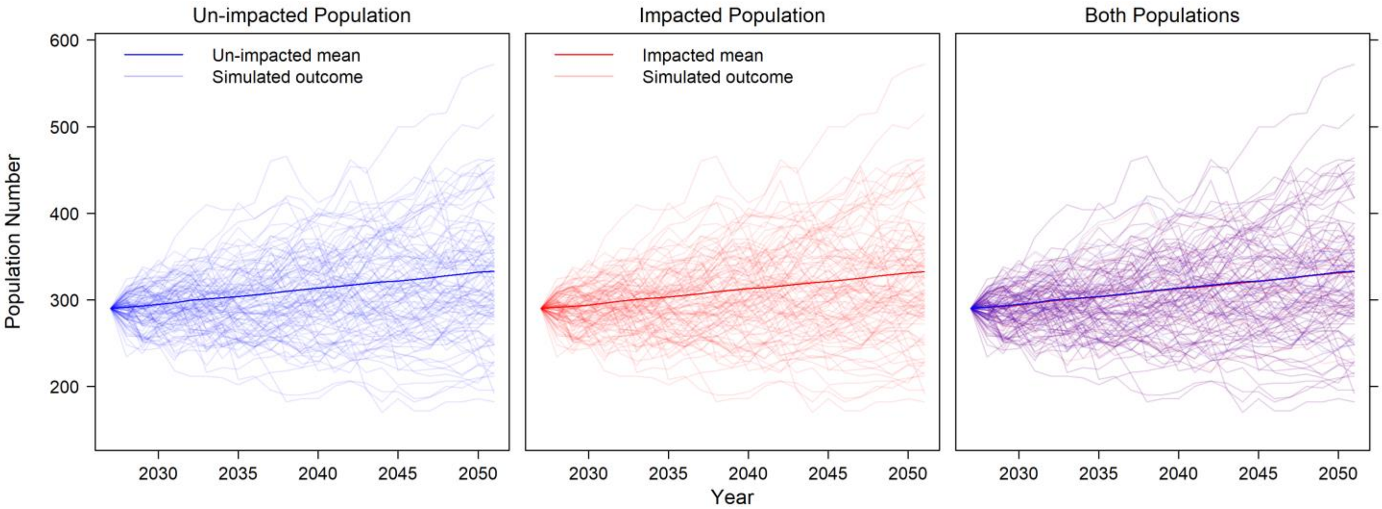

Figure B. 10: Simulated bottlenose dolphin population trajectories (fertility rate = 0.30) in an unimpacted versus impacted population, for the maximum spatial scenario.

B.4.2.1.19 The median counterfactual of population size for scenario BND-02b was 1.0000 throughout the 26-year simulation, whereas the mean counterfactual reduced to 0.9976 at time point 4, before increasing to 0.9981 by time point 26. Therefore, given that the differences in impacted to unimpacted populations returned to a ratio of 1 there is not considered to be a potential for an effect from piling scenario BND-02b upon bottlenose dolphin.

B.4.2.2 Cumulative projects

B.4.2.2.1 Results of the iPCoD modelling at the time points described in Table B. 12 for bottlenose dolphin using the maximum spatial cumulative scenarios are presented in Table B. 24 to Table B. 27 and illustrated in Figure B. 11 to Figure B. 14.

B.4.2.2.2 As for the two project-alone scenarios for bottlenose dolphin based upon a fertility rate of 0.22, there appears to be a decline in both impacted and unimpacted populations (see section B.4.2.1) in cumulative scenarios BND-CT, BND-CTM, BND-C1 and BND-C2, for which models were also parameterised with a fertility rate of 0.22. However, when compared directly, a lower population trajectory is visible in the third panel of Figure B. 11 to Figure B. 14 for the impacted population in all cumulative scenarios for bottlenose dolphin, regardless of fertility rate.

Scenario BND-CT: Morgan and Morecambe Offshore Wind Farms: Transmission Assets

B.4.2.2.3 For scenario BND-CT, in which a total of 90 days of piling occur at the Morgan Generation Assets alongside a maximum of six days of piling at the Morgan and Morecambe Offshore Wind Farms: Transmission Assets, these results indicate a fluctuation of a maximum one fewer animal in the impacted population, compared to the unimpacted population (Table B. 24), throughout the simulation.

B.4.2.2.4 At time point 7, which corresponds to the six-year reporting period formerly required under the Habitats Directive, the difference between impacted and unimpacted populations is zero animals (0.000% of the reference population). When compared to the equivalent time point from scenario BND-02a (maximum spatial scenario for the Morgan Generation Assets alone, using the lower fertility rate of 0.22: n = 1), this is a difference of one animal.

B.4.2.2.5 The median counterfactual of population size for scenario BND-CT was 1.0000 at the end of the 26-year simulation, while the mean counterfactual was 0.9986 (Table B. 24). Therefore, given that the differences in disturbed to undisturbed populations approaches a ratio of 1 there is not considered to be a potential for a long-term MU population-level effect from this cumulative piling scenario upon harbour porpoise.

Table B. 24: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for bottlenose dolphin for cumulative scenario BND-CT.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	290	**290**	290	290	**290**	290	1.0000	1.0000
2	256	**288**	314	256	**288**	314	0.9996	1.0000
3	242	**285**	320	242	**285**	320	0.9982	1.0000
7	214	**278**	334	214	**278**	334	0.9984	1.0000
9	204	**274**	342	204	**274**	342	0.9986	1.0000
11	200	**270**	342	198	**270**	342	0.9986	1.0000
13	190	**265**	340	190	**265**	340	0.9986	1.0000
21	158	**252**	358	156	**251**	358	0.9987	1.0000
26	144	**243**	356	144	**243**	356	0.9986	1.0000

B.4.2.2.6 This suggests that after an initial effect of disturbance upon the bottlenose dolphin population from the cumulative projects, peaking approximately five years after the start of piling, this effect is expected to stabilise across the duration of the modelled time series (i.e. the counterfactual of population size is not expected to reduce below the ratio predicted at six years).

B.4.2.2.7 As for the maximum temporal and maximum spatial scenarios for the Morgan Generation Assets alone, there appears to be a decline in both impacted and unimpacted populations for bottlenose dolphin (see section B.4.2.1). However, when compared directly, a slightly lower population trajectory is visible in the third panel of Figure B. 11 for the impacted population for cumulative scenario HP-C1.

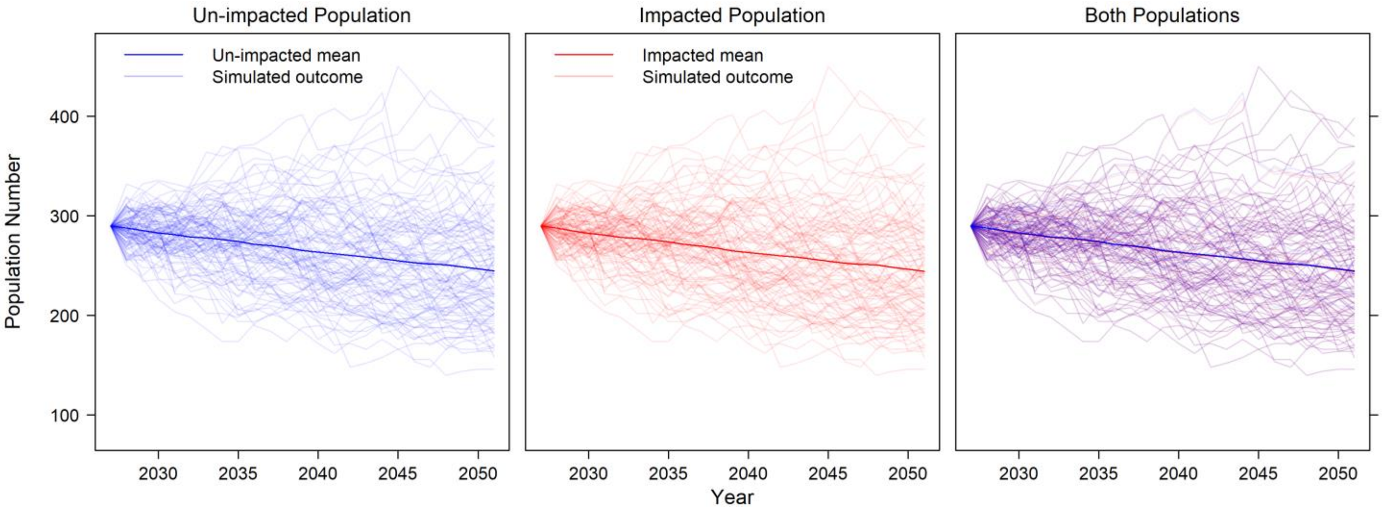

Figure B. 11: Simulated bottlenose dolphin population trajectories in an unimpacted versus impacted population, for cumulative scenario BND-CT (Morgan and Morecambe Offshore Wind Farms: Transmission Assets only).

Scenario BND-CTM: Morgan and Morecambe Offshore Wind Farms: Transmission Assets and Morecambe Generation Assets

B.4.2.2.8 For scenario BND-CTM, in which a total of 90 days of piling occur at the Morgan Generation Assets alongside a maximum of six days of piling at the Morgan and Morecambe Offshore Wind Farms: Transmission Assets and up to 42 days of piling at Morecambe Generation Assets, these results indicate a fluctuation of a maximum one fewer animal in the impacted population, compared to the unimpacted population (Table B. 24), throughout the simulation.

B.4.2.2.9 At time point 7, which corresponds to the six-year reporting period formerly required under the Habitats Directive, the difference between impacted and unimpacted populations is zero animals (0.000% of the reference population). When compared to the equivalent time point from scenario BND-02a (maximum spatial scenario for the Morgan Generation Assets alone, using the lower fertility rate of 0.22: n = 0), there is also no difference.

B.4.2.2.10 When compared to the equivalent time point from scenario BND-CT (Morgan Generation Assets alongside piling at the Morgan and Morecambe Offshore Wind Farms: Transmission Assets) the difference is one animal. It is important to emphasise, however, that the small fluctuations (i.e. a maximum of one animal) in these particular trajectories suggest that any difference at time point 26 may simply be an artefact of the respective model simulations.

Table B. 25: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for bottlenose dolphin for cumulative scenario BND-CTM.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	290	**290**	290	290	**290**	290	1.0000	1.0000
2	256	**288**	314	256	**288**	314	0.9995	1.0000
3	244	**285**	322	242	**285**	320	0.9981	1.0000

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
7	220	**278**	336	220	**278**	336	0.9982	1.0000
9	212	**275**	342	212	**274**	342	0.9984	1.0000
11	202	**271**	344	202	**271**	344	0.9984	1.0000
13	196	**268**	344	196	**268**	344	0.9984	1.0000
21	166	**253**	350	166	**253**	348	0.9984	1.0000
26	150	**245**	358	150	**245**	356	0.9984	1.0000

B.4.2.2.11 The median counterfactual of population size for scenario BND-CTM was 1.0000 at the end of the 26-year simulation, while the mean counterfactual was 0.9984 (Table B. 24). Therefore, given that the differences in disturbed to undisturbed populations approaches a ratio of 1 there is not considered to be a potential for a long-term MU population-level effect from this cumulative piling scenario upon harbour porpoise.

B.4.2.2.12 This suggests that after an initial effect of disturbance upon the bottlenose dolphin population from the cumulative projects, peaking approximately five years after the start of piling, this effect is expected to stabilise across the duration of the modelled time series (i.e. the counterfactual of population size is not expected to reduce below the ratio predicted at six years).

B.4.2.2.13 As for the maximum temporal and maximum spatial scenarios for the Morgan Generation Assets alone (section B.4.2.1), there appears to be a decline in both impacted and unimpacted populations for bottlenose dolphin (Figure B. 12).

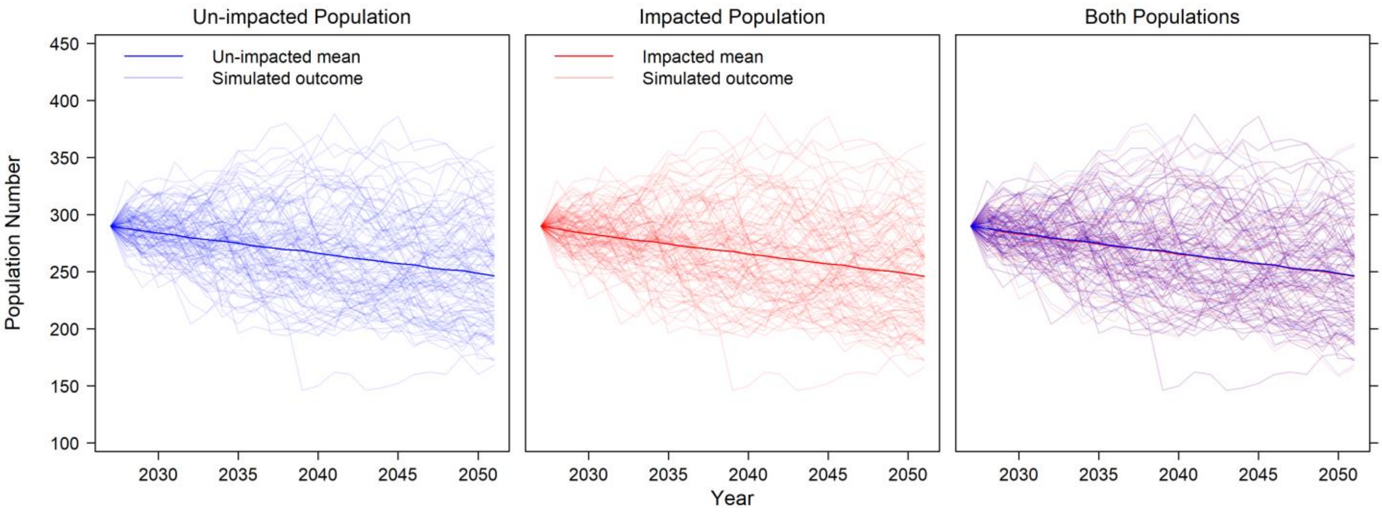

Figure B. 12:Simulated bottlenose dolphin population trajectories in an unimpacted versus impacted population, for cumulative scenario BND-CTM (Morgan and Morecambe Offshore Wind Farms: Transmission Assets and Morecambe Generation Assets).

Scenario BND-C1: Tier 1 projects

B.4.2.2.14 For scenario BND-C1a, in which a total of 90 days of piling occur at the Morgan Generation Assets alongside up to 90 days of piling at the Mona Offshore Wind Project and up to 201 days of piling at Awel y Môr, these results indicate a difference of five fewer animals in the impacted population at time point 26, compared to the unimpacted population (Table B. 26).

B.4.2.2.15 At time point 7, which corresponds to the six-year reporting period formerly required under the Habitats Directive, the difference between impacted (n = 273) and unimpacted populations (n = 280) is seven animals (2.391% of the reference population). When compared to the equivalent impacted population estimate from scenario BND-02a (i.e. the maximum spatial scenario for the Morgan Generation Assets alone, using a fertility rate of 0.22: n = 278), this is a difference of five animals.

Table B. 26: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for bottlenose dolphin under the maximum spatial scenario BND-C1.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	290	**290**	290	290	**290**	290	1.0000	1.0000
2	260	**288**	314	260	**288**	314	0.9983	1.0000
3	246	**286**	322	236	**281**	322	0.9810	1.0000
7	224	**280**	336	212	**273**	336	0.9760	1.0000
8	218	**277**	342	206	**271**	336	0.9775	1.0000
9	212	**275**	344	204	**270**	342	0.9788	1.0000
11	208	**272**	348	198	**266**	346	0.9796	1.0000
13	194	**268**	342	188	**262**	340	0.9788	1.0000
21	168	**253**	354	160	**247**	350	0.9785	1.0000
26	150	**242**	354	144	**237**	348	0.9783	1.0000

B.4.2.2.16 As for the maximum temporal and maximum spatial scenarios for the Morgan Generation Assets alone, there appears to be a decline in both impacted and unimpacted populations for bottlenose dolphin (see section B.4.2.1). However, when compared directly, a slightly lower population trajectory is visible in the third panel of Figure B. 13 for the impacted versus the unimpacted population, for cumulative scenario BND-C1.

B.4.2.2.17 The potential effect from cumulative piling upon the bottlenose dolphin population within the IS MU would be expected to reduce over the longer term, although this should be considered against a background of an already contracting population (given an estimated fertility rate of 0.22).

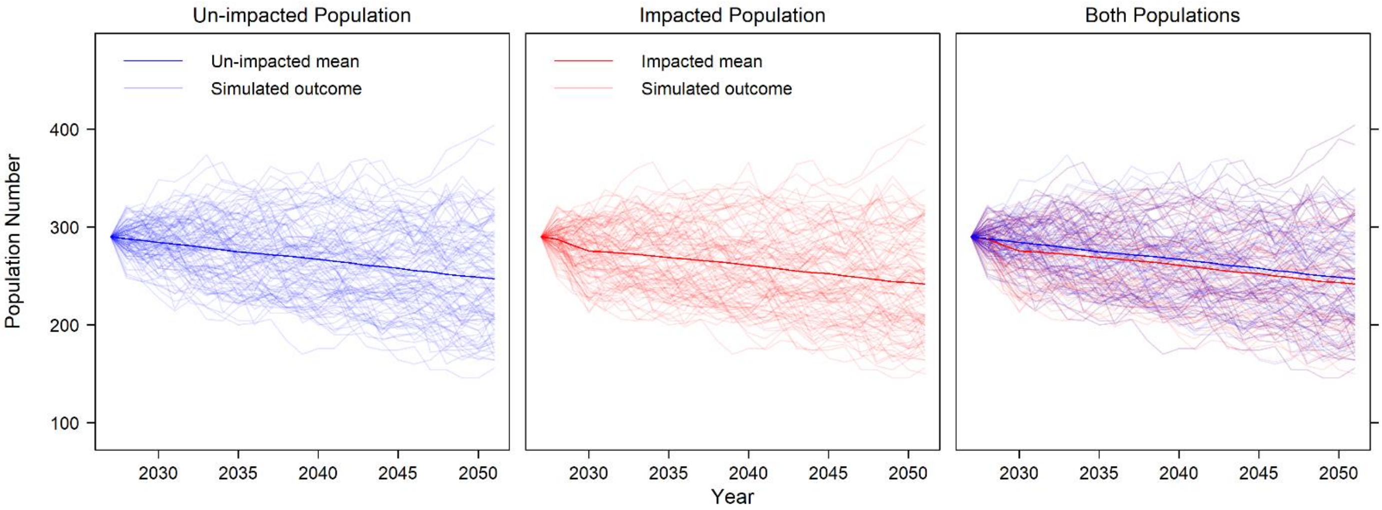

Figure B. 13: Simulated bottlenose dolphin population trajectories in an unimpacted versus impacted population, for cumulative scenario BND-C1 (Tier 1 projects only).

B.4.2.2.18 The median counterfactual of population size for scenario BND-C1a was 1.0000 throughout the 26-year simulation, while the mean counterfactual ratio at time point 26 was 0.9783. However, given that the differences in impacted to unimpacted populations at all time points approaches a ratio of 1 there is expected to be no potential for a long-term effect from cumulative piling scenario BND-C1 upon the IS MU bottlenose dolphin population.

B.4.2.2.19 The lowest counterfactual of 0.9696 was calculated at time point 4, and at time point 7 this was 0.9760. This suggests that after an initial effect of disturbance upon the bottlenose dolphin population from the cumulative projects, peaking approximately three years after the start of piling, this effect is expected to stabilise across the duration of the modelled time series (i.e. the counterfactual of population size is not expected to reduce below the ratio predicted at six years).

Scenario BND-C2: Tier 1 and Tier 2 projects

B.4.2.2.20 For scenario BND-C2, in which a total of 90 days of piling occur at the Morgan Generation Assets alongside a total of 435 piling days at Tier 1 and Tier 2 cumulative projects (Table B. 10), these results indicate a difference of six fewer animals in the impacted population at time point 26, compared to the unimpacted population (Table B. 27).

B.4.2.2.21 At time point 7, which corresponds to the six-year reporting period formerly required under the Habitats Directive, the difference between impacted (n = 272) and unimpacted (n = 279) populations is seven animals (2.389% of the reference population). When compared to the equivalent impacted population estimate from scenario BND-02 (i.e. the maximum spatial scenario for the Morgan Generation Assets alone: n = 278), this is a difference of six animals, and when compared to scenario BND-C1 (i.e. Tier 1 projects only: n = 273), this is a difference of one animal.

Table B. 27: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for bottlenose dolphin under the maximum spatial scenario BND-C2.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	290	**290**	290	290	**290**	290	1.0000	1.0000
2	256	**288**	314	254	**288**	314	0.9982	1.0000
3	246	**287**	322	234	**281**	320	0.9800	1.0000
7	220	**279**	342	210	**272**	340	0.9749	1.0000
8	212	**277**	340	206	**270**	338	0.9762	1.0000
9	204	**274**	340	200	**268**	338	0.9772	1.0000
11	200	**271**	342	194	**265**	338	0.9782	1.0000
13	192	**267**	344	188	**261**	340	0.9771	1.0000
21	162	**252**	358	158	**246**	352	0.9762	1.0000
26	152	**244**	352	148	**238**	348	0.9762	1.0000

B.4.2.2.22 The median counterfactual of population size for scenario BND-C2 was 1.0000 throughout the 26-year simulation, while the mean counterfactual at time point 26 was 0.9762. However, given that the differences in impacted to unimpacted populations at all time points approach a ratio of 1 there is expected to be no potential for a long-term effect from cumulative piling scenario BND-C2 upon the IS MU bottlenose dolphin population.

B.4.2.2.23 The lowest counterfactual of 0.9687 was calculated at time point 4, and at time point 7 this was 0.9749. This suggests that after an initial effect of disturbance upon the bottlenose dolphin population from the cumulative projects, peaking approximately three years after the start of piling (i.e. time point 4), this effect is expected to stabilise across the duration of the modelled time series, and the counterfactual of population size is not expected to reduce below the ratio predicted at six years (Figure B. 14).

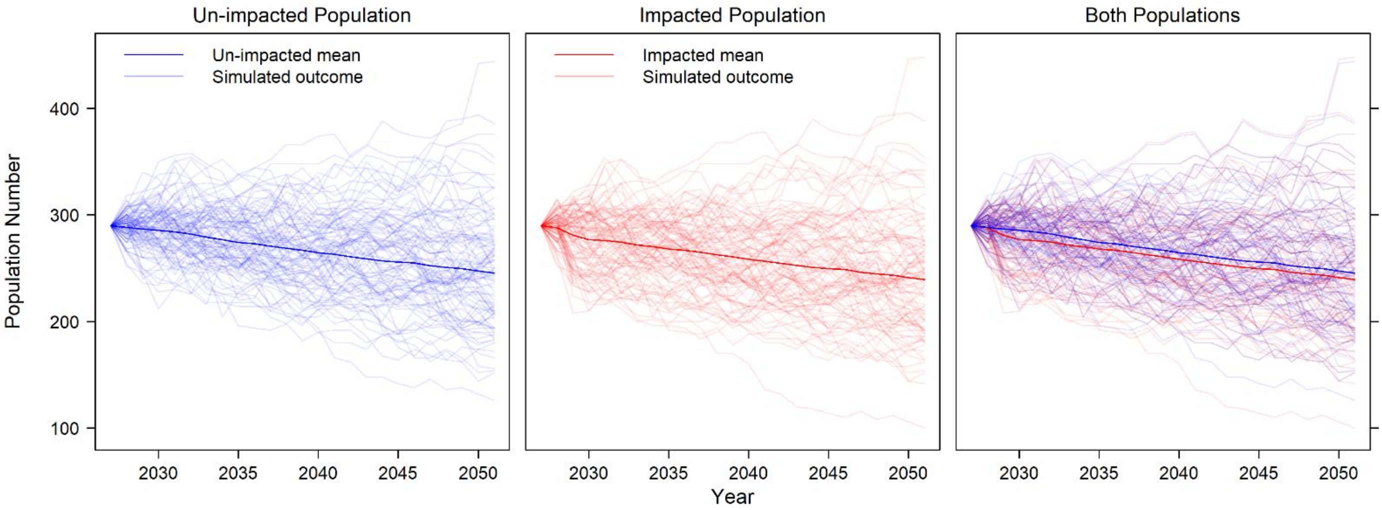

Figure B. 14: Simulated bottlenose dolphin population trajectories in unimpacted versus impacted populations, for cumulative scenario BND-C2 (Tier 1 and Tier 2 projects).

B.4.3 Minke whale

B.4.3.1 Project alone

B.4.3.1.1 Results of the iPCoD modelling for minke whale, at the time points described in Table B. 8, under the maximum temporal and maximum spatial scenarios for the Morgan Generation Assets alone, are presented in Table B. 28 and Table B. 29. Simulated trajectories of both unimpacted and impacted populations of minke whale appear to be broadly stable in size and are illustrated in Figure B. 15 and Figure B. 16, respectively.

Scenario MW-01: maximum temporal scenario

B.4.3.1.2 For the maximum temporal scenario the results of iPCoD simulations indicate a very small difference in the trajectory of minke whale between the unimpacted population and impacted population (Table B. 28). At all time points there was very little difference in the mean size of the impacted and unimpacted populations (Figure B. 15).

B.4.3.1.3 At time point 3, which represents the end of the two-year piling phase, the impacted population was predicted to be five animals smaller than the unimpacted population. At time point 7, representing six years following the start of piling, and corresponding to the six-year reporting period formerly required under the Habitats Directive, the difference between impacted and unimpacted populations was 13 animals, corresponding to approximately 0.065% of the CGNS reference population.

Table B. 28: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for minke whale under the maximum temporal scenario.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	20,120	**20,120**	20,120	20,120	**20,120**	20,120	1.0000	1.0000
2	17,863	**20,131**	21,876	17,863	**20,131**	21,876	1.0000	1.0000

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
3	17,580	**20,169**	22,496	17,574	**20,164**	22,492	0.9998	0.9999
7	16,676	**20,041**	23,578	16,653	**20,028**	23,578	0.9994	0.9998
9	16,249	**19,965**	24,022	16,249	**19,950**	24,022	0.9992	0.9996
11	16,131	**19,945**	24,646	16,089	**19,928**	24,630	0.9991	0.9995
13	15,752	**19,969**	24,752	15,728	**19,949**	24,739	0.9990	0.9994
21	15,001	**19,926**	25,997	14,997	**19,906**	25,997	0.9990	0.9994
26	14,616	**19,907**	26,835	14,616	**19,888**	26,831	0.9990	0.9995

B.4.3.1.4 At time point 26, which represents the population at the end point of the iPCoD modelling, 25 years after the start of piling (and 23 years after the cessation of piling), this difference has increased to 19 animals, corresponding to approximately 0.095% of the reference population (Table B. 26). This suggests that there would not be a long-term increase in any potential effect from piling upon the minke whale population within the CGNS MU.

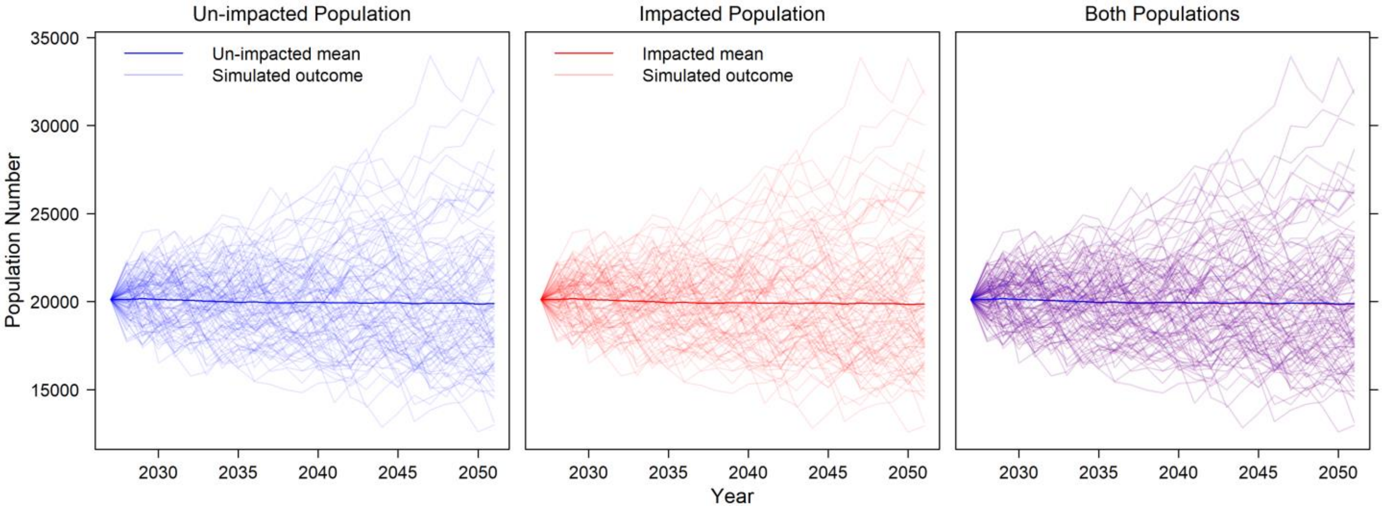

Figure B. 15: Simulated minke whale population trajectories in an unimpacted versus impacted population, for the maximum temporal scenario.

B.4.3.1.5 The median counterfactual for scenario MW-01 reduced from 1.0000 to 0.9995 through the 26-year simulation, whereas the mean counterfactual reduced to 0.9990. Therefore, given that the differences in disturbed to un-disturbed populations approaches a ratio of 1 there is not considered to be a potential for a long-term effect from this piling scenario upon minke whale.

Scenario MW-02: maximum spatial scenario

B.4.3.1.6 For the maximum spatial scenario the results indicate a very small difference in the population trajectory of minke whale between the unimpacted population and impacted population (Table B. 29 and Figure B. 16).

B.4.3.1.7 At all time points there was very little difference in the mean size of the impacted and unimpacted populations. At time point 3, corresponding to the end of the two-year piling phase, the impacted population was predicted to be 10 fewer than the unimpacted population, corresponding to approximately 0.050% of the reference population. At time point 7, representing six years following the start of piling, and corresponding to the six-year reporting period formerly required under the Habitats Directive, the difference between impacted and unimpacted populations was 25 animals (approximately 0.124% of the reference population).

B.4.3.1.8 At time point 26, which represents the population at the end point of the iPCoD modelling, 25 years after the start of piling (and 23 years after the cessation of piling), this difference was 38 animals, equivalent to approximately 0.189% of the reference population (Table B. 29). This suggests that there would not be a long-term increase in any potential effect from piling upon the minke whale population within the CGNS MU.

Table B. 29: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for minke whale under the maximum spatial scenario.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	20,120	**20,120**	20,120	20,120	**20,120**	20,120	1.0000	1.0000
2	17,834	**20,097**	21,826	17,832	**20,094**	21,820	0.9999	1.0000
3	17,726	**20,147**	22,531	17,716	**20,137**	22,527	0.9995	0.9997
7	16,694	**20,075**	23,650	16,676	**20,050**	23,639	0.9988	0.9991
9	16,430	**20,038**	24,277	16,412	**20,009**	24,223	0.9985	0.9989
11	16,065	**19,992**	24,320	16,014	**19,959**	24,276	0.9983	0.9988
13	15,830	**20,052**	24,779	15,806	**20,015**	24,752	0.9982	0.9986
21	14,906	**19,975**	26,283	14,858	**19,936**	26,187	0.9980	0.9984
26	14,488	**19,953**	27,277	14,486	**19,915**	27,221	0.9981	0.9985

B.4.3.1.9 The median counterfactual of population size for scenario MW-02 was 0.9985 at the end of the 26-year simulation, whereas the mean counterfactual ratio at time point 26 had reduced from 1.0000 to 0.9981. Therefore, given that the differences in disturbed to undisturbed populations approaches a ratio of 1 there is not considered to be a potential for a long-term effect from this piling scenario upon minke whale.

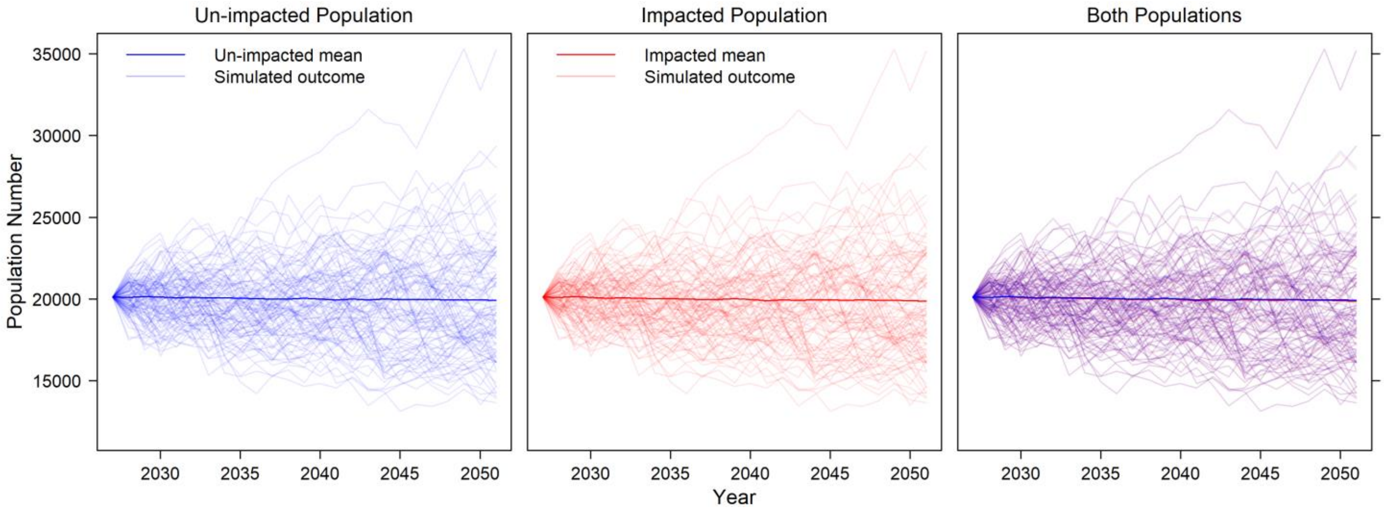

Figure B. 16:Simulated minke whale population trajectories in an unimpacted versus impacted population, for the maximum temporal scenario.

B.4.3.2 Cumulative projects

B.4.3.2.1 Results of the iPCoD modelling at the time points described in Table B. 11 for minke whale using the maximum spatial cumulative scenarios are presented in Table B. 30 to Table B. 33 and illustrated in Figure B. 17 to Figure B. 20.

Scenario MW-CT: Morgan and Morecambe Offshore Wind Farms: Transmission Assets

B.4.3.2.2 For scenario MW-CT, in which a total of 90 days of piling occur at the Morgan Generation Assets alongside a total of four piling days at the Morgan and Morecambe Offshore Wind Farms: Transmission Assets, these results indicate a difference of 36 fewer animals in the impacted population at time point 26, compared to the unimpacted population (Table B. 30).

B.4.3.2.3 At time point 7, which corresponds to the six-year reporting period formerly required under the Habitats Directive, the difference between impacted and unimpacted populations is 24 animals (0.119% of the reference population). When compared to the equivalent time point from scenario MW-02 (maximum spatial scenario for the Morgan Generation Assets alone: n = 25), this is a difference of one animal.

B.4.3.2.4 The median counterfactual of population size for scenario MW-CT was 0.9986 at the end of the 26-year simulation, while the mean counterfactual was 0.9982 (Table B. 30). Therefore, given that the differences in disturbed to undisturbed populations approaches a ratio of 1 there is not considered to be a potential for a long-term MU population-level effect from this cumulative piling scenario upon minke whale.

Table B. 30: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for minke whale for cumulative scenario MW-CT.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	20,120	**20,120**	20,120	20,120	**20,120**	20,120	1.0000	1.0000

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
2	17,911	**20,110**	21,836	17,907	**20,107**	21,834	0.9999	1.0000
3	17,536	**20,119**	22,513	17,529	**20,109**	22,507	0.9995	0.9997
7	16,790	**20,092**	23,666	16,780	**20,068**	23,658	0.9988	0.9993
9	16,410	**20,136**	24,403	16,372	**20,108**	24,391	0.9986	0.9991
11	15,965	**20,080**	24,876	15,872	**20,048**	24,841	0.9984	0.9989
13	15,637	**20,071**	25,104	15,635	**20,036**	25,056	0.9982	0.9987
21	14,844	**20,068**	26,327	14,806	**20,030**	26,275	0.9981	0.9985
26	14,444	**19,977**	27,843	14,384	**19,941**	27,767	0.9982	0.9986

B.4.3.2.5 As for the maximum temporal and maximum spatial scenarios for the Morgan Generation Assets alone (section B.4.3.1, both the impacted and unimpacted populations for minke whale appear to be stable. A slight difference in the impacted and unimpacted population trajectories is visible in the third panel of Figure B. 17, although this difference is very small.

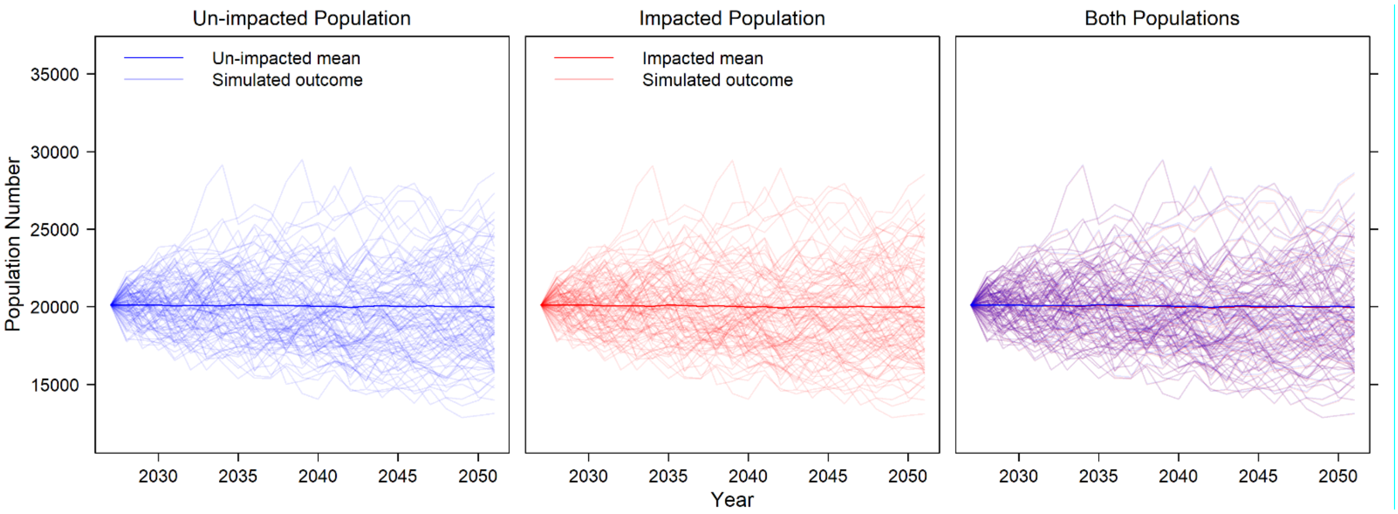

Figure B. 17:Simulated minke whale population trajectories in an unimpacted versus impacted population, for cumulative scenario HP-CT (Morgan and Morecambe Offshore Wind Farms: Transmission Assets only).

Scenario MW-CTM: Morgan and Morecambe Offshore Wind Farms: Transmission Assets and Morecambe Generation Assets

B.4.3.2.6 For scenario MW-CTM, in which a total of 90 days of piling occur at the Morgan Generation Assets alongside a total of four piling days at the Morgan and Morecambe Offshore Wind Farms: Transmission Assets and up to 42 days at Morecambe Generation Assets, these results indicate a difference of 38 fewer animals in the impacted population at time point 26 (equivalent to approximately 0.189% of the reference population), compared to the unimpacted population (Table B. 31).

B.4.3.2.7 At time point 7, which corresponds to the six-year reporting period formerly required under the Habitats Directive, the difference between impacted and unimpacted populations is 25 animals (0.124% of the reference population). When compared to the size difference for impacted versus unimpacted populations at the equivalent time point from scenario MW-02 (maximum spatial scenario for the Morgan Generation Assets alone: n = 25), this is no difference for scenario MW-CTM.

B.4.3.2.8 The median counterfactual of population size for scenario MW-CTM was 0.9986 at the end of the 26-year simulation, while the mean counterfactual was 0.9981 (Table B. 31). Therefore, given that the differences in disturbed to undisturbed populations approaches a ratio of 1 there is not considered to be a potential for a long-term MU population-level effect from this cumulative piling scenario upon minke whale.

Table B. 31: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for minke whale for cumulative scenario MW-CTM.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	20,120	20,120	20,120	20,120	20,120	20,120	1.0000	1.0000
2	18,032	20,142	21,828	18,028	20,140	21,818	0.9999	1.0000
3	17,599	20,135	22,567	17,580	20,124	22,537	0.9995	0.9997
7	16,796	20,138	23,723	16,761	20,113	23,723	0.9988	0.9991
9	16,342	20,159	24,560	16,332	20,130	24,516	0.9985	0.9990
11	16,415	20,136	25,017	16,395	20,102	24,978	0.9983	0.9988
13	16,148	20,151	25,499	16,100	20,115	25,460	0.9982	0.9986
21	14,984	20,014	26,686	14,984	19,974	26,654	0.9980	0.9985
26	14,611	19,936	26,989	14,565	19,898	26,866	0.9981	0.9986

B.4.3.2.9 As for the maximum temporal and maximum spatial scenarios for the Morgan Generation Assets alone and MW-CT for the addition of the Morgan and Morecambe Offshore Wind Farms: Transmission Assets, (section B.4.3.1) both the impacted and unimpacted populations for minke whale appear to be stable. When compared directly, a slight difference in the impacted and unimpacted population trajectories is visible in the third panel of Figure B. 18 although this difference is very small.

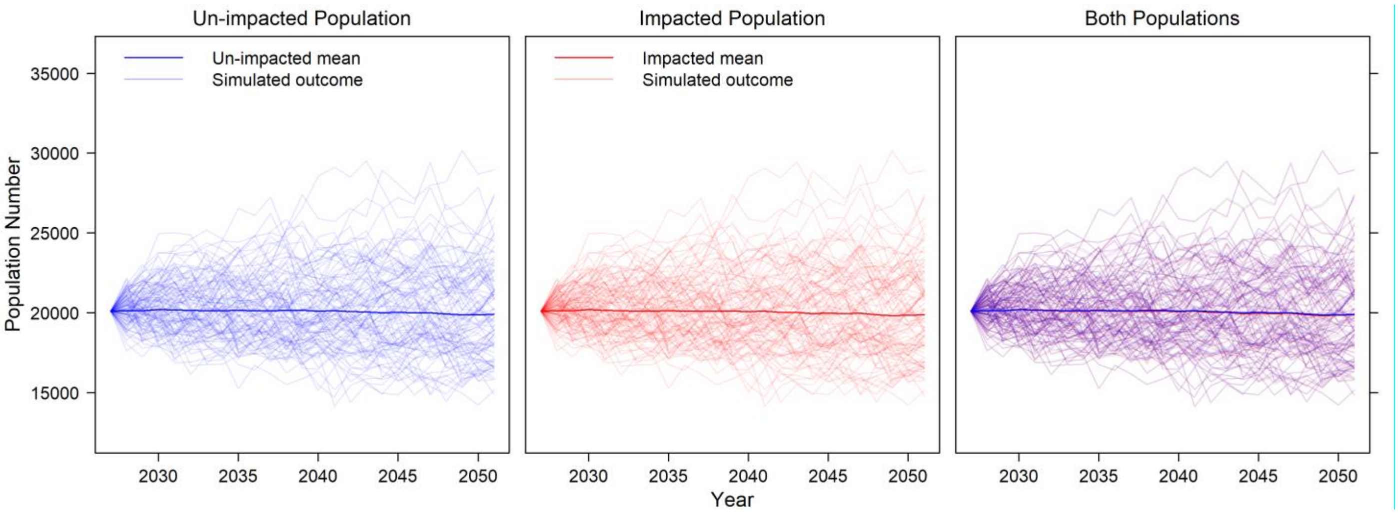

Figure B. 18:Simulated minke whale population trajectories in an unimpacted versus impacted population, for cumulative scenario MW-CTM (Morgan and Morecambe Offshore Wind Farms: Transmission Assets and Morecambe Generation Assets).

Scenario MW-C1: Tier 1 projects

B.4.3.2.10 For scenario MW-C1, in which a total of 90 days of piling occur at the Morgan Generation Assets alongside a total of 225 piling days across Tier 1 cumulative projects (18 days at Project Erebus, six days at White Cross Offshore Wind Farm and 201 days at Awel y Môr), these results indicate a difference of 40 fewer animals in the impacted population at time point 26, compared to the unimpacted population (Table B. 18).

Table B. 32: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for minke whale for cumulative piling scenario MW-C1.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	20,120	**20,120**	20,120	20,120	**20,120**	20,120	1.0000	1.0000
3	17,242	**20,106**	22,595	17,242	**20,106**	22,595	1.0000	1.0000
4	17,070	**20,114**	22,962	17,064	**20,111**	22,956	0.9999	1.0000
5	17,150	**20,087**	23,302	17,130	**20,076**	23,296	0.9995	0.9997
7	16,716	**20,014**	23,686	16,693	**19,994**	23,681	0.9990	0.9994
9	16,331	**19,962**	24,332	16,275	**19,936**	24,329	0.9987	0.9991
10	16,383	**20,015**	24,258	16,348	**19,986**	24,262	0.9986	0.9990
11	16,199	**20,013**	24,674	16,199	**19,982**	24,584	0.9985	0.9989
13	15,998	**20,009**	25,089	15,924	**19,974**	25,007	0.9983	0.9987

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
15	15,220	**19,931**	25,472	15,178	**19,893**	25,415	0.9981	0.9986
23	14,559	**19,827**	26,600	14,520	**19,786**	26,492	0.9980	0.9984
26	14,418	**19,903**	27,041	14,382	**19,864**	26,961	0.9980	0.9984

B.4.3.2.11 At time point 7, which corresponds to the six-year reporting period formerly required under the Habitats Directive, the difference between impacted and unimpacted populations is 20 animals (0.099% of the reference population). When compared to the equivalent population estimate from scenario MW-02 (n = 25), this is a difference between of five animals.

B.4.3.2.12 The median counterfactual of population size for scenario MW-C1 was 0.9984 at the end of the 26-year simulation, while the mean counterfactual was 0.9980. Therefore, given that the differences in disturbed to un-disturbed populations approaches a ratio of 1 there is not considered to be a potential for a long-term MU population-level effect from this cumulative piling scenario upon minke whale.

B.4.3.2.13 As for scenarios MW-01 and MW-02 for the Morgan Generation Assets alone (see section B.4.3.1), both the impacted and unimpacted populations for minke whale appear to be stable. However, when compared directly, a slightly lower population trajectory is visible in the third panel of Figure B. 19 for the impacted population for cumulative scenario MW-C1.

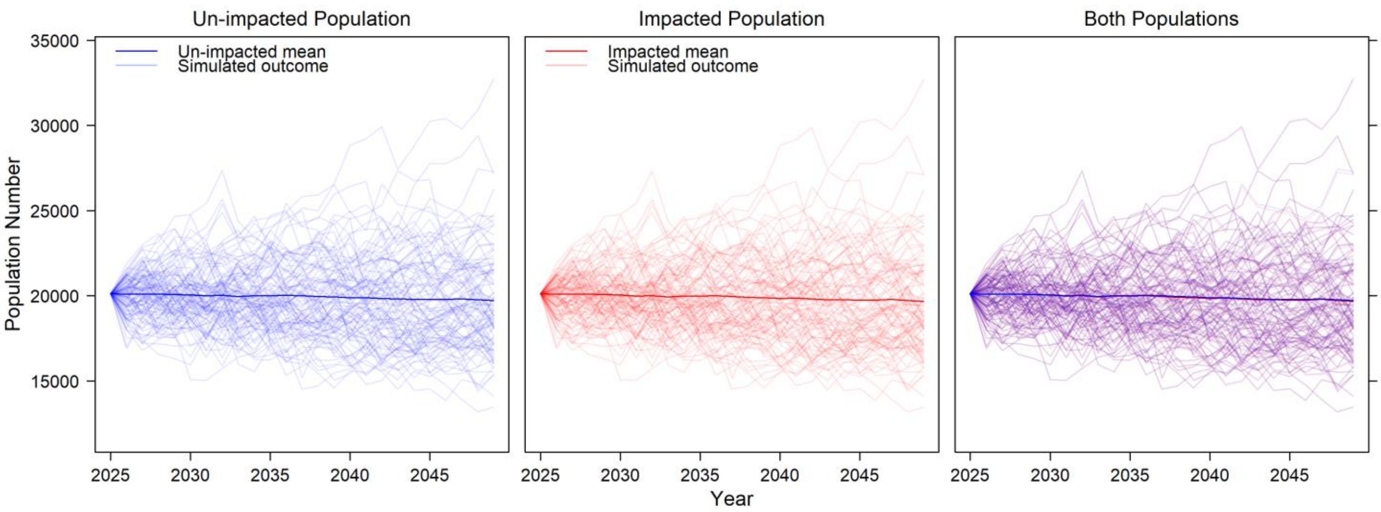

Figure B. 19:Simulated minke whale population trajectories in an unimpacted versus impacted population, for cumulative scenario MW-C1 (Tier 1 projects only).

Scenario MW-C2: Tier 1 and Tier 2 projects

B.4.3.2.14 The results for scenario MW-C2 (i.e. 90 days of piling for the Morgan Generation Assets alongside up to 451 piling days from Tier 1 and Tier 2 cumulative projects) indicate a similar pattern in the population trajectory as scenario MW-C1 (Table B. 33).

B.4.3.2.15 The impacted population size at time point 26 is estimated to be 40 animals fewer than the unimpacted population (0.199% of the reference population), and for time point 7, this difference reduces to 20 animals fewer than the unimpacted population. As for scenario MW-C1 (i.e. piling at the Morgan Generation Assets alongside piling at Tier 1 cumulative projects), both the impacted and unimpacted populations for minke whale appear to be stable. Similarly for scenario MW-C1, when compared directly, a slight difference in the impacted and unimpacted population trajectories is visible in the third panel of Figure B. 20, although this difference is very small.

Table B. 33: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for minke whale for cumulative piling scenario MW-C2.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	20,120	**20,120**	20,120	20,120	**20,120**	20,120	1.0000	1.0000
3	17,550	**20,169**	22,547	17,550	**20,169**	22,547	1.0000	1.0000
4	17,132	**20,136**	22,912	17,132	**20,133**	22,911	0.9999	1.0000
5	17,027	**20,101**	23,151	17,011	**20,091**	23,150	0.9995	0.9997
7	16,784	**20,089**	23,823	16,769	**20,069**	23,801	0.9990	0.9994
9	16,458	**20,120**	24,070	16,408	**20,093**	24,040	0.9987	0.9992
10	16,222	**20,088**	24,390	16,172	**20,059**	24,375	0.9986	0.9991
11	16,251	**20,090**	24,248	16,207	**20,059**	24,178	0.9985	0.9990
13	15,937	**20,109**	25,161	15,937	**20,073**	25,061	0.9983	0.9988
15	15,574	**20,043**	25,380	15,567	**20,005**	25,354	0.9981	0.9986
23	14,383	**19,950**	26,635	14,271	**19,909**	26,554	0.9980	0.9985
26	14,421	**19,951**	27,661	14,382	**19,911**	27,526	0.9980	0.9985

B.4.3.2.16 The median counterfactual of population size for scenario MW-C2 was 0.9985 at the end of the 26-year simulation, while the mean counterfactual at the same time point was 0.9980. Therefore, given that the differences in disturbed to undisturbed populations approaches a ratio of 1 there is not considered to be a potential for a long-term MU population-level effect from this cumulative piling scenario upon minke whale.

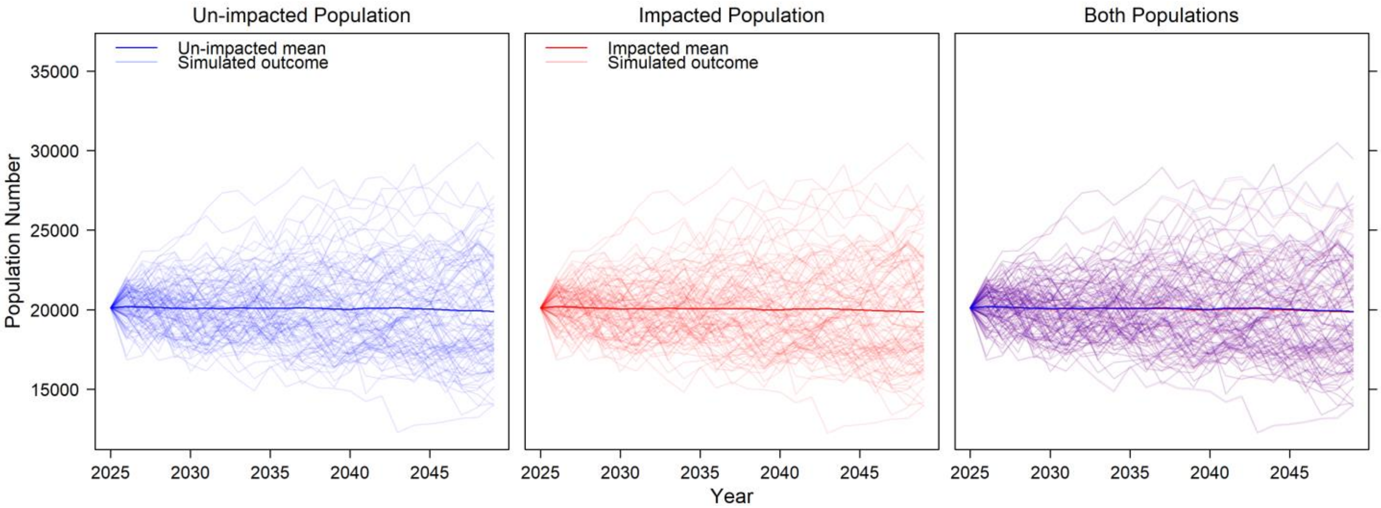

Figure B. 20:Simulated minke whale population trajectories in unimpacted versus impacted populations, for cumulative scenario MW-C2 (Tier 1 and Tier 2 projects).

B.4.4 Grey seal

B.4.4.1 Project alone

B.4.4.1.1 Results of the iPCoD modelling at the time points described in Table B. 8 for grey seal under the maximum temporal and maximum spatial piling scenarios are presented in Table B. 34 and Table B. 35. Based upon the vital rates used to parameterise these models, simulated trajectories of the GSRP to be increasing in size and are illustrated in Figure B. 21 and Figure B. 22.

B.4.4.1.2 For grey seal, iPCoD models incorporating the maximum temporal scenario and the maximum spatial scenario were based upon two reference populations: the GSRP (as described in section B.3.3 and Table B. 4).

Scenario GS-01: maximum temporal scenario

B.4.4.1.3 For the maximum temporal scenario for the GSRP, the results of iPCoD modelling indicate no difference in the population trajectory of grey seal between the unimpacted population and impacted population (Table B. 34 and Figure B. 21).

B.4.4.1.4 At all time points there was a no difference in the mean size of the impacted and unimpacted populations. This includes at time point 3 (cessation of two-year piling phase), time point 7 (corresponding to the six-year reporting period formerly required under the Habitats Directive) and time point 26 (25 years after the start of the piling phase). This suggests that there would not be a short- or long-term effect from piling at the Morgan Generation Assets upon the grey seal population within the SMUs that comprise the GSRP.

Table B. 34: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for grey seal under the maximum temporal scenario.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	12,908	**12,908**	12,908	12,908	**12,908**	12,908	1.0000	1.0000
2	11,944	**13,095**	13,946	11,944	**13,095**	13,946	1.0000	1.0000
3	11,812	**13,247**	14,392	11,812	**13,247**	14,392	1.0000	1.0000
7	11,666	**13,961**	16,134	11,666	**13,961**	16,134	1.0000	1.0000
9	11,570	**14,327**	16,862	11,570	**14,327**	16,862	1.0000	1.0000
11	11,803	**14,710**	17,726	11,803	**14,710**	17,726	1.0000	1.0000
13	12,044	**15,121**	18,404	12,044	**15,121**	18,404	1.0000	1.0000
21	12,497	**16,772**	21,594	12,497	**16,772**	21,594	1.0000	1.0000
26	12,862	**17,896**	23,971	12,862	**17,896**	23,971	1.0000	1.0000

B.4.4.1.5 Both the median and mean counterfactual of population size for scenario GS-01 were 1.0000 throughout the 26-year simulation. Therefore, given that the differences between impacted and unimpacted populations equate to a ratio of 1 there is not considered to be a potential for an effect from this piling scenario upon grey seal in the SMUs that comprise the GSRP.

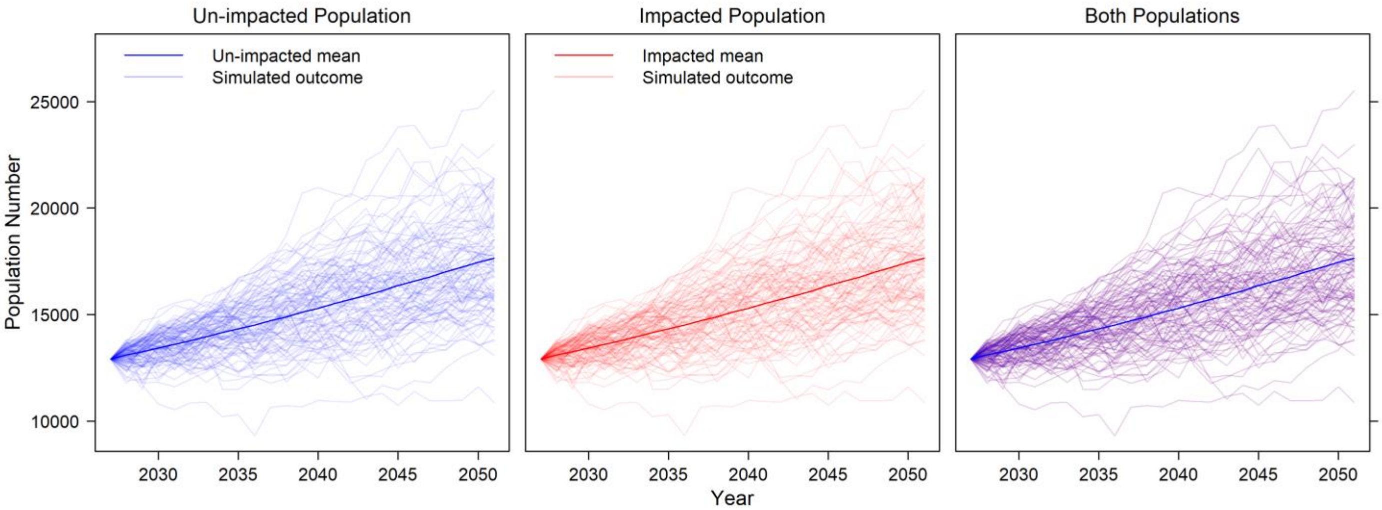

Figure B. 21: Simulated grey seal population trajectories in an unimpacted versus impacted population, for the maximum temporal scenario.

Scenario GS-02: maximum spatial scenario

B.4.4.1.6 For the maximum spatial scenario for the GSRP, the results of iPCoD modelling indicate no difference in the population trajectory of grey seal between the unimpacted population and impacted population (Table B. 35 and Figure B. 22).

B.4.4.1.7 At all time points there was a no difference in the mean size of the impacted and unimpacted populations. This includes at time point 3 (cessation of two-year piling phase), time point 7 (corresponding to the six-year reporting period formerly required under the Habitats Directive) and time point 26 (25 years after the start of the piling phase). This suggests that there would not be a short- or long-term effect from piling at the Morgan Generation Assets upon the grey seal population within the SMUs that comprise the GSRP.

Table B. 35: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for grey seal under the maximum spatial scenario.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	12,908	**12,908**	12,908	12,908	**12,908**	12,908	1.0000	1.0000
2	11,964	**13,074**	13,888	11,964	**13,074**	13,888	1.0000	1.0000
3	11,898	**13,237**	14,396	11,898	**13,237**	14,396	1.0000	1.0000
7	11,661	**13,928**	16,156	11,661	**13,928**	16,156	1.0000	1.0000
9	11,788	**14,302**	16,982	11,788	**14,302**	16,982	1.0000	1.0000
11	11,942	**14,760**	17,662	11,942	**14,760**	17,662	1.0000	1.0000
13	11,836	**15,143**	18,488	11,836	**15,143**	18,488	1.0000	1.0000
21	12,391	**16,839**	21,768	12,391	**16,839**	21,768	1.0000	1.0000
26	12,751	**17,993**	23,830	12,751	**17,993**	23,830	1.0000	1.0000

B.4.4.1.8 Both the median and mean counterfactual of population size for scenario GS-02 were 1.0000 throughout the 26-year simulation. Therefore, given that the differences between impacted and unimpacted populations equate to a ratio of 1 there is not considered to be a potential for an effect from this piling scenario upon grey seal in the SMUs that comprise the GSRP.

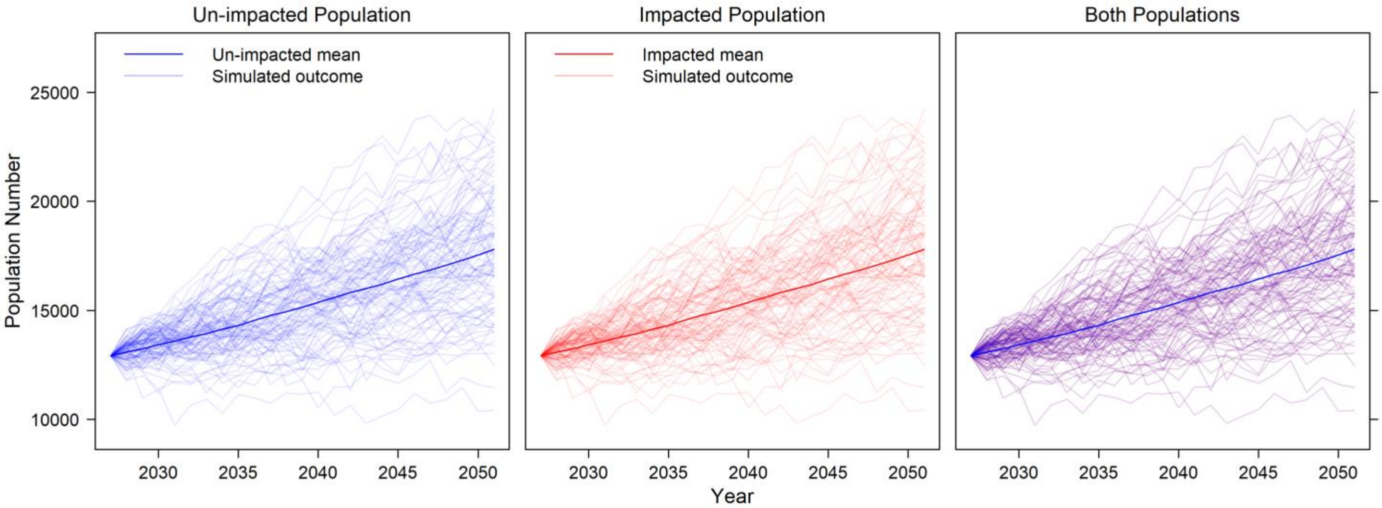

Figure B. 22:Simulated grey seal population trajectories in an unimpacted versus impacted population, for the maximum spatial scenario.

B.4.4.2 Cumulative projects

B.4.4.2.1 Results of the iPCoD modelling at the time points described in Table B. 11 for grey seal under the maximum temporal and maximum spatial piling scenarios are presented in Table B. 38 to Table B. 39. As for the Morgan Generation Assets alone, simulated trajectories of the GSRP appear to be increasing in size and are illustrated in Figure B. 23 to Figure B. 26.

Scenario GS-CT: Morgan and Morecambe Offshore Wind Farms: Transmission Assets

B.4.4.2.2 For scenario GS-CT, in which a total of 90 days of piling occur at the Morgan Generation Assets alongside a total of four piling days at the Morgan and Morecambe Offshore Wind Farms: Transmission Assets, these results indicate no difference in the size of the impacted population compared to the unimpacted population (Table B. 38).

B.4.4.2.3 At all time points there was a no difference in the mean size of the impacted and unimpacted populations. This includes at time point 3 (cessation of two-year piling phase), time point 7 (corresponding to the six-year reporting period formerly required under the Habitats Directive) and time point 26 (25 years after the start of the piling phase). This suggests that there would not be a short- or long-term effect from piling at the Morgan Generation Assets upon the grey seal population within the SMUs that comprise the GSRP.

Table B. 36: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for grey seal for cumulative piling scenario GS-CT.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	12,908	**12,908**	12,908	12,908	**12,908**	12,908	1.0000	1.0000
2	11,904	**13,066**	13,916	11,904	**13,066**	13,916	1.0000	1.0000
3	11,755	**13,237**	14,368	11,755	**13,237**	14,368	1.0000	1.0000
7	11,776	**13,938**	16,092	11,776	**13,938**	16,092	1.0000	1.0000
9	11,858	**14,342**	17,122	11,858	**14,342**	17,122	1.0000	1.0000
11	11,813	**14,758**	17,943	11,813	**14,758**	17,943	1.0000	1.0000
13	11,976	**15,159**	18,569	11,976	**15,159**	18,569	1.0000	1.0000
21	12,661	**16,868**	21,972	12,661	**16,868**	21,972	1.0000	1.0000
26	12,841	**18,003**	23,729	12,841	**18,003**	23,729	1.0000	1.0000

B.4.4.2.4 Both the median and mean counterfactual of population size for scenario GS-CT were 1.0000 throughout the 26-year simulation. Therefore, given that the differences between impacted and unimpacted populations equate to a ratio of 1 there is not considered to be a potential for an effect from this piling scenario upon grey seal in the SMUs that comprise the GSRP.

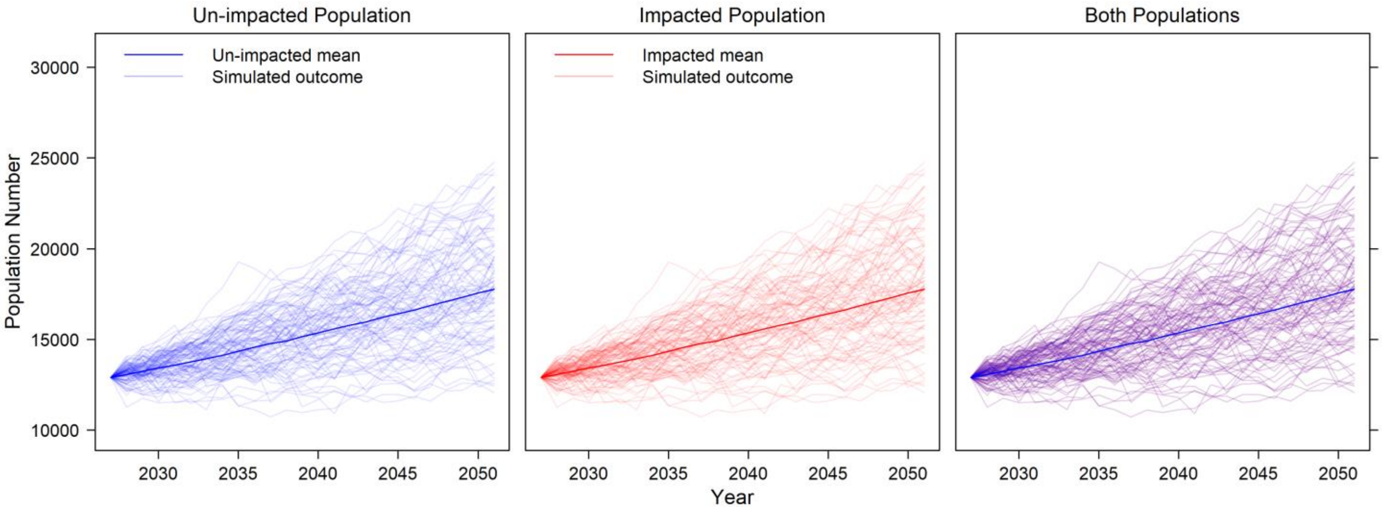

Figure B. 23: Simulated grey seal population trajectories in an unimpacted versus impacted population, for cumulative scenario GS-CT (Morgan and Morecambe Offshore Wind Farms: Transmission Assets only).

Scenario GS-CTM: Morgan and Morecambe Offshore Wind Farms: Transmission Assets and Morecambe Generation Assets

B.4.4.2.5 For scenario GS-CTM, in which a total of 90 days of piling occur at the Morgan Generation Assets alongside a total of four piling days at the Morgan and Morecambe Offshore Wind Farms: Transmission Assets and up to 42 days at Morecambe Generation Assets, these results indicate no difference in the size of the impacted population compared to the unimpacted population (Table B. 37).

B.4.4.2.6 At all time points there was a no difference in the mean size of the impacted and unimpacted populations. This includes at time point 4 (cessation of two-year piling phase), time point 7 (corresponding to the six-year reporting period formerly required under the Habitats Directive) and time point 26 (23 years after the start of the Morgan Generation Assets piling phase). This suggests that there would not be a short- or long-term effect from piling at the Morgan Generation Assets upon the grey seal population within the SMUs that comprise the GSRP.

Table B. 37: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for grey seal for cumulative piling scenario GS-CTM.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	12,908	**12,908**	12,908	12,908	**12,908**	12,908	1.0000	1.0000
2	11,932	**13,078**	13,906	11,932	**13,078**	13,906	1.0000	1.0000
3	11,882	**13,226**	14,320	11,882	**13,226**	14,320	1.0000	1.0000
7	11,792	**13,964**	16,134	11,792	**13,964**	16,134	1.0000	1.0000
9	11,562	**14,357**	17,016	11,562	**14,357**	17,016	1.0000	1.0000
11	11,606	**14,737**	17,668	11,606	**14,737**	17,668	1.0000	1.0000
13	11,702	**15,105**	18,424	11,702	**15,105**	18,424	1.0000	1.0000

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
21	12,329	**16,797**	21,900	12,329	**16,797**	21,900	1.0000	1.0000
26	12,522	**17,985**	23,695	12,522	**17,985**	23,695	1.0000	1.0000

B.4.4.2.7 Both the median and mean counterfactual of population size for scenario GS-CTM were 1.0000 throughout the 26-year simulation. Therefore, given that the differences between impacted and unimpacted populations equate to a ratio of 1 there is not considered to be a potential for an effect from this piling scenario upon grey seal in the SMUs that comprise the GSRP.

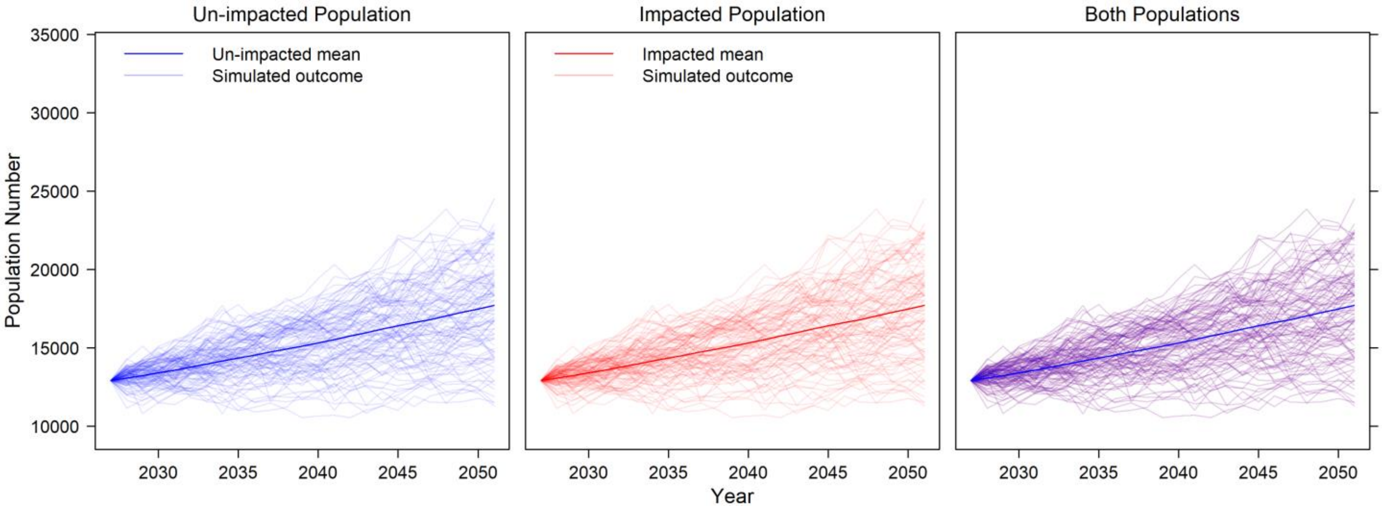

Figure B. 24: Simulated grey seal population trajectories in an unimpacted versus impacted population, for cumulative scenario GS-CTM (Morgan and Morecambe Offshore Wind Farms: Transmission Assets and Morecambe Generation Assets).

Scenario GS-C1: Tier 1 projects

B.4.4.2.8 For scenario GS-C1, in which a total of up to 90 days of piling occur at the Morgan Generation Assets alongside a total of 315 piling days across Tier 1 cumulative projects (90 days at Mona Offshore Wind Project, 18 days at Project Erebus, six days at White Cross Offshore Wind Farm and 201 days at Awel y Môr), these results indicate no difference in the population trajectory of grey seal between the unimpacted population and impacted population (Table B. 38 and Figure B. 25) for the SMUs that comprise the GSRP.

B.4.4.2.9 At all time points there was no difference in the mean size of the impacted and unimpacted populations. This includes time point 5 (cessation of two-year piling phase at Morgan Generation Assets), time point 7 (corresponding to the six-year reporting period formerly required under the Habitats Directive) and time point 26 (25 years after the start of the piling phase). This suggests that there would not be a short- or long-term effect from piling at the Morgan Generation Assets upon the grey seal population within the SMUs that comprise the GSRP.

Table B. 38: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for grey seal for cumulative piling scenario GS-C1.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	12,908	**12,908**	12,908	12,908	**12,908**	12,908	1.0000	1.0000
3	11,814	**13,272**	14,436	11,814	**13,272**	14,436	1.0000	1.0000
4	11,750	**13,448**	14,774	11,750	**13,448**	14,774	1.0000	1.0000
5	11,709	**13,625**	15,164	11,709	**13,625**	15,164	1.0000	1.0000
7	11,614	**13,990**	16,056	11,614	**13,990**	16,056	1.0000	1.0000
9	11,557	**14,369**	16,923	11,557	**14,369**	16,923	1.0000	1.0000
10	11,535	**14,547**	17,381	11,535	**14,547**	17,381	1.0000	1.0000
11	11,650	**14,754**	17,837	11,650	**14,754**	17,837	1.0000	1.0000
13	11,810	**15,187**	18,974	11,810	**15,187**	18,974	1.0000	1.0000
15	12,002	**15,636**	19,545	12,002	**15,636**	19,545	1.0000	1.0000
23	12,194	**17,399**	23,554	12,194	**17,399**	23,554	1.0000	1.0000
26	12,626	**18,160**	24,895	12,626	**18,160**	24,895	1.0000	1.0000

B.4.4.2.10 Both the median and mean counterfactual of population size for scenario GS-C1 were 1.0000 throughout the 26-year simulation. Therefore, given that the differences between impacted and unimpacted populations equate to a ratio of 1 there is not considered to be a potential for an effect from this piling scenario upon grey seal in the SMUs that comprise the GSRP.

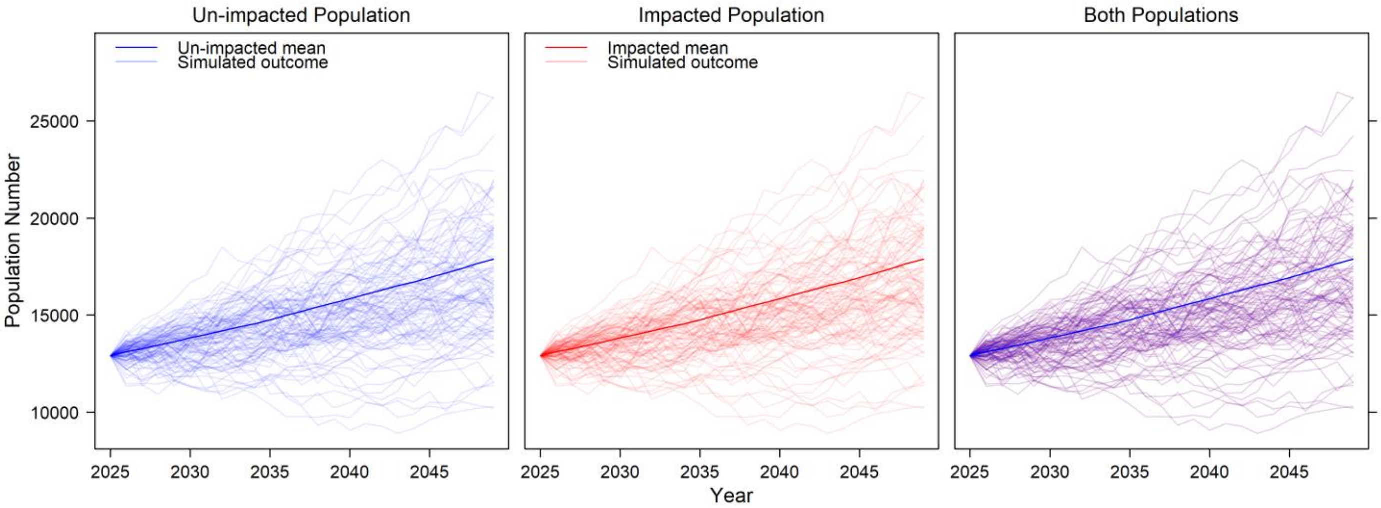

Figure B. 25:Simulated grey seal population trajectories in an unimpacted versus impacted population, for cumulative scenario GS-C1 (Tier 1 projects only).

Scenario GS-C2: Tier 1 and Tier 2 projects

B.4.4.2.11 The results for scenario GS-C2 (i.e. 90 days of piling for the Morgan Generation Assets alongside up to 451 piling days from Tier 1 and Tier 2 cumulative projects (Table B. 10) indicate a similar pattern in the population trajectory as scenario GS-C1 which includes Tier 1 projects only. The results indicate no difference in the population trajectory of grey seal between the unimpacted population and impacted population (Table B. 39 and Figure B. 26) for the SMUs that comprise the GSRP.

Table B. 39: Population estimates for the unimpacted and impacted populations and counterfactuals of population size for grey seal for cumulative piling scenario GS-C2.

Time point	Unimpacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Mean	Median
1	12,908	**12,908**	12,908	12,908	**12,908**	12,908	12,908	12,908
3	11,886	**13,254**	14,338	11,886	**13,254**	14,338	11,886	13,254
4	11,965	**13,454**	14,736	11,965	**13,454**	14,736	11,965	13,454
5	11,924	**13,635**	15,240	11,924	**13,635**	15,240	11,924	13,635
7	11,728	**13,991**	16,156	11,728	**13,991**	16,156	11,728	13,991
9	11,768	**14,383**	16,944	11,768	**14,383**	16,944	11,768	14,383
10	11,792	**14,545**	17,446	11,792	**14,545**	17,446	11,792	14,545
11	11,863	**14,737**	17,941	11,863	**14,737**	17,941	11,863	14,737
13	11,898	**15,151**	18,682	11,898	**15,151**	18,682	11,898	15,151
15	11,954	**15,560**	19,371	11,954	**15,560**	19,371	11,954	15,560
23	12,642	**17,274**	22,907	12,642	**17,274**	22,907	12,642	17,274
26	12,742	**17,921**	24,102	12,742	**17,921**	24,102	12,742	17,921

B.4.4.2.12 At all time points there was no difference in the mean size of the impacted and unimpacted populations. This includes at time point 5 (cessation of piling phase at all cumulative projects), time point 7 (corresponding to the six-year reporting period formerly required under the Habitats Directive) and time point 26 (25 years after the start of the piling phase). This suggests that there would not be a short- or long-term effect from piling at the Morgan Generation Assets upon the grey seal population within the SMUs that comprise the GSRP.

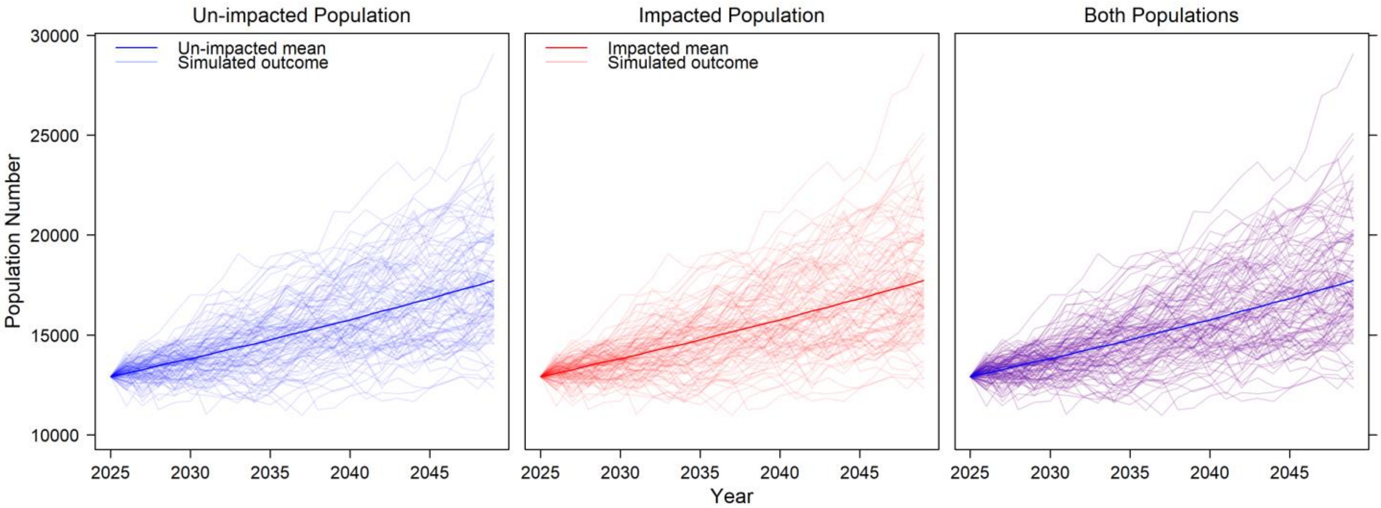

Figure B. 26: Simulated grey seal population trajectories in an unimpacted versus impacted population, for cumulative scenario GS-C2 (Tier 1 and Tier 2 projects).

B.4.4.2.13 Both the median and mean counterfactual of population size for scenario GS-C2 were 1.0000 throughout the 26-year simulation. Therefore, given that the differences between impacted and unimpacted populations equate to a ratio of 1 there is not considered to be a potential for an effect from this piling scenario upon grey seal in the SMUs that comprise the GSRP.

B.5. Summary

B.5.1.1.1 This appendix presents the results of the iPCoD population modelling undertaken for key marine mammal species with the potential to be affected by the Morgan Generation Assets and for cumulative projects that overlap with the relevant species' MUs. Overall, the iPCoD modelling results demonstrate that there would be no long-term differences between impacted and unimpacted populations of harbour porpoise, bottlenose dolphin, minke whale and grey seal.

B.5.1.1.2 The iPCoD models were run to predict potential changes in population size as a result of piling at the Morgan Generation Assets. Reference populations were based on the latest estimates of population size for these species' MUs, as summarised in Table B. 4.

B.5.1.1.3 The numbers of animals potentially experiencing disturbance were based on two maximum design scenarios. The maximum temporal scenario of a combination of 3,000 kJ and 4,400 kJ maximum hammer energies (depending on the foundation type) across a maximum of 114 days, and the maximum spatial scenario of the same maximum hammer energies, incorporating some concurrent piling at 3,000 kJ, across a total of up to 90 days. However, these would not be the maximum hammer energies for all locations, and the realistic hammer energy would likely be lower, affecting fewer animals.

B.5.1.1.4 Conservative estimates of demographic rates were used to parameterise the models, ensuring that these aligned across scenarios to allow direct comparison. The precautionary assumption was made that animals would be disturbed both on the day of piling and for 24 hours the following day, building additional conservatism in the models.

B.5.1.1.5 The modelling demonstrated that for all species there was predicted to be no long-term decline in the population as a result of piling at the Morgan Generation Assets, with negligible to small differences between the impacted to unimpacted population size. Even where there were differences in the simulated population trajectories for the Morgan Generation Assets alone (i.e. a maximum of 0.341% of the reference population in the case of bottlenose dolphin, corresponding to a difference of one individual) it is considered likely that this variation would fall within the natural stochasticity of the population and therefore would not represent a measurable (or significant) long-term difference.

B.5.1.1.6 Similarly, for cumulative projects there were no long-term population level effects predicted for any species. The simulations were based on the MDS for each respective cumulative project (i.e. largest number of animals potentially disturbed at any one time) and therefore represents a conservative approach to the cumulative assessment.

B.5.1.1.7 Results of the cumulative models should be interpreted with caution as limited information on the actual piling schedules was available to inform the iPCoD models presented here. However, the parameters used to develop the models for the cumulative projects have been informed by the respective Environmental Statements, and are considered to represent a conservative and accurate depiction of these projects.

B.5.1.1.8 Though the iPCoD models attempt to incorporate major sources of uncertainty, results will always vary greatly due to environmental and demographic stochasticity. Whilst the models show no evidence of population change associated with the Morgan Generation Assets, there are sources of uncertainty.

B.5.1.1.9 Variation in demographic rates between years may exist as a result of changes in environmental conditions, as a result of random processes or chance events which impact vital rates (e.g. survival, fertility, etc.), or other sources of heterogeneity. In two, otherwise identical populations that experience exactly the same sequence of environmental conditions, demographic stochasticity will mean populations could follow slightly different trajectories over time.

B.5.1.1.10 These models assume that the effects of environmental variation on survival and fertility are adequately reflected by the range of values obtained from the expert elicitation (and shown in the spread of trajectories around the means in Figure B. 1 to Figure B. 26). In addition, the model assumes that survival and fertility rates are not density-dependent and are therefore not affected by population size.

B.5.1.1.11 Whilst it is understood that iPCoD is a relatively simplified population model (simulating the link between days of disturbance and changes in individual vital rates), the most obvious sources of uncertainty are considered to have been adequately captured in the development of these models. In addition, the marine mammal assessment has adopted a precautionary approach in recognition of the uncertainties in how animals respond to repeated piling over time.

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