# MORGAN OFFSHORE WIND PROJECT: GENERATION ASSETS

## Preliminary Environmental Information Report

### Volume 2, chapter 9: Marine Mammals


Image of an offshore wind farm

April 2023
FINAL

## Document status

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**Prepared for:**

**Morgan Offshore Wind Ltd.**

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## Glossary

| Term | Meaning |
|---|---|
| Ensonified | Filled with sound. |
| Teuthophagous | That feeds on cephalopods. |

## Acronyms

| Acronym | Description |
|---|---|
| ADD | Acoustic Deterrent Device |
| BACI | Before-After-Control-Impact |
| BEIS | Department for Business, Energy and Industrial Strategy |
| CEA | Cumulative Effects Assessment |
| Cefas | Centre for Environment, Fisheries and Aquaculture Science |
| CGNS MU | Celtic and Greater North Sea Management Unit |
| CIEEM | Chartered Institute of Ecology and Environmental Management |
| CMACS | Centre for Marine And Coastal Studies |
| CTV | Crew Transfer Vessel |
| CCW | Countryside Council for Wales |
| DCO | Development Consent Order |
| DDT | Dichlorodiphenyltrichloroethane |
| DECC | Department of Energy and Climate Change |
| EA | Environment Agency |
| EIA | Environmental Impact Assessment |
| EMF | Electromagnetic Fields |
| EMP | Environmental Management Plan |
| EPS | European Protected Species |
| ENIS | European Nature Information System |
| EWG | Expert Working Group |
| GIS | Geographical Information System |
| HF | High Frequency |
| HRA | Habitats Regulation Appraisal |
| HVAC | High Voltage Alternating Current |
| IAMMWG | Inter-Agency Marine Mammal Working Group |
| IEF | Important Ecological Feature |
| IoM | Isle of Man |
| IPC | Infrastructure Planning Commission |
| iPCoD | Interim Population Consequences of Disturbance Model |
| IUCN | International Union for Conservation of Nature |
| JCP | Joint Cetacean Protocol |
| JNCC | Joint Nature Conservation Committee |
| LF | Low Frequency |
| LSE | Likely Significant Effect |
| MWDW | Manx Whale and Dolphin Watch |
| MBES | Multi-Beam Echo-Sounder |
| MDS | Maximum Design Scenario |
| MHWS | Mean High Water Springs |
| MLWS | Mean Low Water Springs |
| MMMP | Marine Mammal Mitigation Protocol |
| MMO | Marine Management Organisation |
| MMOs | Marine Mammal Observers |
| MPCP | Marine Pollution Contingency Plan |
| MU | Management Units |
| NMOI | National Marine Plan Interactive |
| NRA | Navigational Risk Assessment |
| NRW | Natural Resources Wales |
| NRW (A) | Natural Resources Wales Advisory Team |
| NS MU | North Sea Management Unit |
| NSP | Navigational Safety Plan |
| NSPVMP | Navigational Safety Plan combined with Vessel Management Plan |
| OC | Organochlorines |
| ORJIP | Offshore Renewables Joint Industry Programme |
| OSP | Offshore Substation Platform |
| PAM | Passive Acoustic Monitoring |
| PCB | PolyChlorinated Biphenyl |
| POP | Persistent Organic Pollutants |
| PTS | Permanent Threshold Shift |
| QA | Quality Assurance |
| RIAA | Report to Inform Appropriate Assessment |

| Acronym | Description |
|---|---|
| SAC | Special Area of Conservation |
| SBES | Single Beam Echosounder |
| SBP | Sub-Bottom Profilers |
| SCANS | Small Cetacean Abundance in the North Sea |
| SEA | Strategic Environmental Assessment |
| SEL | Sound Exposure Level |
| $SEL_{cum}$ | Cumulative Sound Exposure Level |
| SCOS | Special Committee on Seals |
| SMRU | Sea Mammal Research Unit |
| SPL | Sound Pressure Level |
| $SPL_{pk}$ | Peak Sound Pressure Level |
| SSC | Suspended Sediment Concentrations |
| SSS | Sidescan Sonar |
| TBT | Tributyltin |
| TTS | Temporary Threshold Shift |
| TWT | The Wildlife Trusts |
| UHRS | Ultra High Resolution Seismic |
| UK | United Kingdom |
| US | United States |
| USBL | Ultra-short Baseline |
| 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 |
| $kgm^{-3}$ | Kilograms per cubic metre |
| m | Metre |
| $ms^{-1}$ | Metres per second |
| $ms^{-2}$ | Metres per second squared |
| MW | Megawatt |
| nm/s | Nano metres per second (10-9) |
| s | Second |

# 9 Marine Mammals

## 9.1 Introduction

### 9.1.1 Overview

9.1.1.1 This chapter of the Preliminary Environmental Information Report (PEIR) presented the assessment of the potential impact of the Morgan Offshore Wind Project: Generation Assets (Morgan Generation Assets) on marine mammals. Specifically, this chapter considered the potential impact of the Morgan Generation Assets seaward of Mean High Water Springs (MHWS) during the construction, operations and maintenance, and decommissioning phases.

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

- Volume 2, chapter 8: Fish and shellfish chapter of the PEIR
- Volume 2, chapter 12: Shipping chapter of the PEIR
- Volume 3, annex 3.1: Underwater sound technical report of the PEIR
- Volume 2, chapter 15: Inter-related effects (offshore) of the PEIR.

9.1.1.3 This chapter also draws upon information contained within volume 4, annex 9.1: Marine mammal technical report of the PEIR. 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 PEIR.

### 9.1.2 Purpose of chapter

9.1.2.1 The primary purpose of the PEIR is outlined in volume 1, chapter 1: Introduction of the PEIR. 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 PEIR constitutes the Preliminary Environmental Information for Morgan Generation Assets and sets out the findings of the EIA to date to support the pre-application consultation activities required under the 2008 Act. The EIA will be finalised following completion of pre-application consultation and the Environmental Statement will accompany the application to the Secretary of State for Development Consent.

9.1.2.2 The PEIR forms the basis for statutory consultation which will last for 47 days and conclude on 4 June 2023. At this point, comments received on the PEIR will be reviewed and incorporated (where appropriate) into the Environmental Statement, which will be submitted in support of the application for Development Consent scheduled for quarter four of 2023.

9.1.2.3 In particular, this PEIR chapter:

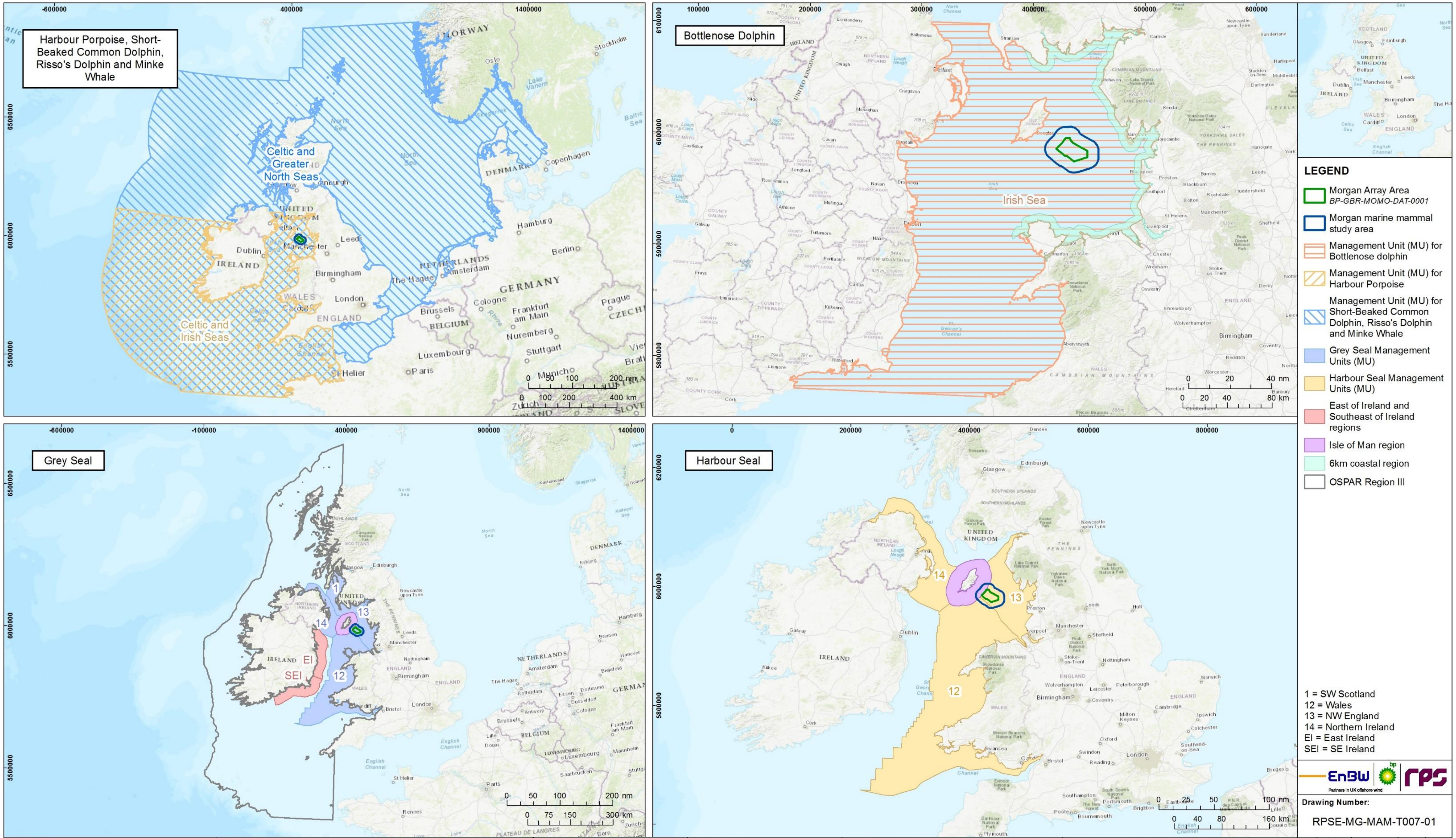
- Presents the existing environmental baseline established from desk studies, site-specific surveys and consultation
- Identifies any assumptions and limitations encountered in compiling the environmental information
- Presents the potential environmental effects on marine mammals arising from the Morgan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

### 9.1.3 Study area

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

- Morgan marine mammal study area: this area comprises the Morgan Array Area plus a 10km buffer (Figure 9.1)
- 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. Species specific populations were considered over a regional scale, within the context of their relevant species Management Units (MUs) (Figure 9.1). For the purpose of the cumulative assessment and, as agreed with consultees during the Marine Mammals Expert Working Group meeting (EWG) #2, screening focussed on the Irish Sea extending into the Celtic Sea rather than the entire extent of the largest MU: the Celtic and Greater North Seas (CGNS) MU (Figure 9.1). This was to ensure a proportionate 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).

9.1.3.2 The regional marine mammal study area boundaries were discussed during the EWG meetings (with a summary provided in volume 4, annex 9.1: Marine mammal technical report of the PEIR and in Table 9.5 in this chapter). In accordance with advice received during consultation, population level effects were informed by species MUs. Figure 9.1 shows the Morgan Array Area, Morgan marine mammal study area, marine mammal MUs and reference populations (OSPAR Region III; East of Ireland and Southeast of Ireland regions; Isle of Man region; and 6km coastal region). Management Units are described in detail in section 9.4.6.

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|---|---|---|---|---|---|---|
| **Project Name:** MORGAN OFFSHORE WIND PROJECT | **Drawing Title:** MARINE MAMMAL STUDY AREAS AND RELEVANT SPECIES MANAGEMENT UNITS (MUS) | | **Geodetic Information:** Datum: ETRS 1989 Projection: ETRS 1989 UTM Zone 30N Scale: 1:0 @ A3 | **Data Sources:** Client, JNCC, MarineScotland, NPWS, OSPAR, DAERA, MMO | **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 | |

| VER | DATE | DETAILS | BY | CHECK |
|---|---|---|---|---|
| 00 | 18/11/22 | Initial Issue | NA | LB |
| 01 | 22/11/22 | Revision | NA | LB |

**Figure 9.1: Marine mammal study area.**

## 9.2 Policy context

### 9.2.1 National Policy Statements

9.2.1.1 Planning policy on renewable energy infrastructure is presented in volume 1, chapter 2: Policy and legislation of the PEIR. Planning policy on offshore renewable energy Nationally Significant Infrastructure Projects (NSIPs), specifically in relation to marine mammals, is contained in the Overarching National Policy Statement (NPS) for Energy (EN-1; DECC, 2011a) and the NPS for Renewable Energy Infrastructure (EN-3, DECC, 2011b.

9.2.1.2 NPS EN-1 and NPS EN-3 include guidance on what matters are to be considered in the assessment. These are summarised in Table 9.1 below. 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 9.2 below.

9.2.1.3 Where text differs between the current NPS EN-1 and NPS EN-3 and the draft NPS EN-1 and NPS EN-3 this has been presented with the text of the draft NPS in brackets.

**Table 9.1: 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 PEIR |
|---|---|
| **NPS-EN1** | |
| "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, on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity. The applicant should provide environmental information proportionate to the infrastructure where EIA is not required to help the Secretary of State consider thoroughly the potential effects of a proposed project."<br>(NPS EN-1 paragraph 5.3.3) | The potential effects on internationally, nationally and locally designated sites for ecological or geological features of conservation importance have been assessed for Morgan Generation Assets.<br>The Morgan Habitats Regulations Assessment (HRA) Screening identifies direct or indirect effects on sites which could be affected, and those sites will be assessed in the Morgan HRA Stage 2 Information to Support Appropriate Assessment (ISAA).<br>Important protected areas for marine mammals are discussed in volume 4, annex 9.1: Marine mammal technical report of the PEIR and in section 9.4.4. |
| "Many Sites of Special Scientific Interest (SSSI) are also designated as sites of international importance and will be protected accordingly. Those that are not, or those features of SSSIs not covered by an international designation, should be given a high degree of protection. All National Nature Reserves are notified as SSSIs."<br>(NPS EN-1 paragraph 5.3.10) | There are no SSSIs considered to be at risk of effect from the Morgan Generation Assets, and no further consideration of SSSIs have been given. |
| "Development proposals provide many opportunities for building-in beneficial biodiversity or geological features as part of good design. When considering proposals, the Secretary of State should maximise such opportunities in and around developments, using requirements or planning obligations where appropriate."<br>(NPS EN-1 paragraph 5.3.15) | Measures adopted as part of the Morgan Generation Assets are presented in Table 9.16. |
| "Many individual wildlife species receive statutory protection under a range of legislative provisions"<br>(NPS EN-1 paragraph 5.3.16) | Relevant policy and legislation for marine mammals is listed in section 9.2 of this chapter and in volume 2, chapter 2: Policy and legislative context of the PEIR. |
| "By using requirements or planning obligations other species and habitats have been identified as being of principal importance for the conservation of biodiversity in England and Wales and thereby requiring conservation action. The Secretary of State should ensure that these species and habitats are protected from the adverse effects of development."<br>(NPS EN-1 paragraph 5.3.17) | All species receptors are summarised in section 9.4. These include species and habitats of principal importance in England. |
| "The applicant should include appropriate mitigation measures as an integral part of the Morgan Generation Assets. In particular, the applicant should demonstrate that:<br>During construction, they will seek to ensure that activities will be confined to the minimum areas required for the works;<br>During construction and operations 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;<br>Habitats will, where practicable, be restored after construction works have finished."<br>(NPS EN-1 paragraph 5.3.18) | Primary and tertiary mitigation relevant for marine mammals which will be adopted as part of Morgan Generation Assets are detailed in section 9.7. |
| **NPS-EN3** | |
| "Assessment of offshore ecology and biodiversity should be undertaken by the applicant for all stages of the lifespan of the proposed Offshore Wind Farm (OWF) and in accordance with the appropriate policy for OWF EIAs."<br>(NPS EN-3 Paragraph 2.6.64) | The construction, operations and maintenance and decommissioning phases of the Morgan Generation Assets have been assessed in section 9.1. |
| "Consultation on the assessment methodologies should be undertaken at early stages with the statutory consultees as appropriate."<br>(NPS EN-3 Paragraph 2.6.65) | Throughout the Morgan Generation Assets consultations with relevant statutory and non-statutory stakeholders have been carried out (e.g. via Expert Working Groups) and are given in Table 9.5. |
| "Any relevant data that has been collected as part of post-construction ecological monitoring from existing, operational OWFs should be referred to where appropriate."<br>(NPS EN-3 Paragraph 2.6.66) | To inform the assessment of Morgan Generation Assets , relevant data collected during post construction monitoring from other offshore wind projects has informed the assessment (see section 9.7). |
| "The assessment should include the potential of the scheme to have both positive and negative effects on marine ecology and biodiversity."<br>(NPS EN-3 Paragraph 2.6.67) | Both potential positive and negative effects have been considered on marine mammals for Morgan Generation Assets (see section 9.1). |
| "Mitigation may be possible in the form of careful design of the development itself and the construction techniques employed"<br>(NPS EN-3 paragraph 2.6.70) | For marine mammals, embedded mitigation is detailed in section 9.7. |

| Summary of NPS EN-3 and EN-1 provision | How and where considered in the PEIR |
|---|---|
| "Ecological monitoring is likely to be appropriate during the construction and operations phases to identify the actual impact so that, where appropriate, adverse effects can then be mitigated and to enable further useful information to be published relevant to future projects."<br>(NPS EN-3 paragraph 2.6.71) | Marine mammal monitoring has been considered in section 9.8.10 and any monitoring will be used to inform mitigation and enable further useful information for future projects. |
| "Where necessary, assessment of the effects on marine mammals should include details of:<br>• Likely feeding areas<br>• Known birthing areas/haul out sites<br>• Nursery grounds<br>• Known migration or commuting routes<br>• Duration of the potentially disturbing activity including cumulative/in-combination effects with other plans or projects<br>• Baseline noise levels<br>• Predicted noise levels in relation to mortality, permanent threshold shift (PTS) and temporary threshold shift (TTS)<br>• Soft-start noise levels according to<br>• Proposed hammer and pile design<br>• Operational sound."<br>• (NPS EN-3 paragraph 2.6.92). | The effects on marine mammals have been assessed in section 9.7 and likely feeding areas, known birthing areas/haul out sites; known migration or commuting routes are considered within volume 4, annex 9.1: Marine mammal technical report of the PEIR and in section 9.4.4.<br>Duration of potentially disturbing activity including cumulative/in-combination effects with other plans or projects is presented in section 9.9.<br>Baseline noise levels, predicted noise levels in relation to mortality, Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS), soft-start noise levels according to proposed hammer and pile design, and operational sound are all considered within section 9.9. |
| "The applicant should discuss any proposed piling activities with the relevant body. Where assessment shows that noise from offshore piling may reach noise levels likely to lead to an offence as described in 2.6.91 above, the applicant should look at possible alternatives or appropriate mitigation before applying for a license."<br>(NPS EN-3 paragraph 2.6.93) | The Morgan Generation Assets piling activity is discussed in section 9.1.1, and appropriate appropriate measures adopted as part of the Morgan Generation Assets to minimise the potential for an offence, along with those specific to construction, operational and maintenance and decommissioning are discussed in paragraph 9.1.1.1. |
| "Fixed submerged structures such as foundations are likely to pose little collision risk for marine mammals and the Secretary of State is not likely to have to refuse to grant consent for a development on the grounds that offshore wind farm foundations pose a collision risk to marine mammals."<br>(NPS EN-3 paragraph 2.6.96) | For marine mammals, potential collision risk is assessed in section 9.8.6. |
| "Monitoring of the surrounding area before and during the piling procedure can be undertaken."<br>(NPS EN-3) | A summary of the monitoring proposed is provided in section 9.8.10. |
| "During construction, 24-hour working practices may be employed so that the overall construction programme and the potential for impacts to marine mammal communities is reduced in time."<br>(NPS EN-3 paragraph 2.6.98) | Morgan Generation Assets may employ 24-hour working practices for some offshore construction works which will minimise impacts to marine mammal communities. The predicted time frame for the project is discussed in section 9.6.1. |
| "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 significant adverse impacts are caused."<br>(NPS EN-3 paragraph 2.6.98) | Soft start procedures for pile driving are detailed in volume 2, annex 3.1: Underwater sound technical report of the PEIR. |

**Table 9.2: Summary of NPS EN-1 and NPS EN-3 policy on decision making relevant to marine mammals.**

| Summary of NPS EN-1 and EN-3 provision | How and where considered in the PEIR |
|---|---|
| **NPS EN-3** | |
| "The Secretary of State should consider the effects of a proposal on marine ecology and biodiversity taking into account all relevant information made available to it."<br>(NPS EN-3 paragraph 2.6.68) | The effects on marine mammals from the construction, operations and maintenance, and decommissioning of the Morgan Generation Assets have been described and considered within this assessment. |
| 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 so as to reasonably minimise significant disturbance effects on marine mammals. Unless suitable noise mitigation measures can be imposed by requirements to any development consent the Secretary of State may refuse the application.<br>(NPS EN-3 paragraph 2.6.94) | Different foundation options and hammer energies have been considered for Morgan Generation Assets. The maximum design scenario (MDS) has been defined as those that represent the realistic MDS that have the potential to occur and are assessed and presented in section 9.6.1. |
| The conservation status of marine European Protected Species and seals are of relevance to the Secretary of State, and the Secretary of State should take into account the views of the relevant statutory advisors.<br>(NPS EN-3 paragraph 2.6.95) | Species' conservation status has been factored into the assessment (section 9.5.2). |
| Mitigation: monitoring of a mitigation area for marine mammals surrounding the piling works prior to commencement of, and during, piling activities. During construction, 24 hour working practices may be employed to reduce the total construction programme and the potential for impacts. Soft-start procedures during pile driving may be implemented to avoid significant adverse impacts.<br>(NPS EN-3 paragraph 2.6.97) | Measures adopted as part of the Morgan Generation Assets are presented in section 9.7. |

| Summary of NPS EN-1 and EN-3 provision | How and where considered in the PEIR |
|---|---|
| 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 so as to reasonably minimise significant disturbance effects on marine mammals. Unless suitable noise mitigation measures can be imposed by requirements to any development consent the Secretary of State may refuse the application." (NPS EN-3 paragraph 2.6.94) | The maximum potential impact associated with construction, operating and decommissioning at Morgan Generation Assets are assessed in section 9.1. Measures adopted as part of the Morgan Generation Assets are discussed within each relevant impact section. |

### 9.2.2 North West Inshore and North West Offshore Coast Marine Plans

9.2.2.1 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 Coast Marine Plans (MMO, 2021). Key provisions are set out in Table 9.3 along with details as to how these have been addressed within the assessment.

**Table 9.3: North West Inshore and North West Offshore Marine Plan policies of relevance to marine mammals.**

| Policy | Key provisions | How and where considered in the PEIR |
|---|---|---|
| NW-SCP-1 | Proposals within or relatively close to nationally designated areas should have regard to the specific statutory purposes of the designated area. | The process of identifying designated sites has been undertaken for the regional marine mammal study area, and was done to ensure all habitats and features or species of conservation importance were considered in this assessment. |
| 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.<br>Proposals that may have adverse impacts on the objectives of marine protected areas must demonstrate that they will, in order of preference:<br>a. avoid<br>b. minimise<br>c. mitigate;<br>adverse impacts, with due regard given to statutory advice on an ecologically coherent network. | As part of this chapter the process of identifying designated sites has been undertaken for the Morgan marine mammal study area, and was done to ensure all habitats and features or species of conservation importance were considered in this assessment. |
| 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. | Mitigation is considered where the significance of an impact is moderate or major to reduce the significance of the impact to negligible or minor. This assessment is undertaken for each impact (see section 9.1) |
| 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. | Cumulative effects have been quantified and their significance assessed in section 9.10. This section includes the consideration of mitigation where the significance is found to be moderate or major. |

### 9.2.3 The Marine Strategy Framework Directive

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

**Table 9.4: 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 PEIR |
|---|---|
| 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 effects on biological diversity has been described and considered within the assessment for Morgan Offshore Wind Project both alone (section 9.7) and in the Cumulative Effects Assessment (CEA) (section 9.10). |
| 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 effects 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 Offshore Wind Project both alone (section 9.7) and in the CEA (section 9.10). |
| 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 effects on temporary and long term habitat loss and introduction of new habitat on marine mammal prey species within the Morgan marine mammal study area has been described and considered within the assessment for the Morgan Offshore Wind Project both alone (section 9.7) and in the CEA (section 9.10). |
| Descriptor 8: Contaminants: Concentrations of contaminants are at levels not giving rise to pollution effects. | The effects of contaminants on marine mammal receptors were scoped out as agreed in the Morgan EIA Scoping Report and as agreed with EWG (section 9.6.2). |
| 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.<br>The offshore EMP will also outline any procedures implemented during the operations and maintenance phase.<br>A Decommissioning Plan will be developed and implemented during the decommissioning phase. |

| MSFD Descriptor relevant to marine mammals | How and where considered in the PEIR |
|---|---|
| Descriptor 11: Energy including underwater noise: Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment. | The effects of underwater sound from piling of wind turbines, 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 Offshore Wind Project both alone (section 9.8) and in the CEA (section 9.10).<br>It is noted that the EU recently adopted thresholds for maximum acceptable levels for impulsive (e.g. piling) and continuous noise (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 noise over a year. Similarly, no more than 20% of a marine habitat can be exposed to impulsive noise over a given day, and no more than 10% over a year. |

## 9.3 Consultation

9.3.1.1 A summary of the key issues raised during consultation activities undertaken to date specific to marine mammals is presented in Table 9.5 below, together with how these issues have been considered in the production of this PEIR chapter. Further detail is presented within volume 4, annex 9.1: Marine mammal technical report of the PEIR.

### 9.3.2 Evidence plan

9.3.2.1 The purpose of the Evidence Plan process 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, with Natural Resources Wales (NRW), Natural England, Marine Management Organisation (MMO), Joint Nature Conservation Committee (JNCC), Isle of Man Government, the Planning Inspectorate, the Royal Society for Protection of Birds (RSPB), the Centre for Environment, Fisheries and Aquaculture Science (Cefas), the Environment Agency (EA) and The Wildlife Trusts (TWT). The Evidence Plan seeks to ensure compliance with the Habitat Regulations Assessment (HRA) and EIA.

9.3.2.2 Discussion to date regarding marine mammals with consultees via the EWG has focused on providing consultees with information on baseline data sources and defining both the Regional marine mammal study area and the Morgan marine mammal study area (as described in section 9.1.3) for use in the impact assessment.

9.3.2.3 An underwater sound technical note explaining the modelling approach was provided to the EWG on 24 May 2022, providing 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. This information is also presented in the volume 3, annex 3.1: Underwater sound technical report of the PEIR.

**Table 9.5: 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 |
|---|---|---|---|
| Feb-22 | **Marine Mammals Expert Working Group 1 –** Natural England, Marine Management Organisation (MMO), Joint Nature Conservation Committee (JNCC), 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 9.1: Marine mammal technical report of the PEIR. Coverage for the Morgan aerial surveys stands at at least 12%, which exceeds some previously consented projects and the 10% minimum coverage suggested by literature (BSH, 2013). Coefficient of variation (CVs) 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 can be measured to aid in species-level identification. APEM 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 9.1: Marine mammal technical report of the PEIR). 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'). Full details of the survey methodology, data processing, data analyses, and assumptions and limitations are provided in Appendix A of volume 4, annex 9.1: Marine mammal technical report of the PEIR. |
| | | 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 were discussed and agreed with NRW as part of the EWG and the regional study was defined as the Celtic and Irish seas. |
| | | Key species must include minke whale, often sighted around the Isle of Man. | Baseline description of minke whales is included in volume 4, annex 9.1: Marine mammal technical report of the PEIR, and has been scoped into the assessment in section 9.8 of in this chapter. |
| | | 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. |
| May-22 | **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.<br><br>Feeback included:<br>**NRW**:<br>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.<br><br>**Natural England**:<br>It would be beneficial to consider modelling piling with noise abatement systems in place, to understand the possible reduction in underwater sound (and associated impacts) if such mitigation methods are used. Similarly, sound abatement for Unexploded Ordnance (UXO) clearance where deflagration is not an option should also be considered.<br>A quantitative assessment of the TTS impact ranges and the number of animals within those ranges would expect to be seen.<br>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. | In the absence of species-specific data for other cetacean species the same dose response curve was assumed to apply to all cetacean Important Ecological Features (IEFs) in this assessment, but note that this is a highly precautionary approach.<br>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 9.8.2.7<br>Piling has been modelled with Acoustic Deterrent Devices (ADDs) and is discussed in the assessment.<br>Where relevant (e.g. for UXO assesment), TTS has been discussed with quantiative assessment.<br>Consecutive scenarios have been modelled and assessed and included in section 9.5. |

| Date | Consultee and type of response | Issues raised | Response to issue raised and/or where considered in this chapter |
|---|---|---|---|
| | | 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 PEIR.<br>Request clarification as to whether consecutive piling (i.e. multiple piles, one after the other) is also within the project design envelope.<br><br>**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. | |
| Jul-22 | **Marine Mammals Expert Working Group 2 –** Natural England, MMO, JNCC, NRW, TWT, Cefas. | 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 MUs were used as reference populations. Celtic and Irish Sea (harbour porpoise MU) was adopted as the regional marine mammal study area (as per agreement) and has been used to screen in cumulative projects. |
| | | Discussion of species to scope in/out of the EIA and HRA. Agreement that white-beaked dolphin can be scoped out. | Harbour seal included in the baseline environment of the technical report. White-beaked dolphin are scoped out. |
| Nov 22 | **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. | Due to the timing of the workshop ahead of publishing the PEIR, some aspects of the discussion outputs will be incorporated into the Environmental Statement.<br>• Approach to density and reference populations for Risso's dolphin, short-beaked common dolphin and minke whale and use of Carter *et al* (2022) maps for seal densities agreed, is included in PEIR. Reference population for grey seal includes Isle of Man (IoM) population and two Ireland regions following discussions at EWG 03 and impact assessment is also considered against OSPAR Region III, both are detailed in 9.4.6. Aspects which were discussed, but have not been included in the PEIR include:<br>• Density estimates for harbour porpoise and bottlenose dolphin from the Marine Mammal Atlas - not currently in public domain so is not included at PEIR. Assuming avaiable prior to publishing the Environmental Statement, density estimates will be incorporated into the Environmental Statement. |
| | | Approach to assessment presented, covering:<br>• Dose response curves and use of NMFS (or other) thresholds<br>• Assumptions of the cumulative assessment | Dose response curve derived from Graham *et al.* (2019) for cetaceans due to lack of other approach for species. NMFS thresholds are also included in PEIR assessment.<br>An assessment of 140dB threshold for harbour porpoise (ASCOBANS) and 145dB thresholds (Lucke *et al.,* 2009) will be investigated for the Environmental Statement<br>A tiered approach is used in the cumulative assessment, with modelling carried out across Tier 1 projects to provide a qualitative assessment. As more information becomes available on the Tier 2 projects these will be incorporated into modelling for the application. Description of the cumulative assessment approach is provided in section 9.9 |
| | | Inital underwater sound modelling outputs for piling presented to the EWG.<br><br>Highlighted sensitivy of iPCoD modelling to parameters chosen. | Permanent Threshold Shift (PTS) has been carried forward to the assessment in section 9.8.3. The ranges for TTS are presented in the Volume 3, annex 3.1: Underwater sound technical report of the PEIR but are not included in the assessment for injury and disturbance for elevated underwater sound during piling.<br>The method for iPCoD modelling used to understand long term population effects is presented in paragraph 9.8.3.12, and a detailed iPCoD report is presented in Appendix A. |
| | | Assessment on grey seal haul outs | A qualitative assessment, looking at grey seal movements between established haul outs and the Morgan Generation Assets will be incorporated into the Environmental Statement |
| Jul-22 | **Scoping Opinion**<br>The Planning Inspectorate | Agreement on defining the mitigation zone using the dual metric approach of SPLpk and SELcum. | The dual metric approach has been used in the impact assessment of the PEIR (section 9.8). |
| | | 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 a assessment for this species with the Expert Working Group (EWG). | Harbour seal has been scoped into the assessment (section 9.8 and 9.10), and baseline information is presented in section 9.4. The scope of assessment for harbour seal has been agreed with the EWG. |

| Date | Consultee and type of response | Issues raised | Response to issue raised and/or where considered in this chapter |
|---|---|---|---|
| | | 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 impacts; Irish and Celtic seas have been defined as regional and cumulative study areas in agreement with relevant stakeholders in the second EWG (see later in this table). |
| | | The ES 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. | Permanent Threshold Shift (PTS), Temporary Threshold Shift (TTS) and disturbance ranges are presented for each species for relevant impacts in the marine mammals PEIR chapter (section 9.8). Proximity to designated sites has been considered for relevant impacts in the marine mammals PEIR chapter (section 9.8). The potential for overlap of disturbance with designated sites has been considered in the Morgan HRA Stage 1 Screening and relevant sites have been taken forward for assessment in the Morgan ISAA. |
| | | The ES should clearly identify all sources of underwater noise and vibration, for all phases of the Proposed Development, and assess the impacts from these activities where significant effects are likely to occur. The ES should set out the methodology and assumptions for all modelling undertaken. | Sources of underwater sound from piling, unexploded ordnance (UXO) clearance, vessel use and other activites including cable trenching, laying and jack up rigs have been modelled and included in section 9.8.4 of in this chapter, with a summary methodology and assumptions set out. The noise modelling methodology and result are presented in full in volume 3, annex 3.1: Underwater sound technical report of the PEIR. |
| | | The ES 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. | Undewater sound modelling accounted for concurrent piling according to the maximum design scenario including parameters for minimum and maximum distance between two concuttent piling events (volume 3, annex 3.1: Underwater sound technical report of the PEIR). The maximum design scenario is set out in Table 9.14 and noise impacts are assessed in section 9.8. |
| | | Geophysical surveys are a source of underwater noise and should be assessed in the ES 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 9.8.7), and as part of the cumulative effects assessment (section 9.10). |
| | | The ES 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 9.10. At PEIR stage any assessment of minor significance or above have been carried forward for cumulative effects assessment. |
| | **Scoping Opinion**<br>JNCC | Morgan and Mona regional marine mammal study areas – JNCC query study area extent. | Study areas were discussed and agreed with JNCC as part of the EWG and the regional study was defined as the Celtic and Irish seas for use in both 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, but harbour seal has been scoped in as result of EWG discussions |
| | **Scoping Opinion**<br>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 discussions. |
| | | 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 and precautionary density estimates have been carried forward to the assessment (Table 9.10). |
| | | Data source suggestions for inclusion. | All suggested data sources have been included in the baseline (volume 4, annex 9.1: Marine mammal technical report of the PEIR). |
| | | 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 9.1: Marine mammal technical report of the PEIR (appendix A)). |

| Date | Consultee and type of response | Issues raised | Response to issue raised and/or where considered in this chapter |
|---|---|---|---|
| Jul-22 | | The ES 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 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).<br>The ES 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. | Information in relation to designated sites is set out in the baseline environement section of this PEIR (section 9.4.2), and any overlap of designated sites, with disturbance contours is set out in section 9.8. The full assessment with respect to the conservation objectives of a particular site will be provided in the ISAA. |
| | | We 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 9.8.8 and includes an assesment of underwater sound emissions from operational wind turbines (detailed in volume 3, annex 3.1: Underwater sound technical report of the PEIR). |
| | | 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 recent Carter et al (2022) maps are used in the PEIR for obtaining marine mammal densities to inform the environmental baseline (section 9.4) and the Assessment of significant effects (section 9.8) and Cumulative effects assessment section 9.10. Telemetry data obtained from SMRU are also incorporated into volume 4, annex 9.1: Marine mammal technical report of the PEIR to inform movements of seals in the regional marine mammal study area. |
| | **Scoping Opinion**<br>IOM 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, section 9.4.4. These include relevant Marine Nature Reserves (MNR) in Isle of Man waters. |
| | | 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. The Assessment of significant effects has considered relevant marine mammals (cetaceans and pinnipeds) in section 9.8.<br>Screening of transboundary effects are given in volume 3, Chapter 5.2 Transboundary impacts screening and is set out in section 9.11 of the PEIR. |

## 9.4 Baseline environment

### 9.4.1 Methodology to inform baseline

9.4.1.1 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 9.6 below.

**Table 9.6: Summary of key desktop reports.**

| Title | Source | Year | Author |
|---|---|---|---|
| Awel Y Môr Wind farm surveys | APEM Ltd. | 2019 to 2021 | Sinclair *et al*., 2021 |
| Gwynt y Môr 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 |
| Estimates of cetacean abundance in European Atlantic waters from the SCANS aerial and shipboard surveys | SCANS | 1994; 2005; 2016 | Hammond *et al*., 2002; Hammond *et al*., 2017; Hammond *et al*., 2021 |
| Joint Cetacean Protocol (JCP) Phase I, III Analysis | JCP | 1994 to 2010 | Paxton and Thomas, 2010, Paxton *et al*. 2016 |
| JNCC Report 544: Harbour Porpoise Density | JNCC | 1994 2011 | Heinänen and Skov (2015) |
| Welsh Marine Atlas | Countryside Council for Wales (CCW) | 1990 to 2009 | Baines and Evans (2012) |
| ObSERVE surveys | National Parks and Wildlife Service (NPWS) | 2015 to 2017 | Rogan *et al* (2018) |
| Strategic Environmental Assessment 6 | SMRU | 2005 | Hammond *et al*. (2005) |
| Special Committee on Seals (SCOS) Reports | SMRU | 1990 to 2020 | SMRU |
| Seal Telemetry Data | SMRU | 2004 to 2018 | Wright and Sinclair (2022) |
| Habitat-based predictions of at-sea distribution for grey and harbour seals in the British Isles | Report to BEIS | 1996 to 2015 | Carter *et al*. (2020) |
| Sympatric Seals, Satellite Tracking and Protected Areas: Habitat-Based Distribution Estimates for Conservation and Management | Frontiers in Marine Science 9:875869 | 2005 to 2019 | Carter *et al.* (2022) |
| Manx Whale and Dolphin Watch (MWDW) surveys | MWDW | 2006 to 2022 | Felce (2015); Clark *et al*. (2019); Adams (2017) |
| 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) |
| Updated abundance estimates for cetacean Management Units in UK waters | JNCC | 2021 | IAMMWG (2021) |
| Aerial digital surveys for the Morgan Array Area | Aerial Survey Report in volume 4, annex 9.1: Marine mammal technical report of the PEIR. | 2022 | RPS (2022) |

### 9.4.2 Identification of designated sites

9.4.2.1 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, Special Committee on Seals (SCOS), National Marine Plan Interactive (NMPI) and European Nature Information System (EUNIS) websites.
- Step 2: Information was compiled on the relevant marine mammal qualifying interests 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 (paragraph 9.4.1.1) and site-specific surveys presented within volume 4, annex 9.1: Marine mammal technical report of the PEIR (appendix A).
- 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 such that
  - Sites and associated features were located within the potential Zone Of Influence (ZOI) for impacts associated with the Morgan Generation Assets (e.g. potential effect ranges of underwater sound as a result of piling activities during construction section 9.8.3)
  - Marine mammal features of a designated site were either recorded as present during historic surveys or recent Morgan aerial digital surveys within the Morgan Array Area, or identified during the desktop study as having the potential to occur within the Morgan marine mammal study area.

### 9.4.3 Site specific surveys

9.4.3.1 In order to inform the PEIR, site-specific surveys were undertaken, as agreed with the marine mammal EWG (see Table 9.5 for further details). A summary of the surveys undertaken to inform the marine mammal impact assessment is outlined in Table 9.7 below. Only the first year of data was available to inform the PEIR however the site-specific digital aerial surveys are ongoing until March 2023 and the full two years worth of data will be presented in the Environmental Statement.

**Table 9.7: 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 10km buffer | Aerial digital survey | APEM Ltd. | April 2021 to March 2022 | Aerial Survey Report in volume 4, annex 9.1: Marine mammal technical report of the PEIR. |

### 9.4.4 Baseline summary

9.4.4.1 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 region: harbour porpoise *Phocoena phocoena*, bottlenose dolphin *Tursiops truncatus*, short-beaked common dolphin *Delphinus delphis*, Risso's dolphin *Grampus griseus*, minke whale *Balaenoptera acutorostrata*, grey seal *Halichoerus grypus* and harbour seal *Phoca vitulina*. Other cetacean species are occasional or rare visitors.

9.4.4.2 The distribution of marine mammals in the Irish Sea is patchy, and cetaceans in particular are highly mobile, and their occurrence unpredictable. Harbour porpoise occur throughout the area, whilst short-beaked common dolphin and Risso's dolphin are largely restricted the south of the Irish sea and sightings of bottlenose dolphin are highest in the Cardigan Bay SAC.

9.4.4.3 Grey seal extensively use 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 Lleyn 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, Lleyn Peninsula and the Sarnau SAC and the Saltee Islands SAC (Ireland) (SCOS, 2014).

9.4.4.4 Harbour seal 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 harbour seal 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.

9.4.4.5 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 9.8 and in detail in volume 4, annex 9.1: Marine mammal technical report of the PEIR.

**Table 9.8: Summary of Marine Mammals Baseline Ecology.**

| Species | Baseline Summary | Conservation Importance |
|---|---|---|
| Harbour porpoise<br>*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).<br>Data from the Morgan Generation Assets for the first year of survey found that harbour porpoise were recorded in all months of the year. Wide-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).<br>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). Heinänen and Skov (2015) (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 >3.0km$^2$ 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, and persistent high density areas were identified in these areas, with lower densities towards the Morgan Generation Assets.<br>Estimates from the Morgan Aerial Survey Area indicated densities of 0.247 animals per km$^2$ in the summer bio-season, and 0.145 animals per km$^2$ in the winter bio-season (when adjusted for availability bias). This summer bio-season high density is applied to the Morgan marine mammal study area in the assessment (Table 9.10).<br>Harbour porpoise is a qualifying interest of a number of Special Areas of Conservation (SACs) and Marine Nature Reserves (MNRs) (Isle of Man) within the regional marine mammal study area (Table 9.9). | 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, IUCN Red List Least Concern. |
| Bottlenose dolphin<br>*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 groups near the coast, centred upon Cardigan Bay, dispersing more widely and generally northwards, where they may form very large groups in winter).<br>Interim data from the Morgan Generation Assets for the first year of survey found that nine bottlenose dolphin were sighted across the 12-month Morgan aerial digital survey period, all sighted in June 2021.<br>Using lower uniform densities for this area (such as those in SCANS-III) 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 F. 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). It can be reasonably assumed that most bottlenose dolphin given their coastal distribution, will be located within a 6km region from the coastline, and those coastal areas may be comparable to other high use areas in the regional marine mammal study area, such as in outer Cardigan Bay which has higher densities, of 0.035 animals per km$^2$, as described in Lohrengel *et al.,* 2018. This assessment has taken a precautionary approach, and has considered the highest density of 0.035 animals per km$^2$, for bottlenose dolphin (Table 9.10).<br>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 9.9). | Annex II species protected under the Habitats Directive within a European Marine Site, EPS, IUCN Red List Least Concern. |
| Risso's dolphin<br>*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 0.031 animals per km$^2$ (CV = 0.686). This density is applied to the Morgan marine mammal study area in the assessment (Table 9.10).<br>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.<br>Risso's dolphin is a feature of interest for four MNRs in the Isle of Man (Table 9.9). | Annex II species protected under the Habitats Directive within a European Marine Site, EPS, IUCN Red List Least Concern. |

| Species | Baseline Summary | Conservation Importance |
|---|---|---|
| Short-beaked common dolphin<br>*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 metres. 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.<br>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 common dolphin were sighted within that block or the adjacent Block E. No animals were sighted during the first year of survey for the Morgan Generation Assets. 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). This density is applied to the Morgan marine mammal study area in the impact assessment (Table 9.10). | Annex II species protected under the Habitats Directive within a European Marine Site, EPS, IUCN Red List Least Concern. |
| Minke whale<br>*Balaenoptera acutorostrata* | Minke whales inhabit 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).<br>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). 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). The SCANS II Flock F density of 0.0173 animals per $km^2$ is applied to the Morgan marine mammal study area in the impact assessment (Table 9.10).<br>Minke whale is a feature of interest for one MNR in the Isle of Man (Table 9.9). | Annex II species protected under the Habitats Directive within a European Marine Site, EPS, IUCN Red List Least Concern. |
| Grey seal<br>*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 Management Units.<br>Interim data from the Morgan Generation Assets for the first year of survey found that grey seal were sighted in nine months of 12-month Morgan aerial digital survey period, with July, October and November being the only months in which animals were not sighted. Mean absolute density (i.e. density adjusted for availability bias) across the whole survey period was 0.075 animals per $km^2$, with a mean absolute density of 0.084 animals per $km^2$ during the pupping season (August to November) and 0.072 animals per $km^2$ during the non-pupping season (December to July).<br>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 and buffer zone was estimated at 0.0412 animals per $km^2$ (Carter *et al.*, 2022).<br>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 overview of grey seal abundance is provided in the marine mammal Technical Report (volume 4, annex 9.1), based upon visual counts at haul-out sites. (Table 9.10).<br>Grey seal is a qualifying interest of several SACs and three MNRs (Isle of Man) within the regional marine mammal study area (Table 9.9). 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). | Annex II species protected under Habitats Directive within a European Marine Site, IUCN Red List Least Concern |
| Harbour seal<br>*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.<br>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 $km^2$. and only one animal observed during the 24-month Morgan digital aerial survey. Interim data from the Morgan Generation Assets for the first year of survey found that grey seal were sighted in six months of 12-month Morgan aerial digital survey period. (Table 9.10).<br>Harbour seal is a qualifying interest of several SACs and three MNRs (Isle of Man) within the regional marine mammal study area (Table 9.9). 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 |

### 9.4.5 Legal status and designated sites

9.4.5.1 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 9.9.

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

9.4.5.3 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)
- The Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR) protects marine mammals under Annex V, including the prevention and control of adverse impacts from human activities, such as anthropogenic sound.

9.4.5.4 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 9.9: Designated sites and relevant qualifying interests for the marine mammal chapter.**

| Designated site | Closest distance to the Morgan Array Area (km) | Relevant qualifying interest |
|---|---|---|
| Langness MNR | 16.8 | • Harbour seal *Phoca vitulina*<br>• Grey seal *Halichoerus grypus*<br>• Harbour porpoise *Phocena phocoena*<br>• Risso's dolphin *Grampus griseus.* |
| North Anglesey Marine/Gogledd Môn Forol SAC | 28.2 | • Harbour porpoise *Phocena phocoena.* |
| Douglas Bay MNR | 22.2 | • Bottlenose dolphin *Tursiops truncatus*<br>• Risso's dolphin *Grampus griseus.* |
| Laxey Bay MNR | 22.4 | • Harbour porpoise *Phocena phocoena*<br>• Minke whale *Balaenoptera acutorostrata*<br>• Bottlenose dolphin *Tursiops truncates.* |
| Baie Ny Carrickey MNR | 30.2 | • Risso's dolphin *Grampus griseus*<br>• Harbour porpoise *Phocena phocoena*<br>• Bottlenose dolphin *Tursiops truncates* |
| Calf and Wart Bank MNR | 35.8 | • Risso's dolphin *Grampus griseus*<br>• Harbour porpoise *Phocena phocoena* |
| Ramsey Bay MNR | 26.5 | • Harbour seal *Phoca vitulina*<br>• Grey seal *Halichoerus grypus.* |
| Port Erin Bay MNR | 36.9 | • Harbour porpoise *Phocena phocoena* |
| Niarbyl MNR | 36.7 | • Harbour porpoise *Phocena phocoena*<br>• Grey seal *Halichoerus grypus.* |
| West Coast MNR | 38.2 | • Harbour porpoise *Phocena phocoena*<br>• Harbour seal *Phoca vitulina*<br>• Grey seal *Halichoerus grypus.* |
| North Channel SAC | 60.6 | • Harbour porpoise *Phocena phocoena.* |
| Strangford Lough SAC | 91.1 | • Harbour seal *Phoca vitulina.* |
| Murlough SAC | 97.6 | • Harbour seal *Phoca vitulina.* |
| Pen Llŷn a`r Sarnau/Llŷn Peninsula and the Sarnau SAC | 106.8 | • Bottlenose dolphin *Tursiops truncatus*<br>• Grey seal *Halichoerus grypus.* |
| West Wales Marine/Gorllewin Cymru Forol SAC | 112.7 | • Harbour porpoise *Phocena phocoena.* |
| Rockabill to Dalkey Island SAC | 123.4 | • Harbour porpoise *Phocena phocoena.* |
| Lambay Island SAC | 130.5 | • Harbour seal *Phoca vitulina*<br>• Grey seal *Halichoerus grypus.* |
| Cardigan Bay/Bae Ceredigion SAC | 168.2 | • Bottlenose dolphin *Tursiops truncatus*<br>• Grey seal *Halichoerus grypus.* |
| Slaney River Valley SAC | 189.2 | • Harbour seal *Phoca vitulina.* |
| Pembrokeshire Marine/Sir Benfro Forol SAC | 233.9 | • Grey seal *Halichoerus grypus.* |

| Designated site | Closest distance to the Morgan Array Area (km) | Relevant qualifying interest |
|---|---|---|
| Saltee Islands SAC | 259.79 | • Grey seal Halichoerus grypus. |
| Bristol Channel Approaches /Dynesfeydd Môr Hafren SAC | 300.15 | • Harbour porpoise Phocena phocoena. |
| Lundy SAC | 334.95 | • Grey seal Halichoerus grypus. |

## 9.4.6 Important ecological features

9.4.6.1 Important ecological features (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.

Table 9.10 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. Where a range has been used, average and maximum values are given. For harbour porpoise, the average is based upon SCANS-III (Hammond *et al.,* 2021) whilst the maximum is based upon aerial surveys for the Morgan marine mammal study area. 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 9.4.4) and therefore the value of all marine mammal IEFs was determined to be international.

**Table 9.10: Marine mammal IEFs, densities, MU populations and their importance within the regional marine mammal study area.**

| IEF | Density (animals per km$^2$) | Relevant MU | Abundance in MU | Importance |
|---|---|---|---|---|
| Harbour porpoise | 0.086 - 0.247 | Celtic and Irish Seas (IAMMWG, 2021) | 62,517 | International |
| Bottlenose dolphin | 0.035 | Irish Seas (IAMMWG, 2021) | 293 | International |
| Risso's dolphin | 0.0313 | Celtic and Greater North Seas (IAMMWG, 2021) | 12,262 | International |
| Short-beaked common dolphin | 0.018 | Celtic and Greater North Seas (IAMMWG, 2021) | 102,656 | International |
| Minke whale | 0.0173 | Celtic and Greater North Seas (IAMMWG, 2021) | 20,118 | International |
| Harbour seal | 0.00005 | Wales, NW England, N. Ireland SMUs (Wright and Sinclair, 2022) | 1,427 | International |
| Grey seal | 0.0412 | • OSPAR Region III<br>• Wales, NW England, N. Ireland, SW Scotland (Wright and Sinclair, 2022) *plus* Isle of Man reference population (Howe, 2018) *plus* East Ireland and South East Ireland regions (Duck and Morris, 2019) (hereafter referred to as 'Grey Seal reference population' (GSRP)) | • 60,780<br>• 13,563 | International |

## 9.4.7 Future baseline scenario

9.4.7.1 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.

9.4.7.2 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 will be 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.

9.4.7.3 Marine mammals are known to be impacted by various anthropogenic activities, including offshore developments but also fisheries, anthropogenic sound and transportation. Avila *et al*. (2020) 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 (by-catch) 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.

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

9.4.7.5 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).

9.4.7.6 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, for some species 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

9.4.7.7 Harbour porpoise are severely vulnerable to incidental entanglements in fishing gear, known as bycatch (Moan *et al.,* 2020). Harbour porpoise are most likely 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.

9.4.7.8 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.

9.4.7.9 Harbour porpoise has high parasitic exposure, with post-mortem examinations of 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) showed show stable and often high levels of PCBs 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).

9.4.7.10 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).

9.4.7.11 Data from SCANS II and SCANS III suggested that the abundance of harbour porpoise in the North Sea (NS) MU is stable (IAMMWG, 2015; IAMMWG, 2021). 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.

9.4.7.12 Climate change may also affect prey distribution, having implications for predators such as harbour porpoise (as discussed in section 9.4.7.8). 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 (164km) but a small shift (16km) in overlap between herring and porpoise.

9.4.7.13 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

9.4.7.14 Abundance estimates of bottlenose dolphin in the Irish Sea (IS) MU have declined in recent years (IAMMWG, 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 have been monitored annually in Cardigan Bay since 2001 and increased in abundance until peaking in 2007 to 2008 but have generally declined since then, although numbers now are similar to those in 2001 (Lohrengel *et al*., 2017).

9.4.7.15 The impacts of climate change for cetaceans are described in section 9.4.7.10. For the Irish Sea, Evans and Waggitt (2020) suggested no obvious trends in bottlenose dolphins since 2005 (Hammond *et al*., 2013, 2017).

9.4.7.16 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).

9.4.7.17 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 a 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

9.4.7.18 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 dolphins 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.

9.4.7.19 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 north North Sea (Evans *et al*., 2003; MacLeod *et al*., 2005). Short-beaked common dolphin show a positive relationship with increasing temperature (Evans and Waggit, 2020), and thus warming waters may lead to a shift in the range of short-beaked common dolphin (MacLeod *et al*., 2005).

9.4.7.20 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).

9.4.7.21 Common dolphins, as with all marine mammals, are susceptible to persistent organic pollutants (POPs) which may biomagnify (higher levels higher up the food chain) and bioaccumulate (increased concentration with age). As discussed in 9.4.7.9, 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 NE Atlantic from 2001 to 2003, found the threshold reported to have adverse health effects (17mg $kg^{-1}$) 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.

9.4.7.22 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

9.4.7.23 In the Irish Sea and Celtic Sea, there appears to be no obvious trends in status for Risso's dolphin (Baines & 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.

9.4.7.24 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).

9.4.7.25 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, 1995b) and during El Nino 1997–1998 and La Nina 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 9.4.7.21, Risso's dolphin are also susceptible to POPs and PCBs.

9.4.7.26 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

9.4.7.27 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 *clupea harengus* and sprat *Sprattus sprattus*, and less in areas with mackerel. 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).

9.4.7.28 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).

9.4.7.29 Major threats affecting minke whales 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 and SCANS III suggested that the abundance of minke whale in the CGNS MU is stable (IAMMWG, 2015; IAMMWG, 2021).

9.4.7.30 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

9.4.7.31 UK grey seal numbers are currently stable or increasing throughout their monitored range (SMRU, 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 (1993–2011), pup production has increased by an average of 10% per annum between 2011 and 2015 (Bull *et al*., 2017).

9.4.7.32 Pinnipeds are vulnerable to impacts of climate change (Evans and Waggitt, 2022). The Sea Mammal Research Unit (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).

9.4.7.33 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).

9.4.7.34 Impacts on the food chain may also occur due to climate change and reduce food availability. It has also been suggested that some 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). 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).

9.4.7.35 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

9.4.7.36 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, Robinson *et al*., 2018).

9.4.7.37 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.

9.4.7.38 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. 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 Phocine distemper virus (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 9.4.7.33, those species that occupy both terrestrial and marine habitats may risk more exposure to pathogens.

9.4.7.39 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).

### 9.4.8 Data limitations

9.4.8.1 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 9.1: Marine mammal technical report of the PEIR).

9.4.8.2 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.

9.4.8.3 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 (see paragraph 9.8.2.19).

## 9.5 Impact assessment methodology

### 9.5.1 Overview

9.5.1.1 The marine mammals impact assessment has followed the methodology set out in volume 1, chapter 5: EIA methodology of the PEIR. 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)
- Joint Nature Conservation Committee guidelines for minimising the risk of injury to marine mammals from geophysical surveys JNCC (2017)
- Joint Nature Conservation Committee 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).

9.5.1.2 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).

9.5.1.3 Full descriptions of relevant legislation is described in volume 1, chapter 2: Policy and legislation of the PEIR.

### 9.5.2 Impact assessment criteria

9.5.2.1 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 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.

9.5.2.2 The criteria for determining the significance of effects is a two-stage process that involves defining the magnitude of the 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 PEIR.

9.5.2.3 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 effects could occur arising from a particular activity (e.g. area of effect/number of animals in a population affected), how long animals are exposed to an activity that could cause an effect in the context of the life-history of a species (i.e. the duration), the frequency of the exposure that could lead to a change (i.e. continuous or intermittent) and whether or not the resultant change in exposed animals is reversible. The criteria for defining magnitude in this chapter are outlined in Table 9.11 below.

**Table 9.11: 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 lifetime reproductive success 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). |

| Magnitude of Impact | Definition |
|---|---|
| | 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). |

9.5.2.4 The criteria for defining sensitivity in this chapter are outlined in Table 9.12 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 tolerance to that impact and its ability to recover back to pre-impact conditions. Tolerance is defined as the susceptibility of a species to disturbance, damage or death, from a specific external factor. Recoverability is the ability of the same species to return to a state close to that which existed before the activity or event which caused change. It is dependent on the ability of the individuals to recover following cessation of the activity that causes the impact. Information on these aspects of sensitivity of the marine mammal 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 9.12.

**Table 9.12: 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 rates may be affected.<br>No tolerance; effect is very likely to cause a change in both reproduction and survival of individuals.<br>No ability for the animal to recover from the effect. |
| High | Limited ability to adapt behaviour so that survival and reproduction rates may be affected.<br>Limited tolerance; effect may cause a change in both reproduction and survival of individuals.<br>Limited ability for the animal to recover from the effect. |
| Medium | Ability to adapt behaviour so that reproduction rates may be affected but survival rates not likely to be affected.<br>Some tolerance; effect unlikely to cause a change in both reproduction and survival rates.<br>Ability for the animal to recover from the effect. |
| Low | Receptor is able to adapt behaviour so that survival and reproduction rates are not affected.<br>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. |
| Negligible | Very little or no effect on the behaviour of the receptor. |

9.5.2.5 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 9.13. Where a range of significance of effect is presented in Table 9.13, 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 is 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 significant effects provided in section 9.1 is quantified with reference to appropriate geographic scales (e.g. species-specific MUs).

9.5.2.6 In some cases the matrix suggests a range for the significance of effect (i.e. the range is given as minor to moderate) (Table 9.13). 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.

9.5.2.7 For the purposes of this assessment, any effects with a significance level of slight 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 9.13: Matrix used for the assessment of the significance of the effect.**

| Sensitivity of Receptor | Magnitude of Impact | | | | |
|---|---|---|---|---|---|
| | **No Change** | **Negligible** | **Low** | **Medium** | **High** |
| **Negligible** | No change | Negligible | Negligible or Minor | Negligible or Minor | Minor |
| **Low** | No change | Negligible or Minor | Negligible or Minor | Minor | Minor or Moderate |
| **Medium** | No change | Negligible or Minor | Minor | Moderate | Moderate or Major |
| **High** | No change | Minor | Minor or Moderate | Moderate or Major | Major |
| **Very High** | No change | Minor | Moderate or Major | Major | Major |

### 9.5.3 Designated sites

9.5.3.1 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 9.4.4 of this chapter (with the assessment on the site itself deferred to the Draft Report to Inform Appropriate Assessment). With respect to nationally and locally designated sites, where these sites fall within the boundaries of an internationally designated site (e.g.

SSSIs which have not been assessed within the ISAA 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).

9.5.3.2 The Draft ISAA has been prepared in accordance with Advice Note Ten: Habitats Regulations Assessment Relevant to Nationally Significant Infrastructure Projects (The Planning Inspectorate, 2022).

## 9.6 Key parameters for assessment

### 9.6.1 Maximum design scenario

9.6.1.1 The maximum design scenarios (MDS) identified in Table 9.14 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 provided in volume 1, chapter 3: Project description of the PEIR. 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 9.14: 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] | | | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | C | O | D | | |
| Injury and disturbance from elevated underwater sound during piling | ✓ | × | × | **Construction phase:**<br>• Monopiles:<br>– Wind turbines: installation of up to 68 wind turbines with a 16m diameter monopile foundations installed by impact piling<br>– Offshore substation platforms (OSPs): installation of one OSP with foundations consisting of two 16m diameter piled monopile foundations installed by impact piling<br>– Maximum hammer energy of up to 5,500kJ<br>– Up to two vessels piling concurrently (minimum distance 875m, maximum distance 28.5km, between piling vessels)<br>– Maximum of up to 9.5 hours of piling for a monopile with a cumulative total of up to 665 hours.<br>– Consecutive piling over a maximum of 24 hours.<br>– One monopile installed per 24 hours per vessel = 70 days for a single vessel (maximum temporal) or 35 days for two vessels (maximum spatial).<br><br>• Pin piles<br>– Wind turbines: installation up to 68 3-legged jacket foundations with one pile per leg (a total of up to 204 piles), or up to 2 piles per leg (a total of 408 piles), and each pile with a diameter of 5.5m installed by impact piling<br>– OSP: installation of one OSP with 6-legged jacket foundations, with three piles per leg (a total of 18 piles) and each pile with a diameter of 5.5m installed by impact piling<br>– Maximum hammer energy of up to 3,700kJ<br>– Up to two vessels piling concurrently (minimum distance 875m, maximum distance 28.5km, between piling vessels)<br>– Wind turbines: maximum duration of up to 8.02 hours piling per pile (where only a single pin-pile is used per leg) or up to 4.01 hours per pile (where two pin-piles are used per leg, which also equates to 8.02 hours per leg), total duration of piling per wind turbine foundation =16.04 hours of piling per day (with a cumulative total of up to 1,638 hours)<br>– OSP foundation: maximum duration of up to 8.02 hours piling per pile with a cumulative total of up to 144.36 hours; installation of OSP over 9 days (=16.04 hours piling per day)<br>– Consecutive piling over a maximum of 24 hours.<br>– Single piling of 103 days for wind turbine plus approx. 9 days for OSP = 112 days (maximum temporal) or 56 days for two vessels (maximum spatial).<br>Total piling phase (foundation installation) of up to two years within a four-year construction programme. | For both monopiles and pin piles the largest hammer energy and maximum spacing between concurrent piling events 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.<br><br>For both monopiles and pin piles the maximum temporal scenario was assessed on the greatest number of days on which piling could occur based on the number of piles that could be installed within a 24-hour period.<br>Consecutive piling is assumed over a maximum period of 24 hours. |
| Injury and disturbance from elevated underwater sound during site investigation surveys | ✓ | × | × | **Construction phase**<br>• Geophysical site investigation activities include:<br>– Multi-beam echo-sounder (MBES) - 200-500 kHz; 180-240dB re 1μPa re 1m (rms)<br>– Sidescan Sonar (SSS) - 200-700kHz; 216-228dB re 1μPa re 1m (rms)<br>– Single Beam Echosounder (SBES) - 20-400kHz; 180-240dB re 1μPa re 1m (rms)<br>– Sub-Bottom Profilers (SBP) - 0.2-14kHz chirp; 2-7 kHz pinger; 200-240 chirp dB re 1μPa re 1m (rms); 200-235 pinger dB re 1μPa re 1m (rms)<br>– Ultra High Resolution Seismic (UHRS) (0.05-4kHz; 182dB re 1μPa re 1m (rms))<br><br>• Geotechnical site investigation activities include:<br>– Boreholes<br>– Cone penetration tests (CPTs)<br>– Vibrocores<br><br>Pre-construction site investigation surveys will involve the use of several geophysical/geotechnical survey vessels and take place over up to a period of up to eight months. | 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 effect (e.g. highest source, fastest pulse rate, longest pulse duration) and as such were those that would lead to the greatest spatial extent for injury. |

| Potential impact | Phase[a] C | O | D | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| Injury and disturbance from elevated underwater sound during unexploded ordnance (UXO) clearance | ✓ | × | × | **Construction phase**<br>• Clearance of up to 13 UXOs within the Morgan Array Area<br>• A range of UXO sizes assessed from 25kg up to 907kg with 130kg the most likely maximum.<br>• For high order detonation donor charges of 1.2kg (most common) and 3.5kg (single barracuda blast charge)<br>• Up to 0.5kg NEQ clearance shot for neutralisation of residual explosive material at each location<br>• Clearance during daylight hours only.<br>MDS is for high order clearance but assessment also considered:<br>• Low order clearance charge size of 0.08kg<br>• Low yield clearance configurations of 0.75kg charges (up to 4x0.75kg) | 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, highlighting the most likely size (common) to be encountered.<br>Most likely and maximum donor charges assessed for high order detonation.<br>Assumption of a clearance shot of up to 0.5kg at all locations although noting that this may not always be required.<br>For low order/low yield clearance charges are based on the maximum required to initiate clearance event. |
| Injury and disturbance from elevated underwater sound due to vessel use and other (non-piling) activities | ✓ | ✓ | ✓ | **Construction phase**<br>*Vessels*<br>• Up to a total of 63 construction vessels on site at any one time (22 main installation and support vessels, eight tug/anchor handlers, four cable lay installation and support vessels, one guard vessels, five survey vessels, seven seabed preparation vessels, 11 Crew Transfer Vessels (CTVs), three scour protection installation vessels and two cable protection installation vessels)<br>• Up to 1878 installation vessel movements (return trips) during construction (521 main installation and support vessels, 74 tug/anchor handlers, 8 cable lay installation and support vessels, 50 guard vessel, 29 survey vessels, 18 seabed preparation vessels, 1,135 CTVs, 41 scour protection installation vessels and 2 cable protection installation vessels)<br>**Other activities:**<br>– Up to 100% of overall piles are anticipated to require drilling (107 4-legged wind turbine jacket foundations with a diameter of 2.6m and four 4-legged OSP jacket foundations with a diameter of 3.0m); up to two concurrent drilling vessels<br>– Burial of up to 500km of inter-array cables and 50km of interconnector cables via ploughing, trenching and jetting; cable burial and rock dumping.<br>• Maximum offshore construction duration of up to 4 years.<br>**Operations and maintenance Phase**<br>• Up to a total of 21 operations and maintenance vessels on site at any one time (six CTVs/workboats, three jack-up vessels, four cable repair vessels, four Service Operation Vessels (SOV) or similar and four excavators/backhoe dredgers)<br>• Up to 2,351 operations and maintenance vessel movements (return trips) each year (2,190 CTVs/workboats, 25 jack-up vessels, 16 cable repair vessels, 104 SOV or similar and 16 excavators/backhoe dredgers)<br>• Operational lifetime of up to 35 years.<br>**Decommissioning Phase**<br>• Vessels used for a range of decommissioning activities such as removal of foundations<br>• Sound from vessels assumed to be as per vessel activity described for construction phase above. | The MDS 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 noise signatures within the marine environment to affect marine mammal receptors.<br>The MDS considers the maximum durations which activities could be conducted for. |
| Underwater sound from wind turbine operation | × | ✓ | × | **Operations and maintenance phase**<br>• Up to 68 monopile foundations monopile; 16m foundation diameter | The MDS considers the largest of potential turbine options for the Morgan Generation Assets. As turbine size is the main factor influencing the noise from operational wind farms, this represents the potential for highest underwater sound levels. |
| Increased risk of injury due to collision with vessels | ✓ | ✓ | ✓ | **Construction phase**<br>• As described for vessel disturbance above.<br>**Operations and maintenance phase**<br>• As described for vessel disturbance above.<br>**Decommissioning phase**<br>• As described for vessel disturbance above. | The MDS 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. |

| Potential impact | Phase[a] | | | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | C | O | D | | |
| Changes in fish and shellfish communities affecting prey availability | ✓ | ✓ | ✓ | **Construction phase**<br>• As described in volume 2, chapter 8: Fish and shellfish ecology of the PEIR for:<br>– Temporary habitat loss/disturbance<br>– Long term habitat loss/disturbance<br>– Increased suspended sediment concentrations and associated sediment deposition<br>– Injury and/or disturbance to fish and shellfish from underwater sound and vibration.<br>**Operations and maintenance phase**<br>• As described in volume 2, chapter 8: Fish and shellfish ecology of the PEIR for:<br>– Temporary habitat loss/disturbance<br>– Long term subtidal habitat loss<br>– Increased suspended sediment concentrations and associated sediment deposition<br>– Electromagnetic fields (EMF) from subsea electrical cabling<br>– Colonisation of foundations, scour protection and cable protection.<br>**Decommissioning phase**<br>• As described in volume 2, chapter 8: Fish and shellfish ecology of the PEIR for:<br>– Temporary habitat loss/disturbance<br>– Long term habitat loss/disturbance<br>– Increased suspended sediment concentrations and associated sediment deposition<br>– Injury and/or disturbance to fish and shellfish from underwater sound and vibration. | As described in volume 2, chapter 8: Fish and shellfish ecology of the PEIR. |

### 9.6.2 Impacts scoped out of the assessment

9.6.2.1 On the basis of the baseline environment and the description of development outlined in volume 1, chapter 5: Project description of the PEIR, a number of impacts are proposed to be scoped out of the assessment for marine mammals These impacts are outlined, together with a justification for scoping them out, in Table 9.15.

**Table 9.15: Impacts scoped out of the assessment for marine mammals.**

| Potential impact | Justification |
|---|---|
| Accidental pollution | 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.<br>With implementation of an Environmental Management Plan (EMP) (including Marine Pollution Contingency Plan (MPCP) secured by deemed Marine Licence conditions under the DCO) 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 windfarm'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.<br>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.<br>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.<br>Consultees (The Planning Inspectorate, MMO) agreed to scope out this impact for all stages of the Morgan Generation Assets via the Morgan EIA Scoping Opinion (Planning Inspectorate, 2022). |
| Increased suspended sediment concentrations and associated sediment deposition | Disturbance to water quality as a result of construction and decommissioning operations can have both direct and indirect impacts on marine mammals.<br>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 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.<br>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.<br>In addition, there is likely to be large natural variability in the SSC within the Morgan marine mammal study area, so marine mammals living here are considered likely to be tolerant of any small-scale increases, such as those associated with the construction activities.<br>In summary, the ZOI of increased SSC will be small, particularly in the context of the wider available habitat, and the duration of effects 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.<br>Consultees agreed to scope out this impact for all stages of the Morgan EIA Scoping Opinion (Planning Inspectorate, 2022). |
| Impact of 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).<br>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 their 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.<br>Consultees agreed to scope out this impact during marine mammals via the Morgan EIA Scoping Opinion (Planning Inspectorate, 2022). |

## 9.7 Measures adopted as part of the Morgan Generation Assets

9.7.1.1 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 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 (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 (referred to as tertiary mitigation in IEMA, 2016).

9.7.1.2 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 9.16 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 9.7 below (i.e. the determination of magnitude and therefore significance assumes implementation of these measures).

9.7.1.3 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 section 9.7 below.

**Table 9.16: 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** | | |
| Implementation of initiation stage, piling soft start and ramp up measures.<br>During piling operations, an initiation phase and soft start will be used. This will involve the implementation of a low hammer energy with a low number of strikes used initially, followed by lower hammer energies at a higher strike rate at the beginning of the piling sequence before energy input is 'ramped up' (increased) over time to required higher levels.<br>For monopiles, a 10 minute initiation phase is used with hammer energy of 550kJ (10% of full power piling) at a strike rate of 0.67 per minute (1 strike every 90 seconds) and then soft start duration is 20 minutes, with a hammer energy of 550kJ (10% of full power piling) and strike rate of 10 per minute. Ramp up will then increase from 550 to 5000kJ with strike rate of 15 strike per minute for 20 minutes.<br>For pin-piles, a 10 minute initiation phase is used with hammer energy of 300kJ at a strike rate of 0.67 per minute (1 strike every 90 seconds) and then soft start duration is 20 minutes with hammer energy of 300kJ with strike rate of 10 per minute. Ramp up will then increase from 300 to 2500kJ with strike rate of 15 strike per minute for 20 minutes. | This measure will minimise the risk of injury to marine mammal and fish species in the immediate vicinity of piling operations, allowing individuals to flee the area before sound levels reach a level at which injury may occur. It is considered that compliance with these guidelines will, in most cases, reduce the risk of injury to marine mammals to negligible levels. | Proposed to be secured through a condition in the marine licence(s) |
| Inclusion of low order techniques 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 | Low order techniques generate less underwater sound than high order techniques and therefore present a lower risk to noise 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 (SNCBs, 2022).<br>Note, however, that low order techniques are not always possible and are dependent upon the individual situations surrounding each UXO. Given that high order detonation may be used the MMMP will also include mitigation to reduce the risk of injury from UXO clearance. | Proposed to be secured through a condition in the marine licence(s) |
| **Tertiary measures: Measures required to meet legislative requirements, or adopted standard industry practice** | | |
| For the Environmental Statement, a Draft MMMP will be consulted on and approved by Planning Inspectorate and implemented prior to construction. The 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 MMMP will be developed on the basis of the most recent published statutory guidance and in consultation with key stakeholders.<br><u>Piling</u>: for the purpose of developing the MMMP, a mitigation zone will be defined based on the maximum predicted injury range from the dual metric sound modelling for the maximum spatial scenario (monopiles and pin piles) and across all marine mammal species. The Draft MMMP will set out the measures to apply in advance of and during piling activity including the use of:<br>• Marine mammal observers (MMOs),<br>• Passive acoustic monitoring (PAM) and<br>• Acoustic deterrent devices (ADDs)<br>Therefore following the latest JNCC guidance (JNCC, 2010a).<br><u>UXO clearance</u>: 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).<br><u>Geophysical surveys</u><br>Mitigation for injury during high resolution geophysical surveys using a sub-surface sensor from a conventional vessel may 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 (<200m) are not subject to the requirements of mitigation. | The implementation of an approved MMMP 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 MMMP will also minimise the potential for collision risk, or potential injury to, marine mammals and other marine megafauna (e.g. basking shark and sea turtles). The MMMP will include 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 from injury risk zones may be applied in some instances (e.g. ADDs or soft start charges). | Proposed to be secured through a condition in the marine licence(s) |

| Measures adopted as part of the Morgan Generation Assets | Justification | How the measure will be secured |
|---|---|---|
| Offshore Environmental Management Plan (EMP) with measures to minimise disturbance to marine mammals from transiting vessels, requiring them to:<br>• Not deliberately approach marine mammals as a minimum<br>• Avoid abrupt changes in course or speed should marine mammals approach the vessel to bow-ride.<br>The offshore EMP will be adhered to at all times. | To minimise the potential for collision risk, or potential injury to, marine mammals and megafauna. | An offshore EMP will be issued to all Project vessel operators. Proposed to be secured through a condition in the marine licence(s). |
| Development of, and adherence to, an EMP, including Marine Pollution Contingency Plan (MPCP). | 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 even occurs, that plans are in place to respond quickly and effectively to ensure any spillage is minimised and effects on the environment are ideally avoided or minimised.<br>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. | Proposed to be secured through a condition in the marine licence(s). |
| Development of, and adherence to, a Decommissioning Plan. | The aim of this plan is to adhere to the existing UK and international 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.<br>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 9.1. | Requirement for a decommissioning plan is proposed to be secured as a requirement of the DCO. |

## 9.8 Assessment of significant effects

9.8.1.1 The impacts of the construction, operations and maintenance, and decommissioning phases of the Morgan Generation Assets have been 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 9.14, along with the MDS against which each impact has been assessed.

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

### 9.8.2 Underwater sound and marine mammals

9.8.2.1 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 effects on marine mammals.

9.8.2.2 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 effects, and the evidence base from which they are derived, are given below.

#### Injury

9.8.2.3 Auditory injury in marine mammals can occur either as a Temporary Threshold Shift (TTS), where an animal's auditory system can recover, or a Permanent Threshold Shift (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 6dB 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 40dB 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.

9.8.2.4 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 ranges.

9.8.2.5 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 9.8.2.21) also lead to an overestimation of ranges. Notably, Hastie *et al*. (2019) found that during pile driving there were range dependant changes in signal characteristics with received sound losing its impulsive characteristics at ranges of several kilometres, especially beyond 10km. As such, TTS is not considered a useful predictor of the effects of underwater sound on marine mammals where ranges exceed more than c. 10km 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 in volume 3, annex 3.1: Underwater sound technical report of the PEIR. Ranges for TTS were, however, modelled for completeness for all sound-related impacts and are presented in volume 3, annex 3.1: Underwater sound technical report of the PEIR. For marine mammals, injury thresholds are based on both peak sound pressure levels ($SPL_{pk}$) (i.e. unweighted) and marine mammal hearing-weighted cumulative sound exposure level ($SEL_{cum}$) as per the latest guidance (Southall *et al.*, 2019) (see volume 3, annex 3.1: Underwater sound technical report of the PEIR). 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 (further detail in Volume 3, annex 3.1: Underwater sound technical report of the PEIR, summarised in Table 9.17).

**Table 9.17: Assessment swim speeds of marine mammals that are likely to occur within the Irish Sea for the purpose of exposure modelling for Morgan Generation Assets.**

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

### Disturbance

9.8.2.6 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. Typically, a threshold approach has been adopted in offshore wind farm assessments in the UK to quantify the scale of the effects. For example, the United States (US) National Marine Fisheries Service (NMFS) (NMFS, 2005) define strong disturbance in all marine mammals as Level B harassment and for impulsive sound suggests a threshold of 160dB re 1 µPa (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 guidelines suggest a precautionary level of 140 dB re 1 µPa (rms) to indicate the onset of low-level marine mammal disturbance effects for all mammal groups for impulsive sound (NMFS, 2005), although this is not considered likely to lead to a 'significant' disturbance response. The assessment adopted the NMFS criteria of non-trivial (strong) disturbance (160dBrms) and trivial (mild) disturbance (140dBrms) for all impulsive sound sources, other than for piling which used a dose-response approach as described below.

#### Dose-response

9.8.2.7 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 4.8km from the piles, whilst at greater distances (10km 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 9.2).

9.8.2.8 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 5km x 5km 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 142dB and 151dB re 1µPa$^2$s.

9.8.2.9 More recently, a study by Whyte *et al.* (2020) used tracking data from 24 harbour seal to estimate the 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 25km or $SEL_{ss}$ (averaged across depths and pile installations) above 145 dB re 1lPa$^2$. 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. A dose response curve derived from this study (Figure 9.3) 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 5dB isopleths in decreasing increments from 180dB to 120dB re.1µPa$^2$s using the highest modelled received sound level.

9.8.2.10 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 5dB isopleth were calculated from the spatial GIS map and a proportional expected response, derived from the dose response curve for each isopleth area, was used to calculate the number of animals potentially disturbed. These numbers were subsequently summed across all isopleths to estimate the total number of animals disturbed during piling. The number of animals predicted to respond was based on species specific densities as agreed with statutory consultees (Table 9.10).

9.8.2.11 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 $SEL_{ss}$. 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 9.2).

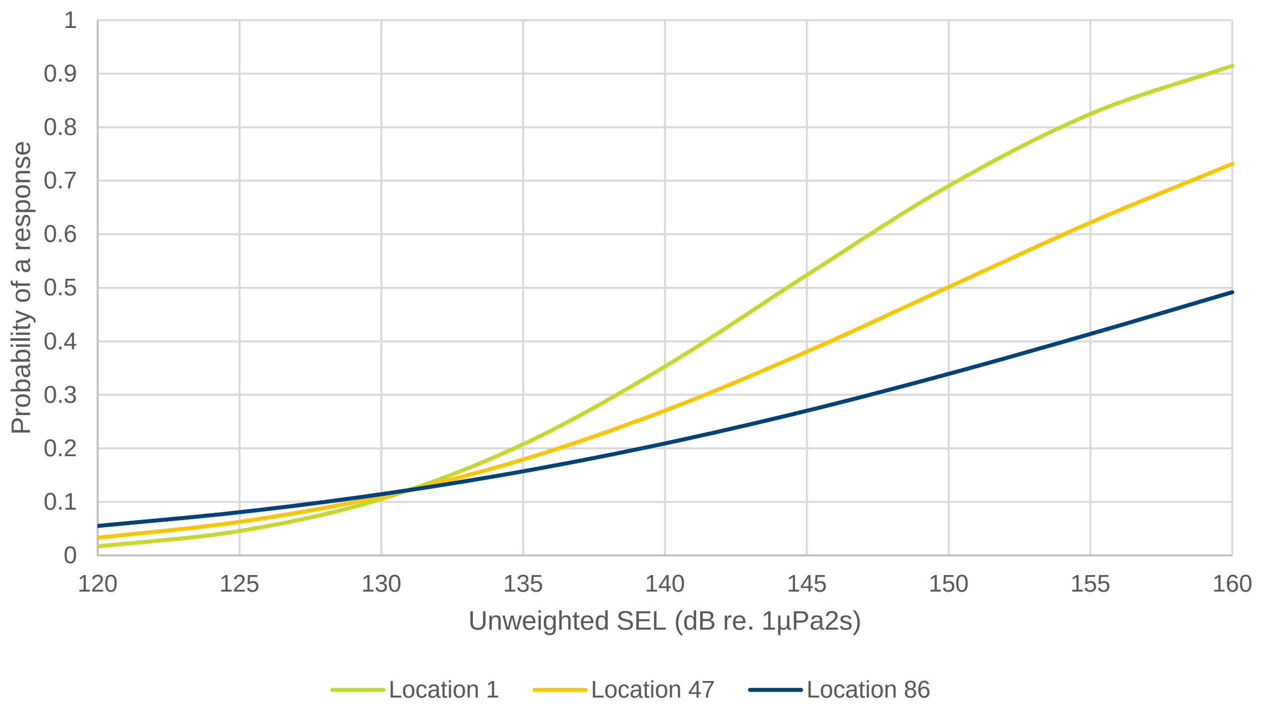



**Figure 9.2: The probability of a harbour porpoise response (24 hr) in relation to the partial contribution of unweighted received single-pulse SEL for the first location piled (green line), the middle location (yellow line) and the final location piled (blue line). Reproduced from Graham *et al*. (2019).**

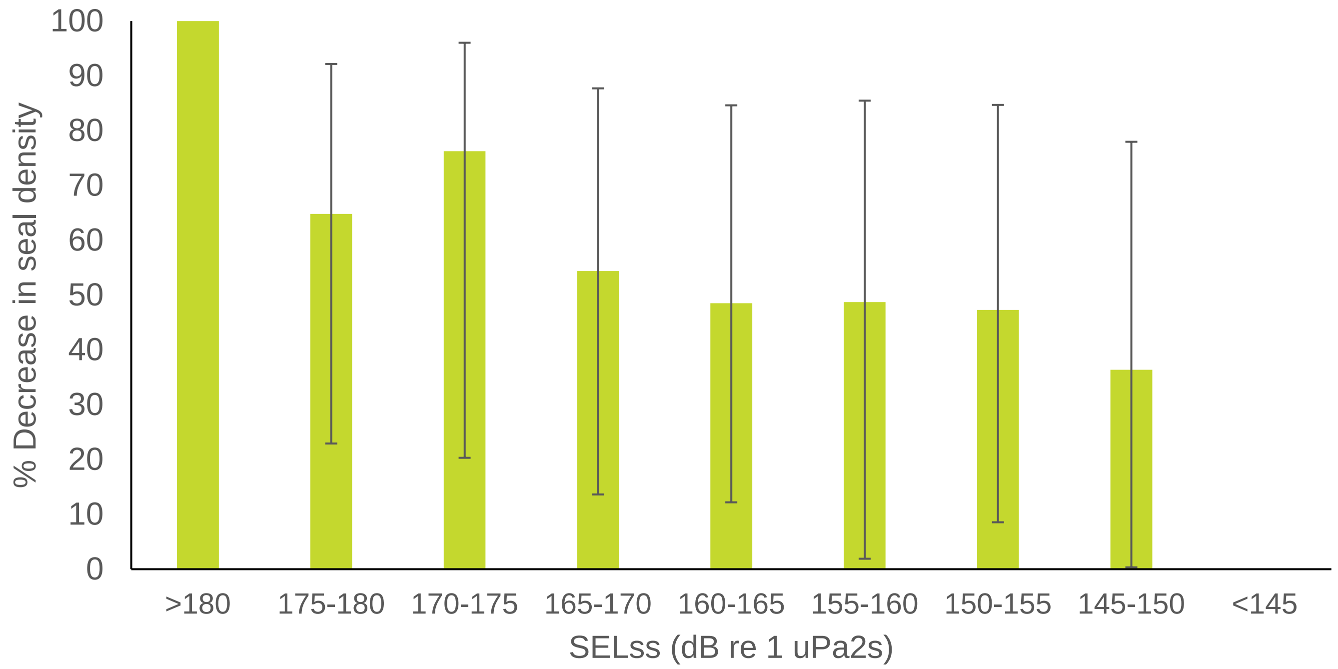



**Figure 9.3: Predicted decrease in seal density as a function of estimated sound exposure level, error bars show 95% CI (from Whyte *et al.,* 2020).**

9.8.2.12 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 NRW. It has been assumed that all seals are displaced at sound exposure levels above 180 dB re 1 μPa$^2$s. This is a conservative assumption since there 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 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 are available, and it is considered to be an appropriate proxy for grey seals given both species are within the same hearing group (Phocid Carnivores in Water (PCW)).

9.8.2.13 Dose response is an accepted approach to understanding the behavioural effects from piling and has been applied at other UK offshore wind farms (for example Awel y Môr (RWE, 2022), Seagreen (Seagreen Wind Energy Ltd, *2012*) and Hornsea Project Three (Orsted, 2018).

**Importance of context**

9.8.2.14 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 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).

9.8.2.15 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.

9.8.2.16 Even where studies have been able to assign responses to these categories based on acute exposure there is still limited understanding of how longer term (chronic) exposure could translate into population-level effects. 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 (paragraph 9.8.3.12 to 9.8.3.18).To explore 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.

9.8.2.17 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 risk of longer-term population consequences. Booth (2020) highlighted 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).

9.8.2.18 The marine mammals considered in this assessment vary biologically and therefore have different ecological requirements that may affect their sensitivity to disturbance. This point is illustrated by the differences between the two seal species identified as key biological receptors in the baseline. Grey seals 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.

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

- Conservative assumptions in the marine mammal baseline (e.g. use of seasonal density peaks for harbour porpoise and grey seal, offshore and inshore densities for bottlenose and pinniped species, excluding Manx bottlenose population due to temporal regime with Cardigan Bay)
- Conservative assumptions in the MDS for the project parameters (Table 9.14)
- Conservative assumptions in the underwater sound modelling (see summary below) (Volume 3, annex 3.1: Underwater sound technical report of the PEIR).

9.8.2.20 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

9.8.2.21 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 PEIR). 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 worst case assessed in the Environmental Statement and only six out of 86 asset locations reached maximum hammer energy (Beatrice, 2018))
- The soft start procedure simulated does not allow for short pauses in piling (e.g. for realignment) and therefore the modelled $SEL_{cum}$ is likely to be an overestimate since, in reality, these pauses will reduce the 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 6.2m/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 10km from the sound source (Hastie *et al*., 2019) (Volume 3, annex 3.1: Underwater sound technical report of the PEIR). Since the precise range at which this transition occurs is unknown (not least because the transition also depends on the response of the marine mammal's ear), sound models still adopt the impulsive thresholds at all ranges which 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 1.5.5.26 to 1.5.5.29 of volume 3, annex 3.1: Underwater sound technical report of the PEIR, 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 1.5.5.28 of volume 3, annex 3.1: Underwater sound technical report of the PEIR).

9.8.2.22 These measures of conservatism highlight that both PTS and TTS onset ranges predicted using the $SEL_{cum}$ threshold are likely to lead to overestimates in the ranges and therefore should be interpreted with caution.

## 9.8.3 Injury and disturbance from elevated underwater sound during piling

9.8.3.1 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 9.14.

### Summary of piling scenarios

9.8.3.2 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 behavioural effects on 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 PEIR).

9.8.3.3 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 9.8.2.22).

9.8.3.4 The $SEL_{cum}$ metric was modelled over a single installation sequence for a monopile or pin pile. 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).

9.8.3.5 The scenarios modelled were based on the absolute maximum hammer energy (5,500kJ for monopiles and 3,700kJ for pin piles), for the longest possible duration, noting that piling is unlikely to reach and maintain the absolute maximum hammer energy of at all locations (Table 9.14). To inform development of the primary mitigation a sound modelling workshop was undertaken to test sensitivities of different hammer initiation and soft start scenarios. Subsequently 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 auditory injury (see volume 3, annex 3.1: Underwater sound technical report of the PEIR).

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

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

- Separation distance of 980m (the minimum distance between foundations) as a maximum adverse scenario for injury and
- Separation distance of up to 28.5km as a maximum adverse scenario for disturbance.

9.8.3.8 Underwater sound modelling assumed concurrent piling at two wind turbine foundations as the MDS (as opposed to wind turbines and OSPs) due to the large distances between wind turbines (i.e. maximum spatial separation). Installation does not, however, preclude concurrent piling at a wind turbine foundation and OSP foundation but this scenario is captured in the MDS for concurrent piling at two wind turbine foundations. 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). The concurrent scenarios also considered consecutive piling over 24 hours.

9.8.3.9 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. For monopiles the longest duration of piling for wind turbines or OSPs is 9.5 hours per pile, with a cumulative total of 665 hours of piling. Piling at wind turbine foundations and OSPs would occur over a maximum of 70 days using a single vessel (with the assumption of one monopile installed per 24 hours).

9.8.3.10 For pin piles, the longest duration of piling for wind turbines is 8.02 hours per pile with three piles per foundation. The total duration of piling for wind turbines is 1,638 hours and would take up to 103 days to install. Each wind turbine foundation would take up to two days to install. For the OSP the longest duration of piling is up to 8.02 hours per pile with 18 piles for this foundation. The total duration of piling for the OSP foundation is 145.4 hours and would take up to nine days to install. For both wind turbine and the OSP foundation piling would occur over a maximum of 112 days with a single vessel.

9.8.3.11 A summary of the scenarios assessed is provided in the following table (Table 9.18).

**Table 9.18: 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).**

| Scenario | Hammer energy (kJ) | Number of piles | | Duration per Pile (hours) | | Duration of Piling per 24 hours (per vessel) | | Total Days of Piling | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Monopiles (Wind Turbine and OSP)** | | | | | | | | | | |
| Single | 5,500 | 70 | | 9.5 | | 9.5 (24)* | | 70 | | |
| Concurrent | 5,500 | 70 | | 9.5 | | 9.5 | | 35 | | |
| **Pin piles (Wind Turbine and OSP)** | | | | | | | | | | |
| | | **WT** | **OSP** | **WT** | **OSP** | **WT** | **OSP** | **WT** | **OSP** | **Total** |
| Single | 3,700 | 204 | 18 | 8.02 | 8.02 | 16.04 (24)* | 16.04 | 103 | 9 | 112 |
| Concurrent | 3,700 | 204 | 18 | 8.02 | 8.02 | 16.04 | 16.04 | 52 | 5 | 56 |

### Summary of interim population consequences of disturbance (iPCoD) modelling

9.8.3.12 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.

9.8.3.13 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 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).

9.8.3.14 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 model (Harwood *et al*., 2014).

9.8.3.15 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 (section A.3.4). The results are summarised in relation to the forecasted population size over time with forecasts made at certain timepoints (e.g. two, seven, 13, 19 and 25 years) after piling commences. In addition, the model calculates the median ratio of the impacted to unimpacted population size at these timepoints[1]. A caveat of this model, however, is that the model does 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).

9.8.3.16 Whilst there are many limitations to this process, iPCoD modelling 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 (Table 9.5). In addition, any uncertainties 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 are considered to be inherently cautious and should be interpreted as such.

9.8.3.17 Population modelling using iPCoD was carried out for the following species due to the potential number of animals affected relative to the relevant MU populations:

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

9.8.3.18 Population modelling was not carried out for short-beaked common dolphin or Risso's dolphin as there was no facility in iPCoD to consider these two species. Harbour seal was not included due to the very small number of animals potentially behaviourally

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

disturbed and therefore very low risk of a population level effect occurring for this species.

## Construction phase

**Magnitude of impact**

### Auditory Injury

9.8.3.19 The maximum spatial effect was predicted for monopiles with a hammer energy of 5,500kJ. At hammer initiation instantaneous injury leading to PTS, based on $SPL_{pk}$, could occur out to a maximum range of 299m across all species, with the maximum range predicted for harbour porpoise (Table 9.19). Using the same metric the maximum range of injury was predicted at 961m at full hammer (although this assumes animals do not move away at the start of piling, which is unlikely). Considering cumulative exposure using the $SEL_{cum}$ metric the risk of PTS was predicted to occur out to a maximum range of 5,360m as predicted for minke whale, assuming consecutive piling over 24 hours (Table 9.20).

9.8.3.20 Spatial effects were smaller for the 2,800kJ pin piles with a maximum range of 186m for instantaneous injury (at hammer initiation) and 707m at full hammer (although this assumes animals do not move away at the start of piling, which is unlikely). The maximum range for cumulative exposure for concurrent piling, was 1,651m as predicted for minke whale, assuming consecutive piling over 24 hours (Table 9.19 and Table 9.20). Injury ranges were considerably smaller for the pin piles compared to monopiles due to: 1) lower source levels; 2) shorter installation time (relevant for the $SEL_{cum}$ metric); and 3) reduction in source levels once the pile is below the water line (the maximum level occurred during the very short period of piling just before the pile is fully submerged).

9.8.3.21 The maximum temporal effect was predicted as the longest duration for either monopiles or pin piles. 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 9.18 piling will be intermittent over a two year piling phase and will occur on a maximum of up to 70 days for monopiles or 112 days for pin piles.

9.8.3.22 Tertiary mitigation in the form of a MMMP will be implemented to reduce the risk of PTS. Such mitigation will include deployment of an ADD as recommended in the JNCC guidelines (2010). 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 9.8.3.24). The exact duration of an 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.

9.8.3.23 The assessment of magnitude with respect to auditory injury is presented below (paragraph 9.8.3.29) on a species-specific basis, where the maximum adverse scenario is identified for each species.

**Table 9.19: Summary of $SPL_{pk}$ PTS injury ranges and areas of effect for marine mammals for single monopile and single pin pile installation (N/E = threshold not exceeded).**

| Species | Threshold (unweighted peak) | Hammer energy level | Monopile | | Pin pile | |
|---|---|---|---|---|---|---|
| | | | Range of effect (m) | Area of effect ($km^2$) | Range of effect (m) | Area of effect ($km^2$) |
| Harbour porpoise (VHF) | 202dB re 1 µPa (pk) | Initiation (first strike) | 299 | 0.28 | 186 | 0.12 |
| | | Full energy (maximum) | 961 | 2.90 | 707 | 1.57 |
| Bottlenose, Risso's, Common dolphin (HF) | 230dB re 1 µPa (pk) | Initiation (first strike) | 29 | 0.002 | 16 | 0.001 |
| | | Full energy (maximum) | 94 | 0.03 | 62 | 0.01 |
| Minke (LF) | 219dB re 1 µPa (pk) | Initiation (first strike) | 73 | 0.02 | 42 | 0.01 |
| | | Full energy (maximum) | 234 | 0.17 | 161 | 0.08 |
| Phocids (Grey seal and harbour seal) (PCW) | 218dB re 1 µPa (pk) | Initiation (first strike) | 25 | 0.002 | 46 | 0.01 |
| | | Full energy (maximum) | 255 | 0.20 | 176 | 0.10 |

**Table 9.20: Summary of $SEL_{cum}$ PTS injury ranges and areas of effect for marine mammals for monopile and pin pile installation (N/E = threshold not exceeded).**

| Species | Threshold (SEL weighted) | Scenario | Monopile | | Pin pile | |
|---|---|---|---|---|---|---|
| | | | PTS range (m) | Area of effect ($km^2$) | PTS range (m) | Area of effect ($km^2$) |
| Harbour porpoise (VHF) | PTS - 155 dB re 1 µPa2s | Single | 1,665 | 8.71 | N/E | 0.00 |
| | | Concurrent | 2,727 | 23.33 | N/E | 0.00 |
| | | Consecutive (24hrs) | 1,725 | 9.35 | N/E | 0.00 |
| Bottlenose, Risso's, Common dolphin (HF) | PTS - 185 dB re 1 µPa2s | Single | N/E | 0.00 | N/E | 0.00 |
| | | Concurrent | N/E | 0.00 | N/E | 0.00 |
| | | Consecutive (24hrs) | N/E | 0.00 | N/E | 0.00 |
| Minke (LF) | PTS - 183 dB re 1 µPa2s | Single | 3,865 | 46.93 | 656 | 1.35 |
| | | Concurrent | 5,360 | 90.26 | 1,651 | 8.56 |
| | | Consecutive (24hrs) | 3,965 | 49.39 | 671 | 1.41 |

| Species | Threshold (SEL weighted) | Scenario | Monopile | | Pin pile | |
|---|---|---|---|---|---|---|
| | | | PTS range (m) | Area of effect ($km^2$) | PTS range (m) | Area of effect ($km^2$) |
| Phocids (Grey seal and harbour seal) (PCW) | PTS - 185 dB re 1 µPa2s | Single | N/E | 0.00 | N/E | 0.00 |
| | | Concurrent | N/E | 0.00 | N/E | 0.00 |
| | | Consecutive (24hrs) | N/E | 0.00 | N/E | 0.00 |

*MMMP (Tertiary mitigation)*

9.8.3.24 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.

9.8.3.25 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 ORJIP, the use of ADDs for mitigation at offshore wind farms has gained momentum. For 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 measures (MMOs and PAM) which, as mentioned previously, has limitations with respect to effective detection over distance (Parsons *et al*., 2009; Wright and Cosentino, 2015).

9.8.3.26 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. The type of ADD and approach to mitigation (including activation time and procedure) will be included in the draft MMMP, and will be discussed and agreed with relevant stakeholders.

9.8.3.27 Sound modelling was carried out to determine the potential efficacy of using this device 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 PEIR). Assuming conservative swim speeds, it was demonstrated that activation of an ADD for 30 minutes would deter all animals beyond the maximum injury zone predicted using $SPL_{pk}$ at hammer initiation (and full hammer energy) for both monopiles and pin piles (Table 9.21). This corroborates findings of other studies that reported that ADDs deter different marine mammals over several hundreds of metres or indeed several kilometres from the source (reviewed in McGarry *et al*., 2020).

**Table 9.21: Summary of peak pressure ($SPL_{pk}$) injury ranges at hammer initiation for marine mammals due to single piling of monopiles at 5,500kJ hammer energy and pin piles at 3,700kJ hammer energy, showing whether the individual can flee the injury range during the 30 minutes of ADD activation. Numbers in parentheses are the injury ranges at full hammer energy.**

| Species | Threshold | PTS range monopiles (m) | InjuPTSry range pin piles (m) | Swim Speed (m/s) | Swim distance (m) | Flee |
|---|---|---|---|---|---|---|
| Minke whale | 219 dB re 1 µPa (pk) | 73 (234) | 42 (161) | 2.3 | 4140 | Yes |
| Bottlenose dolphin, Risso's dolphin, short-beaked common dolphin | 230 dB re 1 µPa (pk) | 29 (94) | 16 (62) | 1.52 | 2736 | Yes |
| Harbour porpoise | 202 dB re 1 µPa (pk) | 299 (961) | 186 (707) | 1.5 | 2700 | Yes |
| Grey seal, harbour seal | 218 dB re 1 µPa (pk) | 79 (255) | 46 (176) | 1.8 | 3240 | Yes |

9.8.3.28 The assessment also shows that the use of an ADD reduced the maximum injury zones based on the $SEL_{cum}$ metric concurrent piling at monopiles and pin piles with respect to harbour porpoise and minke whale (the threshold had been exceeded for this species) (Table 9.22). Activation of an ADD 30 minutes prior to commencement of piling of monopiles reduced PTS to a level not exceeding the injury thresholds for all species, except minke whale and harbour porpoise during concurrent piling suggesting that there is a residual risk of injury to animals. For pin piles, activation of 30 minutes of ADD prior to commencement of piling reduced PTS in all species (Table 9.22).

**Table 9.22: Injury ranges for marine mammals due to consecutive piling (24 hours) of monopiles and pin piles with and without 30 minutes of ADD. (N/E = threshold not exceeded).**

| Species/Group | Threshold (weighted $SEL_m$) | Range monopiles (m) | | Range pin piles (m) | |
|---|---|---|---|---|---|
| | | Without ADD | With ADD | Without ADD | With ADD |
| **Single** | | | | | |
| Minke whale | PTS - 183dB re 1µPa²s | 3,865 | N/E | 656 | N/E |
| Harbour porpoise | PTS - 155dB re 1µPa²s | 1,665 | N/E | N/E | N/E |
| **Concurrent** | | | | | |
| Minke whale | PTS - 183dB re 1µPa²s | 5,360 | 1,221 | 1,651 | N/E |
| Harbour porpoise | PTS - 155dB re 1µPa²s | 2,725 | 20 | N/E | N/E |
| **Consecutive** | | | | | |

| Species/Group | Threshold (weighted $SEL_m$) | Range monopiles (m) | | Range pin piles (m) | |
|---|---|---|---|---|---|
| | | Without ADD | With ADD | Without ADD | With ADD |
| Minke whale | PTS - 183 dB re 1 µPa2s | 3,965 | N/E | 671 | N/E |
| Harbour porpoise | PTS - 155 dB re 1 µPa2s | 1,725 | N/E | N/E | N/E |

*Harbour porpoise*

9.8.3.29 For monopiles, with primary and tertiary mitigation applied, and based on the largest predicted range of 20m (i.e. using the $SEL_{cum}$ metric), the maximum number of individuals that could be potentially injured calculated using the highest density value of 0.247 animals per km$^2$ (Table 9.10) is no more than one animal. The injury range is predicted to be localised to within the Morgan Generation Assets and therefore there is no potential for spatial overlap with the North Anglesey Marine SAC, the closest site designated for harbour porpoise which is located at a distance of ~28km

9.8.3.30 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 112 days, within a two year piling programme (as defined in Table 9.18), 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.

9.8.3.31 The impact (elevated underwater sound arising 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 9.8.3.48). The magnitude is therefore considered to be **low**.

*Dolphin species*

9.8.3.32 For bottlenose dolphin, short-beaked common dolphin and Risso's dolphin, with primary and tertiary mitigation applied, and based on the largest predicted range of 94m (i.e. using the $SPL_{pk}$ metric), there is no residual risk of injury during piling.

9.8.3.33 The impact (elevated underwater sound arising 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 is no residual risk of injury. Taking a precautionary approach the magnitude is therefore considered to be **negligible**.

*Minke whale*

9.8.3.34 With primary and tertiary mitigation applied and based on the largest predicted range of 1,221m (i.e. using the $SEL_{cum}$ metric), the maximum number of individuals that could be potentially injured calculated using the highest density value of 0.0173 animals per km$^2$ (Table 9.10) is no more than one animal. The injury range is therefore localised to within the Morgan Generation Assets and there are no designed sites for minke whale in the vicinity.

9.8.3.35 Minke whale typically lives 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.

9.8.3.36 The impact (elevated underwater sound arising 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 9.8.3.71). The magnitude is therefore considered to be **low**.

*Pinnipeds*

9.8.3.37 For both grey seal and harbour seal, with primary and tertiary mitigation applied, and based on the largest predicted range of 255m (i.e. using the $SPL_{pk}$ metric), there is no residual risk of injury during piling.

9.8.3.38 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 and grey seal is classified as medium term.

9.8.3.39 The impact (elevated underwater sound arising 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. Taking a precautionary approach the magnitude is therefore considered to be **negligible.**

#### Behavioural Disturbance

9.8.3.40 Disturbance during piling was predicted to have far-reaching effects across the north part of the Irish Sea, noting however, that the extent is likely to be an overestimate as it assumes that the sound 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 noise and this is an ongoing active area of research (see paragraph 9.8.2.5 and 9.8.2.21, and paragraphs 1.5.5.26 to 1.5.5.29 of Volume 3, annex 3.1: Underwater sound technical report of the PEIR 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 9.8.2.14). With 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 9.23. Additional context is also provided in the discussion for each species with respect to the thresholds of strong disturbance and mild disturbance at 160dB re 1 µPa (rms) and 140dB re 1 µPa (rms) as per NMFS (2005).

9.8.3.41 The estimated numbers of animals potentially disturbed are based on the maximum adverse piling scenario which describes 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, minke whale, short-beaked common dolphin and Risso's dolphin a quantitative assessment of the number of animals predicted to experience disturbance was undertaken by multiplying the density values (Table 9.10) with the areas within each 5dB isopleth and correcting the value using the relevant proportional response from Graham *et al.*, (2019) for the unweighted $SEL_{ss}$ level (Figure 9.2).

9.8.3.42 For bottlenose dolphin, it can be reasonably assumed that most animals will be located within a 6km region from the coastline, and those coastal areas may be comparable to other high use areas in the regional marine mammal study area (such as in outer Cardigan Bay which has higher densities, as described in Lohrengel *et al*., 2018). The assessment for bottlenose dolphin therefore considered the overlap of the ensonified area with the coastal areas; applying the high density value of 0.035 animals per km$^2$ (as compared to the offshore density of 0.008 animals per km$^2$ given by SCANS-III) (Table 9.10). Proportional response was again applied for the predicted $SEL_{ss}$ levels which overlapped the coastal areas as per Graham *et al.* (2019) (Figure 9.2).

9.8.3.43 For grey seal and harbour seal 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 5x5km grid cell was summed for each isopleth and corrected using the proportional response as per Whyte *et al*. (2020) (Figure 9.3).

**Table 9.23: Potential number of animals predicted to be disturbed within weighted $SEL_{ss}$ sound contours as a result of different piling scenarios.**

| Species | Scenario | Monopiles | | Pin piles | |
|---|---|---|---|---|---|
| | | Number of Animals | % Reference Population (MU) | Number of Animals | % Reference Population (MU) |
| Harbour porpoise | Single | 979 | 1.57% | 779 | 1.25% |
| | Concurrent | 1,370 | 2.19% | 1,089 | 1.74% |
| Bottlenose dolphin | Single | 11 | 3.70% | 9 | 2.75% |
| | Concurrent | 16 | 5.28% | 11 | 3.65% |
| Short-beaked common dolphin | Single | 72 | 0.07% | 57 | 0.06% |
| | Concurrent | 100 | 0.10% | 79.34 | 0.08% |
| Risso's dolphin | Single | 125 | 1.01% | 99 | 0.80% |
| | Concurrent | 174 | 1.42% | 138 | 1.13% |
| Minke whale | Single | 69 | 0.34% | 55 | 0.27% |
| | Concurrent | 96 | 0.48% | 77 | 0.38% |
| Grey seal | Single | 31 | 0.22% (GSRP) | 25 | 0.18% (GSRP) |
| | | | 0.05% (OSPAR Region III) | | 0.04% (OSPAR Region III) |
| | Concurrent | 48 | 0.35% (GSRP) | 37 | 0.27% (GSRP) |
| | | | 0.08% (OSPAR Region III) | | 0.06% (OSPAR Region iii) |
| Harbour seal | Single | < 1 | 0.0014% | < 1 | 0.0031% |
| | Concurrent | < 1 | 0.009% | < 1 | 0.005% |

*Harbour porpoise*

9.8.3.44 The most conservative estimate of disturbance led to up to 1,370 animals (based on peak seasonal density) predicted to experience potential disturbance from concurrent piling of monopiles at a maximum hammer energy of 5,500kJ (Table 9.23; Figure 9.5). This equates to 2.19% of the Celtic and Irish Seas MU population. As a comparison with the US National Marine Fisheries Service thresholds NMFS (2005) for mild and strong disturbance (140$dB_{rms}$ and 160$dB_{rms}$ respectively) it can be estimated that, up to 248 of those animals are predicted to experience strong disturbance (above 160 dBrms), whist up to 1,038 animals are likely to experience mild disturbance (between 140 and 160 dBrms ≡ 130 to 150 dB $SEL_{ss}$).

9.8.3.45 The estimated numbers of individuals potentially impacted are based on conservative densities and in 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 9.1: Marine mammal technical report of the PEIR for further detail), it was assumed that the peak seasonal density of 0.247 animals per km$^2$ is uniformly distributed within all sound contours to provide a precautionary assessment.

9.8.3.46 As described in volume 4, annex 9.1: Marine mammal technical report of the PEIR, there are 14 SACs and nine MNRs within the regional marine mammal study area. The North Anglesey Marine SAC is located in closest proximity to the Morgan Array Area (~28km) and is designated for harbour porpoise. North Anglesey Marine/Gogledd Môn Forol SAC, Baie Ny Carrickey MNR, Calf and Wart Bank MNR, North Channel SAC, Rockabill to Dalkey Island SAC are also designated for harbour porpoise and there is potential for overlap of sound disturbance contours with any of these designated sites. Lying outside the disturbance contours, West Wales Marine/Gorllewin Cymru Forol SAC, Bristol Channel Approaches/Dynesfeydd Môr Hafren SAC, Port Erin Bay MNR, Niarbyl MNR, West Coast MNR and Bristol Channel Approaches/Dynesfeydd Môr Hafren SAC are 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 a small number of individuals from these SAC populations may be occasionally present within the disturbance contours.

9.8.3.47 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 9.8.3.30). As discussed during the third marine mammal EWG consultation (Table 9.5) population modelling was carried out to explore the potential for disturbance during piling to affect the population trajectory over time, and to provide additional certainty in the predictions of the assessment of effects. Results of the iPCoD modelling for harbour porpoise against the MU population showed that the median ratio of the impacted population to the un-impacted population was 1 at 25 years which means that there is no significant difference between the population trajectories for an unimpacted population and impacted population (Table A.8). Small changes in the impacted population size over time are similar to those predicted for an unimpacted population, as can be seen in Figure 9.4.

9.8.3.48 The impact (elevated underwater sound arising 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 2.19%) of the CIS 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 harbour porpoise population. The magnitude is therefore considered to be **low.**

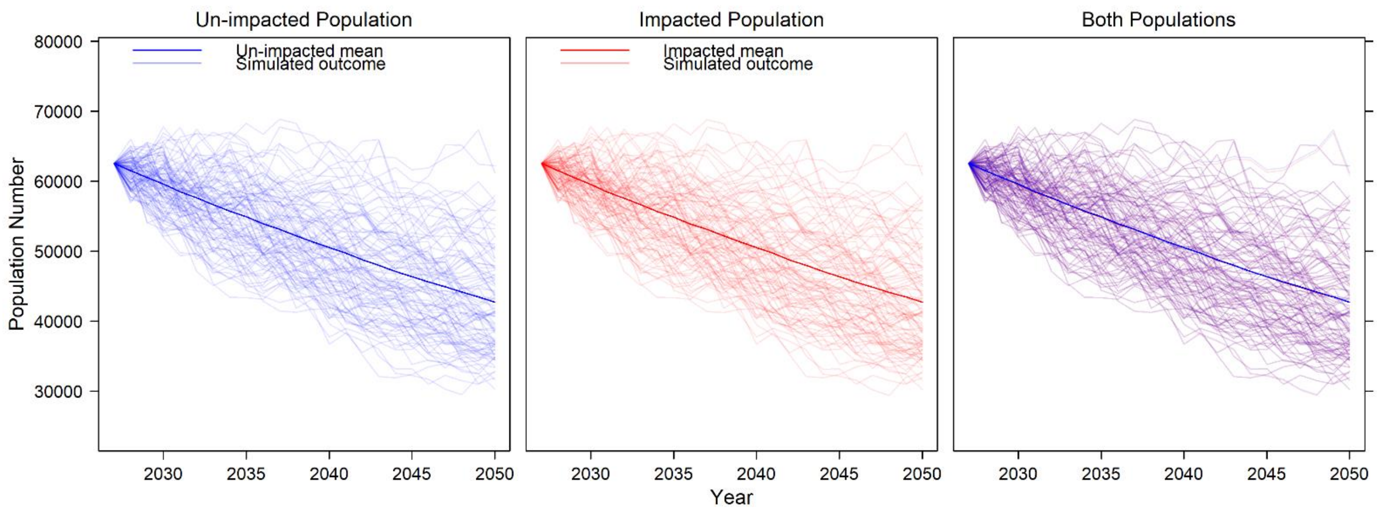



**Figure 9.4: Simulated harbour porpoise population sizes for both the baseline and the impacted populations under the concurrent monopile scenario.**

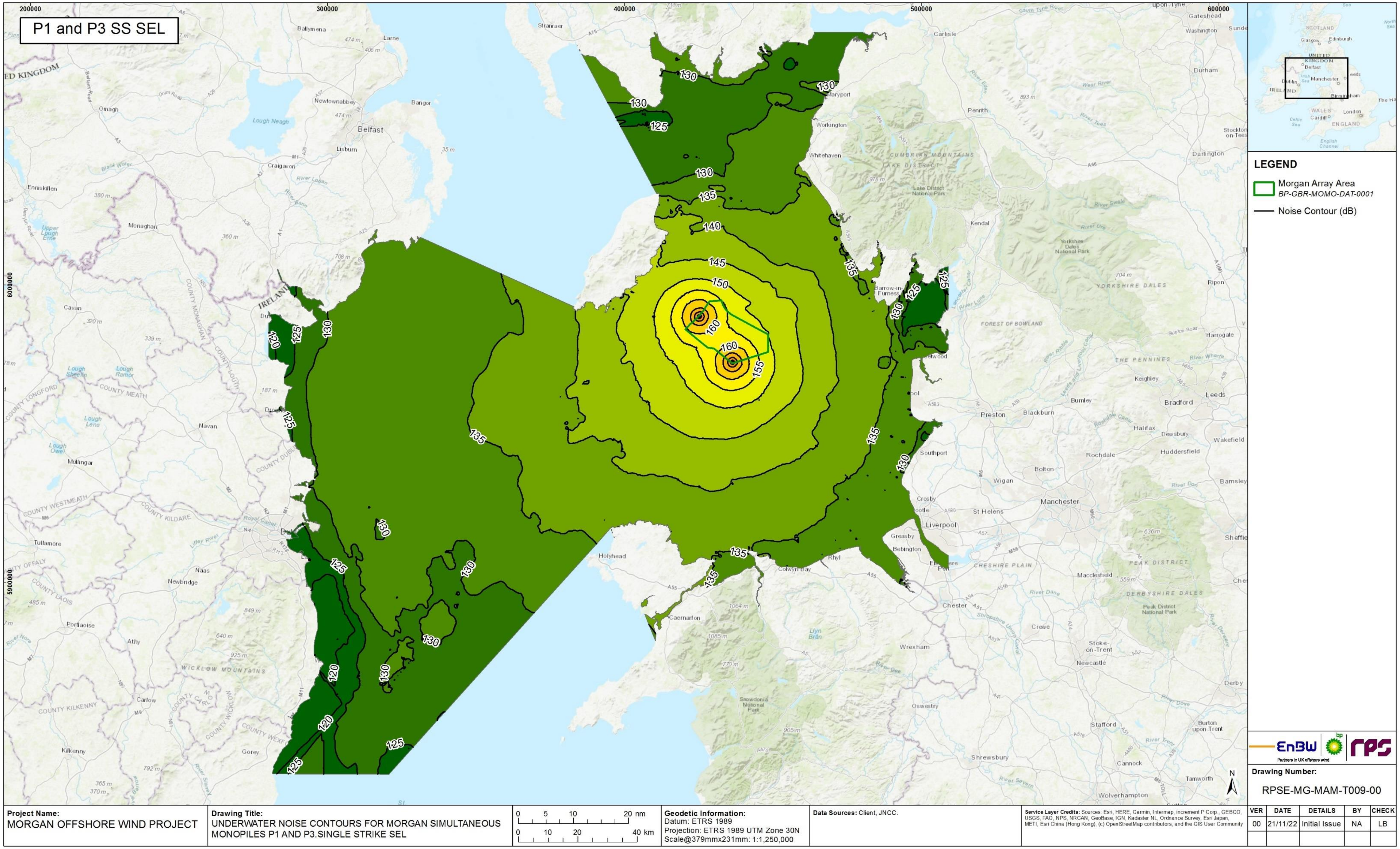



**Figure 9.5: Concurrent piling of monopiles at a maximum hammer energy of 5,500kJ at the greatest spatial extent showing $SEL_{ss}$ contours in 5dB isopleths.**

*Bottlenose dolphin*

9.8.3.49 The outermost sound contours predicted from the maximum hammer energy of 5,500kJ reaches the coastal areas and therefore overlaps with the key distribution of bottlenose dolphin (Figure 9.5). The most conservative estimate of disturbance led to up to 16 animals predicted to experience potential disturbance from concurrent piling of monopiles at a maximum hammer energy of 5,500kJ (Figure 9.5; Table 9.23). This equates to 5.28% of the Irish Sea MU population.

9.8.3.50 This is a highly conservative estimate using high density values for the coastal regions and assumes a uniform distribution throughout the area. In addition, the 6km coastal area lies ~30km from the nearest boundary of the Morgan Array Area and at this distance the received level from piling will have lost much of the impulsive characteristics (paragraph 9.8.2.5 and 9.8.2.21).). Thus, the estimated number of bottlenose dolphin with the potential to be disturbed in offshore waters, should be interpreted with caution as this is likely to be an overestimate.

9.8.3.51 As described in volume 4, annex 9.1: Marine mammal technical report of the PEIR, there are 14 SACs and nine Marine Nature Reserves (MNRs) within the regional marine mammal study area. Douglas Bay MNR is the closest MNR to the Morgan Generation Assets and there is potential for overlap of sound disturbance contours with this designated site. Further away 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, 2022a), with inshore areas being used for both feeding and reproduction. Given that bottlenose dolphin can travel over large distances, there is a possibility that a small number of individuals from these SAC populations may be occasionally present within the disturbance contours.

9.8.3.52 Since the outer 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 6km coastal region are predicted to reach maximum $SEL_{ss}$ levels of 140dB. This is equivalent to $150dB_{rms}$ and therefore below the NMFS (2005) threshold for strong disturbance (=$160dB_{rms}$) and is likely to elicit less severe disturbance reactions. According to the behavioural response severity matrix suggested by Southall *et al*. (2021) low level disturbance (scoring between 0 to 3 on 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 9.8.3.91 *et seq*., but for the purposes of assessing magnitude, it is considered that up to five animals could experience mild disturbance in the 6km coastal area, but that this is unlikely to lead to barrier effects as animals are unlikely to be excluded from the coastal areas.

9.8.3.53 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 of 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 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 intermittently during piling only (e.g. 35 days for concurrent piling or 70 days for single piling of monopiles) and may affect the fecundity of some individuals over the medium term.

9.8.3.54 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 effects. Results of the iPCoD modelling for bottlenose dolphin against the MU population showed that the median ratio of the impacted population to the unimpacted population was 1 at 25 years (Table A.9). Small differences in the population size over time between the impacted and unimpacted population fall within the natural variance of the population and there was no discernible reduction in the population over time (Figure 9.6). Therefore, it was considered that there is no potential for a long-term effect on this species. It is important to highlight that whilst any model is sensitive to input parameters (as evidenced in Appendix A), the parameters (recommended by NRW through the Evidence Plan Process) used in the iPCoD model represent a conservative assessment of population changes.

9.8.3.55 The impact (elevated underwater sound arising 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 approximately 5.3% of the reference population would 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**.

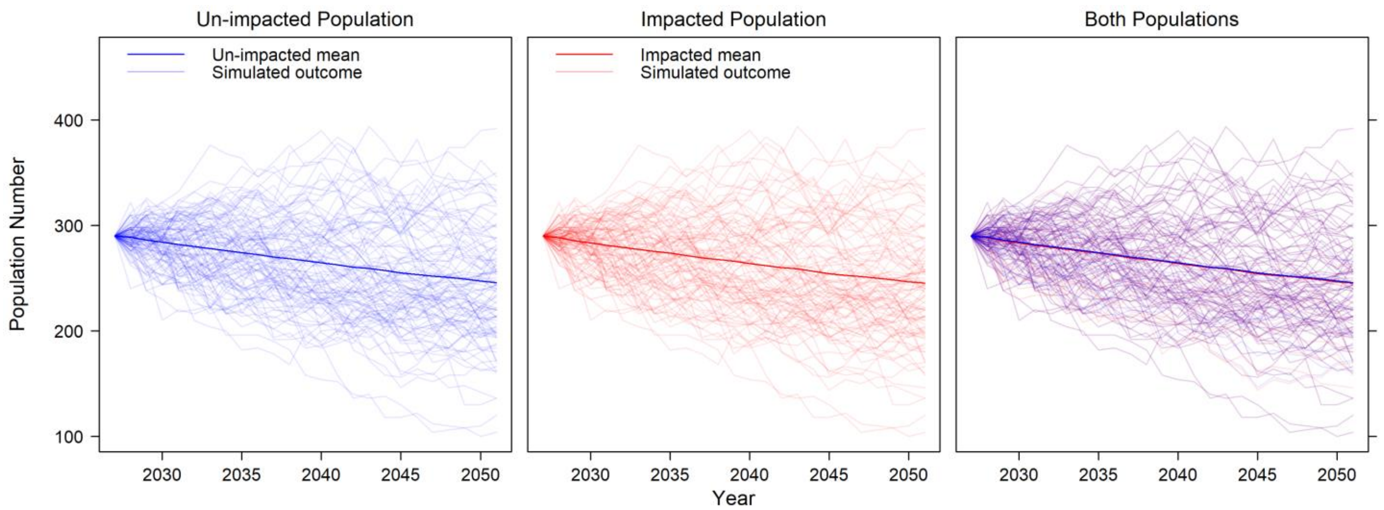



**Figure 9.6: Simulated bottlenose dolphin population sizes for both the baseline and the impacted populations under the maximum adverse scenario.**

*Short-beaked common dolphin*

9.8.3.56 For short-beaked common dolphin, the most conservative estimate of disturbance led to up to 100 animals predicted to experience potential disturbance from concurrent piling of monopiles (Figure 9.5) at a maximum hammer energy of 5,500kJ. This equates to 0.10% of the Celtic and Greater North Seas MU population. Of these, however, up to 29 of those animals are predicted to experience strong disturbance (above 160dBrms), whist up to 76 animals are likely to experience mild disturbance (between 140 and 160dBrms) as per the NMFS (2005) thresholds.

9.8.3.57 The maximum numbers presented in Table 9.23 are considered to be conservative as these are based on the SCANS-II block O densities (0.018 animals per km$^2$) and assume uniform distribution. There were no short-beaked common dolphin reported for SCANS-III surveys for the blocks overlapping the Morgan marine mammal study area and two years of site specific data from aerial surveys of Morgan Array Area did not record any short-beaked common dolphin in the surveys. Therefore, the number of short-beaked common dolphins 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.

9.8.3.58 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 four months before her next pregnancy, so calving intervals are 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. The magnitude of the impact could also result in a small but measurable alteration to the distribution of marine mammals intermittently during piling only (e.g. 35 days for concurrent piling or 70 days for single piling of monopiles) and may affect fecundity of some individuals (up to 0.10% of the CGNS MU population) over the medium term.

9.8.3.59 The use of iPCoD was discussed during the third EWG (Table 9.5) and since iPCoD does not facilitate modelling for short-beaked common dolphin, no population modelling was carried out for this species.

9.8.3.60 The impact (elevated underwater sound arising 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. The magnitude of the impact could result in a small but measurable alteration to the distribution of short-beaked common dolphin during piling only leading to possible displacement or interrupting key survival strategies (i.e. feeding or breeding) of some individuals (up to 0.10% of the CGNS MU population) 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 **low**.

*Risso's dolphin*

9.8.3.61 For Risso's dolphin, the most conservative estimate of disturbance led to up to 174 animals predicted to experience potential disturbance from concurrent piling of monopiles (Figure 9.5) at a maximum hammer energy of 5,500kJ. This equates 1.42% of the Celtic and Greater North Seas MU population. However of these, up to 32 of those animals are predicted to experience strong disturbance (above 160 dBrms), whist up to 132 animals are likely to experience mild disturbance (between 140 and 160 dBrms).

9.8.3.62 The maximum numbers presented in Table 9.23 are considered to be conservative as the estimate assumed uniform distribution which is unlikely to be the case. In addition, the calculation was based on the SCANS-III densities (0.0313 animals per km$^2$) for block E to the south of the Morgan Array Area (since there was no reported densities for Block F overlapping the Morgan marine mammal study area). Site specific survey data from Morgan digital aerial surveys did not record any Risso's dolphin in the surveys. 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.

9.8.3.63 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. 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 fecundity of some individuals (up to 1.42% of the CGNS MU population) over the medium term.

9.8.3.64 Since iPCoD does not facilitate modelling for Risso's dolphin, no population modelling was carried out for this species.

9.8.3.65 The impact (elevated underwater sound arising 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. The magnitude of the impact could result in a small but measurable alteration to the distribution of Risso's dolphin during piling only leading to possible displacement or interrupting key survival strategies (i.e. feeding or breeding) of some individuals (up to 1.42% of the CGNS MU population) 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 **low**.

*Minke whale*

9.8.3.66 Based on SCANS III block E minke whale density estimates (0.0173 animals per km), up to 96 animals have the potential to be disturbed as a result of concurrent piling (Figure 9.5) at a maximum hammer energy of 5,500 kJ, which equates to 0.48% of the CGNS MU.

9.8.3.67 The maximum numbers presented in Table 9.23 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 whales 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 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.

9.8.3.68 As described in more detail in volume 4, annex 9.1: Marine mammal technical report of the PEIR, site specific survey data from aerial surveys of Morgan Array Area did not record any minke whale in the surveys. Therefore, the number of minke whales disturbed as a result of all piling scenarios should be interpreted with caution as these animals are likely to be present in lower densities.

9.8.3.69 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 9.8.3.35). 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 fecundity of some individuals (up to 0.48% of the CGNS MU population) 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).

9.8.3.70 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 effects. 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 effects. Results of the iPCoD modelling for minke whale against the MU population showed that the median of the ratio of the impacted population to the unimpacted population was 1 at 25 years (Table A.10). Small differences in the population size over time between the impacted and unimpacted population fall within the natural variance of the population as can be seen in Figure 9.7.

9.8.3.71 The impact (elevated underwater sound arising 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 0.48%) of the GCNS reference population would be affected intermittently 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 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**.

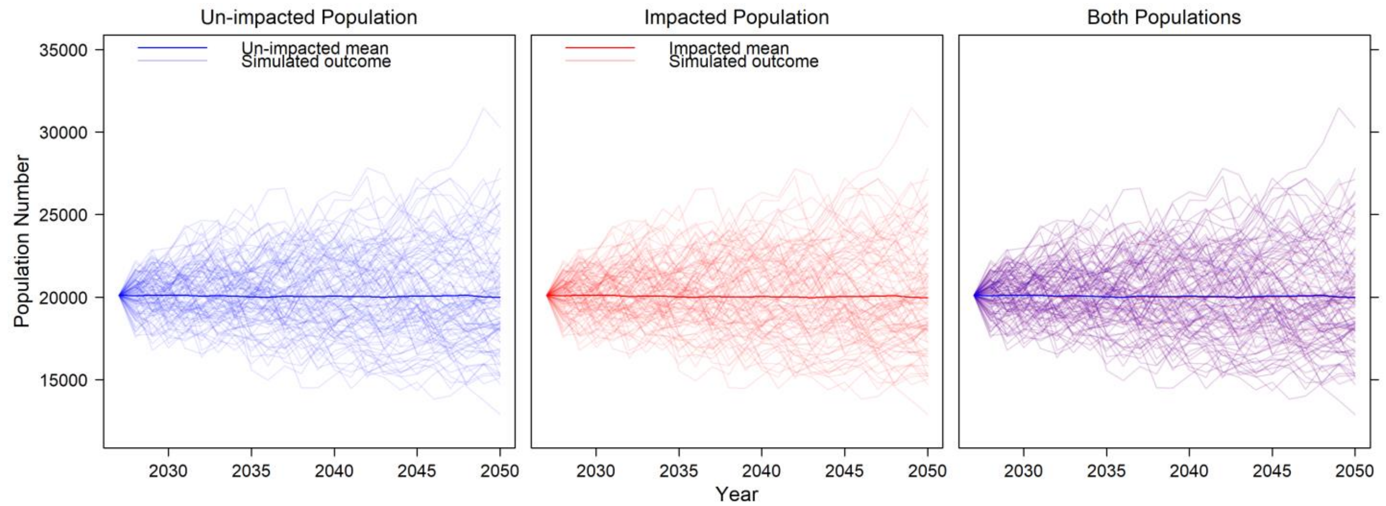



**Figure 9.7: Simulated minke whale population sizes for both the baseline and the impacted populations under the concurrent monopile scenario**

### *Grey seal*

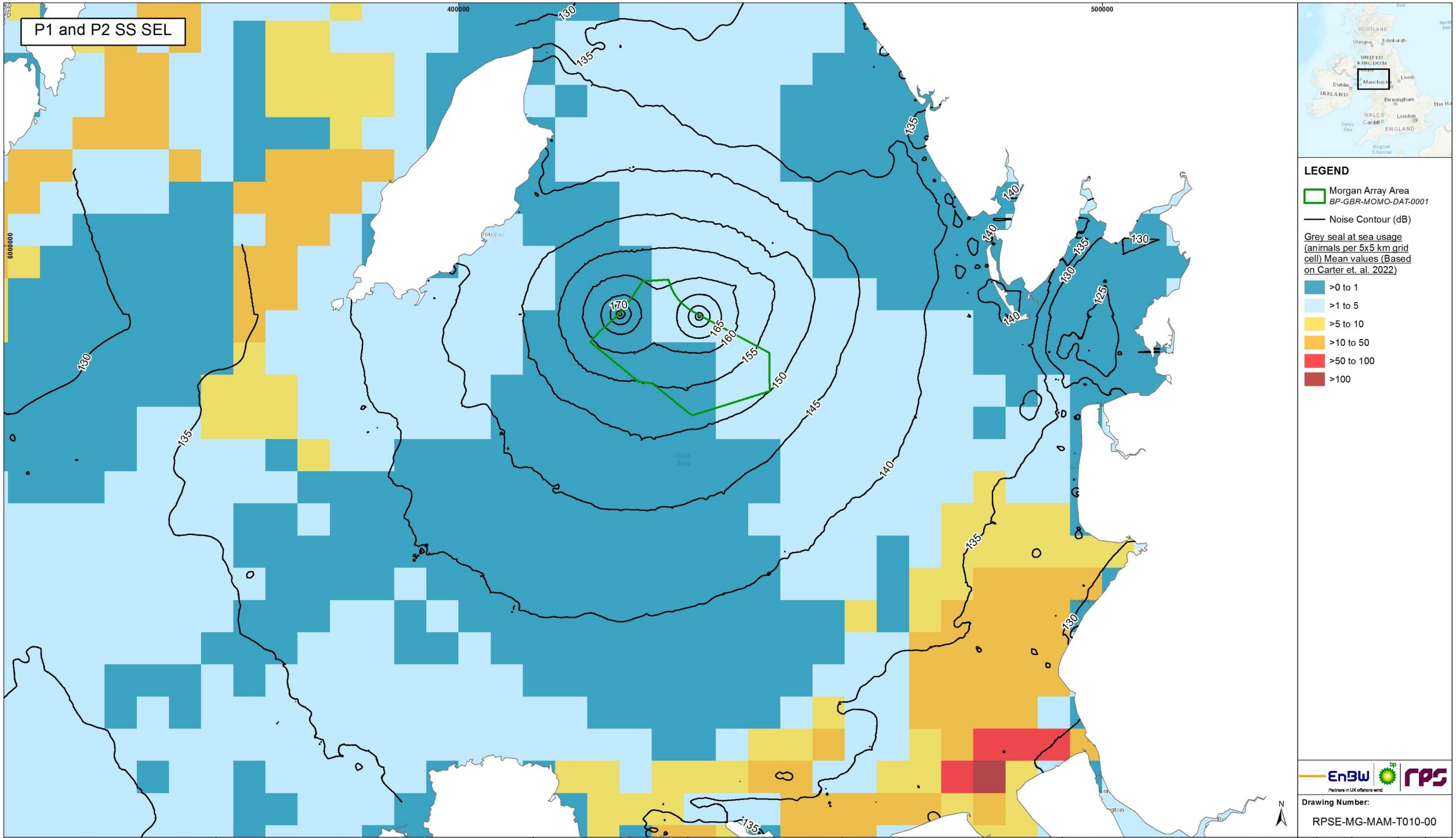
9.8.3.72 For grey seal, the most conservative estimate of disturbance led to up to 48 animals (Carter *et al.* 2022 densities) predicted to experience potential disturbance from concurrent piling of monopiles (Figure 9.8) at a maximum hammer energy of 5,500kJ. This equates to 0.35% of the Grey Seal reference population (as described in Table 9.10), and 0.08% of the OSPAR Region III reference population. Telemetry studies (presented in volume 4, annex 9.1: Marine mammal technical report of the PEIR) demonstrate that grey 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 MUs have been summed, alongside the Isle of Man reference population and the East Ireland and South East Ireland regions to give one reference population against which to assess potential disturbance. In addition, further to consultation at the third marine mammal EWG (Table 9.5) the number of animals disturbed was assessed with reference to the OSPAR III population.

9.8.3.73 As identified in volume 4, annex 9.1: Marine mammal technical report of the PEIR, ten sites which are designated for protection of grey seal are located within the regional marine mammal study area (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 and Lundy SAC, Langness MNR, Ramsey Bay MNR, Niarbyl MNR, West Coast MNR). There is potential overlap of disturbance contours with Langness MNR, Ramsey Bay MNR, and Lambay Island SAC. Telemetry tracks presented in volume 4, annex 9.1: Marine mammal technical report of the PEIR demonstrated high levels of connectivity between designated sites and therefore there is potential that some of the animals within the impacted area may be associated with wider SACs.

9.8.3.74 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 $SEL_{ss}$ 135 dB (= 145 $dB_{rms}$) (Whyte *et al.,* 2020). This falls within the NMFS (2005) threshold which suggests mild disturbance out to 140$dB_{rms}$. 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).

9.8.3.75 With respect to the above, it was considered that grey seal close to the coast could experience 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 448km 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.

9.8.3.76 Grey 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 grey seal is classified as medium term.

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| MORGAN OFFSHORE WIND PROJECT | MORGAN OFFSHORE WIND PROJECT AND GREY SEAL AT-SEA USAGE (CARTER ET AL., 2022) OVERLAID WITH SELCUM CONTOURS DUE TO CONCURRENT IMPACT PILING (TURBINE LOCATION 1 & 2) OF WIND TURBINE MONOPILES AT MAXIMUM HAMMER ENERGY (5,500 KJ) | 0 2.5 5 10 nm; 0 5 10 km | Datum: ETRS 1989; Projection: ETRS 1989 UTM Zone 30N; Scale@379mmx231mm: 1:600,000 | Client, JNCC. | 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 |

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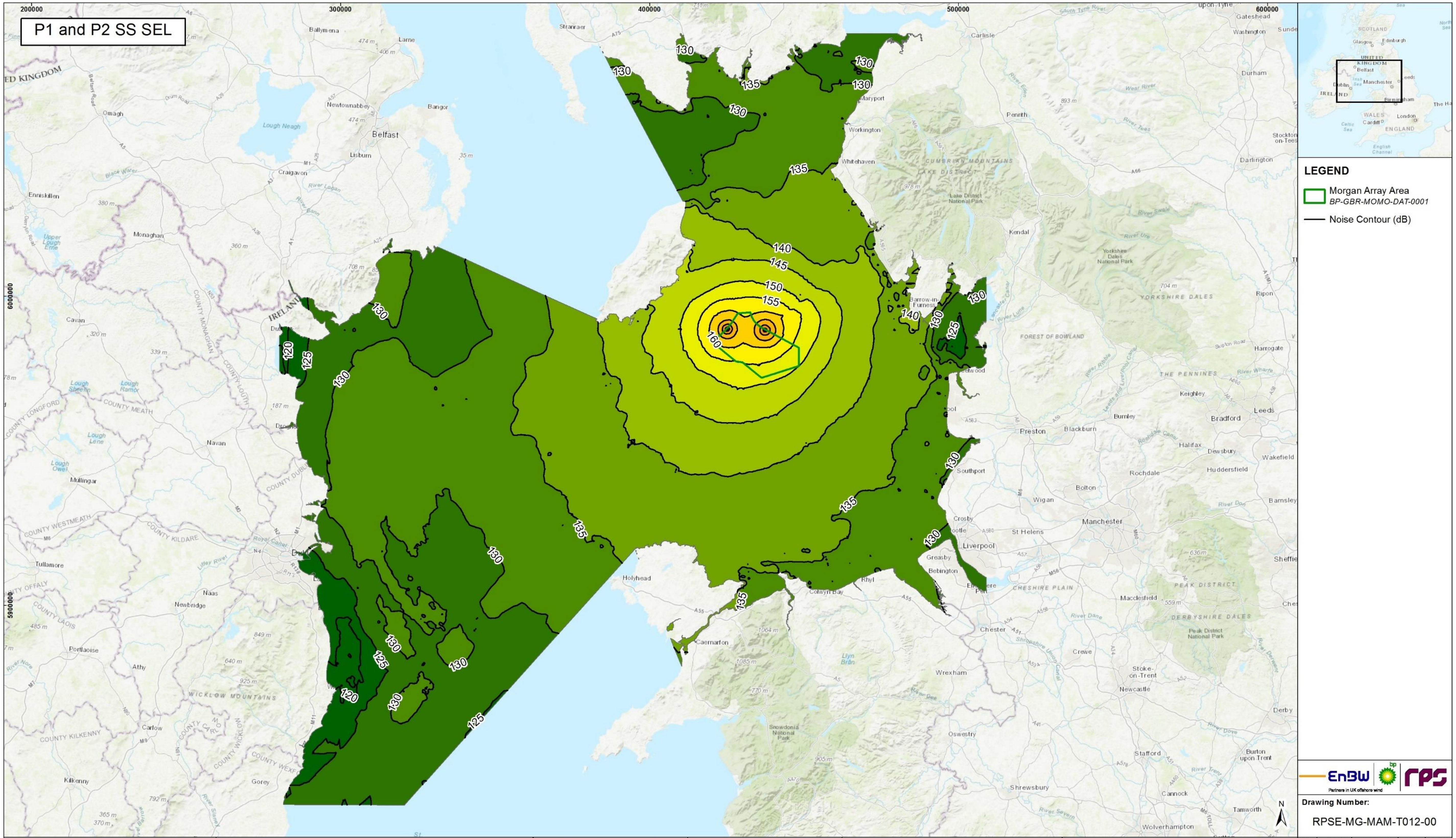
**Figure 9.8: Morgan Generation Assets and grey seal at-sea usage (Carter *et al*., 2022) overlaid with unweighted $SEL_{ss}$ contours due to concurrent impact piling of wind turbine monopiles at maximum hammer energy (5,500 kJ).**

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| MORGAN OFFSHORE WIND PROJECT | UNDERWATER NOISE CONTOURS FOR MORGAN SIMULTANEOUS MONOPILES P1 AND P2.SINGLE STRIKE SEL | Datum: ETRS 1989<br>Projection: ETRS 1989 UTM Zone 30N<br>Scale@379mmx231mm: 1:1,250,000 | Client, JNCC. | 00 | 22/11/22 | Initial Issue | NA | LB |

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**Figure 9.9: Concurrent piling of monopiles at a maximum hammer energy of 5,500kJ leading to greatest impact for bottlenose dolphin showing $SEL_{ss}$ contours in 5dB isopleths.**

9.8.3.77 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 impact assessment. Results of the iPCoD modelling for grey seal showed that the median of the ratio of the impacted population to the unimpacted population (when using both the grey seal reference population and OSPAR region III) was 1 at 25 years (Table A.11), and simulated grey seal population sizes for both baseline and impacted populations showed no difference (Figure 9.10). Therefore, it was considered that there is no potential for a long-term effect on this species.

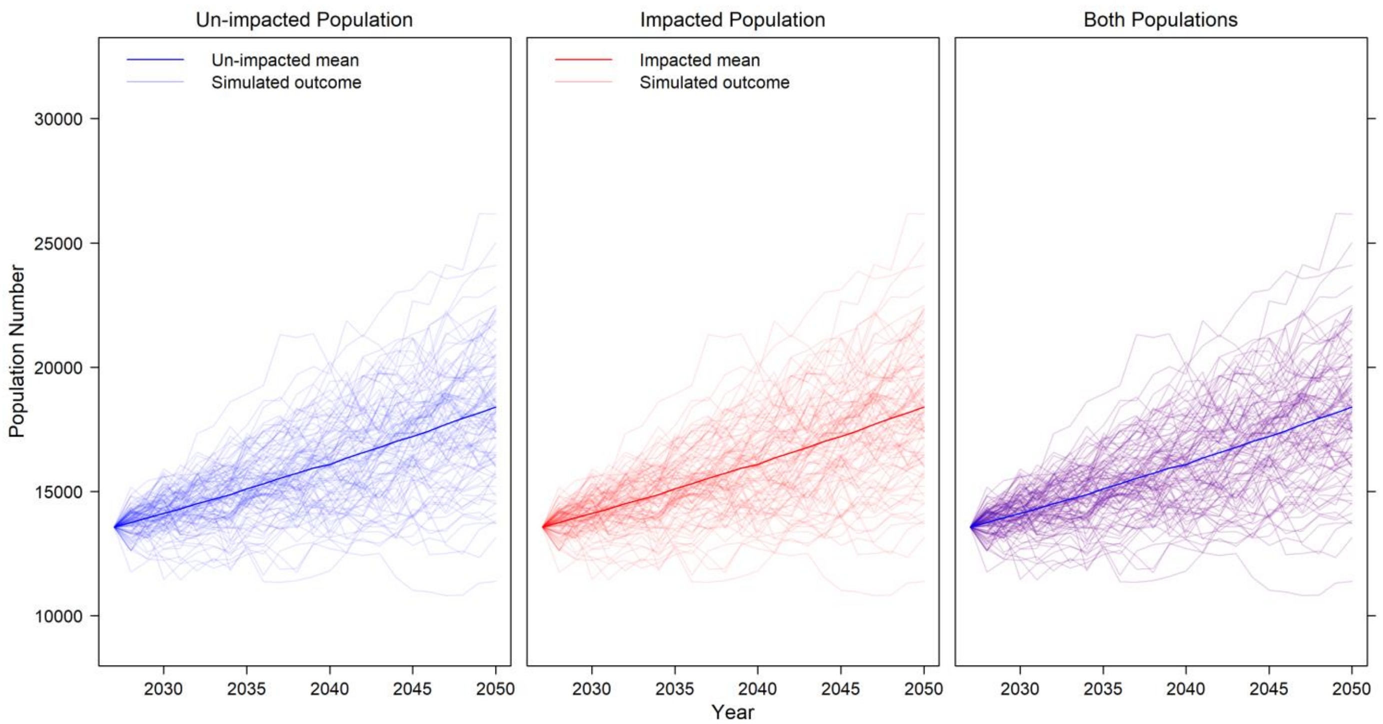



**Figure 9.10: Simulated grey seal population sizes for both the baseline and the impacted populations under the maximum adverse scenario, using the Grey Seal reference population.**

9.8.3.78 The impact (elevated underwater sound arising 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 0.35% of the Grey Seal Reference population, or 0.08% of OSPAR Region III) 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*

9.8.3.79 For harbour seal, the most conservative estimate of disturbance led to less than one animal (Carter *et al.* 2022 densities) predicted to experience potential disturbance from concurrent piling of monopiles at a maximum hammer energy of 5,500kJ. This equates to 0.009% of the harbour seal reference population (Wales, NW England, and Northern Ireland). Telemetry studies (presented volume 4, annex 9.1: Marine mammal technical report of the PIER) demonstrate that harbour seal transverse all three MUs and therefore population estimates for three management units have been summed to give one reference population for which to assess potential disturbance against.

9.8.3.80 As identified in volume 4, annex 9.1: Marine mammal technical report of the PEIR, seven sites designated for protection of 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). There is potential overlap of sound contours with Langness MNR, Ramsey Bay MNR, Strangford Lough SAC, Murlough SAC and Lambay Island SAC. Telemetry tracks presented in volume 4, annex 9.1: Marine mammal technical report of the PEIR demonstrated some connectivity both between designated sites, and between the Morgan Generation Assets and designated sites, therefore there is potential that some of the harbour seals within the impacted area may be associated with other wider SACs. It must be noted that harbour seals have a smaller maximum foraging range (273km) (Carter *et al.,* 2022) and therefore levels of connectivity between SACs are less than for grey seal which forage further distances.

9.8.3.81 The potential for barrier effects (i.e. the ability to move between key areas such as haul-out sites and foraging areas offshore) is 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 $SEL_{ss}$ 135 dB (= 145 $dB_{rms}$) (Whyte et al., 2020). This falls within the NMFS (2005) threshold which suggests mild disturbance out to 140dBrms. 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).

9.8.3.82 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 the coastal areas. Furthermore, as mentioned in paragraph 9.8.3.75, animals can travel to other areas to feed during piling, although harbour seal tend to forage within 50km 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.

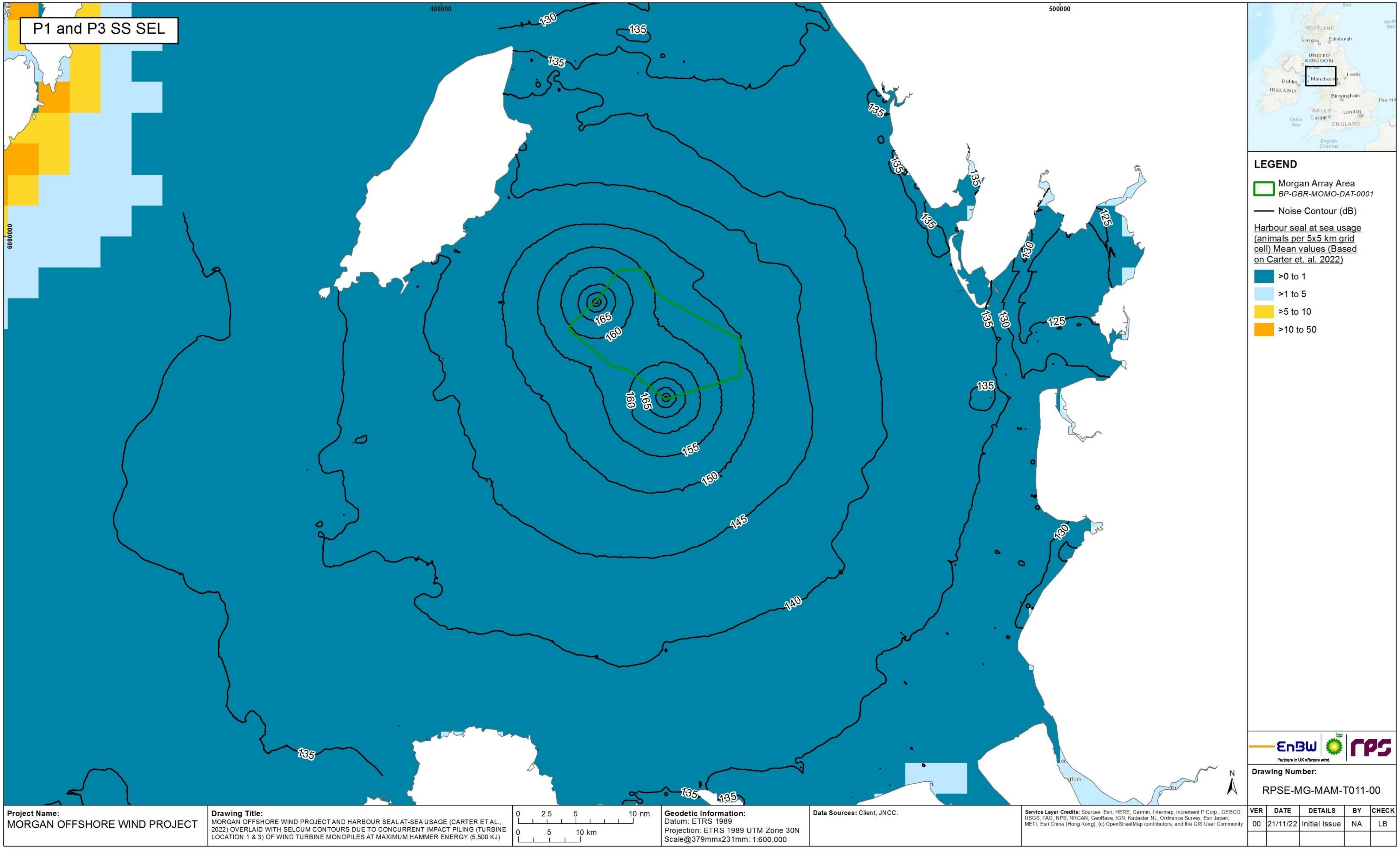
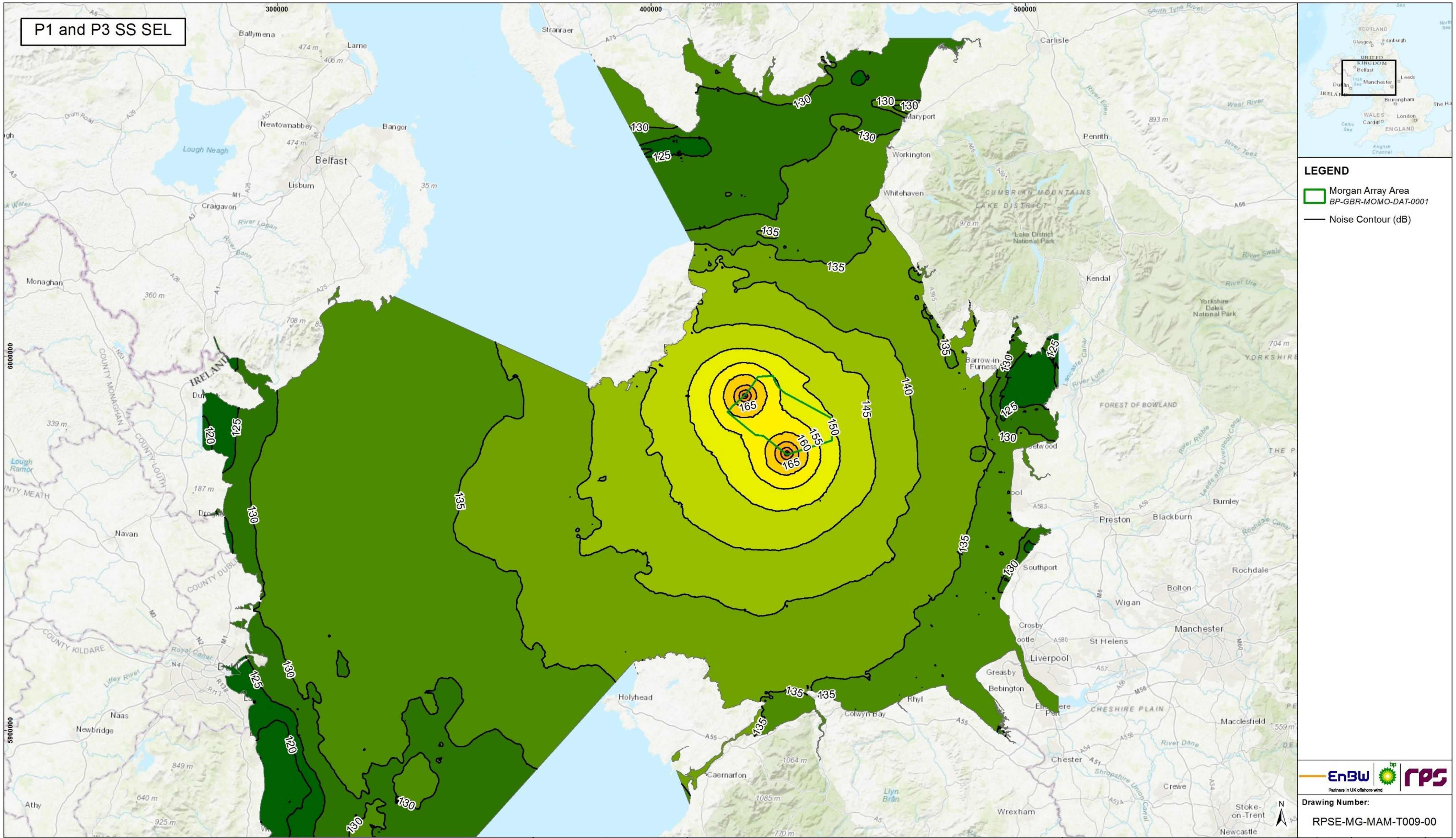



**Figure 9.11: Morgan Generation Assets and harbour seal at-sea usage (Carter *et al*., 2022) overlaid with unweighted $SEL_{ss}$ contours due to concurrent impact piling of wind turbine monopiles at maximum hammer energy (5,500 kJ).**

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| MORGAN OFFSHORE WIND PROJECT | UNDERWATER NOISE CONTOURS FOR MORGAN SIMULTANEOUS MONOPILES P1 AND P3.SINGLE STRIKE SEL | 0 5 10 nm; 0 10 20 km | Datum: ETRS 1989<br>Projection: ETRS 1989 UTM Zone 30N<br>Scale@379mmx231mm: 1:1,032,595 | Client, JNCC. | 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 |

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**Figure 9.12: Concurrent piling of monopiles at a maximum hammer energy of 5,500kJ.**

9.8.3.83 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 0.009% of the combined total of MU population 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.

9.8.3.84 The impact (elevated underwater sound arising 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*

9.8.3.85 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's hearing around 125kHz (the key frequency for echolocation) was not affected. Instead, a measurable threshold shift in hearing was induced at frequencies of 4kHz to 8kHz, although the magnitude of the hearing shift was relatively small (2.3dB to 3.6dB at 4kHz to 8kHz) 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 125kHz (Kastelein *et al*., 2017).

9.8.3.86 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, 2015).

9.8.3.87 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 reproducibility of TTS in a harbour porpoise after exposure to repeated airgun sounds, and suggested the discrepancies may be due to self-mitigation.

9.8.3.88 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). On the top of studies conducted in controlled environment, 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).

9.8.3.89 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.

9.8.3.90 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 tolerance, low recoverability and is of international value. The sensitivity of the receptor to PTS is therefore, considered to be **high.**

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

9.8.3.91 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 9.8.3.85 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 3kHz and 80kHz found that there was increased susceptibility to auditory fatigue between frequencies of 10 to 30kHz (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.

9.8.3.92 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.

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

*Minke whale*

9.8.3.94 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 17Hz and 35kHz and are likely that they rely on low frequency hearing (Ketten and Mountain, 2011). A strong reaction to a 15kHz 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.

9.8.3.95 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.

9.8.3.96 Minke whale is deemed to have limited tolerance 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*

9.8.3.97 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*., 2018a). 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, this indicated that 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.

9.8.3.98 Reichmuth *et al*. (2019) reported the first confirmed case of PTS following a known acoustic exposure event in a seals. 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, and rather than the expected pattern of TTS onset and growth, an abrupt threshold shift of >47dB was observed half an octave above the exposure frequency. Hearing at 4.1kHz recovered within 48 hours, however, there was a PTS of at least 8dB at 5.8kHz, and hearing loss was evident for more than ten years.

9.8.3.99 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*., 2018a).

9.8.3.100 The telemetry data 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.

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

**Behavioural Disturbance**

*Harbour porpoise*

9.8.3.102 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 considers porpoises to be present year around in the Irish sea (for more details see volume 4, annex 9.1: Marine mammal technical report of the PEIR). Therefore harbour porpoise could be vulnerable to piling at any time of year.

9.8.3.103 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.

9.8.3.104 In recent study, Kastelein *et al.* (2022) studied effects of six piling sounds (average in the pool of up to 135dB re 1 $\mu Pa^2s$) 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. changing her respiration rate, moving away from the sound source), her behaviour was observed to return to normal immediately. At sea measurements reported by Brandt *et al.* (20210) observed reduced porpoise acoustic activity within a 2.6km 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.

9.8.3.105 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 4.8km from the piles, whilst at greater distances (10km 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 2km) of the construction site and were reduced for about one to two hours post-piling, whilst at the maximum effect distances (from 17km out to approximately 33km) avoidance only occurred during the hours of piling. Porpoise detections during piling were found at sound levels exceeding 143dB re 1 $\mu Pa^2 s$ 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 -140 dB re 1 $\mu Pa^2 s$), detectable responses may not be evident from region to region.

9.8.3.106 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 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.

9.8.3.107 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.

9.8.3.108 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.

9.8.3.109 Harbour porpoise is deemed to have some tolerance 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 dolphin, Risso's dolphin*

9.8.3.110 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.

9.8.3.111 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 128dB re. 1$\mu Pa^2 s$ and 141dB re. 1$\mu Pa^2 s$ 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.

9.8.3.112 The severity spectrum presented by Southall *et al*. (2021) 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.

9.8.3.113 Short-beaked 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. The Morgan digital aerial surveys did not record any short-beaked dolphin across the duration of aerial surveys. Bottlenose dolphin is 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 was corroborated by site specific aerial surveys with bottlenose dolphin records in June 2021. Risso's dolphin are mostly common in Manx territorial waters and there is a potential for these species to be present in the vicinity of Morgan marine mammal study area in summer months (for more details see volume 4, annex 9.1: Marine mammal technical report of the PEIR). Therefore, due to their distribution and seasonality these species are unlikely to be disturbed as a result of piling throughout the year. Additionally, these is no indication that waters within the Morgan marine mammal study area are important for foraging or breeding for these species.

9.8.3.114 Bottlenose dolphin, short-beaked dolphin and Risso's dolphin may be able to avoid the disturbed area and whilst there may some impacts on reproduction in closer proximity to the source (i.e. within the area of 'strong disturbance'), these are unlikely to impact on survival rates as 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.

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

*Minke whale*

9.8.3.116 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, 2018). 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 8: Fish and shellfish ecology of the PEIR. 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).

9.8.3.117 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.

9.8.3.118 The minke whale is deemed to some tolerance 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*

9.8.3.119 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 monopiles or 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.

9.8.3.120 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 seals 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 therefore it can be anticipated such decisions are consistent with a risk/profit balancing approach.

9.8.3.121 Empirical data has been used to study seal behaviour during offshore wind farm installation. Russell *et al*. (2016) studied movements of tagged harbour seals during piling at the Lincs Offshore Wind Farm in the Greater Wash and reported significant avoidance of the wind farm by harbour seals. Within this study, seal abundance significantly reduced over a distance of up to 25km 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 seals 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 seals 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 with profit. Whilst approximately half of the tracked seals were absent from the pile-driving area altogether, this may be because animals were drawn to other more profitable 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, seals exposed to pile-driving at distances shorter than 30km 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.

9.8.3.122 Changes in behaviour and subsequent barrier effects have the potential to affect the ability of phocid seals to accumulate 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. Grey seals accumulate reserves of subcutaneous blubber which they use to synthesize milk during lactation, particularly during the third trimester of pregnancy (Hall *et al*., 2001). Therefore during this period, grey seals 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.

9.8.3.123 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 seals 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 (lasts 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 seals return to the water and must forage extensively to build up lost energy reserves.

9.8.3.124 Harbour seal and grey seal are deemed to have some tolerance 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

*Harbour porpoise*

9.8.3.125 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 unlikely to affect the international value of the species as there is no long-term decline predicted in the regional population 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.

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

9.8.3.126 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*

9.8.3.127 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 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*

9.8.3.128 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.

#### Behavioural disturbance

*Harbour porpoise*

9.8.3.129 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.

9.8.3.130 There is, however, predicted to be a spatial overlap with the North Anglesey Marine SAC and consequently this will be considered as part of the Habitats Regulation Assessment.

*Bottlenose dolphin*

9.8.3.131 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 Irish Sea MU as there is no long-term decline in the regional population predicted as demonstrated with the iPCoD modelling assessment. The effect on bottlenose dolphin will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

*Short-beaked common dolphin and Risso's dolphin*

9.8.3.132 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 on short-beaked common dolphin and Risso's dolphin will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

*Minke whale*

9.8.3.133 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 on minke whale will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

*Grey seal*

9.8.3.134 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 combined Irish Sea MUs as there is no long-term decline in the regional population predicted as demonstrated with the iPCoD modelling assessment. The effect on grey seal will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

*Harbour seal*

9.8.3.135 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 Irish Sea MUs. The effect on harbour seal will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

## 9.8.4 Injury and disturbance from elevated underwater sound during UXO clearance

9.8.4.1 The clearance of UXO prior to commencement of construction may result in detonation (high order) of a 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 effectss of this activity will depend on sound source characteristics, the receptor species, distance from the sound source and sound attenuation within the environment.

9.8.4.2 Further detail on sound modelling of UXO clearance are provided in volume 3, annex 3.1: Underwater sound technical report of the PEIR. 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 level. Frequency dependent weighting functions were applied to allow comparison with marine mammal hearing weighted thresholds.

9.8.4.3 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 9.8.4.2 but using a smaller donor charge size.

### Construction phase

#### Magnitude of impact

9.8.4.4 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) and 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 the onset of a moving away response. 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. A project specific draft MMMP will be developed in order to reduce the potential to experience injury.

9.8.4.5 It is anticipated that up to 13 UXOs within the Morgan Array Area are to be cleared. The maximum UXO size is assumed to be 907kg, the most common size is 130kg and the smallest UXO size is 25kg (Table 9.14), thus all sizes have been assessed. A low order clearance donor charge of 0.08kg is assumed whilst low-yield donor charges are multiples of 0.75kg (up to four required for the largest UXO). For donor charges for high-order clearance activities, charge weights of 1.2kg (the most common) and 3.5kg (single barracuda blast charge) have been included.

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

**Permanent threshold shift (PTS)**

9.8.4.7 PTS ranges for low order and low yield UXO clearance activities are presented in Table 9.24, donor charges used in High Order UXO clearance presented in Table 9.25 and high order clearance of UXO presented in Table 9.26. The number of animals predicted to experience PTS due to low order is presented in Table 9.27, donor charges in Table 9.28 and high order clearance in Table 9.29.

9.8.4.8 It is considered that there is a small risk that a low order clearance could result in high order detonation of UXO, and 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 PEIR). The NMFS (2018) guidance suggests an estimate of 3km for transition from impulsive to continuous (although this was not subsequently presented in later guidance (Southall *et al*., 2019)). Hastie *et al*. (2019) suggests that some measures of impulsiveness (for seismic airguns and pile-driving) change markedly within approximately 10km of the source. Therefore, great 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 predicted.

9.8.4.9 An explosive mass of 907kg (high order explosion) yielded the largest PTS ranges for all species, with the greatest injury range (15,370m) seen for harbour porpoise ($SPL_{pk}$) (Table 9.24). However, the more common 130kg charge results in this injury range being reduced to 8,045m for harbour porpoise ($SPL_{pk}$). Conservatively, the number of harbour porpoise that could be potentially injured, based on the peak seasonal densities from the Morgan digital aerial surveys, was estimated as 184 animals for 907kg UXO high order explosion equating to 0.29% of the Celtic and Irish Seas MU. Predicted numbers were much smaller for the 130kg and 25kg UXOs with up to 51 animals and 17 animals potentially experiencing PTS respectively. For low order techniques, the largest range of 2,290m was predicted from the 4x0.75kg low-yield charges, which has the potential to injure up to five harbour porpoise within this range.

9.8.4.10 The underwater sound assessment 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 890m for the detonation of charge size of 907kg, but this is reduced to 464m for 130kg and 268m for 25kg. Therefore conservatively, during high order detonation of any size of UXO up to the maximum the number of individuals that could be potentially injured for any of these species (based on densities presented in Table 9.10) was estimated as no more than one. With reference to the wider populations of these species, this equated to very small proportions of the relevant MUs (0.03% for bottlenose dolphin, 0.00004% for short-beaked common dolphin and 0.0006% for Risso's dolphin). For low order techniques, the injury ranges were considerably lower with a maximum of 133m estimated with no more than one animal of any species likely to be present within this range.

9.8.4.11 The underwater sound assessment found that the maximum injury (PTS) range estimated for minke whale using the SEL metric is 4,215m for the detonation of charge size of 907kg, but this is reduced to 1,705m for 130kg and 775m for 25kg. Therefore conservatively, during high order detonation of any size of UXO up to the maximum the number of individuals that could be potentially injured (based on densities presented in Table 9.10) was estimated as less than one. This equates to a maximum of 0.002% of the CGNS MU. For low order techniques, the maximum range predicted was up to 406m and there would be no more than one animal potentially within this range.

9.8.4.12 The underwater sound assessment found that the maximum injury (PTS) range estimated for grey seal using the $SPL_{pk}$ metric was 3,015m for the detonation of charge size of 907kg, but this was reduced to 1,580m for 130kg and 910m for 25kg. Therefore conservatively, the number of individuals that could be potentially injured, based on the inshore densities, was estimated as up to two animals for 907kg UXO high order explosion, which equates to 0.01% of the Grey Seal reference population, and 0.0019% of the OSPAR Region III reference population and less than one animal for both 130kg and 25kg UXO. For low order techniques, the maximum range predicted was up to 449m and there would be no more than one animal potentially within this range.

9.8.4.13 The underwater sound assessment found that the maximum injury (PTS) range estimated for harbour seal using the $SPL_{pk}$ metric was 3,015m for the detonation of charge size of 907kg, but this was reduced to 1,580m for 130kg and 910m for 25kg. Therefore conservatively, the number of individuals that could be potentially injured, was estimated as less than one animal for 907kg UXO high order explosion, 130kg UXO and 25kg UXO, which equates to 0.0001% of the reference population (Wales, NW England and Northern Ireland SMUs). For low order techniques, the maximum range predicted was up to 449m and there would be no more than one animal potentially within this range.

**Table 9.24: Potential PTS ranges for Low Order and Low Yield UXO clearance activities.**

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

**Table 9.25: Potential PTS ranges for donor charges used in High Order UXO clearance activities.**

| Charge Size | PTS range, m | | | | |
|---|---|---|---|---|---|
| | Threshold | VHF | HF | LF | PCW |
| 1.2kg | SPL | 1690 | 98 | 299 | 331 |
| | SEL | 596 | 6 | 176 | 34 |
| 3.5kg | SPL | 2415 | 140 | 427 | 473 |
| | SEL | 885 | 10 | 297 | 57 |

**Table 9.26: 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 | $SPL_{pk}$ | 4645 | 268 | 825 | 910 |
| | SEL | 1645 | 27 | 775 | 147 |
| 130 kg UXO – high order explosion | $SPL_{pk}$ | 8045 | 464 | 1425 | 1580 |
| | SEL | 2520 | 61 | 1705 | 323 |
| 907 kg UXO – high order explosion | $SPL_{pk}$ | 15,370 | 890 | 2,720 | 3,015 |
| | SEL | 3,820 | 151 | 4,215 | 800 |

**Table 9.27: Number of animals with the potential to experience PTS due to Low Order and Low Yield UXO clearance activities.**

| 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** | | | | | | | |
| $SPL_{pk}$ | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| SEL | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| **0.5 kg clearing shot** | | | | | | | |
| $SPL_{pk}$ | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| SEL | <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 | <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 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |

**Table 9.28: 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 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** | | | | | | | |
| $SPL_{pk}$ | 3 | <1 | <1 | <1 | <1 | <1 | <1 |
| SEL | <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 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |

**Table 9.29: Number of animals with the potential to experience PTS 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 |
| **25kg UXO – high order explosion** | | | | | | | |
| $SPL_{pk}$ | 17 | <1 | <1 | <1 | <1 | <1 | <1 |
| SEL | 3 | <1 | <1 | <1 | <1 | <1 | <1 |
| **130kg UXO – high order explosion** | | | | | | | |
| $SPL_{pk}$ | 51 | <1 | <1 | <1 | <1 | <1 | <1 |
| SEL | 5 | <1 | <1 | <1 | <1 | <1 | <1 |
| **907kg UXO – high order explosion** | | | | | | | |
| $SPL_{pk}$ | 184 | <1 | <1 | <1 | <1 | 2 | <1 |
| SEL | 12 | <1 | <1 | <1 | 1 | <1 | <1 |

9.8.4.14 For the purposes of this assessment, it has been assumed that the maximum design scenario will be clearance of UXO with a Net Explosive Quantity (NEQ) of 907kg cleared by either low order or high order techniques although clearance of UXO with an NEQ of 130kg is considered the more likely (common) scenario. 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 low order is included in the assessment.

9.8.4.15 With primary measures in place the assessment found that there would be a residual risk of injury over a range of 2,290m that would require additional tertiary mitigation measures (Table 9.24). Where low order/low yield measures are not possible there is a maximum risk of injury (predicted for harbour porpoise) out to 15km for a 907kg UXO and 8km for a 130kg UXO. Therefore, adopting standard industry practice (JNCC, 2010b) tertiary mitigation will applied as part of a MMMP (Table 9.16).

9.8.4.16 The injury ranges (for both low order and high order clearance) are considerably larger than the standard 1,000m 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. 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 multi-species deterrent. Brandt *et al.* (2012) reported effective deterrence of harbour porpoise out to 7.5km whilst Dähne *et al.* (2017) suggests detectable deterrence to 12km. Olesiuk *et al.* (2002) report a displacement range of 3.5km for the Airmar dB plus II ADD whilst Kyhn *et al.* (2015) report effective deterrence to

2.5km for harbour porpoise. A full review of available devices is provided in McGarry *et al.*, (2020). 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.

9.8.4.17 Details of appropriate tertiary mitigation as set out in the MMMP will be discussed and agreed with consultees post-consent when further details of the size and type of potential UXOs are understood. To illustrate what this may entail for high order clearance of the most likely scenario (130kg NEQ), based on a swim speed of 1.52m/s for harbour porpoise, a total of 88 minutes of deterrence activities would be required for animals to clear the risk zone.

9.8.4.18 Adopting a precautionary approach, and assuming application of tertiary measures, the assessment considered the magnitude for a high order detonation. 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 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 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 ranges of effect are large and there is considered to be a residual risk of PTS to a small number of individuals, therefore the magnitude is considered to be **low** (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), 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 (Temporary threshold shift (TTS) as a proxy)

9.8.4.19 A second threshold assessed was the onset of TTS where the resulting effect would be a potential temporary loss in hearing. This is assumed that 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 therefore not considered likely to lead to any long-term effects on the individual. The onset of TTS also corresponds to a 'fleeing response' as this is the threshold at which animals are likely to move away or flee from the ensonified area. Thus, the onset of TTS also reflects the threshold at which behavioural displacement could occur.

9.8.4.20 As previously described in paragraph 9.8.4.4, 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 PEIR). It is particularly important when interpreting results for TTS with ranges of up to 34.37km as these are likely to be significantly lower than predicted.

9.8.4.21 As before, the assessment of TTS considered low order and low yield UXO clearance activities (Table 9.30), donor charges for high order UXO disposal (Table 9.31) and high order explosions (Table 9.32). The largest ranges using $SPL_{pk}$ were predicted for clearance of the 907kg UXO with potential TTS/moving away response over a distance of up to ~28km for harbour porpoise for example (Table 9.32). Ranges predicted for other species using $SPL_{pk}$ were smaller for all other species, however, for minke whale a larger TTS range of ~34km was predicted using the $SEL_{cum}$ threshold.

**Table 9.30: Potential TTS ranges for Low Order and Low Yield UXO clearance activities.**

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

**Table 9.31: Potential TTS ranges for donor charges high order UXO.**

| Charge Size | TTS range, m | | | | |
|---|---|---|---|---|---|
| | Threshold | VHF | HF | LF | PCW |
| 1.2kg | SPL | 3,110 | 180 | 551 | 610 |
| | SEL | 155 | 85 | 2,400 | 183 |
| 3.5kg | SPL | 4,445 | 257 | 790 | 875 |
| | SEL | 157 | 141 | 3,940 | 183 |

**Table 9.32: Potential TTS 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 | 159 | 343 | 9,325 | 183 |
| 130 kg UXO – high order explosion | $SPL_{pk}$ | 14,825 | 855 | 2,625 | 2,905 |
| | SEL | 160 | 680 | 17,755 | 183 |
| 907 kg UXO – high order explosion | $SPL_{pk}$ | 28,320 | 1,635 | 5,015 | 5,550 |
| | SEL | 162 | 1,380 | 34,365 | 184 |

9.8.4.22 The number of animals that would potentially experience TTS due to low order and low yield UXO clearance activities is presented in Table 9.33, donor charges for high order UXO disposal in Table 9.34 and high order explosions in Table 9.35. As seen for PTS the highest number of animals affected, based on high order detonation of a 907kg UXO, was found for harbour porpoise where up to 623 animals could experience TTS within the 28km range equating to 1% of the MU population (based on $SPL_{pk}$). The number of grey seal within a predicted 5.5km TTS range was estimated as four animals (0.03% of the Grey Seal reference population, and 0.007% of the OSPAR Region III reference population, based on the $SPL_{pk}$ metric) and for minke whale up to 65 animals may occur within the 34.3km TTS range (0.319% of the MU population, based on the $SEL_{cum}$ metric). For all other species the number of animals predicted to experience TTS/fleeing was very small with no more than one animal within the predicted effect zones.

9.8.4.23 Application of tertiary mitigation to reduce the risk of PTS will also to some extent reduce the risk of TTS/moving away, although notably the ranges for the latter are much larger. However, such effects are reversible and therefore animals that experience this effect this are anticipated to fully recover. It is, however, recognised that where tertiary mitigation applies deterrence measures (i.e. ADD and soft start charges) these measures by their nature would contribute to, rather than reduce, the moving away response.

**Table 9.33: Number of animals with the potential to experience TTS 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 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| **0.5 kg clearing shot** | | | | | | | |
| $SPL_{pk}$ | 5 | <1 | <1 | <1 | <1 | <1 | <1 |
| SEL | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| **2 x 0.75 kg low-yield charge** | | | | | | | |
| $SPL_{pk}$ | 9 | <1 | <1 | <1 | <1 | <1 | <1 |
| SEL | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| **4 x 0.75 kg low-yield charge** | | | | | | | |
| $SPL_{pk}$ | 14 | <1 | <1 | <1 | <1 | <1 | <1 |
| SEL | <1 | <1 | <1 | <1 | <1 | <1 | <1 |

**Table 9.34: Number of animals with the potential to experience TTS 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 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| **3.5 kg donor blast-fragmentation charge for high-order UXO disposal** | | | | | | | |
| $SPL_{pk}$ | 16 | <1 | <1 | <1 | <1 | <1 | <1 |
| SEL | <1 | <1 | <1 | <1 | <1 | <1 | <1 |

**Table 9.35: Number of animals with the potential to experience TTS 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** | | | | | | | |
| $SPL_{pk}$ | 57 | <1 | <1 | <1 | <1 | <1 | <1 |
| SEL | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| **130 kg UXO – high order explosion** | | | | | | | |
| $SPL_{pk}$ | 171 | <1 | <1 | <1 | <1 | 2 | <1 |
| SEL | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| **907 kg UXO – high order explosion** | | | | | | | |
| $SPL_{pk}$ | 623 | <1 | <1 | <1 | <1 | 4 | <1 |
| SEL | <1 | <1 | <1 | <1 | <1 | <1 | <1 |

9.8.4.24 Adopting a precautionary approach, and with tertiary measures adopted, the assessment considered the magnitude for a high order detonation. The magnitude of TTS 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. the elevation in underwater sound only occurs during detonation event) and effect of TTS are 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

#### Permanent Threshold Shift

9.8.4.25 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 PEIR). 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 porpoises were most often studied in a scientific literature due to their high sensitivity to sound. The effects of explosives on harbour porpoise in the south North Sea was studied by Von Benda-Beckmann *et al*. (2015). The study measured SEL and peak overpressure (in kPa) at distances up to 2km from the explosions of seven aerial bombs (charge mass of 263kg and 121kg) detonated at approximately 26m to 28m depth, on a sandy substrate. The results suggested that the largest distance at which a risk of ear trauma could occur was at 500m and that sound-induced PTS was likely to occur greater than the 2km range that was measured during the study since the SEL recorded at this distance was 191 dB re. 1 µPa2s (i.e. 1dB 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 (RLNN) and the Royal Netherlands Meteorological Institute (RNMI) over a two year period (2010 and 2011). Using the empirical measurements of SEL out to 2km to validate the, the authors found that the effect distances ranged between hundreds of metres to just over 10km (for charges ranging from 10kg up to 1,000kg). 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 5km. However, whilst the model could provide a reasonable estimate of the SEL within 2km (since the empirical measurements were made out to this point), estimates above this distance required further validation since the uncorrected model systematically overestimated SEL.

9.8.4.26 Estimating how individuals are exposed to sound over time depends on an animals' mobility. Aarts *et al.,* (2016) demonstrated 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, fewer animals would receive PTS and TTS than those free-roaming but more individuals would be subjected to repeated exposures.

9.8.4.27 Salomons *et al*. (2021) analysed the sound measurements performed near two detonations of UXO (charge masses of 140kg and 325kg) and derived a PTS effect distance in the range 2.5km to 4km (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 porpoises are at risk of permanent hearing loss at distances of several kilometres, i.e. distance between 2km and 6km based on 140kg and 325kg charge masses, respectively.

9.8.4.28 Due to paucity of studies on these species, less is known about sensitivity of bottlenose dolphin, short-beaked dolphin, Risso's dolphin and minke whale to blasting. During a clearance of relatively small explosive (35kg charge) at an important feeding area for a resident community of bottlenose dolphin in Portugal, acoustic pressure levels in excess of 170dB e 1 µPa were measured and despite pressure levels being 60dB higher than ambient sound, no adverse effects were recorded in the behaviour or appearance of 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).

9.8.4.29 Robinson *et al*. (2020) found that using low order UXO disposal methods offer a substantial reduction in acoustic output over traditional high-order detonations, with the peak $SPL_{pk}$ and $SEL_{cum}$ observed being typically >20dB 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 the evidence that low order techniques offer the potential for greatly reduced acoustic sound exposure of marine mammals.

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

#### Behavioural Disturbance (Temporary Threshold Shift as a proxy)

9.8.4.31 Although the 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 explosion. 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.

9.8.4.32 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*

9.8.4.33 SEAMARCO (2011) measured recovery rates of harbour porpoise following exposure to sound source of 75db re 1 µPa (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).

9.8.4.34 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 0.5kHz 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 dolphin and Risso's dolphin*

9.8.4.35 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 6dB in response to levels up to 221dB 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 196dB and 209dB 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.

9.8.4.36 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 therefore animals can recover their hearing after they are no longer exposed to elevated sound levels. It can be anticipated that both white-beaked dolphin and bottlenose dolphin would be able to tolerate the effect without any impact on reproduction or survival rates with ability to return to previous behavioural states or activities once the impacts had ceased.

*Minke whale*

9.8.4.37 There is no species-specific recovery rates for minke whale to TTS. However, there is no evidence to suggest that recovery will be significantly different to harbour porpoise recovery rates as studies reported that minke whales avoid a 15 kHz ADD and clearly react to signals at the likely upper limit of their hearing sensitivity (Boisseau *et al*., 2021). 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*

9.8.4.38 Kastelein *et al*. (2018a) measured recovery rates of harbour seal following exposure to a sound source of 193 dB re 1 µPa2s ($SEL_{cum}$) 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 very fast (around 30 minutes) and the higher the hearing threshold shift, the longer the recovery. Kastelein *et al*. (2019a) also reported relatively fast recover, with full hearing recovery within two hours following exposure.

9.8.4.39 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.

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

**Significance of effect**

9.8.4.41 In the case that a low order technique is not possible, or results in a high order detonation (as per paragraph 9.8.4.8,) conclusions presented in 9.8.4.42 onwards are based on the assessment for high order clearance.

**Auditory injury**

9.8.4.42 Overall, 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 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.

9.8.4.43 Overall, with tertiary mitigation applied, for harbour porpoise, the magnitude of the impact is deemed to be **low,** and the sensitivity of the receptors 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 unlikely to affect the international value of the species. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

**TTS**

9.8.4.44 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.

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

9.8.5.1 Increased vessel movements during the construction, operational 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.

9.8.5.2 The assessment of impacts from elevated underwater sound due to vessel use and other activities is based on 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 PEIR. 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

9.8.5.3 During the construction phase of the Morgan Generation Assets, the increased levels of vessel activity will contribute to the total underwater sound levels.

9.8.5.4 The maximum design scenario for construction activities associated with site preparation and inter-array cable is up to a total of 63 construction vessels on site at any one time.

9.8.5.5 For the Morgan Array Area, total installation vessels and movements includes a maximum of 22 main installation and support vessels, carrying out 521 trips. Eight tug/anchor handlers will carry out 74 return trips. Four cable lay installation and support vessels will carry out eight return trips across the construction period. One guard vessel will carry out 50 return trips. Five survey vessels will carry out 29 return trips. A maximum of seven seabed preparation vessels for boulder removal, grapnel, pre-sweep and levelling will carry out 18 return trips. Eleven 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.

9.8.5.6 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.

9.8.5.7 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, commercial ferry routes between the UK mainland (Liverpool, Heysham) and the IoM (Douglas) total approximately 1,912 crossings, between the UK mainland (Liverpool) and Northern Ireland (Belfast) 1,696 crossings, between UK mainland (Heysham) and Ireland (Dublin) 604 crossings and UK mainland (Heysham) and Northern Ireland (Warrenpoint) 1087 in 2019, highlighting there is a high ferry vessel baseline alone in the area.

9.8.5.8 As described in the Navigational Risk Assessment (NRA) (volume 4, annex 12.1: Navigational Risk Assessment of the PEIR), occasional vessel traffic movements associated with jack-ups and other platforms also occur in the region.

9.8.5.9 Other sound-generating activities for the Morgan Generation Assets will include drilled piling and cable burial. Up to 100% of overall piles are anticipated to require drilling (107 4-legged turbine jacket foundations with a diameter of 2.6m plus four 4-legged OSP jacket foundations with a diameter of 3.0m) with up to two concurrent drilling vessels. Burial of inter-array cables (500km) will also occur, with 50km of interconnector cables via ploughing, trenching and jetting; cable burial and rock dumping. See Volume 3, annex 3.1: Underwater sound technical report of the PEIR for more information about SELs associated with above construction activities.

9.8.5.10 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 PEIR). 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.

9.8.5.11 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). The sound modelling results indicate that the threshold for PTS was not exceeded for any species for all vessels, drilled piling and cable burial activities. Therefore there is no 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 conducted for TTS for completeness (see volume 3, annex 3.1: Underwater sound technical report of the PEIR) however ranges indicated are likely to be overestimates (see paragraph 9.8.2.5). Ranges for TTS were between < 15m and 5,700m for vessels, and between <10m and 4,480m for piled drilling and cable burial activities.

9.8.5.12 Whilst the likelihood of auditory injury to animals is considered unlikely, the maximum duration of the construction phase is up to four years (48 months).

9.8.5.13 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 – with the exception of cable trenching where PTS was <10m for harbour porpoise only - the magnitude is considered to be **negligible**.

##### Behavioural disturbance

9.8.5.14 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, the Morgan Generation Assets is located in a relatively busy shipping area and therefore background sound levels are likely to be relatively high.

9.8.5.15 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. The estimated ranges within which there is a potential for disturbance to marine mammals are presented in Table 9.36.

9.8.5.16 The greatest modelled disturbance range was for survey and support vessels, crew transfer vessels, scour/cable protection and seabed preparation/installation vessels, at 21km, for all marine mammal species. Cable trenching resulted in disturbance ranges of 18km, whilst sandwave clearance, construction and installation, rock placement and cable installation vessels, had disturbance ranges out to 8km. Cable laying also had disturbance ranges of 8km, and tug/anchor handlers had a disturbance range of 6km (Table 9.36). In comparison, boulder clearance has the potential to result in a disturbance range of 1km; jack-up rigs had a disturbance range of 10m; and drilled piling had a disturbance range of 1.4km (Table 9.36).

**Table 9.36: Estimated disturbance ranges for marine mammals as a result of vessels and other activities.**

| Threshold | Disturbance Range (km) |
|---|---|
| Sandwave clearance, Installation vessel, construction vessel (Dynamic Positioning), rock placement vessel and cable installation vessels | 8 |
| Boulder Clearance | 1 |
| Tug/anchor handlers, Guard vessels | 6 |
| Survey vessel and support vessels, Crew transfer vessel, Scour/Cable Protection/Seabed Preparation/Installation Vessels | 21 |
| Cable trenching | 18 |
| Cable laying | 8 |
| Jack-up rig | <0.01 |
| Drilled piling | 1.4 |

9.8.5.17 For impulsive sound sources there is an understanding of the difference between strong and mild disturbance, whereas for non-impulsive (continuous) sound sources, there is only a single available threshold (120 dB re 1 µPa (rms)), which is classed as the distance beyond which no animals would be disturbed. Given that ranges for disturbance for vessels are presented up to the 120 dB re 1 µPa (rms) threshold, and there is no distinction between mild and strong disturbance, it can be assumed that not all animals found within those ranges (Table 9.36) would be disturbed. 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), although there is no dose-response curve available to apply in the context of non-impulsive sound sources. 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 construction phase, instead carried out over a shorter number of days within the period. 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.

9.8.5.18 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**

9.8.5.19 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**

9.8.5.20 The sensitivity of marine mammal receptors to auditory injury has been assessed in piling (Section 9.8.2) and is not reiterated here.

9.8.5.21 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**

9.8.5.22 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).

9.8.5.23 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.

9.8.5.24 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 (16 kHz third-octave). Heinänen and Skov (2015) found that the occurrence of harbour porpoise declines significantly when the number of vessels in a 5km$^2$ 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 4km, when comparing occurrence and foraging activity between two offshore windfarms in the Moray Firth.

9.8.5.25 Other species of dolphin (e.g. 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*., 2020; Marley *et al.*, 2017; Miller *et al*., 2008). Meza *et al.* (2020) found increased foraging in bottlenose and common dolphins' behavioural budgets, but a decreased 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.

9.8.5.26 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).

9.8.5.27 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.

9.8.5.28 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 dolphins 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.

9.8.5.29 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 sited into the sea (Jansen *et al.,* 2010; Anderson *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 studying 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 500m of the beach showed strong influence on the proportion of grey seals 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 100m of a haul-out (Richardson *et al*., 2005). This disturbance to seal haul-outs could have negative consequences in pupping season, due to trade-offs between feeding and nursing (see 9.8.5.29). 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).

9.8.5.30 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 seals 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.

9.8.5.31 There is some evidence of habituation to boat traffic, and anthropogenic sounds and activities in general (Vella *et al.*, 2001), and therefore a slight increase from the existing levels of traffic in the vicinity of the Morgan Generation Assets may not result in high levels of disturbance. The Liverpool Bay area already has a high level of anthropogenic activities as a baseline. 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 50km 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). 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 did not have a negative effect on the local population of bottlenose dolphin, although it did note that foraging may be disrupted by disturbance from vessels, which was also suggested by Benhemma-Le Gall *et al.* (2021) (see paragraph 9.8.5.24).

9.8.5.32 All marine mammals are deemed to have some tolerance to auditory injuryhigh recoverability and international value. The sensitivity of the receptor is therefore, considered to be **medium**.

#### Significance of effect

##### Auditory injury

9.8.5.33 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

9.8.5.34 Overall, with designed in measures in place 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

9.8.5.35 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, export cable repair or reburial (subtidal or intertidal) (Table 9.14). 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 2,351 operations and maintenance vessel movements (return trips) will be carried out each year (2,190 CTVs/workboats, 25 jack-up vessels, 16 cable repair vessels, 104 SOV or similar and 16 excavators/backhoe dredgers).

9.8.5.36 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 section 9.1.3. 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 are likely to follow existing shipping routes to/from the ports. In addition, an EMP including measures to minimise disturbance to marine mammals from transiting vessels will be issued to all project vessel operators to minimise the potential for collision risk as described in Table 9.16.

9.8.5.37 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 9.14). 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

9.8.5.38 An overview of potential impacts for auditory injury to marine mammals from elevated underwater sound due to vessel use and other as well as associated effects (auditory injury) are described in paragraph 9.8.5.3 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 **low**.

##### Behavioural disturbance

9.8.5.39 An overview of potential impacts for behavioural disturbance to marine mammals from elevated underwater sound due to vessel use and other activities as well as associated effects (behavioural disturbance) are described in paragraph 9.8.5.14 for the construction phase with behavioural disturbance ranges presented in Table 9.36 and have not been reiterated here for the operational 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

9.8.5.40 The sensitivity of marine mammal receptors to auditory injury has been assessed in paragraph 9.8.5.20 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

9.8.5.41 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 activities is as described previously in 9.8.5.22. All marine mammals, which are IEFs of international value, 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

9.8.5.42 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

9.8.5.43 Overall, with designed in mitigation measures where vessels will follow 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 effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

### Decommissioning phase

#### Magnitude of impact

9.8.5.44 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 9.14).

9.8.5.45 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, this impact 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, where it has been assessed as low.

##### Auditory injury

9.8.5.46 An overview of potential impacts from elevated underwater sound due to vessel use and other activities as well as associated effects (auditory injury) are described in paragraph 9.8.5.3 *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

9.8.5.47 An overview of potential impacts from elevated underwater sound due to vessel use and other activities as well as associated effects (behavioural disturbance) are described in paragraph 9.8.5.14 for the construction phase with behavioural disturbance ranges presented in Table 9.36 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

9.8.5.48 The sensitivity of marine mammal receptors to auditory injury has been assessed in paragraph 9.8.5.20 *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

9.8.5.49 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 activities is as described previously in paragraph 9.8.5.22 *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

9.8.5.50 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

9.8.5.51 Overall, with designed in mitigation measures where vessels will follow 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 effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

## 9.8.6 Increased risk of injury due to collision with vessels

### Construction phase

#### Magnitude of impact

9.8.6.1 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).

9.8.6.2 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).

9.8.6.3 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.

9.8.6.4 Vessel traffic associated with the 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. This increase, described in more detail in paragraph 9.8.5.3, could lead to an increase in interactions between marine mammals and vessels. Vessels travelling at 7m/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. This would be most appropriate for species found within the marine mammal study areas, whereas guidance in the US (NOAA, 2020) suggests lower speeds in relation to larger slow-moving species such as humpback whales *Megaptera novaeangliae* (rare sightings in the Irish Sea). 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 the EMP including measures to minimise disturbance to marine mammals from transiting vessels. The 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 9.16). Therefore, with the Morgan Generation Assets designed in measures in place, the risk of collision is anticipated to be reduced and would only be present for transiting vessels (as opposed to stationary).

9.8.6.5 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 able to move to avoid marine mammals, when 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 EMP will contain measures to minimise disturbance to marine mammals from transiting vessels.

9.8.6.6 With measures adopted as part of the Morgan Generation Assets 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**.

#### Sensitivity of receptor

9.8.6.7 Marine mammals are generally able to detect and avoid vessels, however, it is unclear why some individuals do not always move out of the path of an approaching vessel (Schoeman *et al*., 2020). It has been suggested that behaviours such as resting, foraging, nursing, and socialising could distract animals from detecting the risk posed by vessels (Dukas, 2002). There can be consequences to a 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). Laist *et al*. (2001) reported that collisions between vessels and large whales tended to lead to death, but non-lethal collision has also been reported by Van Waerbeek *et al*. (2007). It must be noted that collisions between cetaceans and vessels are not necessarily lethal on all occasions.

9.8.6.8 Given that harbour porpoise are small and highly mobile and considering their potential avoidance responses to vessel sound (see paragraph 9.8.5.24), it can be anticipated that they will largely avoid vessel collisions. 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).

9.8.6.9 Vessel strikes can result in lethal or non-lethal injuries to dolphins (Schoeman *et al.,* 2020). Olson *et al.* (2020) 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.

9.8.6.10 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.

9.8.6.11 Although the potential to experience injury from construction traffic is relatively low, the consequences of collision risk could be fatal. All marine mammal receptors would be highly vulnerable to a collision, and the effect could potentially cause a change in both reproduction and survival of individuals. However, there is a high likelihood that marine mammals will avoid vessels (disturbed by underwater sound from vessel) and therefore, collision risk is minimised. On the basis that not all collisions that do occur are lethal, there is considered to be a medium potential for recovery.

9.8.6.12 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

9.8.6.13 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

9.8.6.14 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 9.14). 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 9.8.5.35 for the construction phase and have not been reiterated here for the operations and maintenance phase.

9.8.6.15 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

9.8.6.16 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 9.8.6.7 *et seq*.

9.8.6.17 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

9.8.6.18 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

9.8.6.19 An overview of the potential impacts due to vessel presence and associated effects (collision) are described in paragraph 9.8.5.35 for the construction phase and have not been reiterated here for the decommissioning phase.

9.8.6.20 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 9.14). The types of vessels used during the decommissioning will result in a similar MDS as the construction phase.

9.8.6.21 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

9.8.6.22 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 9.8.6.7.

9.8.6.23 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**

9.8.6.24 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.

## 9.8.7 Injury and disturbance from elevated underwater sound during site investigation surveys

9.8.7.1 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 PEIR), which is drawn upon in the assessment below.

### Summary of sound modelling

9.8.7.2 It is understood that several sonar-like sources will potentially be used for the geophysical surveys, including MBES, SSS, SBES, SBP and UHRS (0.05-4 kHz; 182dB re 1µPa re 1m (rms). 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 as continuous (non-impulsive) because they generally compromise 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 PEIR). 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 PEIR.

9.8.7.3 For geotechnical surveys, site activities include boreholes, Cone Penetration Tests (CPTs) and vibrocores. These site investigation surveys will involve the use of several geophysical/geotechnical survey vessels and take place over up to a period of up to 8 months.

### Construction phase

**Magnitude of impact**

Auditory injury

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

9.8.7.5 With respect to the ranges within which there is a potential of PTS occurring to marine mammals as a result of geophysical investigation activities, the maximum PTS is expected to occur out to 254m for harbour porpoise due to SBP (chirp/pinger) (Table 9.37). For dolphin species the maximum PTS is expected to occur out to 41m due to MBES, for minke whale and pinniped species out to 40m due to SBP (Table 9.37).

9.8.7.6 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 threshold was not exceeded for most marine mammal species, except harbour porpoise and minke whale. PTS is expected to occur during cone penetration test, out to a maximum of 55m and 4m for harbour porpoise and minke whale, respectively, and for vibro-coring to a maximum of 79m for harbour porpoise.

**Table 9.37: PTS ranges (m) for marine mammals during geophysical and geotechnical site investigation surveys, compared to Southall *et al.* (2019) SEL thresholds. Comparison to ranges for $SPL_{pk}$ where threshold was exceeded shown in brackets for geotechnical surveys.**

N/E = threshold not exceeded

| Activity | LF | HF | VHF | PCW |
|---|---|---|---|---|
| | PTS | PTS | PTS | PTS |
| **Geophysical** | | | | |
| MBES | 12 | 41 | 68 | 25 |
| SSS | 2 | 2 | 41 | 6 |
| SBES | 12 | 12 | 68 | 25 |
| SBP (chirp/pinger) | 40 | 40 | 254 | 40 |
| UHRS (sparker) | N/E | N/E | 11 | N/E |
| **Geotechnical** | | | | |
| 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 |

9.8.7.7 The number of marine mammals potentially injured within the modelled ranges for PTS presented in

9.8.7.8 Table 9.38 were estimated using the most up to date species-specific density estimates (Table 9.10). Due to low injury ranges, for all marine species, there is the potential for no more than one animal to experience PTS (and 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. Mitigation for injury during 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). The largest range was predicted as 254m (for SBP) and it is considered that standard industry measures will be effective at reducing the risk of injury over this distance. Some multi-beam surveys in shallow waters (<200m) are not subject to the requirements of mitigation (JNCC, 2017). Requirements for mitigation will be agreed with the consultees post PEIR submission.

**Table 9.38: 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 Disturbed | | | | | | |
|---|---|---|---|---|---|---|---|
| | 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** | | | | | | | |
| 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 |

9.8.7.9 The site-investigation surveys are considered to be short term as they will take place over up to a period of several 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.

9.8.7.10 Pre-construction site investigation surveys will involve the use of several geophysical/geotechnical survey vessels and take place over up to a period of up of several months. The impacts of underwater sound associated with vessel movements are described in section 9.8.5.

9.8.7.11 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

9.8.7.12 The estimated maximum ranges for onset of disturbance are based on the sound level being greater than the 120 dB re 1 μPa (rms) threshold applicable for all marine mammals, noting that this threshold is for 'mild disturbance' and therefore is not likely to result in displacement of animals. The disturbance ranges as a result of geophysical and geotechnical site-investigation surveys (Table 9.39) 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 55km during vibro-coring. This is due to the higher source levels for this piece of equipment compared to other types of survey equipment.

**Table 9.39: Disturbance for marine mammals (all species) during geophysical and geotechnical site investigation surveys**

| Activity | Disturbance all species (m) |
|---|---|
| **Geophysical** | |
| MBES | 830 |
| SSS | 310 |
| SBES | 830 |
| SBP (chirp/pinger) | 17,300 |
| UHRS (sparker) | 637 (mild) |
| | 95 (strong) |
| **Geotechnical** | |
| Borehole drilling | 1,360 (strong) |
| Cone penetration testing | 1,350 (mild) |
| | 158 (strong) |
| Vibro-coring | 55,000 |

9.8.7.13 For geophysical surveys the maximum disturbance ranges were predicted for the SBP with mild disturbance potentially up to 17.3km. For geotechnical surveys the maximum disturbance ranges were predicted for vibro-coring potentially up to ~55km (Table 9.39)

9.8.7.14 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 9.10). The largest distance over which mild disturbance could occur is out to 1,350m, and the largest distance over which strong disturbance could occur is out to 158m. 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.

9.8.7.15 As stated in paragraph 9.8.5.17, for impulsive sound sources there is an understanding of the difference between strong and mild disturbance, whereas for non-impulsive (continuous) noise sources (MBES, SSS, SBES, SBP (chirp/pinger), borehole drilling and vibro-coring), there is only a single available threshold (120 dB re 1 µPa (rms)), which is classed as 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 (rms) threshold, and there is no distinction between mild and strong disturbance, it can be assumed that not all animals found within those ranges (Table 9.39) would be disturbed. 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), although there is no dose-response curve available to apply in the context of non-impulsive sound sources. 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 construction phase, instead carried out over a shorter number of days within the period.

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

9.8.7.17 The impact of site investigation surveys leading to behavioural effects 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 site investigation surveys). 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

9.8.7.18 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 254m. 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 400Hz were apparent following exposure to four to ten consecutive pulses ($SEL_{cum}$ 191dB – 195dB re 1 µPa$^2$s; 167dB – 171dB re 1 µPa$^2$s with frequency weighting for phocid carnivores in water). Matthews *et al.* (2020) 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, and 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 the 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.* (2020) therefore demonstrated the importance of using both SPLpk 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 SPLpk measures acute exposure to high-amplitude sounds.

9.8.7.19 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.

9.8.7.20 Marine mammals, which are IEFs of international value, are deemed to be of medium vulnerability and low recoverability. The sensitivity of the receptor to PTS from elevated underwater sound during site investigation surveys is therefore, considered to be **high**.

##### Behavioural disturbance

9.8.7.21 The transmission frequencies of many commercial sonar systems (approximately 12 kHz – 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.

9.8.7.22 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 allowed 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.

9.8.7.23 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 whales *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 (even though findings were not statistically significant).

9.8.7.24 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., 2013;* 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 12kHz MBES to be the most plausible trigger for an extreme behavioural response in melon-headed whales, 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).

9.8.7.25 Fine-scale data from porpoises equipped with high-resolution location and dive loggers when exposed to airgun pulses at ranges of 420m to 690m with sound level estimates of 135 dB–147 dB re 1 $\mu Pa^2 s$ (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.

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

9.8.7.27 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 15km away from any seismic activity but decreases in echolocation signals were detected up to 8km – 12km 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 because 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 porpoises across a 2,000km$^2$ 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 whales, sperm whales *Physeter macrocephalus* and Atlantic spotted dolphins *Stenella frontalis*, demonstrated no evidence of prolonged or large-scale displacement of each species from the region during the survey (Weir, 2008).

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

9.8.7.29 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 (e.g Heide-Jørgensen *et al*., 2013) and the type of survey (as discussed in section 9.8.7.19).

9.8.7.30 It is expected that, to some extent, marine mammals will be able to adapt their behaviour to reduce impacts on survival and reproduction rates and tolerate elevated levels of underwater sound during site investigation surveys. Marine mammals are deemed to be of medium vulnerability and high recoverability. The sensitivity of the receptor to disturbance from elevated underwater sound during site investigation surveys is therefore considered to be **medium.**

**Significance of effect**

9.8.7.31 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.

9.8.7.32 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.

## 9.8.8 Underwater sound from wind turbine operation

### Operations and maintenance phase

#### Magnitude of impact

9.8.8.1 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.

9.8.8.2 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 68 wind turbines of 16m diameter. Volume 3, annex 3.1: Underwater sound technical report of the PEIR assumed an average wind speed of 10 m/s.

#### Auditory injury

9.8.8.3 Potential injury ranges for marine mammals were calculated based on 24 hours exposure for a static animal. This conservative approach suggested that minke whale would need to remain within 5m of an operational wind turbine for period of 24 hours to reach the PTS threshold. 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 5m of operational wind turbines is considered highly unlikely to occur.

**Table 9.40: Potential injury range for marine mammals due to operational wind turbine sound (static animals 24 hour exposure).**

| Species | PTS threshold (dB re 1 µPa$^2$s) | PTS range (m) |
|---|---|---|
| Harbour porpoise | 173 | N/E |
| Bottlenose dolphin, short-beaked dolphin, Risso's dolphin | 198 | N/E |
| Minke whale | 199 | 5 |
| Grey seal, harbour seal | 201 | N/E |

9.8.8.4 The impact is predicted to be of local spatial extent (up to 5m 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

9.8.8.5 The underwater sound modelling (see volume 3, annex 3.1: Underwater sound technical report of the PEIR) predicted that potential behavioural disturbance to all species of marine mammal could occur within approximately 160m of each wind turbine, based on the sound contour plot 120dB re 1 µPa (rms) contours.

9.8.8.6 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

9.8.8.7 Thomsen *et al.* (2006) reported at 100m distance from 1.5MW wind turbines, the underwater sound would be audible to both harbour porpoise and harbour seal. At a greater distance of 1,000m the signal to ambient or background sound ratio is too low for detection in harbour porpoise, however, detection of 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.

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

9.8.8.9 As discussed in Stöber and Thomsen (2021), studies using long term frequency data from wind farm with 5MW wind 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 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 me mostly negligible (Stöber and Thomsen, 2021).

9.8.8.10 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 (<1km). For example, the results for Kentish Flats (thirty 3MW 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 noise.

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

9.8.8.12 Marmo *et al.* (2013) reported that rotational imbalances tend to occur at very low frequencies (<50Hz), while gear meshing and electromagnetic interactions tend to occur at low to moderate frequencies (8Hz to 2kHz). Wind turbines produce vibration and related sound between 0.5Hz 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 10Hz to 2kHz frequency band and predicted that modelled sound levels are likely to be audible to marine mammals particularly at wind speeds of approximately 15m/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 18km 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.

9.8.8.13 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 @ 1m 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 177dB re 1µPa @ 1m for a geared turbine with a nominal power of 10MW. Whilst the 10MW example was predicted to cause behavioural disturbance of up to 6.3km (based on the 120dBrms threshold) this was below typical sound levels for main installation vessels (see section 9.8.5).

9.8.8.14 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 are valid for smaller wind turbines than those to be built as a part of the Morgan Generation Assets but all available data has been considered and a precautionary approach adopted.

9.8.8.15 Conservatively, it is considered that there is a potential that a cetacean's ability 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, given that 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 8: Fish and shellfish of the PEIR and Volume 2, chapter 7: Benthic subtidal and intertidal ecology of the PEIR).

9.8.8.16 Section 9.8.9 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

9.8.8.17 All marine mammals are deemed to have limited tolerance 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

9.8.8.18 All marine mammals 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

9.8.8.19 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

9.8.8.20 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.

## 9.8.9 Changes in fish and shellfish communities affecting prey availability

9.8.9.1 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 8: Fish and shellfish ecology of the PEIR, may have indirect effects on marine mammals. The assessment includes temporary and long-term habitat loss/disturbance, increased SSC and associated sediment deposition, injury and/or disturbance from underwater sound and vibration, EMF, as well as colonisation of foundations, and scour protection and cable protection.

9.8.9.2 The key prey species for marine mammals include small shoaling fish from demersel or pelagic habitats, particularly gadoids (e.g. cod *Gadus morhua*, haddock

*Melanogrammus aeglefinus*, whiting *Merlangius merlangus*), whiting, *Trispoterus* spp, clupeids (herring), European sprat *Sprattus sprattus,* sandeels, mackerel (*Scomber scombrus*), flatfish (plaice *Pleuronectes platessa*, sole, flounder, dab) and cephalopods.

9.8.9.3 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 8: Fish and shellfish ecology of the PEIR). For example, there are important spawning and nursery grounds for plaice, dover sole *Solea solea*, cod, whiting, sandeel, herring, mackerel and 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

9.8.9.4 Potential impacts on marine mammal prey species during the construction phase have been assessed in volume 2, chapter 8: Fish and shellfish ecology of the PEIR using the appropriate MDS for these receptors. Construction impacts includes temporary and long-term habitat loss/disturbance, underwater sound impacting fish and shellfish receptors, increased suspended sediment concentrations (SSCs) and associated sediment deposition, electromagnetic Fields (EMFs) from subsea electrical cabling and colonisation of hard structures. A summary of the impact assessment for fish and shellfish is given in section 8.8 of Volume 2, chapter 8: Fish and shellfish ecology of the PEIR.

9.8.9.5 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.

9.8.9.6 There is the potential for temporary habitat loss/disturbance to affect up to 87,360,220m$^2$ of subtidal seabed during the construction phase, which equates to approximately 33.12% of the area within the Morgan Array Area overall, although only a small proportion of this will be impacted at any one time.

9.8.9.7 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 8: Fish and shellfish ecology of the PEIR, 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.

9.8.9.8 There is also the potential for underwater sound and vibration during construction pile-driving to result in injury and/or disturbance to fish and shellfish communities. However, for auditory injury for most fish, the impact was predicted to be of regional spatial extent, medium term duration, intermittent and high reversibility, and is unlikely to lead to significant mortality due to primary mitigation, with magnitude for all fish species considered to be medium. 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 (discussed further in 9.8.9.2). Volume 2, chapter 8: Fish and shellfish ecology of the PEIR concluded that for sprat, cod sandeel and herring the impact would be minor adverse, which is not significant in EIA terms. 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), impacts will likely be less significant (section 8.8.3 in volume 2, chapter 8: Fish and shellfish ecology of the PEIR).

9.8.9.9 Other impacts included increased suspended sediment concentrations (SSCs) and associated sediment deposition which may result in short-term avoidance of affected areas by fish and shellfish. 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 8: Fish and shellfish ecology of the PEIR most fish juveniles 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 impacts will be short in duration, returning to background levels relatively quickly. Whilst herring eggs have higher sensitivity to the smothering effects of increased sediment deposition, and the sensitivity 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.

9.8.9.10 No significant adverse effects were predicted to occur to fish and shellfish species (marine mammal prey) as a result of the construction of the Morgan Generation Assets (volume 2, chapter 8: Fish and shellfish ecology of the PEIR). Therefore, 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

9.8.9.11 Although there is interspecific variation in foraging strategies (e.g. income versus capital breeders as discussed in 9.8.2.16), 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 dolphins are semi-resident in Cardigan Bay and grey and harbour seals 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.

9.8.9.12 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.

9.8.9.13 The fish and shellfish communities found within the Morgan Fish and Shellfish Ecology study area (see volume 2, chapter 8: Fish and shellfish ecology of the PEIR) are characteristic of the fish and shellfish assemblages in the wider Irish Sea and 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 50km. 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. (i.e. elevated underwater sound would occur during piling). 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, Tougaard et al. 2003). Displacement may also vary between species, for example Russell *et al*. (2016) showed for harbour seals there was no significant displacement during construction, and displacement was limited to piling activity (within 2 hours of cessation of pile driving, seals were distribution 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 project area due to disturbances to benthic habitat and associated resource (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.

9.8.9.14 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 whales 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 whales 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 whales 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 whales 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.

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

9.8.9.16 For minke whale, due to their reliance on herring as a primary food source in the Irish Sea, they are deemed to 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

9.8.9.17 Overall, the 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 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

9.8.9.18 Potential impacts on marine mammal prey species during the operations and maintenance phase have been assessed in volume 2, chapter 8 using the appropriate MDS for these receptors. These include temporary and long-term habitat loss/disturbance, increased SSC and associated sediment deposition, EMF, as well as colonisation of foundations, scour protection and cable protection.

9.8.9.19 Impacts, with the exception of EMF from subsea electrical cabling, are the same or less than those described for the construction phase in paragraph 9.8.3.19. Operational sound was not assessed in volume 2, chapter 8: Fish and shellfish ecology of the PEIR but impacts on marine mammal prey availability will be less than those in construction phase due to lower underwater sound levels.

9.8.9.20 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.

9.8.9.21 Volume 2, chapter 8: Fish and shellfish ecology of the PEIR 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 (Andersson, 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**

9.8.9.22 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**

9.8.9.23 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.

9.8.9.24 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.

9.8.9.25 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.

9.8.9.26 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, 2007; 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 9.11.

9.8.9.27 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 9.8.9.11. The sensitivity of the receptor is therefore, considered to be **low**.

**Significance of effect**

9.8.9.28 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

9.8.9.29 Potential impacts on marine mammal prey species during the deconstruction phase have been assessed in volume 2, chapter 8: Fish and shellfish of the PEIR using the appropriate MDS for these receptors. Magnitude of impacts are as described for the construction phase in paragraph 9.8.3.19 *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**

9.8.9.30 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 9.8.9.11 *et seq.* The sensitivity of the receptor is therefore, considered to be **low**.

**Significance of effect**

9.8.9.31 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.

### 9.8.10 Future monitoring

9.8.10.1 No marine mammal monitoring to test the predictions made within the impact assessment is considered necessary.

## 9.9 Cumulative effect assessment methodology

### 9.9.1 Methodology

9.9.1.1 The CEA takes into account the impacts associated with the Morgan Generation Assets together with 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 3, annex 5.1: CEA screening matrix of the PEIR). 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.

9.9.1.2 The marine mammals CEA methodology has followed the methodology set out in volume 1, chapter 5: EIA methodology of the PEIR. As part of the assessment, all projects and plans considered alongside the Morgan Generation Assets have been allocated into 'tiers' reflecting their current stage within the planning and development process. These are listed below.

9.9.1.3 A tiered approach to the assessment has been adopted, as follows:

- Tier 1
  - 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
- Tier 2
  - Scoping report has been submitted and is in the public domain
- Tier 3
  - 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.

9.9.1.4 This tiered approach is adopted to provide a clear assessment of the Morgan Generation Assets alongside other projects, plans and activities.

9.9.1.5 The specific projects, plans and activities scoped into the CEA, are outlined in Table 9.41 and shown in Figure 9.13.

**Table 9.41: List of other projects, plans and activities considered within the CEA.**

| Project/Plan | 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** | | | | | | |
| Awel y Môr Offshore Wind Farm | Submitted but not yet determined | 47.24 | Offshore Wind Farm (500MW 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 (Morlais) | Permitted but not yet implemented | 79.25 | 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. |
| Project Erebus | Submitted but not yet determined | 289.85 | Floating Demonstration Projects | 2025 | 2026 to 2051 | Operational activities for the Morgan Generation Assets may overlap with operational activities of Project Erebus. |
| **Tier 2** | | | | | | |
| Mona Offshore Wind Project | Pre-application | 5.52 | 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 |
| Morgan and Morecambe Offshore Wind Farms: Transmission Assets | Pre-application | 11.24 | Transmission Assets for the Morgan Generation Assets and Morecambe Offshore Windfarm | 2026 to 2029 | 2029 to 2065 | Construction and operational activities for the Morgan Generation Assets may overlap with construction and operational activities of Transmission Assets. |
| Morecambe Offshore Wind Farm Generation Assets | Pre-application | 11.24 | Offshore Wind Farm | 2026 to 2028 | 2029 to 2089 | Construction and operational activities for the Morgan Generation Assets may overlap with construction and operational activities of Morecambe Generation Assets |
| North Irish Sea Array | Pre-application | 107.64 | Offshore Wind Farm | 2024 to 2026 | 2027 to 2059 | Construction and operational activities for the Morgan Generation Assets may overlap with construction and operational activities of North Irish Sea Array. |
| Oriel Offshore Wind Farm | Pre-application | 119.43 | Offshore Wind Farm | Unknown | Unknown | Unknown |
| Dublin Array | Pre-application | 134.44 | Offshore Wind Farm | 2025 to 2026 | 2027 to 2062 | Construction and operational activities for the Morgan Generation Assets may overlap with construction and operational activities of Dublin Array. |

| Project/Plan | 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 |
|---|---|---|---|---|---|---|
| Codling Wind Park | Pre-application | 141.17 | Offshore Wind Farm | 2025 to 2027 | 2028 to 2063 | Construction and operational activities for the Morgan Generation Assets may overlap with construction and operational activities of Codling Wind Park. |
| Arklow Bank Wind Park Phase 2 | Pre-application | 165.3 | Offshore Wind Farm | Unknown | Unknown | Unknown |
| Shelmalere Offshore Wind Farm | Pre-application | 201.37 | 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. |
| Llŷr 2 | Pre-application | 295.04 | Floating Demonstration Project | 2024 to 2025 | 2026 to 2051 | Operational activities for the Morgan Generation Assets may overlap with operational activities of Llŷr 2. |
| Llŷr 1 | Pre-application | 298.51 | Floating Demonstration Project | 2024 to 2025 | 2026 to 2051 | Operational activities for the Morgan Generation Assets may overlap with operational activities of Llŷr 1. |
| White Cross | Pre-application | 319.57 | Test and Demonstration Floating Wind Farm | 2025 to 2026 | 2026 to Unknown | Construction and operational activities for the Morgan Generation Assets may overlap with construction and operational activities of White Cross. |
| Inis Ealga Marine Energy Park | Pre-application | 327.03 | Offshore Wind Farm | 2028 to 2029 | 2030 to Unknown | Operational activities for the Morgan Generation Assets may overlap with operational activities of Inis Ealga Marine Energy Park. |
| **Tier 3** | | | | | | |
| MaresConnect Wales-Ireland Interconnector Cable ('MaresConnect') | Pre-application | 48.2 | A subsea and underground electricity interconnector system between Ireland and Great Britain | 2025 | 2027 to 2037 | Construction and operational activities for the Morgan Generation Assets may overlap with construction and operational activities of MaresConnect. |

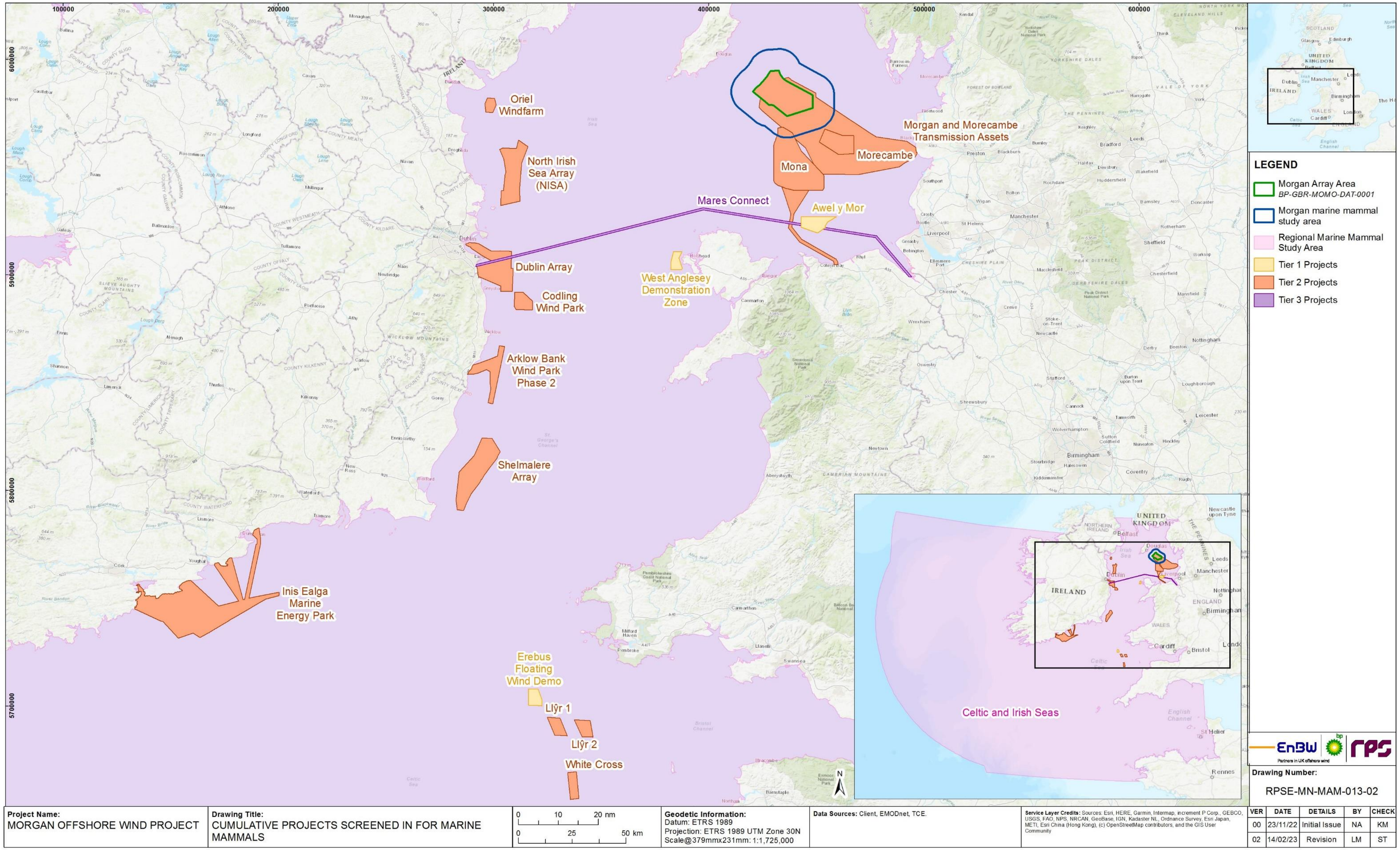


**Figure 9.13: Other projects, plans and activities screened into the CEA with direct impacts on marine mammals.[2]**

[2] The Awel y Môr agreement for lease area extends further to the west than the application boundary presented, however Awel y Môr Offshore Wind Farm Ltd. have decided to develop in the area presented.

## Table 9.42: 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, grey to operations and maintenance phase.

| Tier | 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 |
| | Awel y Mor Offshore Wind Farm | 46.83 | | | | | Piling | | | 2055 |
| | West Anglesey Demonstration Zone | 79.25 | | | | | | | | 2061 |
| | Project Erebus | 289.85 | | | | | | | | 2051 |
| Tier 2 | Mona Offshore Wind Project | 5.52 | | | | Piling | Piling | | | 2065 |
| | Morecambe Offshore Wind Farm Generation Assets | 11.24 | | | | | | | | 2089 |
| | Morecambe/Morgan Transmission Assets | 11.24 | Unknown | | | | | | | |
| | North Irish Sea Array | 107.64 | | | | | | | | 2059 |
| | Oriel Offshore Wind Farm | 119.43 | Unknown | | | | | | | |
| | Dublin Array | 134.44 | | | | | | | | 2062 |
| | Codling Wind Park | 141.17 | | | | | | | | 2063 |
| | Arklow Bank Wind Park Phase 2 | 165.3 | Unknown | | | | | | | |
| | Shelmalere Offshore Wind Farm | 201.37 | | | | | | | | 2055 |
| | Llŷr 2 Project | 295.04 | | | | | | | | 2051 |
| | Llŷr 1 Project | 298.51 | | | | | | | | 2051 |
| | Inis Ealga Marine Energy Park | 306.15 | | | | | | | | Unknown |
| | White Cross | 319.57 | | | | | | | | Unknown |
| Tier 3 | MaresConnect | 48.2 | | | | | | | | 2037 |

### 9.9.2 Maximum design scenario

9.9.2.1 The MDS identified in section 9.6.1 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 PEIR as well as the information available on other projects and plans, in order to inform a 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.

9.9.2.2 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, impacts associated with other projects listed in Table 9.41, may be excluded from further consideration.

9.9.2.3 The assessment of cumulative effects with relevant projects is based on information available in the public domain. Only impacts screened in for the assessment for Morgan Generation Assets alone are considered (Table 9.15). 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 9.10. 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 9.41 for which their operations and maintenance phase overlaps with the operations and maintenance phase of the Morgan Generation Assets. Given the limited data about Tier 3 projects available at the time of writing, projects were screened in precautionarily based on temporal and/or spatial overlap. Isle of Man Wind Farm lease area, also a Tier 3 project, was screened out of the assessment on the basis of low data confidence as there was no information on the construction/operation dates, nor foundation types proposed, with which to undertake any kind of meaningful assessment.

**Table 9.43: Maximum design scenario considered for the assessment of potential cumulative effects on marine mammals.**

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

| Potential cumulative effect | Phase[a] C | O | D | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| Injury and disturbance from elevated underwater sound during piling | ✓ | × | × | MDS as described for the Morgan Generation Assets (Table 9.15) assessed cumulatively with the following other projects/plans:<br>**Tier 1**<br>• Awel y Môr Offshore Wind Farm<br>• Project Erebus.<br>**Tier 2**<br>• Shelmalere Offshore Wind Farm<br>• Mona Offshore Wind Project<br>• Oriel Offshore Wind Farm<br>• North Irish Sea Array<br>• Codling Wind Park<br>• Dublin Array<br>• Inis Ealga Marine Energy Park<br>• Llŷr Projects (Llŷr 1/Llŷr 2)<br>• White Cross<br>• Arklow Bank Wind Park Phase 2<br>• Morecombe Offshore Wind Farm Generation Assets<br>• Morgan and Morecambe Transmission Assets. | The ZOI for pile driving can extend beyond the boundaries of proposed projects listed in Table 9.41 and therefore, adopting a precautionary approach, the assessment has screened in projects within the regional marine mammal study area (the Irish Sea and wider Celtic Sea) 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 impacts.<br>MDS for each project is presented in section 9.10.1. |
| Injury and disturbance from elevated underwater sound during site investigation surveys | ✓ | × | × | MDS as described for the Morgan Generation Assets (Table 9.15) assessed cumulatively with the following other projects/plans:<br>**Tier 1**<br>None of the Tier 1 projects in Table 9.41 have assessed pre-construction site investigation surveys as an effect pathway.<br>**Tier 2**<br>• Mona Offshore Wind Project<br>• Morecambe Offshore Windfarm Generation Assets. | It is anticipated that the magnitude of the impacts will be of a similar scale to that described for the Morgan Generation Assets with the potential to experience disturbance over a range of up to 55km. Therefore, the screening exercise has screened in projects within the 55km buffer from Morgan Generation Assets whose construction phases (which would include pre-construction site investigation surveys) overlap temporally with the construction phase for the Morgan Generation Assets.<br>MDS for each project is presented in section 9.10.1. |

| Potential cumulative effect | Phase[a] C | O | D | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| Injury and disturbance from elevated underwater sound during unexploded ordnance (UXO) clearance | ✓ | × | × | MDS as described for the Morgan Generation Assets (Table 9.15) assessed cumulatively with the following other projects/plans:<br>**Tier 1**<br>• Awel y Môr Offshore Wind Farm<br>• Project Erebus.<br>**Tier 2**<br>• Shelmalere Offshore Wind Farm<br>• Mona Offshore Wind Project<br>• Inis Ealga Marine Energy Park<br>• Llŷr Projects (Llŷr 1/Llŷr 2)<br>• White Cross<br>• Morecambe Offshore Windfarm Generation Assets<br>• Morgan and Morecambe Transmission Assets. | The ZOI for UXO clearance can extend beyond the boundaries of other proposed offshore wind farms. Therefore, of proposed projects listed in Table 9.41, the cumulative assessment has screened in projects within the regional marine mammal study area (the Irish Sea and wider Celtic Sea) 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.<br>MDS for each project is presented in section 9.10.3. |
| Injury and disturbance from elevated underwater sound due to vessel use and other (non-piling) activities | ✓ | ✓ | ✓ | **Construction:**<br>MDS as described for the Morgan Generation Assets (Table 9.15) assessed cumulatively with the following other projects/plans:<br>**Tier 1**<br>• Awel y Môr Offshore Wind Farm<br>• Project Erebus<br>• West Anglesey Demonstration Zone tidal site (Morlais).<br>**Tier 2**<br>• Shelmalere Offshore Wind Farm<br>• Mona Offshore Wind Project<br>• Oriel Offshore Wind Farm<br>• North Irish Sea Array<br>• Codling Wind Park<br>• Dublin Array<br>• Inis Ealga Marine Energy Park<br>• Llŷr Projects (Llŷr 1 and Llŷr 2)<br>• White Cross<br>• Arklow Bank Wind Park Phase 2<br>• Morecambe Offshore Wind Farm Generation Asset<br>• Morgan and Morecambe Offshore Wind Farms: Transmission Assets.<br>**Tier 3**<br>• MaresConnect – Wales-Ireland Interconnector Cable.<br>**Operation:**<br>MDS as described for the Morgan Generation Assets (Table 9.15) assessed cumulatively with the following other projects/plans: | It is expected that each project will contribute to the increase of vessel traffic and hence to the amount of vessel noise in the environment during the construction, operations and maintenance and decommissioning phases. Therefore, of proposed projects listed in Table 9.41, the cumulative assessment has screened in projects within the regional marine mammal study area (the Irish Sea and wider Celtic Sea) whose construction, operations and maintenance and decommissioning phases overlap temporally with the construction, operations and maintenance and decommissioning phases for the Morgan Generation Assets.<br>MDS for each project is presented in section 9.10.4. |

| Potential cumulative effect | Phase[a] C | O | D | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | | | | **Tier 1**<br>• Awel y Môr Offshore Wind Farm<br>• West Anglesey Demonstration Zone tidal site (Morlais)<br>• Project Erebus.<br>**Tier 2**<br>• Shelmalere Offshore Wind Farm<br>• Mona Offshore Wind Project<br>• Oriel Offshore Wind Farm<br>• North Irish Sea Array<br>• Codling Wind Park<br>• Dublin Array<br>• Inis Ealga Marine Energy Park<br>• Llŷr Projects (Llŷr 1 and Llŷr 2)<br>• White Cross<br>• Arklow Bank Wind Park Phase 2<br>• Morecambe Offshore Wind Farm Generation Asset<br>• Morgan and Morecambe Offshore Wind Farms: Transmission Assets.<br>**Tier 3**<br>• MaresConnect – Wales-Ireland Interconnector Cable.<br>**Decommissioning:**<br>*There are currently no known projects which will result in a cumulative effect during this phase of the Morgan Generation Assets.* | |
| Increased risk of injury due to collision with vessels | ✓ | ✓ | ✓ | **Construction:**<br>MDS as described for the Morgan Generation Assets (Table 9.15) assessed cumulatively with the following other projects/plans:<br>**Tier 1**<br>• Awel y Môr Offshore Wind Farm<br>• Project Erebus<br>• West Anglesey Demonstration Zone tidal site (Morlais).<br>**Tier 2**<br>• Shelmalere Offshore Wind Farm<br>• Mona Offshore Wind Project<br>• Oriel Offshore Wind Farm<br>• North Irish Sea Array<br>• Codling Wind Park<br>• Dublin Array<br>• Inis Ealga Marine Energy Park<br>• Llŷr Projects (Llŷr 1 and Llŷr 2) | It is expected that each project will contribute to the increase of vessel traffic and hence to the potential risk 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 9.41, the cumulative assessment has screened in projects within the regional marine mammal study area (the Irish Sea and wider Celtic Sea) whose construction, operations and decommissioning phases overlap temporally with the construction, operations and maintenance and decommissioning phases for the Morgan Generation Assets.<br>MDS for each project is presented in section 9.10.5. |

| Potential cumulative effect | Phase[a] C | O | D | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | | | | • White Cross<br>• Arklow Bank Wind Park Phase 2<br>• Morecambe Offshore Wind Farm Generation Asset<br>• Morgan and Morecambe Offshore Wind Farms: Transmission Assets.<br>**Tier 3**<br>MaresConnect – Wales-Ireland Interconnector Cable.<br>**Operation:**<br>MDS as described for the Morgan Generation Assets (Table 9.15) assessed cumulatively with the following other projects/plans:<br>**Tier 1**<br>• Awel y Môr Offshore Wind Farm<br>• Project Erebus<br>• West Anglesey Demonstration Zone tidal site (Morlais).<br>**Tier 2**<br>• Shelmalere Offshore Wind Farm<br>• Mona Offshore Wind Project<br>• Oriel Offshore Wind Farm<br>• North Irish Sea Array<br>• Dublin Array<br>• Codling Wind Park<br>• Inis Ealga Marine Energy Park<br>• Llŷr Projects (Llŷr 1 and Llŷr 2)<br>• White Cross<br>• Arklow Bank Wind Park Phase 2<br>• Morecambe Offshore Wind Farm Generation Asset<br>• Morgan and Morecambe Offshore Wind Farms: Transmission Assets.<br>**Tier 3**<br>• MaresConnect – Wales-Ireland Interconnector Cable.<br>**Decommissioning:**<br>*There are currently no known projects which will result in a cumulative effect during this phase of the Morgan Generation Assets.* | |
| Effects on marine mammals due to changes in prey availability | ✓ | ✓ | ✓ | **Construction:**<br>MDS as described for the Morgan Generation Assets (Table 9.15) assessed cumulatively with projects list in volume 2, chapter 8: Fish and shellfish ecology.<br>**Operation:** | It is expected that potential cumulative effects on fish and shellfish communities, as identified in volume 2, chapter 8: Fish and shellfish ecology, may have indirect effects on marine mammals. For the purposes of the fish and shellfish ecology assessment of effects, cumulative effects have been assessed within a representative 50km buffer from the Morgan Generation Assets. This 50km buffer applies to all impacts considered in the assessment, except underwater sound, where a larger buffer of 100km has been used to account for the greater zone of influence associated with construction phase.<br>MDS for each project is presented in section 9.10.6. |

| Potential cumulative effect | Phase[a] C | O | D | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | | | | MDS as described for the Morgan Generation Assets (Table 9.15) assessed cumulatively with projects list in volume 2, chapter 8: Fish and shellfish ecology.<br>**Decommissioning:**<br>MDS as described for the Morgan Generation Assets (Table 9.15) assessed cumulatively with projects list in volume 2, chapter 8: Fish and shellfish ecology. | |

## 9.10 Cumulative effects assessment

9.10.1.1 A description of the significance of cumulative effects upon marine mammal receptors arising from each identified impact is given below.

### 9.10.1 Injury and disturbance from elevated underwater sound during piling

9.10.1.1 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 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 from elevated underwater sound during pilling and the cumulative assessment focuses on disturbance only.

**Tier 1**

#### Construction phase

9.10.1.2 The construction of the Morgan Generation Assets, together with construction of Tier 1 projects identified in Table 9.43 may lead to disturbance to marine mammals during piling. Tier 1 projects screened into the assessment within the regional marine mammal study area includes Awel y Môr Offshore Wind Farm and Project Erebus.

9.10.1.3 Each of the projects screened into the cumulative assessment have different construction timelines (Table 9.42). The construction phase of the Morgan Generation Assets will temporally overlap with the construction phase of Awel y Môr Offshore Wind Farm (4 years). Construction of Project Erebus is likely to be completed a year before the commencement of construction activities at the 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.

9.10.1.4 The assessments provided in the Environmental Statements for Awel y Môr Offshore Wind Farm and Project Erebus did not consider effects on harbour seal, as this species was scoped out. Given, that the cumulative assessment for piling is provided on a species-by-species basis, harbour seal will not be considered further for Tier 1 projects.

9.10.1.5 Where cumulative numbers of animals potentially disturbed are presented (e.g. paragraph 9.10.1.9 for harbour porpoise), the calculations take into account the timelines of respective projects (Table 9.42). Given that Project Erebus completes the construction prior to the commencement of construction activities at the 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 the Morgan Generation Assets with the construction phase at Awel y Môr, animals could be disturbed during piling at 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 disturbed by all projects throughout construction phases (see paragraph 9.8.3.12 for more details about iPCoD modelling).

**Magnitude of impact**

**Harbour porpoise**

9.10.1.6 There is potential for a cumulative effect of piling at Awel y Môr Offshore Wind Farm with piling at the Morgan Generation Assets. The maximum duration of piling at the Morgan Generation Assets for monopiles is 70 days over the piling phase between 2027 and 2028. Based on the 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). The maximum number of animals predicted to be disturbed, at Awel y Môr, is up to 2,112 porpoises (Table 9.44). This was the most precautionary estimate based on the Sea Watch Foundation (SWF) density, but an alternative 'realistic' Joint Cetacean Protocol (JCP) density estimate was also provided for context in Table 9.44 (see RWE (2022) for more details about both density estimates and associated caveats). Using JCP densities resulted in an estimate of 275 harbour porpoise experiencing disturbance on each day of pile driving activities (RWE, 2022). The assessment concluded that an absolute maximum of 201 days of piling may temporarily affect fertility rates and probability of calf survival. However, any potential effect was not expected to result in changes in the population trajectory.

9.10.1.7 The potential for temporal overlap of piling activities between the Morgan Generation Assets and Awel y Môr is considered likely. Subsequently, simultaneous piling may take place, 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 the Irish Sea between the Solway Firth and Caernarfon Bay, albeit only mild (<150dB) where the disturbance contours extend towards the coastal area (section 9.8.2). Cumulatively, up to 3,482 harbour porpoise (5.6% of the Celtic and Irish Seas MU) could be disturbed at any one time during piling at the Morgan Generation Assets and Awel y Môr. This is likely to be an overestimate given highly precautionary SWF densities (1.0 porpoise/km$^2$) used for the assessment at Awel y Môr. If more realistic densities (0.13 porpoise/km$^2$, based on JCP Phase III Tool estimate) are taken into account, the cumulative number of porpoises potentially disturbed would be up to 1,645 individuals (2.6% of the Celtic and Irish Seas MU, Table 9.44). 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.

9.10.1.8 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. The construction is planned to take place in 2025 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 9.44). Since the construction phase at Morgan Generation Assets and Awel y Môr commences in 2026 (Table 9.2), there is no potential for piling activity at Project Erebus to coincide with piling at the Morgan Generation Assets and therefore, spatially, there would be no larger cumulative area of disturbance. 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 protection of harbour porpoise. Temporally, Project Erebus would contribute to a slightly longer duration of piling within the cumulative marine mammal study area.

9.10.1.9 Cumulatively (see paragraph 9.10.1.5 for more details), there would be piling at Project Erebus in 2025 affecting 1,967 harbour porpoise, followed by piling at the Morgan Generation Assets in 2027 affecting 1,370 harbour porpoise, and subsequently piling at Awel y Môr and the Morgan Generation Assets in 2028 which may coincide and affect up to 3,482 (if using maximum SWF density for Awel y Môr) harbour porpoise.

**Table 9.44: Harbour porpoise cumulative assessment – numbers predicted to be disturbed as a result of underwater sound during piling for Tier 1 Projects.**

a Based on realistic density of 0.13 animals/km$^2$ (JCP Phase III Tool estimate)

| Project | Reference | Max number of piles | Scenario | Piling Duration | Construction period | Density (animals per km$^2$) | Max No Animals Disturbed | % Reference Population |
|---|---|---|---|---|---|---|---|---|
| Morgan Generation Assets | Section 9.8.2 | 70 | Monopile 5,500kJ<br>Concurrent | 35 days | 24 months | 0.247 | 1,370 | 2.19 (Celtic and Irish Seas MU) |
| Awel y Môr Offshore Wind Farm | RWE (2022) | 50 | Monopile, 5,000kJ | 201 days | 12 months | 1.0<br>(0.13 animals per km$^2$)[a] | 2,112<br>(275)[a] | 3.38 (Celtic and Irish Seas MU) |
| Project Erebus | Blue Gem Wind (2020) | 35 | Pile, 800kJ | 18 days | 8 months | 0.04 | 1,967 | 3.15 (Celtic and Irish Seas MU) |

9.10.1.10 Results of the cumulative iPCoD modelling for harbour porpoise 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 0.996 (Table A.8). Small changes in the impacted population size over time are similar to those predicted for an un-impacted population, as can be seen in Figure 9.14. Therefore, it was considered that there is low potential for a long-term cumulative effect on this species as a result of cumulative piling at the Morgan Generation Assets and Tier 1 projects.

9.10.1.11 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 9.8.3.46 for more information), the effects on the designated features and conservation objectives of designated sites will be considered in the ISAA.

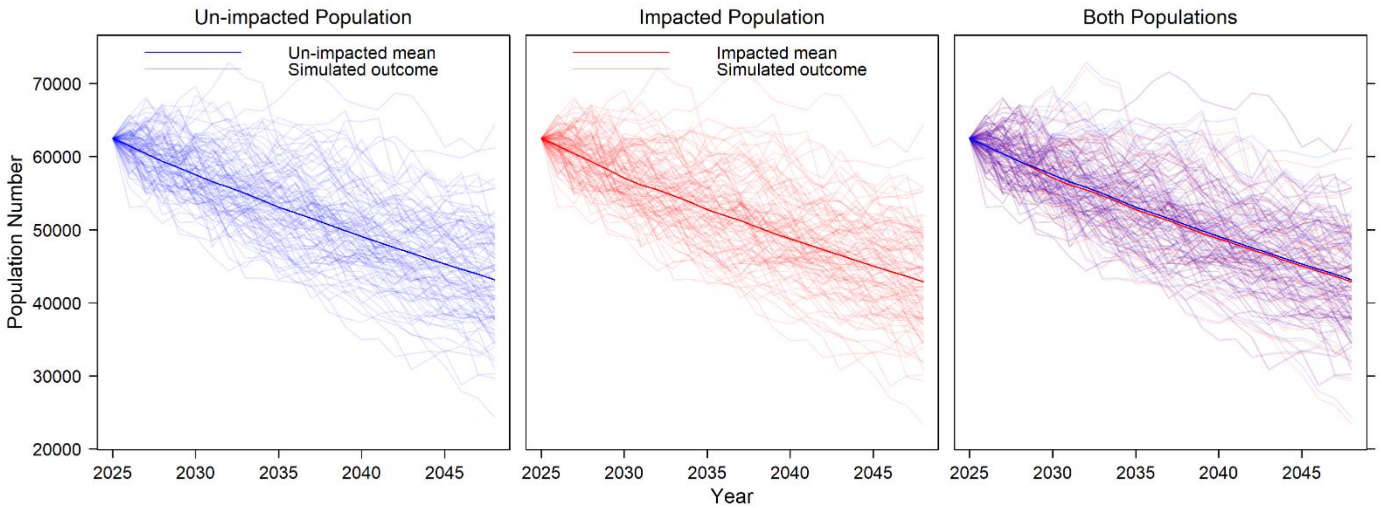


**Figure 9.14: Simulated harbour porpoise population sizes for both the baseline and the impacted populations under the cumulative scenario and no vulnerable subpopulation.**

9.10.1.12 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 25 years after the start of piling there would be no long-term effects on the harbour porpoise population. The magnitude is therefore considered to be **low**.

### Dolphin species

9.10.1.13 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 Awel y Môr Offshore Wind Farm (RWE, 2022) was based on Lohrengel *et al.* (2018) for the coastal 20m depth contour and SCANS III data for the offshore densities (Table 9.45). 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 but iPCoD modelling carried out for Awel y Môr Offshore Wind Farm demonstrated 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 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 lifetime reproductive success to some individuals although not enough to affect the population trajectory over a generational scale. Project Erebus estimated up to 310 bottlenose dolphin (2.8% of the Offshore Channel and Southwest England MU) could be affected by disturbance, also based on data collected as a part of the Lohrengel *et al.* (2018) study (Table 9.45) (Blue Gem Wind, 2020). These short-term and temporary behavioural effects (over 18 days of piling) were considered unlikely to alter the population trajectory of bottlenose dolphin.

9.10.1.14 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 Awel y Môr Offshore Wind Farm was assessed using densities from SCANS III density estimates and the Celtic and Greater North Seas MU as a reference population (RWE, 2022) (Table 9.45). It was assumed that a low proportion 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. 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 (Table 9.45) (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.

9.10.1.15 Awel y Môr assessed the number of Risso's dolphin predicted to be affected by disturbance based on SCANS III densities and the Celtic and Greater North Seas MU as the reference population to inform the assessment (RWE, 2022). The assessment predicted that up to 65 animals 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 were expected to be similar to that of bottlenose dolphin (Blue Gem Wind, 2020).

9.10.1.16 It is anticipated that there will be a temporal overlap with piling at Awel y Môr Offshore Wind Farm and 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 impact) are described in more detail for harbour porpoise in paragraph 9.10.1.7. 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.

9.10.1.17 Therefore, cumulatively (see paragraph 9.10.1.5 for more details), there would be piling at Project Erebus in 2025 affecting 310 bottlenose dolphin, and 2,067 short-beaked common dolphin, followed by piling at Morgan Generation Assets in 2027 affecting 16 bottlenose dolphin, 100 short-beaked common dolphin and 174 Risso's dolphin, and subsequently piling at Awel y Môr and Morgan Generation Assets in 2028 which may coincide and affect up to 39 bottlenose dolphin (13.3% of the Irish Sea MU) and 117 short-beaked dolphin (0.11% of the Celtic and Greater North Seas MU) and 239 Risso's dolphin (1.9% Celtic and Greater North Seas 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 contours are likely to overlap.

9.10.1.18 As described above for harbour porpoise (see paragraph 9.10.1.8), the construction of Project Erebus is planned to take place in 2025 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 or Awel y Môr. Temporally, Project Erebus would contribute to a slightly longer duration of piling within the cumulative study area.

**Table 9.45: Dolphin species cumulative assessment – numbers predicted to be disturbed as a result of underwater sound during piling for Tier 1 Projects.**

| Project | Reference | Max number of piles | Scenario | Piling Duration | Construction period | Density (animals per km$^2$) | Max No Animals Disturbed | % Reference Population |
|---|---|---|---|---|---|---|---|---|
| **Bottlenose dolphin** | | | | | | | | |
| Morgan Generation Assets | Section 9.8.2 | 70 | Monopile 5,500kJ<br>Concurrent | 35 days | 24 months | 0.035 | 16 | 5.28 (Irish Sea MU) |
| Awel y Môr Offshore Wind Farm | RWE (2022) | 50 | Monopile, 5,000kJ | 201 days | 12 months | 0.035 for the 20m depth contour<br>0.008 offshore | 23 | 7.9 (Irish Sea MU) |
| Project Erebus | Blue Gem Wind (2020) | 35 | Pile, 800kJ | 18 days | 8 months | 0.063 (4km buffer + array area)<br>0.3743 (beyond 4km buffer + array area) | 310 | 2.8 (Offshore Channel and Southwest England MU) |
| **Short-beaked common dolphin** | | | | | | | | |
| Morgan Generation Assets | Section 9.8.2 | 70 | Monopile 5,500kJ<br>Concurrent | 35 | 24 months | 0.018 | 100 | 0.10 (Celtic and Greater North Seas MU) |
| Awel y Môr Offshore Wind Farm | RWE (2022) | 50 | Monopile, 5,000kJ | 201 days | 12 months | 0.0081 | 17 | 0.02 (Celtic and Greater North Seas MU) |
| Project Erebus | Blue Gem Wind (2020) | 35 | Pile, 800kJ | 18 days | 8 months | 1.61 site specific<br>0.3743 wider area | 2,067 | 2.01 (Celtic and Greater North Seas MU) |
| **Risso's dolphin** | | | | | | | | |
| Morgan Generation Assets | Section 9.8.2 | 70 | Monopile 5,500kJ<br>Concurrent | 35 | 24 months | 0.0313 | 174 | 1.42 (Celtic and Greater North Seas MU) |

| Project | Reference | Max number of piles | Scenario | Piling Duration | Construction period | Density (animals per km$^2$) | Max No Animals Disturbed | % Reference Population |
|---|---|---|---|---|---|---|---|---|
| Awel y Môr Offshore Wind Farm | RWE (2022) | 50 | Monopile, 5,000kJ | 201 days | 12 months | 0.031 | 65 | 0.53 (Celtic and Greater North Seas MU) |

9.10.1.19 Cardigan Bay, and the Cardigan 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 9.1: Marine mammal technical report of the PEIR, 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 may be used for calving. Although there has been no significant trend for Cardigan Bay 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 (2007-2016). In addition, there is potential for overlap of the disturbance contours during piling at Morgan Generation Assets and Awel y Môr with a number of MNRs around the Isle of Man designated for bottlenose dolphin including Douglas Bay, Laxey Bay and Baie Ny Carrickey MNRs. 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 are investigated using iPCoD modelling as described paragraph 9.10.1.20.

9.10.1.20 Since iPCoD does not facilitate modelling for short-beaked common dolphin and Risso's dolphin, no population modelling was carried out for these species. Two scenarios were explored for the cumulative assessment with respect to understanding bottlenose dolphin population level effects. First, population modelling – using iPCoD (described in paragraph 9.8.3.12), was carried out for projects within the Irish Sea MU only; namely the Morgan Generation Assets and Awel y Môr. Second, projects screened into the wider cumulative assessment region (Celtic and Irish Seas) were added in; this included Project Erebus alongside the Morgan Generation Assets and Awel y Môr. For the second scenario the projects in the cumulative assessment fall within two bottlenose dolphin MUs – Irish Sea MU and Offshore Channel and Southwest England MU (Table 9.45) - and therefore when quantifying the potential consequences for bottlenose dolphin populations of as a result of cumulative disturbance, the combined population of both MUs was considered.

9.10.1.21 The iPCoD model was run for these two scenarios to explore the potential of disturbance during piling to affect the bottlenose dolphin population trajectory over time and provide additional certainty in the predictions of the assessment of effects. Results of the cumulative iPCoD modelling for bottlenose dolphin and cumulative piling at Awel y Môr and the Morgan Generation Assets against the Irish Sea MU population showed that the median ratio of the impacted population to the unimpacted population was 1 at 25 years (Table A.9). There was a small difference between the impacted and unimpacted population size over time, with 5 fewer animals at time point 25, although the model suggests that this falls within the natural variation of the population (Figure 9.15). It should, however, be highlighted that these small differences are predicted against a background of a declining population (based on the conservative demographic parameters provided by NRW). The model is very susceptible to the parameters inputted (detailed further in Appendix A), and for example, increasing the fertility rate to the highest provided value of 0.3 (Sinclair *et al*., 2020) from 0.22 (Arso Civil et al, 2017) changes the trajectory of the population from a declining population to an increasing population, as shown in Figure A.11 .This highlights that the model is sensitive to the demographics chosen, and therefore results should be interpreted with caution.

9.10.1.22 Additionally, cumulative piling at respective projects could displace animals from important summer (piling at Project Erebus) and winter (piling at Awel y Môr and the Morgan Generation Assets) habitats intermittently over 5 years. Considering the result of the iPCoD modelling for cumulative piling at the Morgan Generation Assets, Awel y Môr and Project Erebus against the Offshore Channel and Southwest England MU plus the Irish Sea MU combined population it was notable that in this broader perspective there would be no cumulative effects to bottlenose dolphin. For this scenario the median ratio of the impacted population to the unimpacted population was 1 at 25 years (Table A.9Table A.9: Population trajectory of bottlenose dolphin in monopile scenarios (single, concurrent, cumulative piling) showing the mean and upper and lower confidence limits at different time points (years after start of offshore construction phase) and median ratio of population size.) and there was no discernible difference in the population over time (Figure 9.16). As mentioned in paragraph 9.10.1.21, increasing the fertility rate to 0.3 changes the population trajectory of the model (Figure A.11).

9.10.1.23 Given that bottlenose dolphin can travel over large distances, there is a possibility that a small number of individuals from SAC populations (see paragraph 9.8.3.51 for more information) may be occasionally present within the disturbance contours. The effects on the designated features and conservation objectives of designated sites will be considered in the ISAA. 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.

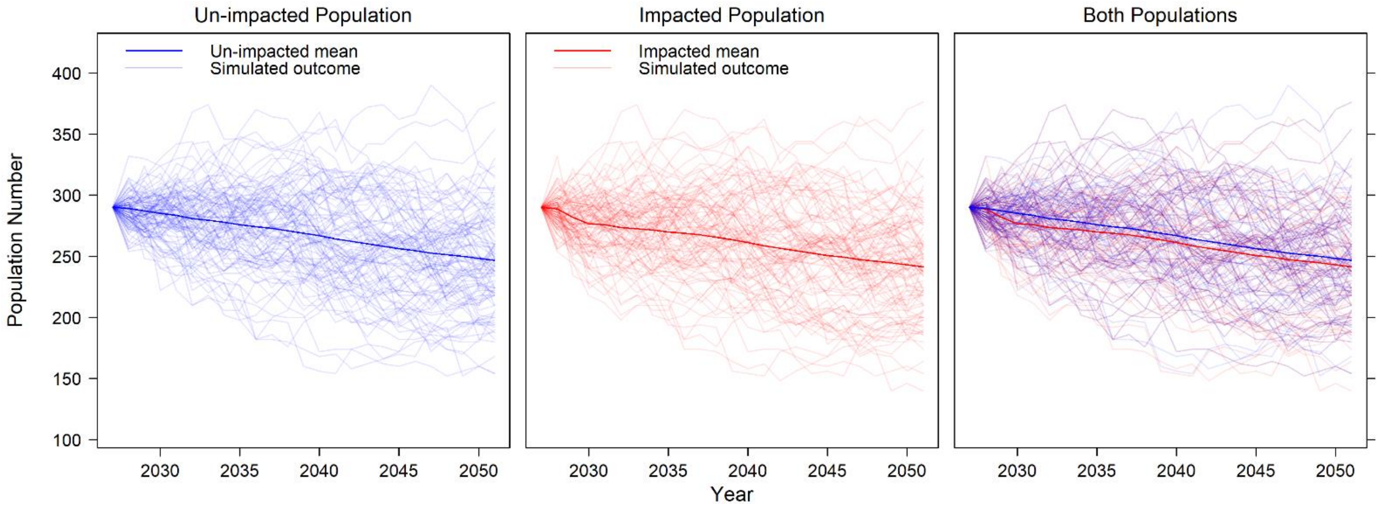

**Figure 9.15: Simulated bottlenose dolphin population sizes (Irish Sea MU) for both the baseline and the impacted populations under the cumulative scenario and no vulnerable subpopulation.**

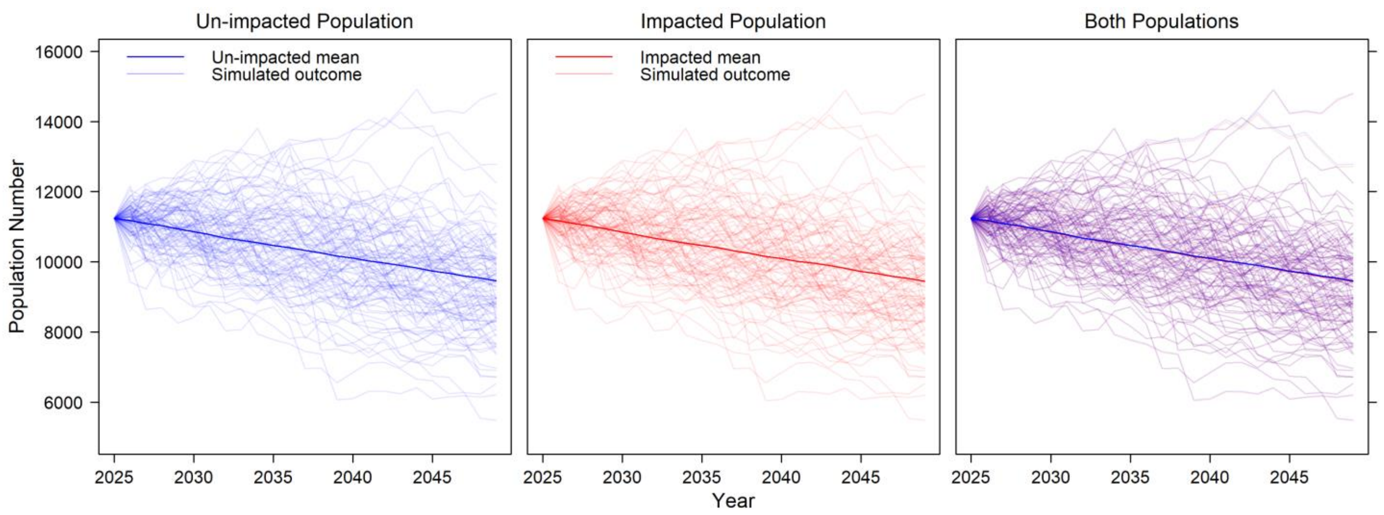


**Figure 9.16: Simulated bottlenose dolphin population sizes (Irish Sea plus Offshore Channel and Southwest England MU) for both the baseline and the impacted populations under the cumulative scenario and no vulnerable subpopulation.**

9.10.1.24 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 Liverpool Bay area (Morgan Generation Assets and Awel y Mor) could result in potential reductions to lifetime reproductive success 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 areas (in offshore areas between the mainland coast and the Isle of Man, including MNRs). 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 possible declining bottlenose dolphin Irish Sea MU population, the magnitude is conservatively, considered to be **medium**. For Project Erebus, which falls outside the Irish Sea MU, the magnitude of cumulative piling is predicted to be **low** as there would be no measurable change in the context of the wider combined population of the Offshore Channel and Southwest England MU plus the Irish Sea MU.

#### Minke whale

9.10.1.25 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 Awel y Môr Offshore Wind Farm (Table 9.46) was based on SCANS III density estimates, and the Celtic and Greater North Seas MU was taken forward as the reference population to inform the assessment (RWE, 2022). With a maximum of 36 animals 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.

9.10.1.26 It is anticipated that there will be a temporal overlap in piling at Awel y Môr Offshore Wind Farm and 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 impact) are described in more detail for harbour porpoise in paragraph 9.10.1.7. Given that minke whale show high seasonality to the area, with detections mostly over summer months (May to December, see volume 4, annex 9.1: Marine mammal technical report of the PEIR 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 the Morgan Generation Assets coincide with piling at Awel y Môr, is up to 132 minke whale (0.66% of the Celtic and Greater North Seas MU). However, this is likely to be an overestimate given highly precautionary densities were used for the respective assessments and overlap of the sound contours.

9.10.1.27 Project Erebus assessed the number of minke whale predicted to be affected by disturbance during piling based on densities from SCANS III block D (Hammond *et al.,* 2021) (Table 9.46). The Celtic and Greater North Seas England MU population taken forward as the reference population to inform the assessment (Blue Gem Wind, 2020). As described above for harbour porpoise (see paragraph 9.10.1.8), the construction of Project Erebus is planned to take place in 2025 with only 18 days over which piling may occur and therefore there is no potential for spatial overlap of piling activity with Morgan Generation Assets. Temporally, Project Erebus would contribute to a slightly longer duration of piling within the cumulative study area.

9.10.1.28 Cumulatively, there would be piling at Project Erebus in 2025 affecting 55 minke whale, followed by piling at the Morgan Generation Assets in 2027 affecting 96 minke whale, and subsequently piling at Awel y Môr and the Morgan Generation Assets in 2028 which may coincide and affect up to 132 (96 + 36) minke whale.

**Table 9.46: Minke whale cumulative assessment – numbers predicted to be disturbed as a result of underwater sound during piling for Tier 1 Projects.**

| Project | Reference | Max number of piles | Scenario | Piling Duration | Construction period | Density (animals per km$^2$) | Max No Animals Disturbed | % Reference Population |
|---|---|---|---|---|---|---|---|---|
| Morgan Generation Assets | Section 9.8.2 | 70 | Monopile 5,500kJ<br>Concurrent | 35 days | 24 months | 0.0173 | 96 | 0.48 (Celtic and Greater North Seas MU) |
| Awel y Môr Offshore Wind Farm | RWE (2022) | 50 | Monopile, 5,000kJ | 201 days | 12 months | 0.017 | 36 | 0.18 (Celtic and Greater North Seas MU) |
| Project Erebus | Blue Gem Wind (2020) | 35 | Pile, 800kJ | 18 days | 8 months | 0.0112 | 55 | 0.3 (Celtic and Greater North Seas MU) |

9.10.1.29 Population modelling was carried out to explore the potential of cumulative disturbance during piling to affect the population trajectory over time and provide additional certainty in the predictions of the assessment of effects. Results of the cumulative iPCoD modelling for minke whale against the MU population showed that the median of the ratio of the impacted population to the unimpacted population was 0.99 at 25 years (Table A.10). Small differences in the population size over time between the impacted and unimpacted population fall within the natural variance of the population as can be seen in Figure 9.17.

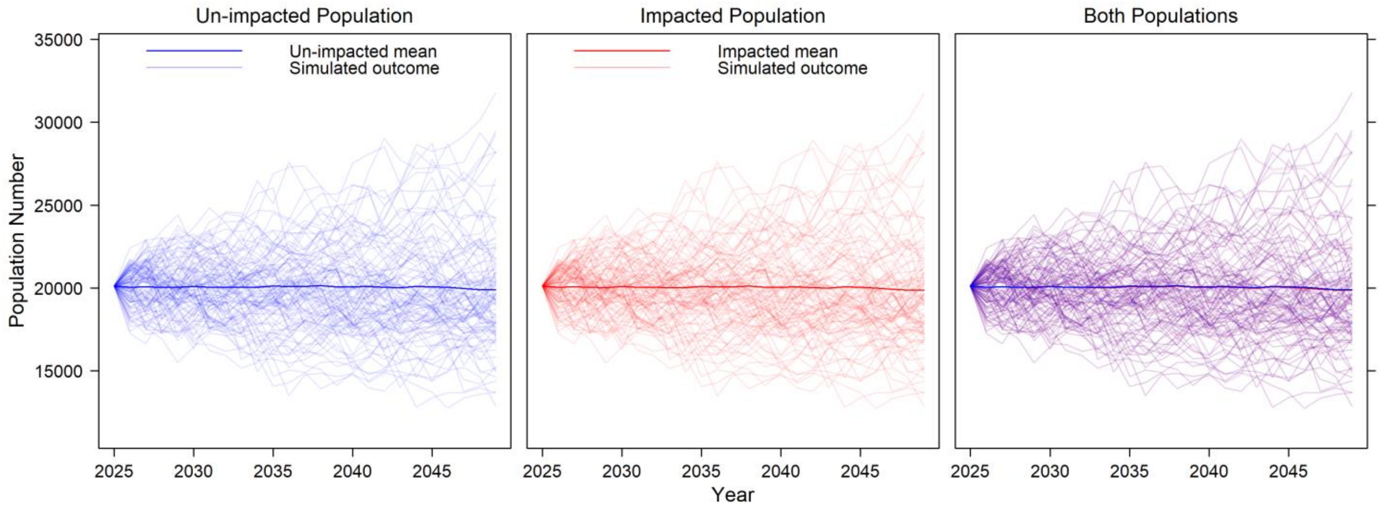


**Figure 9.17: Simulated minke whale population sizes for both the baseline and the impacted populations under the cumulative scenario and no vulnerable subpopulation.**

9.10.1.30 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 and up to 25 years 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

9.10.1.31 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 9.47) 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 (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.

9.10.1.32 It is anticipated that there will be a temporal overlap in piling at Awel y Môr and 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 impact) are described in more detail for harbour porpoise in paragraph 9.10.1.7. The maximum number of animals predicted to be disturbed, if piling activities at the Morgan Generation Assets coincide with piling at Awel y Môr, is up to 129 grey seal. This number represents 0.95% of the GSRP and 0.21% of the OSPAR Region III population. Although grey seal 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. 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 the Morgan Generation Assets and Awel y Môr.

9.10.1.33 Project Erebus assessed the number of grey seal predicted to be affected by disturbance, based on grid specific density estimates from Carter *et al.* (2020) (Table 9.47). 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 9.10.1.8), the construction of Project Erebus is planned to take place in 2025 with only 18 days over which piling may occur, therefore there is no potential for spatial overlap of piling activity with the Morgan Generation Assets. It is, however, important to note that Project Erebus is located in close proximity to the Pembrokeshire Marine/Sir Benfro Forol SAC and Lundy SAC designated for protection of grey seal. Temporally, Project Erebus would contribute to a slightly longer duration of piling within the cumulative study area.

9.10.1.34 Cumulatively (see paragraph 9.10.1.5 for more details), there would be piling at Project Erebus in 2025 affecting 18 grey seal, followed by piling at the Morgan Generation Assets in 2027 affecting 48 grey seal, and subsequently piling at Awel y Môr and the Morgan Generation Assets in 2028 which may coincide and affect up to 129 (48 + 81) grey seal.

**Table 9.47: Grey seal cumulative assessment – numbers predicted to be disturbed as a result of underwater sound during piling for Tier 1 Projects.**

| Project | Reference | Max number of piles | Scenario | Piling duration | Piling phase | Max number of animals disturbed | Density (animal per km$^2$) | % of reference population |
|---|---|---|---|---|---|---|---|---|
| Morgan Generation Assets | Section 9.8.2 | 70 | Monopile 5,500kJ<br>Concurrent | 35 days | 24 months | 48 | N/A – Grid cell specific | 0.35% of the GSRP<br>0.08% of the OSPAR Region iii |
| Awel y Môr Offshore Wind Farm | RWE (2022) | 50 | Monopile, 5,000kJ | 201 days | 12 months | 81 | 0.43 | 1.6 (Wales and NW England MUs)<br>0.1% of the OSPAR Region iii |

| Project | Reference | Max number of piles | Scenario | Piling duration | Piling phase | Max number of animals disturbed | Density (animal per km²) | % of reference population |
|---|---|---|---|---|---|---|---|---|
| Project Erebus | Blue Gem Wind (2020) | 35 | Pile, 800kJ | 18 days | 8 months | 18 | N/A – Grid cell specific | 0.3 (Wales and SW England MUs)<br>0.0% of the OSPAR Region iii |

9.10.1.35 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 impact assessment. Results of the cumulative iPCoD modelling for grey seal showed that the median of the ratio of the impacted population to the unimpacted population (when using both the grey seal reference population and OSPAR region III) was 1 at 25 years (Table A.11: Population trajectory of grey seal in monopile scenarios (single, concurrent, cumulative piling) showing the mean and upper and lower confidence limits at different time points (years after start of offshore construction phase) and median ratio of population size.), and simulated grey seal population sizes for both baseline and impacted populations showed no difference (Figure 9.18, Figure 9.19). Therefore, it was considered that there is no potential for a long-term effects on this species.

9.10.1.36 Given that grey seal telemetry tracks presented in volume 4, annex 9.1: Marine mammal technical report of the PEIR demonstrated some connectivity between the Morgan Generation Assets and designated sites (see paragraph 9.8.3.73 for more information), the cumulative effects on the designated features and conservation objectives of designated sites will be considered in the ISAA.

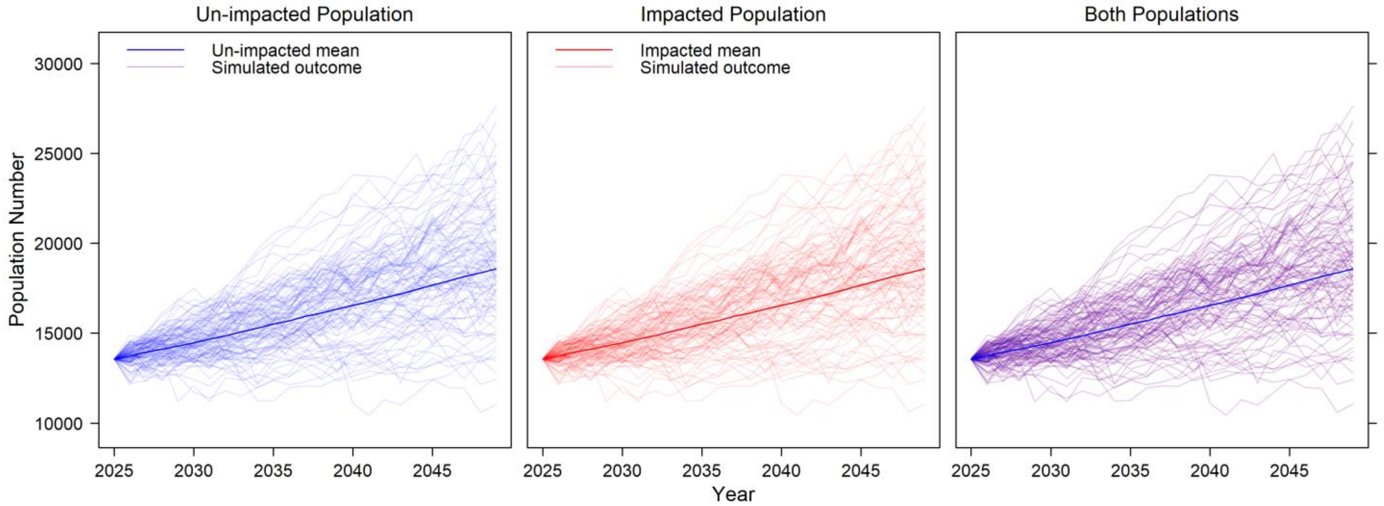


**Figure 9.18: Simulated grey seal population sizes (Grey Seal Reference Population) for both the baseline and the impacted populations under the cumulative scenario and no vulnerable subpopulation.**

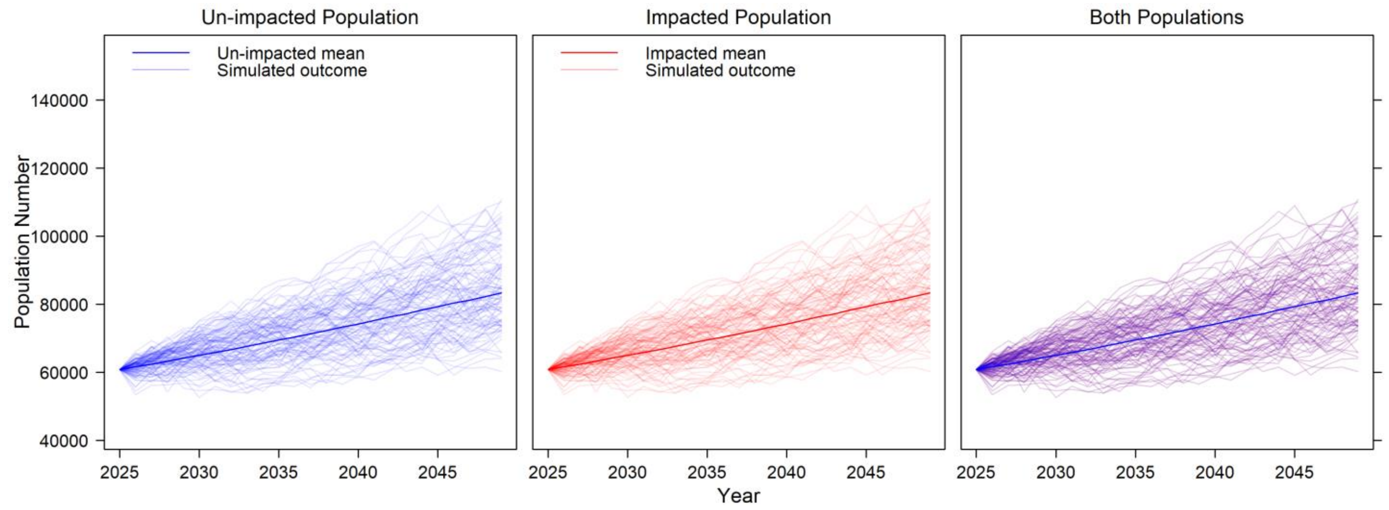


**Figure 9.19: Simulated grey seal population sizes (OSPAR Region III) for both the baseline and the impacted populations under the cumulative scenario and no vulnerable subpopulation.**

9.10.1.37 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 and up to 25 years after the start of piling there would be no long-term effects on the grey seal population in the context of both the OSPAR III and the Grey Seal Reference Population. The magnitude is therefore considered to be **low** in respect of both populations.

**Sensitivity of the receptor**

9.10.1.38 The sensitivity of the different marine mammal IEFs to behavioural disturbance from elevated underwater sound due to piling is as described in section 9.8.3 paragraph 9.8.3.90 for the Morgan Generation Assets alone. Recovery is anticipated to occur between piling events, which will be intermittent for cumulative projects. In particular, baseline levels of activity are anticipated to resume where there are long gaps between piling of respective projects, such as between the end of piling at Project Erebus in 2025 and commencement of piling phase at the Morgan Generation Assets and Awel y Môr.

9.10.1.39 It is important to note, however, that the extent to which an animal will be behaviourally affected is context-dependant 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).

9.10.1.40 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**

9.10.1.41 The significance of effect is presented below and summarised in Table 9.48, with magnitude and sensitivity presented for each species.

**Table 9.48: Summary of disturbance assessment from underwater sound generated during piling at cumulative Tier 1 projects.**

| Species | Magntitude | Sensitivity | Signficance | Justificaion |
|---|---|---|---|---|
| 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 | Low (wider Irish Sea MU plus Offshore Channel and Southwest England MU) | Medium | Minor adverse (wider Irish Sea MU plus Offshore Channel and Southwest England MU) | Cumulative effects could potentially affect the international value of the species in the context of the Irish Sea MU although not in the wider extent for projects in the Offshore Channel and Southwest England MU plus Irish Sea MU. |
| | Medium (Irish Sea MU) | Medium | Moderate adverse (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 the combined grey seal reference population/OSPAR Region III as there is no long-term decline in the regional population predicted as demonstrated with the cumulative iPCoD modelling assessment. |

**Tier 2**

## Construction phase

9.10.1.42 Given the temporal overlap, the construction of the Morgan Generation Assets, together with construction of Tier 1 projects (Awel y Môr and project Erebus) and Shelmalere Offshore Wind Farm, the Mona Offshore Wind Project, Oriel Offshore Wind Farm, North Irish Sea Array, Codling Wind Park, Dublin Array, Inis Ealga Marine Energy Park, Llŷr Projects (Llŷr 1/Llŷr 2), White Cross, Arklow Bank Wind Park Phase 2, the Morecambe Offshore Wind Farm Generation Assets and the Transmission Assets (Table 9.43) may lead to cumulative disturbance to marine mammals from piling.

**Magnitude of impact**

9.10.1.43 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 full, quantitative assessment for this impact. As such, a qualitative assessment is provided below. For Mona Offshore Wind Project, PEIR is available and more detailed information is included.

9.10.1.44 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 (Shelmalere Offshore Wind Farm, 2022; Mona Offshore Wind Ltd, 2022; Oriel Wind Farm Project, 2019; North Irish Sea Array Windfarm Ltd, 2021; Codling Wind Park Limited, 2020; Dublin Array, 2020; Inis Ealga Marine Energy Park Ltd, 2022; Floventis Energy, 2022; White Cross, 2022; Sure Partners Limited, 2020; Morecambe Offshore Wind Ltd, 2022; Morgan Offshore Wind Ltd. and Morecambe Offshore Windfarm Ltd, 2022). The indicative timelines suggest that there will be a temporal overlap of construction phase of the Morgan Generation Assets with the construction phases of all listed projects (Table 9.42), except Llŷr 1/Llŷr 2. The construction phase of Llŷr Projects finishes in 2025 but both projects are screened into cumulative assessment due to the potential for sequential piling. The construction dates are unknown for Arklow Bank Wind park Phase 2 and the Morecambe Offshore Wind Farm Generation Assets, 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.

9.10.1.45 The EIA Scoping Report for the Mona Offshore Wind Project (Mona Offshore Wind Ltd, 2022) identified disturbance of marine mammals resulting from underwater sound during piling as a potential impact during the construction phase of the project. Subsequently, the PEIR predicted that the disturbance during piling will have far-reaching effects across the north part of the Irish Sea (Mona Offshore Wind Ltd, 2023). Number of animals potentially disturbed during piling at the Mona Offshore Wind Project is presented in Table 9.49. Cumulatively, during piling at the Morgan Generation assets and the Mona Offshore Wind Project, up to 1,957 harbour porpoise (3.13% of the MU population), 33 bottlenose dolphin (10.97% of the IS MU population), 209 short-beaked common dolphin (0.21% of the MU population), 364 Risso's dolphin (2.96% of the MU population), 21 minke whale (1.00% of the MU population), 141 grey seal (1.03% of the Grey seal reference population/0.23% of the OSPAR III region) and up to two harbour seal (0.15% of the reference population).

**Table 9.49: The maximum number of animals predicted to be disturbed during concurrent piling of monopiles at the Mona Offshore Wind Project (Mona Offshore Wind Ltd, 2023).**

| Species | Number of Animals | Reference Population and Abundance | % Reference Population (MU)[1] |
|---|---|---|---|
| Harbour porpoise | 587 | Celtic and Irish Seas MU (62,517) | 0.94% |
| Bottlenose dolphin | 17 | Irish Sea MU (293) | 5.69% |
| Short-beaked common dolphin | 109 | Celtic and Greater North Seas MU (102,656) | 0.11% |
| Risso's dolphin | 190 | Celtic and Greater North Seas MU (12,262) | 1.54% |
| Minke whale | 105 | Celtic and Greater North Seas MU (20,118) | 0.52% |
| Harbour seal | <1 | Wales, NW England, N. Ireland SMUs (1,427) | 0.03% |
| Grey seal | 93 | Grey Seal reference population (60,780)<br>OSPAR Region III (13,563) | 0.68% (Grey seal reference population)<br>0.15% (OSPAR Region III) |

9.10.1.46 Most of the projects screened into the cumulative assessment included fixed foundations in their design envelope. Projects such as Shelmalere Offshore Wind Farm, North Irish Sea Array, Codling Wind Park, Dublin Array, Arklow Bank Wind Park Phase 2 and the Morecambe Offshore Wind Farm Generation Assets 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.

9.10.1.47 The EIA Scoping Reports for three of the cumulative projects consists of floating foundation technology for wind turbines: Inis Ealga Energy Park, Llŷr Projects (Llŷr 1/Llŷr 2) and White Cross. However, given that all three projects considered different technologies to ensure that the wind turbines are secured to the seabed, piling is under consideration as a possible anchoring technique. Given wind 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.

9.10.1.48 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 six wind turbines (White Cross) to up to 140 wind turbines (Codling Wind Park) (Table 9.50).

### Table 9.50: Projects screened into the cumulative assessment for underwater sound as a result of piling and number of foundations.

[a] This table includes numbers of foundations for wind turbines for Offshore Wind Farm Projects. for the EIA Scoping Report for the Morgan and Morecambe Offshore Wind Farms: Transmission Assets include the OSPs for the Morgan Offshore Wind Project and the Morecambe Offshore Windfarm. These OSPs are also included in the EIA Scoping Reports for the Morgan Generation Assets and the Morecambe Generation Assets. This assessment therefore double counts the OSP and is precautionary.

| Project Name | Morgan and Morecambe Offshore Wind Farms: Transmission Assets[a] | Mona Offshore Wind Project | Morecambe Offshore Wind Farm Generation Assets | North Irish Sea Array | Oriel Offshore Wind Farm | Dublin Array | Codling Wind Park | Arklow Bank Wind Park Phase 2 | Shelmalere Offshore Wind Farm | Llŷr Projects (Llŷr 1/Llŷr 2) | Inis Ealga Marine Energy Park | White Cross |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of foundations | 7 | 107 | 40 | 36 | 55 | 61 | 140 | 76 | 67 | 61 | 70 | 8 |
| Closest distance to Morgan Generation Assets (km) | 0 | 5.52 | 11.24 | 107.64 | 119.43 | 134.44 | 141.17 | 165.3 | 201.37 | 295.04 | 306.15 | 319.57 |

9.10.1.49 In temporal terms, the first construction phases are anticipated to start in 2024, North Irish Sea Array and Llŷr Projects (Table 9.42). The construction of some of the cumulative projects will last until 2029, including the Mona Offshore Wind Project, Shelmalere Offshore Wind Farm, the Morgan and Morecambe Offshore Wind Farms: Transmission Assets and Inis Ealga Marine Energy Park (Table 9.42). This timescale constitutes a total of six years where construction activities, including piling, will occur across the Irish and Celtic Seas. Piling activities will occur intermittently over 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 9.1: Marine mammal technical report of the PEIR for more details), the duration of impact is classified as medium term, as the exposure to elevated sound levels could occur over a meaningful proportion of their lifespan.

9.10.1.50 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 Mona Offshore Wind Project, Morecambe Offshore Wind Farm Generation Assets, Morgan and Morecambe Offshore Wind Farms: Transmission Assets, North Irish Sea Array and Oriel Wind Farm to the Morgan Generation Assets (Table 9.42), 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 9.8.2). 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 (160dB re 1µPa as discussed in paragraph 9.8.2.6) compared to piling at the Morgan Generation Assets alone.

9.10.1.51 In the context of the wider habitat available within the Celtic and Irish Seas regional study area, it is not anticipated that it will result in a long-term population-level effects on any of the species. The cumulative piling at Mona Offshore Wind Project, Morecambe Offshore Wind Farm Generation Assets, Morgan and Morecambe Offshore Wind Farms: Transmission Assets, North Irish Sea Array and Oriel Wind Farm could, however, further contribute to the impacts on declining population of bottlenose dolphins in the Irish Sea MU (see paragraph 9.10.1.21 for Tier 1 projects). Nevertheless, no measurable change in the context of the wider combined bottlenose dolphin population of the Offshore Channel and Southwest England MU plus the Irish Sea MU is anticipated.

9.10.1.52 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 ISAA.

9.10.1.53 The impact (cumulative elevated underwater sound arising during piling) 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 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. There was also no noticeable difference in the iPCoD model with the addition of the Tier 2 Mona Offshore Wind Project (further described in Appendix A). For these species the magnitude is considered to be **low**.

9.10.1.54 For bottlenose dolphin in the context of the combined Offshore Channel and Southwest England MU plus the Irish Sea MU population, the magnitude is also considered to be low. However, cumulative piling of Tier 1 + Tier 2 projects, could further contribute to the reduction in Irish Sea MU population size for bottlenose dolphin, although it must be noted there was no noticeable difference in the iPCoD model with the addition of the Tier 2 project (Mona Offshore Wind Project) to the Tier 1 cumulative scenario for Morgan Generation Assets (further described in Appendix A). Therefore, in the context of possible declining population, the magnitude is conservatively, considered to be **medium** for bottlenose dolphin within the Irish Sea MU population.

**Sensitivity of the receptor**

9.10.1.55 The sensitivity of marine mammals to disturbance from elevated underwater sound due to piling is as described in paragraph 9.10.1.38 for Tier 1 projects.

9.10.1.56 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**

9.10.1.57 Overall, the magnitude of the impact is deemed to be **low** (harbour porpoise, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal, harbour seal bottlenose dolphin in the context of the wider Offshore Channel and Southwest England MU plus the Irish Sea MU population) and **medium** (bottlenose dolphin in the context of the Irish Sea MU population) and the sensitivity of the receptor is considered to be **medium**.

9.10.1.58 The cumulative effects could potentially affect the international value of bottlenose dolphin in the context of the Irish Sea MU although not in the wider extent for projects in the Offshore Channel and Southwest England MU plus Irish Sea MU area. The effect on bottlenose dolphin will, therefore, be of moderate adverse significance for the bottlenose dolphin Irish Sea MU population, which is significant in EIA terms, but of minor adverse significance for the wider Offshore Channel and Southwest England MU plus Irish Sea MU population, which is not significant in EIA terms. The applicant will seek to address this potential significant effect on the Irish Sea MU bottlenose dolphin population for the Environmental Statement. Any measures considered to reduce the significance or potential further mitigation will be discussed with the Expert Working Group through the Evidence Plan process.

9.10.1.59 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 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.

## 9.10.2 Injury and disturbance from elevated underwater sound during site investigation surveys

9.10.2.1 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 the Morgan Array Area and projects outlined in Table 9.43.

9.10.2.2 Geophysical surveys are detailed in section 9.8.7. The geophysical site investigation is anticipated to include the following activities which are commonly undertaken as best practice for offshore wind projects (note that frequencies and sound levels for sonar equipment has been included based on volume 3, annex 3.1: Underwater sound technical report of the PEIR):

- Multi-beam echo-sounder (MBES) (200-400kHz; 180-240dB re 1 1µPa)
- Sidescan Sonar (SSS) (200-900kHz; 190-245dB re 1 1µPa)
- Single Beam Echosounder (SBES) (200-400kHz; 180-240dB re 1 1µPa)
- Sub-Bottom Profilers (SBP) (0.5 - 12kHz chirp, 4kHz pinger, 100kHz pinger; 200-240 chirp dB re 1 1µPa, 200-235 pinger (both) dB re 1 1µPa)
- Ultra-High Resolution Seismic (UHRS) (19.5 - 33.5kHz; 170-200dB re 11µPa).

9.10.2.3 Geotechnical surveys will be conducted at specific locations within the Morgan Generation Assets and these projects. The geotechnical site investigation is anticipated to include the following activities which are commonly undertaken as best practice for offshore wind projects:

- Boreholes
- Cone penetration tests
- Vibrocores.

9.10.2.4 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 (see section 9.8.7). 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 paragraph 9.10.2.5 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 (volume 5, annex 5.1: Cumulative effects screening matrix of the PEIR).3

9.10.2.5 For Tier 1 projects with temporal overlap with the construction phase of the Morgan Generation Assets, effects as a result of underwater sound from site investigation surveys were not included in the respective Environmental Statements. Therefore all Tier 1 project have been scoped out of the cumulative assessment (see paragraph 9.9.2.2 for more details).

9.10.2.6 As previously described in section 9.9.2, given that the impacts considered within the Morgan Generation Assets alone assessment are specific to a particular phase of development, where there is no spatial or temporal overlap with the site investigation surveys during construction phase of the Morgan Generation Assets, survey activities associated with Tier 2 projects listed in Table 9.43, may be excluded from further consideration. Impacts scoped out from individual assessments of respective projects or from the Morgan Generation Assets alone assessment are not considered further.

### Tier 2

### Construction phase

9.10.2.7 Given the temporal overlap, the construction phase of the Morgan Generation Assets, together with the construction phase of Tier 2 projects (the Mona Offshore Wind Project and the Morecambe Offshore Windfarm Generation Assets (Table 9.43), may lead to disturbance to marine mammals as a result of sound generated by pre-construction site investigation surveys. A cumulative assessment with respect to these three projects is provided below.

#### Magnitude of impact

9.10.2.8 Given that EIA Scoping Reports do not provide detailed information about site investigation surveys involved, it is not possible to undertake full, quantitative assessment for this impact and therefore a qualitative assessment is provided below. However, for Mona Offshore Wind Project the PEIR is available. The PEIR predicted most of the impact ranges to be within 100s of meters, with the greatest distance over which the disturbance can occur out to approximately 31km, during vibro-coring (Mona Offshore Wind Ltd, 2023).

9.10.2.9 Based on the distance from the Morgan Generation Assets to the Mona Offshore Wind Project and the Morecambe Offshore Windfarm Generation Assets, if pre-construction site investigation surveys were to temporally overlap with the construction phase of the Morgan Generation Assets, it is likely that spatial overlap of disturbance ranges would occur, especially for site investigation surveys taking place in the north part of the Mona Array Area and west part of the Morecambe Array Area, nearest to the Morgan Generation Assets. Due to the small distance between projects, animals are likely to be displaced from an area comparable to disturbance contours at the Morgan Generation Assets alone.

9.10.2.10 Although the duration of site-investigation surveys is considered to be short term and localised for each project, it should be noted that these will occur intermittently over a number of years with isolated surveys occurring at different points in time throughout the Irish Sea.

9.10.2.11 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**.

**Sensitivity of the receptor**

9.10.2.12 The sensitivity of marine mammals to injury and disturbance from pre-construction site investigation surveys is as described in paragraph 9.8.7.15 for the Morgan Generation Assets alone.

9.10.2.13 The marine mammal receptors are deemed to have some tolerance, 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**

9.10.2.14 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.

### 9.10.3 Injury and disturbance from elevated underwater sound during UXO clearance

9.10.3.1 As presented in paragraph 9.8.4.4, 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 the onset of displacement or moving away in line with recommendation from Southall *et al.* (2007) (see paragraph 9.8.4.19 for more details).

**Tier 1**

#### Construction phase

9.10.3.2 The construction of the Morgan Generation Assets, together with construction of Tier 1 projects identified in Table 9.43 may lead to injury and/or disturbance (presented as TTS/moving away response) to marine mammals during UXO clearance. Other Tier 1 projects screened into the assessment within the regional marine mammal study area includes Awel y Môr Offshore Wind Farm and Project Erebus.

**Magnitude of impact**

9.10.3.3 Awel y Môr is located 47.24km from the Morgan Generation Assets. The MDS for Awel y Môr 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 assessed both PTS, disturbance as well as TTS as a result of UXO clearance. Awel y Môr used Southall *et al*. (2007) for assessing the impacts from UXO detonation on marine mammals. However, authors of the Awel y Môr Environmental Statement highlight that there is a lack of empirical evidence from UXO detonations using TTS metric, in particular the range dependent characteristics of the peak sounds, and discuss whether current propagation models can accurately predict the range at which these thresholds are reached (RWE, 2022). An estimation of the source level and predicted PTS-onset impact ranges were modelled for a range of expected UXO sizes (5kg TNT NEQ, 15kg 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.

9.10.3.4 The charge sizes used for the Awel y Môr assessment are lower than the maximum modelled for the Morgan Generation Assets, and injury ranges are smaller. For the most sensitive species (harbour porpoise) Awel y Môr assessed the effects on using two densities (JCP 0.13 per $km^2$ and SWF 1.0 per $km^2$), and the maximum number 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 is presented in Table 9.51. The exact mitigation measures contained with the UXO MMMP for Awel y Môr 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).

9.10.3.5 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 26km Effective deterrence ranges (EDR) for high-order detonations, 5km EDR for low order and TTS-onset thresholds for high-order detonations. JNCC advised that an EDR of 26km around the source location should be used to determine the impact 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 5km 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 this is likely to over-estimate true behavioural response due to UXO comprising a single pulse source sound and not lasting a full diel cycle. Large TTS-onset ranges were predicted for harbour porpoise (16km using $SPL_{pk}$) and minke whale (65km using $SEL_{cum}$) for UXO charge size of 164kg. As highlighted in the Awel y Môr Environmental Statement, these ranges may be highly over-precautionary as these do not account for the impulsive sound losing harmful impulsive characteristics and becoming non-impulsive as it propagates from the source (RWE, 2022). Based on the predicted ranges and numbers of animals affected Awel y Môr concluded that the magnitude of the effects of TTS would be low for all species (Table 9.52).

9.10.3.6 Project Erebus anticipated one UXO detonation via low-order deflagration but included assessment for high-order detonations for completeness, highlighting this is not realistic. 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).

9.10.3.7 The number of marine mammals expected to experience PTS-onset is <1 for all species and charge sizes, apart from 2kg NEQ, which could result in PTS in up to five harbour porpoise. For high-order detonation, which is not in the project design for Project Erebus up to 212 harbour porpoise could be affected by PTS (Table 9.51). The Environmental Statement for Project Erebus highlighted 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 a EDR of 5km for low order clearance and 26km for high-order clearance (as was the case for Awel y Môr). Similar to Awel y Môr, Project Erebus used TTS-onset as a proxy for disturbance, and maximum predicted TTS-onset range is 103km for minke whale. It has been highlighted in the Erebus ES 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).

9.10.3.8 A spatial MDS would occur where UXO clearance activities coincide at the respective projects considered in the cumulative assessment. This is however highly unlikely, as due to safety reasons the UXO clearance activities takes place before other construction activities commence. Temporally, sequential UXO clearance at respective projects could lead to a longer duration of impact (affecting marine mammals) for projects whose construction phase finishes in a year preceding the commencement of construction phase at the Morgan Generation Assets (2026). Awel y Môr construction dates are from 2026 therefore UXO clearance there may be some overlap in pre-construction activities with the Morgan Generation Assets. 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 9.8.4.4) event so the impact will be short in temporal duration and therefore the overlap is unlikely. Construction of Project Erebus is likely to be completed a year before the commencement of construction activities at the Morgan Generation Assets and therefore will not overlap with the Morgan Generation Assets UXO clearance. Given the project design for use of low-order UXO clearance techniques only for Project Erebus, cumulative impacts are considered unlikely.

9.10.3.9 The assessments provided in the Environmental Statements for Awel y Môr 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, harbour seal has not been considered further in this cumulative assessment section.

9.10.3.10 The maximum cumulative number of animals potentially affected by PTS (harbour porpoise) in the regional marine mammal study area is 426 animals (Table 9.51), 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 331kg, and the project is seeking consent for one low-order detonation with a maximum of 2kg NEG). Therefore, with measures applied at cumulative projects (i.e. use of low-order clearance only for Project Erebus and MMMPs for Awel y Môr) the residual risk of injury is likely to be very small.

**Table 9.51: Number of animals with the potential to experience PTS during UXO clearance at cumulative Tier 1 projects.**

| Project | Species | Maximum charge size (kg) | Metric | Maximum PTS range (m) | Estimated number within PTS range |
|---|---|---|---|---|---|
| Morgan Generation Assets | Harbour porpoise | 907 | PTS-ONSET SPLPEAK (DB RE 1µPA) | 15,370 | 184 |
| | Bottlenose dolphin, short-beaked dolphin and Risso's dolphin | | | 890 | <1 |
| | Minke whale | | | 2,720 | <1 |
| | Grey seal | | | 3,015 | 2 |
| Awel y Môr | Harbour porpoise | 164 | PTS-ONSET SPLPEAK (DB RE 1µPA) | 8,600 | 30 |
| | Bottlenose dolphin, short-beaked dolphin and Risso's dolphin | | | 500 | <1 |
| | Minke whale | | | 1,500 | <1 |
| | Grey seal | | | 1,600 | 3 |
| Project Erebus | Harbour porpoise | 525 | PTS-ONSET SPLPEAK (DB RE 1µPA) | 13,000 | 212 |
| | Bottlenose dolphin, short-beaked dolphin and Risso's dolphin | | | 730 | 3 (short-beaked common dolphin) <1 (bottlenose dolphin) |
| | Minke whale | | | 2,200 | <1 |
| | Grey seal | | | 2,500 | 1 |

9.10.3.11 Production of underwater sound during detonation of UXOs as a part of the cumulative projects as well as the Morgan Generation Assets have the potential to cause TTS (moving away response) in marine mammal receptors, however, this effect will be very short-lived and reversible. Since TTS is a recoverable injury with a temporary loss in hearing, the potential for cumulative impact is considered to be very limited, even for multiple Tier 1 projects within the regional marine mammal study area (Table 9.52). It is assumed that whilst some ecological functions could be inhibited in the short-term due to TTS (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 9.52: Number of animals with the potential to experience onset TTS during UXO clearance at cumulative Tier 1 projects.**

| Project | Species | Maximum charge size (kg) | Metric | Maximum TTS range (m) | Estimated number within TTS range |
|---|---|---|---|---|---|
| Morgan Generation Assets | Harbour porpoise | 907 | TTS $SPL_{pk}$ | 28,230 | 623 |
| | Bottlenose dolphin, short-beaked dolphin and Risso's dolphin | | | 1,635 | <1 |
| | Minke whale | | SEL | 34,365 | <1 |
| | Grey seal | | TTS $SPL_{pk}$ | 5,550 | 4 |
| Awel y Môr | Harbour porpoise | 164 | TTS onset ranges $SPL_{pk}$ | 1,600 | 804 |
| | Bottlenose dolphin, short-beaked dolphin and Risso's dolphin | | | 920 | <1 |
| | Minke whale | | | 280 | <1 |
| | Grey seal | | | 310 | 13 |
| Project Erebus | Harbour porpoise | 525kg | TTS onset ranges weighted SEL | 4,000 | 20 |
| | Bottlenose dolphin, short-beaked dolphin and Risso's dolphin | | | 530 | 1 (common dolphin)<br>0 (bottlenose dolphin) |
| | Minke whale | | | 103,000 | 103 |
| | Grey seal | | | 20,000 | 52 |

9.10.3.12 Adopting a precautionary approach, and assuming application of standard industry measures (such as MMO/PAM and ADDs), the assessment considered the magnitude for a high-order detonation.

#### PTS

9.10.3.13 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). For harbour porpoise the ranges of effect are large (Table 9.51) and there is considered to be a residual risk of PTS to a small number of individuals, therefore the magnitude is considered to be **low** for harbour porpoise.

#### TTS

9.10.3.14 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 TTS 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 the receptor

9.10.3.15 The sensitivity of marine mammals to PTS from elevated underwater sound due to piling is as described in paragraph 9.8.4.22 for the Morgan Generation Assets alone, whilst TTS (as a proxy for behavioural disturbance) is described in paragraph 9.8.4.29.

9.10.3.16 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.

9.10.3.17 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 was begun. Further secondary 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 the UXO clearance.

9.10.3.18 In terms of PTS as a result of UXO clearance, all marine mammals are deemed to be have limited tolerance, low recoverability and international value. The sensitivity of the receptors to PTS is therefore, considered to be **high.**

9.10.3.19 In terms of TTS as a result of UXO clearance, all marine mammals are deemed to have some tolerance, high recoverability and international value. The sensitivity of the receptor to TTS is therefore, considered to be **low.**

#### Significance of effect

9.10.3.20 In terms of PTS, with standard industry measures applied, for bottlenose dolphin, short-beaked common dolphin, Risso's dolphin, minke whale, grey 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, the magnitude of the cumulative impact is deemed to be **low,** and the sensitivity of the receptors 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 unlikely to affect the international value of the species. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

9.10.3.21 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

**<u>Tier 2</u>**

9.10.3.22 The construction of the Morgan Generation Assets, together with construction of Tier 1 and Tier 2 projects identified in Table 9.43 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: Shelmalere Offshore Wind Farm, Llŷr Projects (Llŷr 1/Llŷr 2), Inis Ealga Marine Energy Park, White Cross, Codling Wind Park, the Mona Offshore Wind Project, the Morgan and Morecambe Offshore Wind Farms: Transmission Assets, the Morecambe Offshore Wind Farm Generation Assets and Arklow Bank Wind Park.

### Construction phase

9.10.3.23 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 9.8.4.22, the duration of impact for each UXO detonation is very short (seconds) and therefore behavioural effects are considered to be negligible in this context. Potential cumulative effects from TTS were also investigated, corresponding to a displacement or moving away response as described in paragraph 9.10.3.5.

**Magnitude of impact**

9.10.3.24 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.

9.10.3.25 For Tier 2 projects, except the Mona Offshore Wind Project, beyond EIA scoping report there was not enough information to do 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.

9.10.3.26 The EIA Scoping Report for the Mona Offshore Wind Project (Mona Offshore Wind Ltd, 2022) identified PTS and disturbance (TTS/moving away response) to marine mammals resulting from underwater sound during UXO clearance as a potential impact during the construction phase of the project. Due to the proximity to the Morgan Generation Assets, a range of UXO sizes were assessed from 25kg up to 907kg with 130kg the most likely maximum. Subsequently, the Mona Offshore Wind PEIR predicted the largest impact ranges as a result of high order detonation of 907kg UXO size for harbour porpoise of up to 15km and 28km for PTS and TTS, respectively (Mona Offshore Wind Ltd, 2023). Numbers of animals potentially impacted are presented in Table 9.53. Construction is expected to be from 2026 to 2030 and therefore may have four years of overlap with the Morgan Generation Assets, though the exact dates are uncertain at this stage. Impacts including PTS and TTS injury and disturbance ranges are similar to those presented for the Morgan Generation Assets alone and given the local proximity there is potential for cumulative effects to occur with the Mona Offshore Wind Project.

**Table 9.53: Number of animals with the potential to experience onset PTS/TTS during UXO clearance at the Mona Offshore Wind Project.**

| Species | Maximum charge size leading to highest impact (kg) | Metric | Maximum range (m) | Estimated number of animals within impact area |
|---|---|---|---|---|
| Harbour porpoise | 907 | PTS-onset $SPL_{pk}$ (dB re 1μPa) | 15,370 | 72 |
| Bottlenose dolphin, short-beaked dolphin and Risso's dolphin | | | 890 | <1 |
| Minke whale | | | 2,720 | <1 |
| Grey seal and harbour seal | | | 3,015 | 6 (grey seal)<br><1 (harbour seal) |
| Harbour porpoise | 907 | TTS $SPL_{pk}$ | 28,230 | 245 |
| Bottlenose dolphin, short-beaked dolphin and Risso's dolphin | | | 1,635 | <1 |
| Minke whale | | TTS SEL | 34,365 | <1 |
| Grey seal and harbour seal | | TTS $SPL_{pk}$ | 5,550 | 19 (grey seal)<br><1 (harbour seal) |

9.10.3.27 The EIA Scoping Reports for Shelmalere Offshore Wind Farm concluded that a detailed UXO survey would be undertaken post-consent, ahead of construction activities commencing (planned for 2023) but will not be complete by the DCO application. 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 means minimal spatial overlap in UXO PTS and TTS ranges and limited potential for cumulative effects.

9.10.3.28 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 proximity of the inshore part of the cumulative marine mammals study area to Castlemartin Range. 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 means minimal spatial overlap in UXO PTS and TTS ranges, and limited potential for cumulative effects.

9.10.3.29 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). 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 means likely minimal spatial overlap in UXO PTS and TTS ranges and limited potential for cumulative effects.

9.10.3.30 White Cross EIA Scoping Report includes clearance of unexploded ordnance at the wind project site and along the cable route to be scoped into the EIA. Potential mitigation measures are to be considered such as noise abatement systems (NAS) and low-order detonations for UXO. White Cross construction is planned for mid-year 2024 and it is unlikely to overlap with UXO clearance for the Morgan Generation Assets. Therefore, there is limited potential for cumulative effects with this project.

9.10.3.31 Codling Wind Park does not explicitly scope in or out sound from UXO clearance but does mention it will consider a MMMP for any potential UXO work. The construction phase is planned to be complete by 2027 and therefore some temporal overlap with the Morgan Generation Assets construction is possible. Despite the lack of information, the smaller proposed extent (less UXOs within the area) and location on the east of Ireland (approximately 141km from the Morgan Generation Assets) means there is limited potential for cumulative effects with Codling Wind Park.

9.10.3.32 The Morgan and Morecambe Offshore Wind Farms: Transmission Assets EIA Scoping Report details that UXO clearance will be assessed further in the EIA. Impacts including PTS and TTS ranges are expected to be similar to those from the Morgan Generation Assets given the local proximity, and assuming construction timeframes overlap the potential for a cumulative effect with the Morgan and Morecambe Offshore Wind Farms: Transmission Assets is possible.

9.10.3.33 For the Morecambe Offshore Wind Farm Generation Assets, the EIA Scoping Report states underwater sound modelling will also be undertaken for the clearance of UXO. However, any UXO clearance, if required, will be assessed as part of a separate marine licence and not part of the DCO. Maximum design impacts for UXO clearance will be included as an appendix within the Morgan Generation Assets Environmental Statement for information only, with a more detailed assessment will be undertaken for the separate marine licence when more information on the requirement for any UXO clearance are available. Therefore, no publicly available information was available, at the time of writing, which quantifies the UXO clearance activities for the Morecambe Offshore Wind Farm Generation Assets. UXO impacts are likely to be similar to those from the Morgan Generation Assets and given the local proximity and potential for overlap in construction timeframes the potential for a cumulative effect with the Morecambe Offshore Wind Farm Generation Assets is possible.

9.10.3.34 On the basis of information available at the time of writing, projects most likely to contribute to a cumulative effect on marine mammals due to UXO clearance for this PEIR include the Mona Offshore Wind Project, the Morgan and Morecambe Offshore Wind Farms: Transmission Assets and the Morecambe Offshore Wind Farm Generation Assets. Adopting a precautionary approach, and assuming application of standard industry measures (such as MMO/PAM and ADDs), the assessment considered the magnitude of impact for a high order detonation.

**PTS**

9.10.3.35 The magnitude of 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, harbour seal). For harbour porpoise the ranges of effect are large (see Table 9.51 and Table 9.53 for PTS ranges for Tier 1 and Tier 2 projects, respectively) and there is considered to be a residual risk of PTS to a small number of individuals, therefore the magnitude is considered to be **low** for harbour porpoise.

**TTS**

9.10.3.36 The magnitude of TTS 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 TTS 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 the receptor**

9.10.3.37 The sensitivity of marine mammals to UXO clearance was as described in paragraph 9.10.3.15.

9.10.3.38 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.**

9.10.3.39 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**

9.10.3.40 In terms of PTS, with standard industry measures applied, for bottlenose dolphin, short-beaked common dolphin, Risso's dolphin, minke whale, grey seal, 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, the magnitude of the cumulative impact is deemed to be **low,** and the sensitivity of the receptors 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. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

9.10.3.41 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.

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

9.10.4.1 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 due to vessel use and other non-piling activities would be expected to be very low. PTS thresholds are unlikely to be exceeded or would be very localised (<10m from the source). The assessment for the Morgan Generation Assets alone (section 9.8.5) identified relatively small injury ranges of effects and therefore the magnitude of the impact and associated effect (PTS) occurring in marine mammals has been assessed as low. 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 provided below focuses on disturbance only for this impact.

**<u>Tier 1</u>**

#### Construction phase

9.10.4.2 Given the temporal overlap, the construction of the Morgan Generation Assets, together with construction and operations and maintenance phases of Awel y Môr Offshore Wind Farm, the operations and maintenance phase of the West Anglesey Demonstration Zone tidal site and Project Erebus (Table 9.43) may lead to cumulative disturbance to marine mammals from vessel use and other (non-piling) sound producing activities.

**Magnitude of impact**

9.10.4.3 Awel y Môr Offshore Wind Farm is located approximately 47km from the Morgan Generation Assets. The MDS for Awel y Môr anticipated up to 101 construction vessels in total, of which 35 may be on site during peak period (RWE, 2022). The assessment of impacts associated with underwater sound due to vessel sound and other construction activities (such as cable laying, dredging, trenching and rock placement) presented in the Environmental Statement is based on a desktop study. The Environmental Statement assumed that based on Benhemma-Le Gall *et al.* (2021), harbour porpoise and other cetaceans may be displaced up to 4km from construction vessels. The assessment also identified localised behavioural disturbance ranges with harbour porpoise and grey seal with avoidance reported up to 5km from the site during dredging activities. For bottlenose dolphin dredging was predicted to cause a reduction in presence and avoidance of the area for five weeks. Similarly, minke whale presence is negatively correlated with construction related activities, including dredging.

9.10.4.4 During the operation of Awel y Môr Offshore Wind Farm, it was anticipated that 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.

9.10.4.5 The Environmental Statement for the West Anglesey Demonstration Zone tidal site (Menter Môn Morlais Limited, 2019), which is located approximately 79km from the Morgan Generation Assets, provided a quantitative assessment of impacts based on a MDS of up to 16 vessels on site at any one time during the operations and maintenance phase of the project.

9.10.4.6 The Project Erebus site is located 289km from the Morgan Generation Assets and comprises up to 10 floating wind turbines over a maximum area of 32km$^2$. The MDS project anticipated a maximum of two crew transfer vessels on site per day during the operations and maintenance phase of the project (Blue Gem Wind, 2020). These vessels would be expected to be stationary or slow moving and would not be a novel impact pathway for marine mammals in the area (Blue Gem Wind, 2020).

9.10.4.7 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, disturbance ranges of up to 21km were predicted for survey and support vessels, crew transfer vessels, scour/cable protection/seabed preparation/installation vessels. It is likely that several activities could be potentially occurring at the same time across several offshore wind projects and therefore ranges of effects may extend from several vessels/locations where the activity is carried out.

9.10.4.8 Therefore, cumulatively across the sites there may be a noticeable uplift in vessel activity within the Irish Sea and wider Celtic Sea regional study area from the baseline, although noting that the assessments are based on the maximum design scenario, the number of vessels present at respective projects at any given time may in reality be lower. Additionally, vessel movements will be confined to the array areas and/or offshore cable corridor routes and are likely to follow existing shipping routes to/from port. As such, it would not be realistic to present simply the sum of all vessels anticipated within each offshore wind farm as per respective maximum design scenarios. Introduction of vessels during construction and operations and maintenance phases of the projects will not be a novel impact for marine mammals present in the area and therefore marine mammals are anticipated to demonstrate some degree of habituation to sound from vessels.

9.10.4.9 Although the duration of vessel activity is considered to be medium term (throughout the construction phase of the Morgan Generation Assets) and localised for each project, it should be noted that 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 0.01 to 6.0km) and therefore the extent of effect will be local. However, where vessels may disturb animals over ranges of 21km, it 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 construction phases of Awel y Môr and the Morgan Generation Assets and both projects are located within the area of relatively low marine mammal densities (except bottlenose dolphins, see Volume 4, annex 9.1: Marine mammal technical report of the PEIR).

9.10.4.10 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 the receptor**

9.10.4.11 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 9.8.5.24 for the Morgan Generation Assets alone.

9.10.4.12 Scientific evidence suggests that there are interspecific differences in the potential sensitivity of cetaceans to sound from vessels with different behavioural reactions to different vessel types, as some species are actively avoiding vessels, whilst other are attracted towards them. Of all marine mammal IEFs, harbour porpoise is likely to be particularly sensitive to sound from vessels and avoidance response in vicinity of vessel traffic is likely to occur (Heinänen and Skov, 2015; Hermannsen and Bedholm, 2014; Dyndo *et al*. 2015). Pirotta *et al*. (2015) combined acoustic data with visual observations to investigate whether dolphin responses varied under different disturbance, context and social conditions. The study found that there is a complex interaction between the physical presence of a boat, the sound it produces and its movement around the animals that affects the perception of risk and determines the onset of animal’s response. The visual data corroborated that the reduction of buzzing activity increased with increasing numbers of boats in the area and this effect it thought to be associated with physical boat presence (Pirotta *et al.,* 2015).

9.10.4.13 However, there may be intrinsic factors that may also contribute to a variance in distribution and abundance (e.g. changes in prey distribution and natural seasonal fluctuations) and therefore the link between vessel sound and reduced marine mammal activity is not straightforward to establish. Despite the known sensitivity of harbour porpoise, Culloch *et al*. (2016) found no detectable decrease in the numbers of harbour porpoise associated with an increase in vessel activity during pipeline construction.

9.10.4.14 The presence of boats near seal haul-outs could lead to disruption of foraging and potentially reduced pupping success. As reported in volume 6, annex 9.1 (Marine mammal technical report) the closest designated haul-out site is located approximately 74km swimming distance away from the Morgan Generation Assets and therefore there is expected to be no direct impacts to seals on land while hauled-out at these designated sites. Given small numbers of harbour seal within the Wales and Northwest England MU, there is no information on the location of harbour seal hauled-out in in these MUs. Given that the vessel movements will be confined to the array areas and/or offshore cable corridor routes of respective projects and are likely to follow existing shipping routes to/from port, it is highly unlikely that harbour seal present within designated haul-out sites would be disturbed.

9.10.4.15 Barrier effects and altered behaviour could affect the ability of phocid seal to accumulate the energy reserves prior to both reproduction and lactation (Sparling *et al.*, 2006). They may be most vulnerable to reduced foraging during this period, as maternal energy storage is extremely important to offspring survival and female fitness (Mellish *et al*., 1999; Hall *et al*., 2001). Therefore, potential exclusion from foraging grounds during this time has the potential to affect reproduction rates and probability of survival. Pen Llŷn a`r Sarnau/Llŷn Peninsula and the Sarnau SAC, Lambay Island SAC, Pembrokeshire Marine/Sir Benfro Forol SAC and Saltee Islands SAC are located within the regional marine mammal study area and support breeding colonies of grey seal. Carter *et al*. (2022) suggested that for grey seal, SACs designated based on breeding numbers cannot be reliably linked to areas where individuals may be exposed to threats at sea due to local redistribution outside of the breeding season and partial migration. Inter-regional movements within the foraging season are believed to be limited for harbour seal. Various sites designated for protection of cetaceans are also located in proximity to the Morgan Generation Assets (see section 9.5.3). Given the existing levels of vessel activity within the Irish Sea, it is expected that marine mammals could tolerate the effects of vessel presence to some extent. The impacts of construction will be highly localised, largely restricted to the boundaries of the respective projects and only a small area will be affected when compared to available foraging habitat. Therefore, it is anticipated that the connectivity with suitable foraging grounds and supporting habitats will not be impaired. Full consideration of potential adverse effects on the integrity on European Sites (AeoI) is given in the ISAA.

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

**Significance of effect**

9.10.4.17 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, be of **minor** adverse significance, which is not significant in EIA terms.

### Operations and maintenance phase

9.10.4.18 Given the temporal overlap, the operations and maintenance of the Morgan Generation Assets, together with operations and maintenance phase of Awel y Môr Offshore Wind Farm, West Anglesey Demonstration Zone tidal site and Project Erebus Floating Wind Farm Demonstration Projects (Table 9.43) may lead to cumulative disturbance to marine mammals from vessel use and other (non-piling) sound producing activities.

**Magnitude of impact**

9.10.4.19 The range of vessel 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. During the operation of Awel y Môr Offshore Wind Farm, it was anticipated that 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 (see paragraph 9.10.4.4).

9.10.4.20 West Anglesey Demonstration Zone tidal site is located 79km from the Morgan Generation Assets. The MDS for the project anticipated up to two drilling activities, two cable installation activities, two cable protection activities and 16 vessels on site (Royal Haskoning DHV, 2019). The maximum predicated behavioural disturbance range across all species was predicted in harbour porpoise for two percussive drilling rigs and cutter-suction dredging as up to 530m and 580m, respectively.

9.10.4.21 The MDS for Project Erebus anticipated a maximum of two crew transfer vessels on site per day, which would be expected to be stationary or slow moving and were not expected to be a novel impact pathway for marine mammals in the area (Blue Gem Wind, 2020). The maximum predicted behavioural disturbance range for large vessels was assessed as 480m for minke whale.

9.10.4.22 The MDS for the operations and maintenance phase of the Morgan Generation Assets is presented in Table 9.14, with up to 21 operations and maintenance vessels on site at any one time. Vessels involved in the operations and maintenance of Awel y Môr Offshore Wind Farm and West Anglesey Demonstration Zone tidal site will include a similar suite of vessels as those described for the Morgan Generation Assets alone, such as CTVs/workboats, jack-up vessels, cable repair vessels, service operation vessels (SOV) and excavators/backhoe dredgers.

9.10.4.23 Therefore, cumulatively across the sites there will be an increase in vessel activity within the Irish Sea and wider Celtic Sea. This represents an uplift from the current baseline, although noting that the assessments are based on the MDS, the number of vessels present at respective projects at any given time will in reality, be lower. Additionally, vessel movements will be confined to the array areas and/or offshore cable corridor routes and are likely to follow existing shipping routes to/from port. As such, it would not be realistic to present a simplistic sum of all vessels anticipated within each offshore wind farm as per respective maximum design scenarios. Introduction of vessels during construction and operations and maintenance phases of the projects will not be a novel impact for marine mammals present in the area and therefore marine mammals are anticipated to demonstrate some degree of habituation to sound from vessels.

9.10.4.24 The duration of vessel activity is considered to be long term (throughout the operational and maintenance phase of the Morgan Generation Assets) and localised for each project with vessel movements occurring intermittently over a number of years. The cumulative number of vessels at any given time is expected to be lower for the operations and maintenance phase compared to construction phases of respective projects. Therefore, the magnitude of the impact for 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 impact will be longer, over the operating lifetime of the project, and therefore a precautionary approach has been taken in assessing the magnitude.

9.10.4.25 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**.

#### Sensitivity of the receptor

9.10.4.26 The sensitivity of marine mammals to cumulative disturbance from elevated underwater sound due to vessel use and other (non-piling) sound producing activities is as described in paragraph 9.10.4.11 for the construction phase.

9.10.4.27 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

9.10.4.28 Overall, with standard industry measures in place (such as 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, be of **minor** adverse significance, which is not significant in EIA terms.

## Tier 2

### Construction phase

9.10.4.29 The construction of the Morgan Generation Assets, together with construction and/or operations and maintenance phases of Tier 1 projects and the construction phase of the Mona Offshore Wind Project, Shelmalere Offshore Wind Farm and Inis Ealga Marine Energy Park, the operations and maintenance phase of the Llŷr Projects (Llŷr 1 and Llŷr 2), and both the construction and operations and maintenance phases of the North Irish Sea Array, Codling Wind Park, Dublin Array and White Cross (Table 9.43) may lead to disturbance to marine mammals from vessel use and other (non-piling) sound producing activities. Timelines of the construction as well as operations and maintenance phases of Oriel Offshore Wind Farm, the Morecambe Offshore Wind Farm Generation Assets and Arklow Bank Wind Park Phase 2 are unknown. However, it has been conservatively assumed that there will be a temporal overlap with the construction phase of the Morgan Generation Assets. Potential impacts as a result of vessel use and other (non-piling) sound producing activities were screened into the assessments for all projects during the construction phase of the Morgan Generation Assets.

#### Magnitude of impact

9.10.4.30 Given that EIA Scoping Reports do not provide detailed information on vessel numbers, it is not possible to undertake full, quantitative assessment for this impact and therefore a qualitative assessment is provided below. However, for Mona Offshore Wind Project, PEIR is available and vessel information is included.

9.10.4.31 Behavioural disturbance ranges depend on the type of vessels used during construction and type of other (non-piling) sound producing activities. Although these ranges may extend beyond the boundaries of the projects screened into cumulative assessment, the extent to which this occurs will depend on the design parameters. The maximum range over which potential disturbance may occur as a result of underwater sound due to vessel use for the Morgan Generation Assets alone as a result of survey and support vessels, crew transfer vessels, scour/cable protection/seabed preparation/installation vessels was out to 21km.

9.10.4.32 The EIA Scoping Report for the Mona Offshore Wind Project (Mona Offshore Wind Ltd, 2022) identified disturbance to marine mammals resulting from underwater sound during vessels and other vessel activities as a potential impact during the construction phase of the project. As presented in the PEIR for this project, cable trenching activities assessed for the Mona Offshore Wind Project alone have the potential to disturb marine mammals out to 19km (Mona Offshore Wind Ltd, 2023). The maximum range over which potential disturbance may occur as a result of underwater sound due to vessel use for the Mona Offshore Wind Project alone as a result of survey vessel, support vessels, crew transfer vessel, scour/cable protection/seabed preparation and installation vessels is predicted out to 22km. The Mona Offshore Wind Project predicted up to 80 vessels to be present on site at any given time during the construction phase (Mona Offshore Wind Ltd, 2023).

9.10.4.33 The impacts for remaining Tier 2 projects are predicted to be localised to within the close vicinity of the respective projects. For some of the Tier 2 projects (including Shelmalere Offshore Wind Farm, North Irish Sea Array, Codling Wind Park, Dublin Array, the Llŷr Projects and Inis Ealga Marine Energy Park) the distances from the Morgan Generation Assets are greater than 100km (see Table 9.41 for distances) and there is no potential for overlap in the behavioural ZOI. Other projects, including the Mona Offshore Wind Project, Morgan and Morecambe Offshore Wind Farms: Transmission Assets and the Morecambe Offshore Windfarm Generation Assets are located in proximity to the Morgan Generation Assets and therefore this could lead to higher levels of traffic within the Liverpool Bay region. Vessel movements and other activities will be largely confined to the array areas and/or offshore cable corridor and vessel routes are likely to follow existing shipping routes to/from port.

9.10.4.34 The duration of vessel activity is considered to be medium term (throughout the construction phase of the Morgan Generation Assets) and localised for each project, however, it should be noted that vessel movements will occur intermittently over a number of years. The cumulative number of vessels for Tier 1 projects represents increase compared to the average vessel traffic (see paragraph 9.10.4.8). Although the exact number of vessels associated with most Tier 2 projects is unknown, if construction phase at all Tier 2 projects will occur simultaneously, vessels associated with each project will contribute further to the increase over a number of years.

9.10.4.35 Cumulatively, construction activities could lead to a larger area of disturbance to marine mammals at any one time across the Irish Sea and wider Celtic Sea region compared to the Morgan Generation Assets alone assuming that projects were to conduct construction activities over similar time periods. Vessels such as boulder clearance, jack-up rigs, tug/anchor handlers and guard vessels will have smaller disturbance ranges (≤6km) and therefore the extent of effect will be local. However, where vessels may disturb animals over ranges of 21-22km, it represents larger proportion of the Irish Sea and wider Celtic Sea and may potentially affect animals over regional scales. Although animals may be disturbed from isolated project areas at different points in time, in the context of the wider habitat available within the Irish Sea and wider Celtic Sea regional study area, the scale of the disturbance effects (which would be localised) is considered to be small.

9.10.4.36 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. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

#### Sensitivity of the receptor

9.10.4.37 The sensitivity of marine mammals to cumulative disturbance from elevated underwater sound due to vessel use and other (non-piling) sound producing activities is as described in paragraph 9.10.4.11.

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

#### Significance of effect

9.10.4.39 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

9.10.4.40 The operations and maintenance phase of the Morgan Generation Assets, together with operations and maintenance phases of Tier 1 projects and maintenance phases of the Mona Offshore Wind Project, Shelmalere Offshore Wind Farm, North Irish Sea Array, Codling Wind Park, Dublin Array, Llŷr Projects, Inis Ealga Marine Energy Park and White Cross may lead to disturbance to marine mammals from vessel use and other (non-piling) sound producing activities (Table 9.43). Timelines of the construction as well as operations and maintenance phases of Oriel Offshore Wind Farm, the Morecambe Offshore Wind Farm Generation Assets, Arklow Bank Wind Park Phase 2 and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets are unknown. However, it has been conservatively assumed that there will be a temporal overlap with the operations and maintenance phase of the Morgan Generation Assets and therefore there is a potential for cumulative effects.

#### Magnitude of impact

9.10.4.41 Given that EIA Scoping Reports do not provide detailed information about numbers of vessels involved, it has not been possible to undertake full, quantitative assessment for all projects. For Mona Offshore Wind Project, the PEIR is available, and it predicted up to 21 vessels to be present on site at any given time during the operations and maintenance phase.

9.10.4.42 The range of vessel used in operations and maintenance activities will be similar to those employed during the construction phases of cumulative projects. The duration of vessel activity is considered to be long term (throughout the operational and maintenance phase of the Morgan Generation Assets) and localised for each project, however, it should be noted that vessel movements will occur intermittently over the lifetime of the Morgan Generation Assets. The number of vessels present during the operational and maintenance phases of respective projects in isolation is considered to be smaller than for construction phase. Nevertheless, cumulatively it could be expected that the total number of vessel movements will exceed the existing average traffic levels.

9.10.4.43 Qualitatively, the impact would lead to a larger area of disturbance within the Celtic and Irish Seas region (see paragraph 9.10.4.23) compared to Morgan Generation Assets. Although animals may be disturbed from isolated project areas at different points in time, in the context of the wider habitat available within the regional marine mammal study area, the scale of the disturbance effects (which would be largely localised) is considered to be small.

9.10.4.44 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 the receptor**

9.10.4.45 The sensitivity of marine mammals to cumulative disturbance from elevated underwater sound due to vessel use and other (non-piling) sound producing activities is as described in paragraph 9.10.4.11 for construction phase.

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

**Significance of effect**

9.10.4.47 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.

### Tier 3

### Construction phase

9.10.4.48 The construction of the Morgan Generation Assets, together with construction and/or operations and maintenance phases of Tier 1 and Tier 2 projects as well as the operations and maintenance phase of MaresConnect (Table 9.41) may lead to cumulative disturbance to marine mammals from underwater sound generated during vessel use and other activities.

**Magnitude of impact**

9.10.4.49 MaresConnect project is in a pre-application phase and no ES is available to inform a quantitative assessment. Therefore, a qualitative assessment is provided below.

9.10.4.50 The construction phase of MaresConnect is anticipated to begin in 2025, with the operations phase commencing in 2026. As such, it is likely that the construction of the MaresConnect will be completed prior to the commencement of construction activities at the Morgan Generation Assets. Maintenance of the cable typically involves considerably smaller number of vessel numbers 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.

9.10.4.51 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 the receptor**

9.10.4.52 The sensitivity of marine mammals to cumulative disturbance from elevated underwater sound due to vessel use and other (non-piling) sound producing activities is as described in paragraph 9.10.4.11.

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

**Significance of effect**

9.10.4.54 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

9.10.4.55 The operations and maintenance of the Morgan Generation Assets, together with operations and maintenance phases of Tier 1 and Tier 2 projects as well as operations and maintenance phases of the MaresConnect (Table 9.43) may lead to cumulative disturbance to marine mammals from underwater sound generated during vessel use and other activities.

**Magnitude of impact**

9.10.4.56 The MaresConnect project is in a pre-application phase and no ES is available to inform a quantitative assessment. Therefore, a qualitative assessment is provided below.

9.10.4.57 As described in paragraph 9.10.4.50, maintenance of the cable typically involves considerably smaller number of vessel numbers 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.

9.10.4.58 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 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**.

**Sensitivity of the receptor**

9.10.4.59 The sensitivity of marine mammals to cumulative disturbance from elevated underwater sound due to vessel use and other (non-piling) sound producing activities is as described in paragraph 9.10.4.11 for construction phase.

9.10.4.60 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**

9.10.4.61 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.

### 9.10.5 Increased risk of injury due to collision with vessels

**<u>Tier 1</u>**

#### Construction phase

9.10.5.1 Given the temporal overlap, the construction of the Morgan Generation Assets, together with Tier 1 projects and construction and operations and maintenance phases of Awel y Môr Offshore Wind Farm and the operations and maintenance phase of the West Anglesey Demonstration Zone tidal site and Project Erebus (Table 9.43) may lead to cumulative impacts on marine mammals from collisions with vessels.

**Magnitude of impact**

9.10.5.2 The number and types of vessel associated with construction and/or operations and maintenance phase of Awel y Môr Offshore Wind Farm is provided in paragraph 9.10.4.3. In the Environmental Statement, Awel y Môr committed to employ a vessel management plan and follow best practice vessel handling protocols to minimise the potential for any impact. As for the Morgan Generation Assets, it is anticipated that a proportion of vessels during construction will be slow moving or even stationary for periods of time and therefore unlikely to pose a significant collision risk to marine mammals (RWE, 2022).

9.10.5.3 The temporal overlap in construction activities of the Morgan Generation Assets with construction/operations and maintenance activities in Awel y Môr and operations and maintenance activities for the West Anglesey Demonstration Zone tidal site and Project Erebus will be approximately three years. The duration of vessel activity is considered to be medium term (throughout the construction phase of the Morgan Generation Assets) and localised for each project, however, it should be noted that vessel movements will occur intermittently over this period. Cumulatively, as described in paragraph 9.10.4.8, total number of vessels associated in construction and/or 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 present at respective projects at any given time will in reality be lower.

9.10.5.4 Vessels involved in the construction phases of Awel y Môr and the Morgan Generation Assets, and the operations and maintenance phase of Awel y Môr, the West Anglesey Demonstration Zone tidal site, and Project Erebus are likely to be travelling slowly, at a speed that is unlikely to cause death or serious injury (below 14-15 knots; Laist *et al.,* 2001, Wilson *et al.,* 2007). This would be most appropriate for species found within the marine mammal study areas, whereas guidance in the US (NOAA, 2020) suggests lower speeds in relation to larger slow-moving species such as humpback whales (rare sightings in the Irish Sea). There is also a potential that the sound emissions from vessels will deter animals from the potential zone of impact. Given that vessel movements will be confined to the array areas and/or offshore cable corridor routes and are likely to follow existing shipping routes to/from port, the risk of collision to marine mammals is expected to be localised to within the boundaries of the respective projects. Additionally, works will take place in the area characterised by relatively high levels of traffic and both projects will be adhering to the best practice protocols. Therefore, it is not anticipated that the cumulative level of vessel activity during construction will cause an increase of collisions with marine mammals.

9.10.5.5 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**.

**Sensitivity of the receptor**

9.10.5.6 The sensitivity of marine mammals to collision risk is as described in paragraph 9.8.6.7 for the Morgan Generation Assets alone.

9.10.5.7 Given that there may be intrinsic factors that may contribute to a variance in marine mammal distribution and abundance (e.g. changes in prey distribution and natural seasonal fluctuations), the link between vessel movements and marine mammal activity is not straightforward to establish. Collision risk could be expected to be higher in the vicinity of haul-out sites, particularly for young seals that have no previous experience of vessel traffic. However, there is no seal haul out sites in the Morgan marine mammal study area.

9.10.5.8 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**

9.10.5.9 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

9.10.5.10 Given the temporal overlap, the operations and maintenance of the Morgan Generation Assets, together with operations and maintenance phases of Awel y Môr Offshore Wind Farm, West Anglesey Demonstration Zone tidal site and Project Erebus (Table 9.43) may lead to cumulative impacts on marine mammals from collisions with vessels.

#### Magnitude of impact

9.10.5.11 The range of vessel 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. Vessels assessed during the operations and maintenance phase of Awel y Môr and Project Erebus are described in paragraph 9.10.4.3 and 9.10.4.6, respectively.

9.10.5.12 The number and types of vessel associated with operations and maintenance of West Anglesey Demonstration Zone tidal site is provided in paragraph 9.10.4.5. The Environmental Statement provided a quantitative assessment of impacts based on up to 16 vessels on site at any one time and the scale of effect in terms of animals potentially affected was very small.

9.10.5.13 The Project Erebus Environmental Statement provided a qualitative assessment of impacts based upon a maximum of two crew-transfer vessels being on site at any one time. These vessels were expected to travel slowly and were not considered to be a novel impact pathway for marine mammals in the area. This project is located 289km from the Morgan Generation Assets and therefore not anticipated to contribute significantly to a cumulative effect.

9.10.5.14 The duration of vessel activity is considered to be long term (throughout the operational and maintenance phase of the Morgan Generation Assets) and localised for each project, however, it should be noted that vessel movements will occur intermittently over a number of years. The cumulative number of vessels is expected to lower for the operations and maintenance phase compared to construction phase (see paragraph 9.10.4.24) of the Morgan Generation Assets,

9.10.5.15 Although the number of vessel movements during the operations and maintenance phase represents an increase in the risk of collision for marine mammals over the existing levels of vessel traffic, there is a potential that the sound emissions from vessels will deter animals from the potential zone of impact. Additionally, given that vessel movements will be confined to the array areas and/or cable routes and are likely to follow existing shipping routes to/from port, the risk of collision to marine mammals is expected to be largely localised to within the boundaries of the respective projects.

9.10.5.16 With standard industry measures in place to reduce the risk of collision, the impact is predicted to be of limited 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 the receptor

9.10.5.17 The sensitivity of marine mammals to collision risk is as described in paragraph 9.10.5.6 for construction phase.

9.10.5.18 All marine mammals, which are deemed to have some tolerance, medium recoverability and international value. The sensitivity of the receptor is therefore considered to be **medium**.

#### Significance of effect

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

## Tier 2

### Construction phase

9.10.5.20 The construction of the Morgan Generation Assets, together with construction and/or operations and maintenance phases of Tier 1 projects and the construction phase of the Mona Offshore Wind Project, Shelmalere Offshore Wind Farm and Inis Ealga Marine Energy Park, the operations and maintenance phase of the Llŷr Projects (Llŷr 1 and Llŷr 2), and both the construction and operations and maintenance phases of the North Irish Sea Array, Codling Wind Park, Dublin Array and White Cross (Table 9.43) may lead to cumulative impacts on marine mammals from collisions with vessels. Timelines of the construction as well as operations and maintenance phases of Oriel Offshore Wind Farm, the Morecambe Offshore Wind Farm Generation Assets, Arklow Bank Wind Park Phase 2 and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets are unknown. However, it has been conservatively assumed that there will be a temporal overlap with the construction phase of the Morgan Generation Assets. Potential impacts associated with risk of collision with vessels were screened into the assessment for all projects during construction and operations and maintenance phases of respective projects.

#### Magnitude of impact

9.10.5.21 Given that EIA Scoping Reports do not provide detailed information about numbers of vessels involved, it has not been possible to undertake full, quantitative assessment for this impact and therefore a qualitative assessment is provided below. For the Morgan Generation Assets, PEIR is available and vessel information is included

9.10.5.22 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, such as main installation and support vessels, tug/anchor handlers, cable lay installation and support vessels, guard vessels, survey vessels, seabed preparation vessels, crew transfer vessels (CTVs), scour protection installation vessels and cable protection installation vessels.

9.10.5.23 As presented in paragraph 9.10.4.32, the Mona Offshore Wind Project PEIR predicted up to 80 vessels to be present on site at any given time during the construction phase.

9.10.5.24 The duration of vessel activity is considered to be medium term (throughout the construction phase of the Morgan Generation Assets) and localised for each project, however, it should be noted that vessel movements will occur intermittently over a number of years. As presented in paragraph 9.10.4.34, 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 Irish Sea and wider Celtic Sea regional study area. If construction phase at all Tier 2 projects will occur simultaneously, vessels associated with each project will contribute further to the increase over a number of years.

9.10.5.25 As previously described for the Morgan Generation Assets alone (see paragraph 9.8.5.3), vessels travelling at 14-15 knots or faster are those most likely to cause death or serious injury to marine mammals (Laist *et al*., 2001). As for construction of the Morgan Generation Assets, vessels involved in the construction phase respective projects are likely to be travelling considerably slower than this. There is also a potential that the sound emissions from vessels will deter animals from the potential ZOI. Additionally, given that vessel movements will be confined to the array areas and/or cable routes and are likely to follow existing shipping routes to/from port, the risk of collision to marine mammals is expected to be largely localised to within the boundaries of the respective projects.

9.10.5.26 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**.

#### Sensitivity of the receptor

9.10.5.27 The sensitivity of marine mammals to collision risk is as described in paragraph 9.10.5.6.

9.10.5.28 All marine mammals, which are deemed to have some tolerance, medium recoverability and international value. The sensitivity of the receptor is therefore considered to be **medium**.

#### Significance of effect

9.10.5.29 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

9.10.5.30 The operation of the Morgan Generation Assets, together with operations and maintenance phases of Tier 1 projects and operations and maintenance phases of the Mona Offshore Wind Project, Shelmalere Offshore Wind Farm, North Irish Sea Array, Codling Wind Park, Dublin Array, Llŷr Projects, Inis Ealga Marine Energy Park and White Cross may lead to cumulative impacts on marine mammals from collisions with vessels (Table 9.43). Timelines of the construction as well as operations and maintenance phases of Oriel Offshore Wind Farm, the Morecambe Offshore Wind Farm Generation Assets, Arklow Bank Wind Park Phase 2 and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets are unknown. However, it has been conservatively assumed that there will be a temporal overlap with the construction phase of the Morgan Generation Assets and therefore there is a potential for cumulative effects.

#### Magnitude of impact

9.10.5.31 The operations and maintenance phase of the Morgan Generation Assets overlaps with the operations and maintenance phase of the respective projects. Given that EIA Scoping Reports do not provide detailed information about numbers of vessels involved in operations and maintenance phase, it has not possible to undertake full, quantitative assessment. For the Mona Offshore Wind Project, PEIR is available and vessel information is included.

9.10.5.32 The types of vessels involved in operations and maintenance activities at the other offshore wind farms 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, removal of marine growth and replacement of access ladders.

9.10.5.33 As presented in paragraph 9.10.4.41 the Mona Offshore Wind Project PEIR predicted up to 21 vessels to be present on site at any given time during the operations and maintenance phase.

9.10.5.34 As presented for construction phase in paragraph 9.10.5.4, there is a potential that the sound emissions from vessels will deter animals from the potential zone of impact. Given that vessel movements will be confined to the array areas and/or offshore cable corridor routes and are likely to follow existing shipping routes to/from port, the risk of collision to marine mammals is expected to be localised to within the boundaries of the respective projects.

9.10.5.35 The duration of vessel activity is considered to be long term (throughout the operational and maintenance phase of the Morgan Generation Assets) and localised for each project, however, it should be noted that vessel movements will occur intermittently over a number of years. The number of vessels present during the operational and maintenance phases of respective projects in isolation is considered to be smaller than for construction phase. Nevertheless, cumulatively it could be expected that the total number of vessel movements will exceed the average traffic levels (see paragraph 9.10.4.42).

9.10.5.36 With standard industry measures in place to reduce the risk of collision, the impact is predicted to be of limited 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, conservatively, considered to be **low**.

#### Sensitivity of the receptor

9.10.5.37 The sensitivity of marine mammals to collision risk is as described in paragraph 9.10.5.6 for the construction phase.

9.10.5.38 All marine mammals, which are deemed to be have some tolerance, medium recoverability and international value. The sensitivity of the receptor is therefore considered to be **medium**.

**Significance of effect**

9.10.5.39 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 3**

### Construction phase

9.10.5.40 The construction of the Morgan Generation Assets, together with construction and/or operations and maintenance phases of Tier 1 and Tier 2 projects as well as the operations and maintenance phase of MaresConnect (Table 9.43) may lead to cumulative impacts on marine mammals from collisions with vessels.

**Magnitude of impact**

9.10.5.41 The MaresConnect project is in a pre-application phase and no Environmental Statement is available to inform a quantitative assessment. Therefore, a qualitative assessment is provided below.

9.10.5.42 The construction phase of MaresConnect is anticipated to begin in 2025, with the operations phase commencing in 2026. As such, it is likely that the construction of the MaresConnect will be completed prior to the commencement of construction activities at the Morgan Generation Assets. Maintenance of the cable typically involves considerably smaller number of vessel numbers 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.

9.10.5.43 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**.

**Sensitivity of the receptor**

9.10.5.44 The sensitivity of marine mammals to collision risk is as described in paragraph 9.10.5.6.

9.10.5.45 All marine mammals, which are deemed to have some tolerance, medium recoverability and international value. The sensitivity of the receptor is therefore considered to be **medium**.

**Significance of effect**

9.10.5.46 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

9.10.5.47 The operations and maintenance of the Morgan Generation Assets, together with operations and maintenance phases of Tier 1 and Tier 2 projects as well as operations and maintenance phases of MaresConnect (Table 9.43) may lead to cumulative impacts on marine mammals from collisions with vessels.

**Magnitude of impact**

9.10.5.48 MaresConnect is in a pre-application phase and no Environmental Statement is available to inform a quantitative assessment. Therefore, a qualitative assessment is provided below.

9.10.5.49 As described in paragraph 9.10.4.50, maintenance of the cable typically involves considerably smaller number of vessel numbers 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.

9.10.5.50

9.10.5.51 With standard industry measures in place to reduce the risk of collision, the impact is predicted to be of limited 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, conservatively, considered to be **low**.

**Sensitivity of the receptor**

9.10.5.52 The sensitivity of marine mammals to collision risk is as described in paragraph 9.10.5.6

9.10.5.53 All marine mammals, which are deemed to have some tolerance, medium recoverability and international value. The sensitivity of the receptor is therefore considered to be **medium**.

**Significance of effect**

9.10.5.54 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.

## 9.10.6 Changes in fish and shellfish communities affecting prey availability

9.10.6.1 Impact on fish and shellfish receptors has been assessed in volume 2, chapter 8: Fish and shellfish of the PEIR, 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 each phase of the Morgan Generation Assets is provided in section 9.8.9.

### Construction phase

**Tier 1**

9.10.6.2 Potential cumulative impacts from Tier 1 projects on marine mammal prey species during the construction phase of the Morgan Generation Assets have been assessed in volume 2, chapter 8: Fish and shellfish ecology of the PEIR. The construction of the Morgan Generation Assets, together with activities at other offshore wind farms, dredging activities, aggregate extraction activities and cables and pipelines may lead to cumulative impacts on marine mammals from changes in prey availability as a result of changes to the fish and shellfish community.

**Magnitude of impact**

9.10.6.3 Potential cumulative impacts from Tier 1 projects on marine mammal prey species during the construction phase of the Morgan Generation Assets include temporary subtidal habitat loss, long term subtidal habitat loss, injury and disturbance from underwater sound, increased SSC and associated sediment deposition and colonisation of hard structures.

9.10.6.4 The cumulative temporary habitat loss and disturbance across all Tier 1 plans, projects, and activities assessed in the cumulative fish and shellfish ecology study area (for more details see volume 2, chapter 8: Fish and shellfish ecology of the PEIR) including the Morgan Generation Assets, was estimated at a maximum of 71.78km$^2$. The significance for temporary habitat loss on fish and shellfish was assessed as negligible to minor, and therefore is unlikely to result in changes in prey availability in marine mammals.

9.10.6.5 The planned construction of the Tier 1 projects alongside the Morgan Generation Assets will introduce up to 1.6km$^2$ of permanent hard structures which will act to represent a cumulative long term habitat loss impact alongside the Morgan Generation Assets. This will act alongside the 1.51km$^2$ of hard structures introduced by the Morgan Generation Assets to represent a potential cumulative long term habitat loss of up to approximately 3.1km$^2$. Given that the construction phase will take place over four years, colonisation of hard structures may commence within that period and continue throughout the operations and maintenance phase. The significance of long-term habitat loss for fish and shellfish has been assessed as minor adverse, and therefore resulting effects due to prey availability on marine mammals are minimal.

9.10.6.6 The construction phase of the Awel y Môr Offshore Wind Farm will have temporal and spatial overlap with the Morgan Generation Assets in terms of sound from construction activities and may impact fish and shellfish (noting that for these receptors the cumulative study area is smaller than the marine mammal cumulative study area). During piling at the Awel y Môr Offshore Wind Farm mortality for group 2 (salmonids and some Scombridae) and 3 (gadoids and eels) fish may occur out to 100m and 8,000m, from the array area respectively. However, sound modelling with inclusion of a moving away response, significantly reduced mortality distances to less than 100m for all groups. The Awel y Môr Offshore Wind Farm indicated behavioural effects to similar ranges as those predicted for the Morgan Generation Assets, at a range of approximately up to tens of kilometres from the piling location at the maximum hammer energies. Given that fact that the cumulative impact will be taking place at distance from herring spawning grounds and due to the short term, intermittent nature of the impact, cumulative significant effects are not predicted to any of fish and shellfish species. Since cumulative effects of piling may also lead to changes in the distribution of marine mammals (section 9.10.1), it is likely that marine mammal will be displaced from the same or greater area as for their prey species.

9.10.6.7 Seabed preparation and installation of foundations and cables for the Morgan Generation Assets alongside Tier 1 projects may increase SSC and associated sediment deposition. As discussed in detail in volume 2, chapter 8: Fish and shellfish ecology of the PEIR, resultant plumes from aggregate extraction or dredging would be advected on the tidal currents, travel in parallel, and not towards one another, and are unlikely to interact. Temporarily overlapping construction activities at Awel y Môr Offshore Wind Farm 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 estimates as minor adverse and therefore this is unlikely to impact marine mammals.

9.10.6.8 The temporal overlap between Tier 1 projects will result in a cumulative increase in the introduction of similar new hard structures. Potential adverse/beneficial effects on fish and shellfish would be localised due to the relatively small area of new hard structures introduced during this phase, compared to the wider cumulative marine mammals study area. As discussed in section 9.8.9, some increased foraging activities could benefit prey availability for marine mammals although this is unlikely to be at a scale that is measurable in terms of the populations within the wider region.

9.10.6.9 No significant adverse cumulative effects were predicted to occur to fish and shellfish species (marine mammal prey) as a result of the construction of the Morgan Generation Assets in combination with Tier 1 projects (volume 2, chapter 8: Fish and shellfish ecology of the PEIR). Therefore, changes in prey availability on marine mammals were predicted to be of local spatial extent, medium-term duration, intermittent/continuous and high reversibility. The magnitude was therefore, considered to be **low.**

**Sensitivity of the receptor**

9.10.6.10 The sensitivity of marine mammals to changes in prey availability was as described in paragraph 9.8.9.10 for the Morgan Generation Assets alone.

9.10.6.11 Most of the marine mammals within the regional marine mammal study area are known to forage over wide areas and exploit a range of prey species. For example, as described in more detail in volume 4, annex 9.1: Marine mammal technical report of the PEIR, a study of the stomach contents of 12 bottlenose dolphin in Irish waters gave a total of 37 prey taxa, suggesting that they have a broad diet. For most marine mammals, the type of food taken depends on local availability and seasonal variations.

Therefore, whilst there may be some potential for cumulative effects to fish and shellfish communities, these effects will be highly localised and short term and therefore marine mammals are likely to be able to compensate and move to alternative foraging grounds.

9.10.6.12 In the Irish sea, herring is an important prey species for harbour porpoise, short-beaked common dolphin, harbour seal and the key prey item for minke whale (see volume 4, annex 9.1: Marine mammal technical report of the PEIR for more detailed account for marine mammal diet), and therefore any significant impacts on herring may impact these predators. Sprat and sandeel are also a part of marine mammal diet (especially for harbour porpoise, minke whale, grey seal and harbour seal). As described above, most species of marine mammal prey on a wide variety of fish species and therefore are likely to be able to adapt to a minor shift in availability of some prey items. Nevertheless, minke whale may be more sensitive than other marine mammal species to changes in prey resources due to their reliance on herring, sprat and sandeel as a primary food source in the Irish Sea.

9.10.6.13 As mentioned for the Morgan Generation Assets alone in paragraph 9.8.9.22, 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. Higher trophic levels, such as fish and marine mammals, are likely to profit from locally increased food availability and/or shelter and therefore have the potential to be attracted to forage within Tier 1 offshore wind project array areas. Although species such as harbour porpoise, minke whale, white-beaked dolphin, harbour seal and grey seal were frequently recorded around offshore oil and gas structures, still relatively little is known about the distribution and diversity of marine mammals around offshore anthropogenic structures.

9.10.6.14 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**.

9.10.6.15 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**

9.10.6.16 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

9.10.6.17 Potential cumulative impacts from Tier 1 projects on marine mammal prey species during the operations and maintenance phase of the Morgan Generation Assets have been assessed in volume 2, chapter 8: Fish and shellfish ecology of the PEIR. The operations and maintenance of the Morgan Generation Assets, together with activities at other offshore wind farms may lead to cumulative impacts on marine mammals from changes in prey availability as a result of changes to the fish and shellfish community.

**Magnitude of impact**

9.10.6.18 Potential cumulative effects on marine mammal prey species during the operations and maintenance phase of the Morgan Generation Assets include long term subtidal habitat loss, EMF from subsea electrical cables and colonisation of hard structures.

9.10.6.19 In terms of long term habitat loss, the effects on fish and shellfish receptors arising during operations and maintenance activities of the Awel y Môr Offshore Wind Farm and the Morgan Generation Assets are likely to be very localised as described for the Morgan Generation Assets operations and maintenance phase alone (paragraph 9.8.9.22. The significance of long-term habitat loss for fish and shellfish has been assessed as minor adverse. Long-term habitat loss and associated colonisation expected for operations and maintenance phase are the key effects but these are unlikely to contribute to any measurable effects at a population level for marine mammals IEFs.

9.10.6.20 Cumulative impacts from EMF associated with the Tier 1 Awel y Môr Offshore Wind Farm will originate from the project's inter-array, interconnector, and offshore export cables, which have the potential for creating a cumulative impact with the cables of the Morgan Generation Assets. The minimum burial depth for cables for Awel y Môr Offshore Wind Farm is expected to be 1m, likely limiting EMFs to a range of up to 10m from the cable (RWE, 2022). .

9.10.6.21 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 projects (volume 2, chapter 8: Fish and shellfish ecology of the PEIR). Whilst most impacts are considered to be adverse there is the potential for some beneficial impacts 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 the receptor**

9.10.6.22 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 in paragraph 9.10.6.10.

9.10.6.23 The sensitivity of the receptor is therefore, considered to be **low to medium.**

**Significance of effect**

9.10.6.24 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.

### Tier 2

## Construction phase

9.10.6.25 Potential cumulative effects from Tier 2 projects on marine mammal prey species during the construction phase of the Morgan Generation Assets have been assessed in Volume 2, chapter 8: Fish and shellfish of the PEIR. The construction of the Morgan Generation Assets, together with the construction of the Tier 1 and Tier 2 projects – the Mona Offshore Wind Project, the Morecambe Offshore Windfarm Generation Assets and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets (volume 2, chapter 8: Fish and shellfish ecology of the PEIR) may lead to cumulative impacts on marine mammals from changes in prey availability as a result of changes to the fish and shellfish community.

#### Magnitude of impact

9.10.6.26 Potential cumulative effects from Tier 2 projects on marine mammal prey species during the construction phase of the Morgan Generation Assets include temporary subtidal habitat loss, long term subtidal habitat loss, injury and disturbance from underwater sound, increased SSC and associated sediment deposition and colonisation of hard structures.

9.10.6.27 The temporary and permanent habitat loss/disturbance predicted to result from the Mona Offshore Wind Project during construction phase is up to 131,068,792m$^2$ and 2,363,092m$^2$ (2.36km$^2$), respectively (Mona Offshore Wind Ltd, 2023). The area available for colonisation for the Mona Offshore Wind Project was estimated as up to 2,856,296m$^2$ (Mona Offshore Wind Ltd, 2023). The increases in SSC and sediment deposition predicted to result from the Mona Offshore Wind Project are similar to those reported for the Morgan Generation Assets with the displacement of up to 33,072,196m$^3$ of total spoil volume.

9.10.6.28 No detailed information was available for the extent of temporary or long-term habitat loss, underwater sound, increased SSC and colonisation of hard structures associated with the Morecambe Offshore Windfarm Generation Assets and Morgan and the Morecambe Offshore Wind Farms Transmission Assets. Therefore, it is not possible to undertake full, quantitative assessment for these impacts and a summary of qualitative assessment is provided below.

9.10.6.29 For Morecambe Offshore Windfarm Generation Assets and Morgan and the Morecambe Offshore Wind Farms Transmission Assets projects, temporary habitat loss is likely to result from site preparation activities in advance of installation activities, cable installation activities and placement of spud-can legs from jack-up operations. Installation of foundation structures, associated scour protection and cable protection is likely to result in long term habitat loss and provide a hard substrate for colonisation. Increased SSC and sediment deposition is likely to occur from site preparation activities including sandwave clearance, drilling for foundation installation, and cable installation and burial activities.

9.10.6.30 As assessed for Tier 1 projects in paragraph 9.10.6.3 with respect to indirect effects on marine mammals, no additional cumulative effects other than those assessed for injury and disturbance to marine mammals as a result of elevated underwater sound during piling (section 9.10.1) are predicted. This is because if prey are disturbed or move away from an area as a result of underwater sound, it is assumed that marine mammals are likely to be disturbed from the same or greater area, and so any changes to the distribution of prey resources would not affect marine mammals as they would already be disturbed from the same (or larger) area.

9.10.6.31 No significant adverse cumulative effects were predicted to occur to fish and shellfish species (marine mammal prey) as a result of the construction of the Morgan Generation Assets in combination with Tier 1 and Tier 2 projects (volume 2, chapter 8: Fish and shellfish ecology of the PEIR). Therefore, changes in prey availability on marine mammals were predicted to be of local spatial extent, medium-term duration, intermittent/continuous and high reversibility. The magnitude was therefore, considered to be **low**.

#### Sensitivity of the receptor

9.10.6.32 The sensitivity of marine mammals to changes in prey availability was as described in paragraph 9.10.6.10 for Tier 1 projects.

9.10.6.33 The sensitivity of the receptor is therefore, considered to be **low to medium.**

#### Significance of effect

9.10.6.34 Overall, the magnitude of the cumulative impact was deemed to be **low** and the sensitivity of the receptor was considered to be **low to medium**. 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 was not significant in EIA terms.

## Operations and maintenance phase

9.10.6.35 Potential cumulative effects from Tier 2 projects on marine mammal prey species during the operations and maintenance phase of the Morgan Generation Assets have been assessed in volume 2, chapter 8: Fish and shellfish ecology of the PEIR. The operations and maintenance of the Morgan Generation Assets, together with the activities at Tier 1 wind farms and operations and maintenance phases of the Tier 2 projects – the Mona Offshore Wind Project, the Morecambe Offshore Windfarm Generation Assets and Morgan and Morecambe Offshore Wind Farms: Transmission Assets may lead to cumulative impacts on marine mammals from changes in prey availability as a result of changes to the fish and shellfish community.

#### Magnitude of impact

9.10.6.36 Potential cumulative effects from Tier 2 projects on marine mammal prey species during the operations and maintenance phase of the Morgan Generation Assets include long term subtidal habitat loss, EMF from subsea electrical cabling and colonisation of hard structures.

9.10.6.37 The long term habitat loss predicted to result from the Mona Offshore Wind Project during operations and maintenance phase is up 2.36km$^2$ (Mona Offshore Wind Ltd, 2023). The area available for colonisation for the Mona Offshore Wind Project was estimated as up to 2,854,062m$^2$ (Mona Offshore Wind Ltd, 2023). In terms of impacts as a result of electromagnetic fields for the Mona Offshore Wind Project, this is likely to result from the operation of up to 500km of 66kV to 132kV inter-array cables, 50km of 275kV HVAC interconnector cable, and up to 360km of 275kV HVAC offshore export cables. Due to similar sizes and extents to the Mona Offshore Wind Project, the effects of EMFs are likely to be similar.

9.10.6.38 At the time of writing, no detailed information was available for the extent or magnitude of impacts listed above associated with the Morecambe Offshore Windfarm Generation Assets and Morgan and the Morecambe Offshore Wind Farms Transmission Assets. Therefore it is not possible to undertake full, quantitative assessment for these impacts and a summary of qualitative assessment is provided below.

9.10.6.39 Presence of foundation structures, associated scour protection and cable protection is likely to result in long term habitat loss for fish species but also provide a hard substrate for colonisation. The maximum EMF impacts associated with the Morecambe Offshore Windfarm Generation Assets and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets projects will originate from the inter-array and interconnector cables and may impact prey sources themselves for marine mammals, however the magnitude is likely to be low for fish and shellfish species and therefore is unlikely to affect marine mammals in the context of their wider available foraging habitat.

9.10.6.40 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 8: Fish and shellfish ecology of the PEIR). Whilst most impacts are considered to be adverse there is the potential for some beneficial impacts 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 the receptor

9.10.6.41 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 for Tier 1 projects in paragraph 9.10.6.10.

9.10.6.42 The sensitivity of the receptor is therefore, considered to be **low to medium.**

#### Significance of effect

9.10.6.43 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 phase

9.10.6.44 Potential cumulative effects on marine mammal prey species during the decommissioning of the Morgan Generation Assets have been assessed in volume 2, chapter 8: Fish and shellfish of the PEIR. The decommissioning of the Tier 2 projects – the Mona Offshore Wind Project, Morecambe Offshore Windfarm Generation Assets and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets will likely have temporal overlap with the decommissioning of the Morgan Generation Assets, which may lead to cumulative impacts on marine mammals from changes in prey availability as a result of changes to the fish and shellfish community.

#### Magnitude of effect

9.10.6.45 Potential cumulative effects on marine mammal prey species during the decommissioning of the Morgan Generation Assets include temporary subtidal habitat loss, long term subtidal habitat loss, increased SSC and associated sediment deposition and colonisation of hard structures.

9.10.6.46 The temporary habitat disturbance predicted to result from the Mona Offshore Wind Project during decommissioning phase is up to 910,800m$^2$ (Mona Offshore Wind Ltd, 2023). The expected magnitude of the long term habitat loss and colonisation of hard structures and SSC will be similar or less to the construction and operations and maintenance phases, due to the leaving in place of scour protection, and cable protection, with no associated sediment clearance or drilling required.

9.10.6.47 At the time of writing, no detailed information was available for the extent or magnitude of impacts listed above associated with the Morecambe Offshore Windfarm Generation Assets and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets. Therefore, it is not possible to undertake full, quantitative assessment for these impacts and a summary of qualitative assessment is provided below.

9.10.6.48 For Morecambe Offshore Windfarm Generation Assets and Morgan and the Morecambe Offshore Wind Farms Transmission Assets, the expected cumulative magnitude of temporary habitat loss, long term habitat loss, increased SSC and associated sediment deposition and colonisation of hard structures during decommissioning is expected to be similar or less than the construction phase provided in paragraph 9.10.6.29.

9.10.6.49 No significant adverse cumulative effects were predicted to occur to fish and shellfish species (marine mammal prey) as a result of the decommissioning of the Morgan Generation Assets in combination with Tier 1 and Tier 2 projects (volume 2, chapter 8: Fish and shellfish ecology of the PEIR). Whilst most impacts are considered to be adverse there is the potential for some beneficial impacts 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, intermittent/continuous and high reversibility. The magnitude was therefore, considered to be **low**.

#### Sensitivity of the receptor

9.10.6.50 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 for Tier 1 projects in paragraph 9.10.6.10.

9.10.6.51 The sensitivity of the receptor is therefore, considered to be **low to medium.**

**Significance of effect**

9.10.6.52 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.

## Tier 3

### Construction phase

9.10.6.53 The construction of the Morgan Generation Assets, together with Tier 1 and Tier 2 projects as well as the Tier 3 project, MaresConnect may lead to cumulative impacts on marine mammals from changes in prey availability as a result of changes to the fish and shellfish community (Volume 2, chapter 8: Fish and shellfish of the PEIR).

**Magnitude of impact**

9.10.6.54 Potential cumulative effects from Tier 3 project on marine mammal prey species during the construction phase of the Morgan Generation Assets include temporary subtidal habitat loss, long term subtidal habitat loss, increased SSC and associated sediment deposition and colonisation of hard structures.

9.10.6.55 The laying and burying of the MaresConnect Interconnector cable may involve introduction of cable protection (assumed as maximum design scenario) which will represent long term habitat loss and will likely follow standard jet trenching and cable protection installation, causing temporary habitat disturbance, although technical specifications will only be released at later development stages. Although no exact specifications are publicly available for the area for potential colonisation, 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. However, given the project is predicted to be operational in 2026, there is unlikely to be any overlap with the Morgan Generation Assets construction phase and therefore there is a no potential for cumulative effects on marine mammal prey species.

9.10.6.56 No significant adverse cumulative effects were predicted to occur to fish and shellfish species (marine mammal prey) as a result of the construction of the Morgan Generation Assets in combination with Tier 1, Tier 2 and Tier 3 projects (volume 2, chapter 8: Fish and shellfish ecology of the PEIR). Therefore, changes in prey availability on marine mammals were predicted to be of local spatial extent, medium-term duration, intermittent/continuous and high reversibility. The magnitude was therefore, considered to be **low**.

**Sensitivity of the receptor**

9.10.6.57 The sensitivity of marine mammals to changes in prey availability was as described in paragraph 9.10.6.10 for Tier 1 projects.

9.10.6.58 The sensitivity of the receptor is therefore, considered to be **low to medium.**

**Significance of effect**

9.10.6.59 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

9.10.6.60 The operations and maintenance of the Morgan Generation Assets, together with Tier 1 and Tier 2 projects as well as the Tier 3 project, MaresConnect may lead to cumulative impacts on marine mammals from changes in prey availability as a result of changes to the fish and shellfish community (Volume 2, chapter 8: Fish and shellfish of the PEIR).

**Magnitude of impact**

9.10.6.61 Potential cumulative effects from Tier 3 projects on marine mammal prey species during the operations and maintenance phase of the Morgan Generation Assets include long term subtidal habitat loss, EMF from subsea electrical cabling and colonisation of hard structures.

9.10.6.62 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 2026.

9.10.6.63 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 cumulative fish and shellfish ecology study area, and so will have only a minor cumulative impact. Effects of EMFs on fish and shellfish receptors are expected to be small and limited to directly around the cable.

9.10.6.64 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, Tier 2 and Tier 3 projects (volume 2, chapter 8: Fish and shellfish ecology of the PEIR). Whilst most impacts are considered to be adverse there is the potential for some beneficial impacts 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 the receptor**

9.10.6.65 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 for Tier 1 projects in paragraph 9.10.6.10.

9.10.6.66 The sensitivity of the receptor is therefore, considered to be **low to medium.**

**Significance of effect**

9.10.6.67 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.

### 9.10.7 Future monitoring

9.10.7.1 As per section 9.8.10 above.

## 9.11 Transboundary effects

9.11.1.1 A screening of 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.

9.11.1.2 Screening of transboundary effects are given in volume 3, Chapter 5.3 Transboundary impacts screening of the PEIR. 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 into Irish and Manx waters and therefore animals transiting between these waters could be behaviourally disturbed across different states. The assessment of the project 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.

9.11.1.3 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 15.3km (for harbour porpoise) whilst a moving away response, using the TTS metric, was predicted up to 34.4km (for minke whale). Ranges of this extent could affect individuals in transboundary nations. These predictions are, however, highly precautionary since low order clearance techniques may be used, which would considerably reduce the potential injury and/or disturbance ranges. For injury, tertiary mitigation measures will also be applied to reduce the risk of PTS (Table 9.16) and with these in place the assessment concluded the magnitude for the project alone, with respect to the relevant MUs, would be negligible to low. Marine mammals are considered to be of high sensitivity to PTS and therefore the significance of effects are of minor adverse significance. UXO clearance would result in very short term impacts on marine mammal IEFs and the assessment concluded the magnitude for the project alone with tertiary measures, with respect to the relevant MUs, would be low or negligible for PTS and low for TTS. Marine mammals are considered to be of high sensitivity to PTS and low to TTS. Therefore the significance of disturbance from UXO clearance at a transboundary level is considered to be minor adverse which is not significant in terms of EIA Regulations.

9.11.1.4 Geophysical and geotechnical surveys, vessel use and other (non-piling) activities could also lead to large disturbance ranges. For vibro-coring, the range of disturbance could extend out to 55km and for SBP (chirp/pinger) disturbance could extend out to 17.3km (all species). For vessels such as survey and support vessels, crew transfer vessels, and installation vessels the range of disturbance could extend out to 21km and for cable trenching the range of disturbance could extend out to 18km. Ranges of this extent could affect individuals in transboundary nations. 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 (rms) threshold, and there is no distinction between mild and strong disturbance, it can be assumed that not all animals found within those ranges would be disturbed. 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.

9.11.1.5 For other impacts, including other (non-piling) activities, collision risk, changes in prey availability and operational 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.

## 9.12 Inter-related effects

9.12.1.1 Inter-relationships are considered to be the 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.

9.12.1.2 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 PEIR.

9.12.1.3 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 to marine mammals from elevated underwater sound during site investigation surveys
- injury and disturbance to marine mammals from elevated underwater sound during UXO clearance
- injury and disturbance to marine mammals from elevated underwater sound due to vessel use and other activities
- increased potential to experience injury by marine mammals due to collision with vessels
- changes in fish and shellfish communities affecting prey availability.

## 9.13 Summary of impacts, mitigation measures and monitoring

9.13.1.1 Information on marine mammals within the Morgan Marine Mammal study area was collected through desktop review, site surveys and consultation with the EWG.

9.13.1.2 Table 9.54 presents a summary of the potential impacts, measures adopted as part of the project and residual effects in respect to marine mammals. The impacts assessed include:

- Injury and disturbance from elevated underwater sound during piling
- Injury and disturbance to marine mammals from elevated underwater sound during UXO clearance
- Increased risk of injury of marine mammals due to collision with vessels
- Injury and disturbance to marine mammals from elevated underwater sound during site investigation surveys
- underwater sound from wind turbine operation
- Changes in fish and shellfish communities affecting prey availability.

9.13.1.3 Overall 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.

9.13.1.4 Table 9.55 presents a summary of the potential cumulative impacts, mitigation measures and residual effects. The cumulative impacts assessed include:

- Injury and disturbance from underwater sound generated during piling
- Injury and disturbance from pre-construction site investigation surveys
- Injury and disturbance from underwater sound from UXO detonation
- Injury due to increased risk of collision with vessels
- Effects on marine mammals due to changes in prey availability.

9.13.1.5 Overall it is concluded that 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 dolphins within the Irish Sea MU. Cumulative impact of piling at projects across the Irish Sea could result in potential reductions to lifetime reproductive success 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. Options for reducing project-alone effects will be explored for the final Environmental Statement.

9.13.1.6 No potential for significant transboundary impacts have been identified in regard to effects of the Morgan Generation Assets.

**Table 9.54: 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 underwater sound generated during piling | ✓ | | | Implementation of initiation stage, soft start, ramp up (primary measures); use of MMO, PAM, ADD (tertiary measures). | Harbour porpoise | Low (injury) Low (disturbance) | High (injury) Medium (disturbance) | Minor adverse (injury/disturbance) | None | Minor adverse (injury/disturbance) | To be agreed post consent and therefore none proposed for PEIR. |
| | | | | | 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) Negligible (disturbance) | High (injury) Medium (disturbance) | Minor adverse (injury/disturbance) | | Minor adverse (injury/disturbance) | |
| Injury and disturbance from elevated underwater sound during UXO clearance | ✓ | | | Inclusion of low order techniques as an option (primary measures); use of MMO, PAM, ADD and soft start charges (tertiary measures) | Harbour porpoise | Low (injury) Low (disturbance) | High (injury) Low (disturbance) | Minor adverse (injury/disturbance) | None | Minor 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) | |
| Injury and disturbance to from elevated underwater sound due to vessel use and other 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) | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 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 risk of injury of 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 | |
| Injury and disturbance from elevated underwater sound during site investigation surveys | ✓ | | | Implementation of soft start and ramp up where possible (primary measures); use of MMO, PAM, (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) | |
| 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) | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Short-beaked common dolphin | Negligible (injury)<br>Low (disturbance) | High (injury)<br>Medium (disturbance) | Minor adverse (injury/disturbance) | | Minor adverse (injury/disturbance) | |
| | | | | | Risso's dolphin | Negligible (injury)<br>Low (disturbance) | High (injury)<br>Medium (disturbance) | Minor adverse (injury/disturbance) | | Minor adverse (injury/disturbance) | |
| | | | | | Minke whale | Negligible (injury)<br>Low (disturbance) | High (injury)<br>Medium (disturbance) | Minor adverse (injury/disturbance) | | Minor adverse (injury/disturbance) | |
| | | | | | Grey seal | Negligible (injury)<br>Low (disturbance) | High (injury)<br>Medium (disturbance) | Minor adverse (injury/disturbance) | | Minor adverse (injury/disturbance) | |
| | | | | | Harbour seal | Negligible (injury)<br>Low (disturbance) | High (injury)<br>Medium (disturbance) | Minor adverse (injury/disturbance) | | Minor adverse (injury/disturbance) | |
| Changes in fish and shellfish communities affecting prey availability | ✓ | ✓ | ✓ | 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 | |
| | | | | | 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 9.55: 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 MMO, PAM, ADD (tertiary measures). | Harbour porpoise | Low | Medium | Minor adverse | Requirements for mitigation will be discussed with the EWG, and other relevant consultees, post PEIR submission | 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 | |
| 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 MMO, PAM, ADD and soft start charges (tertiary measures) | Harbour porpoise | Low (injury)<br>Low (disturbance) | High (injury)<br>Low (disturbance) | Minor adverse | None | Minor adverse | None |
| | | | | | Bottlenose dolphin | Negligible (injury)<br>Low (disturbance) | High (injury)<br>Low (disturbance) | Minor adverse | | Minor adverse | |
| | | | | | Short-beaked common dolphin | Negligible (injury)<br>Low (disturbance) | High (injury)<br>Low (disturbance) | Minor adverse | | Minor adverse | |
| | | | | | Risso's dolphin | Negligible (injury)<br>Low (disturbance) | High (injury)<br>Low (disturbance) | Minor adverse | | Minor adverse | |
| | | | | | Minke whale | Negligible (injury)<br>Low (disturbance) | High (injury)<br>Low (disturbance) | Minor adverse | | Minor adverse | |
| | | | | | Grey seal | Negligible (injury)<br>Low (disturbance) | High (injury)<br>Low (disturbance) | Minor adverse | | Minor adverse | |
| Injury and disturbance to marine mammals from elevated underwater sound due to vessel use and other activities | ✓ | ✓ | × | 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 | |
| Increased risk of injury of marine | ✓ | ✓ | × | 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 | |

| 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 | | | | | | | | |
| mammals due to collision with vessels | | | | transiting vessels (tertiary measures) | 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 | |
| | | | | | 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 MMO, PAM, ADD (tertiary measures). | Harbour porpoise | Low | Medium | Minor adverse | Requirements for mitigation will be discussed with the EWG, and other relevant consultees, post PEIR submission | 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 | |
| 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 MMO, PAM, ADD and soft start charges (tertiary measures) | Harbour porpoise | Low (injury)<br>Low (disturbance) | High (injury)<br>Low (disturbance) | Minor adverse | None | Minor adverse | None |
| | | | | | Bottlenose dolphin | Negligible (injury)<br>Low (disturbance) | High (injury)<br>Low (disturbance) | Minor adverse | | Minor adverse | |
| | | | | | Short-beaked common dolphin | Negligible (injury)<br>Low (disturbance) | High (injury)<br>Low (disturbance) | Minor adverse | | Minor adverse | |
| | | | | | Risso's dolphin | Negligible (injury)<br>Low (disturbance) | High (injury)<br>Low (disturbance) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Minke whale | Negligible (injury)<br>Low (disturbance) | High (injury)<br>Low (disturbance) | Minor adverse | | Minor adverse | |
| | | | | | Grey seal | Negligible (injury)<br>Low (disturbance) | High (injury)<br>Low (disturbance) | Minor adverse | | Minor adverse | |
| | | | | | Harbour seal | Negligible (injury)<br>Low (disturbance) | Medium | Minor adverse | | Minor adverse | |
| Injury and disturbance to marine mammals from elevated underwater sound due to vessel use and other activities | ✓ | ✓ | × | 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 | |
| Increased risk of injury of marine mammals 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 | |
| Injury and disturbance from pre-construction site-investigation surveys | ✓ | × | × | Implementation of soft start and ramp up where possible (primary measures); use of MMO, PAM (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 | |
| **Tier 3** | | | | | | | | | | | |
| Injury and disturbance to marine mammals from elevated underwater sound due to vessel use and other activities | ✓ | ✓ | × | 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 | |
| Increased risk of injury of marine mammals 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 | |
| | | | | | Minke whale | Low | Medium | Minor adverse | | Minor adverse | |
| | | | | | Grey seal | Low | Low | Minor adverse | | Minor adverse | |
| | | | | | Harbour seal | Low | Low | Minor adverse | | Minor adverse | |

## 9.14 Next steps

9.14.1.1 As outlined in section 9.4.3, to date, only one year of the two-year site-specific survey data for Morgan Generation Assets has been available to inform this chapter. The baseline description and impact assessments in this chapter will therefore be updated with this additional data for the final Environmental Statement. Measures to minimise the potential for a significant cumulative effect on the bottlenose dolphin IS MU are currently being investigated and will be discussed with the Expert Working Group through the Evidence Plan process and included in the Environmental Statement.

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# Appendix A: Marine mammal population modelling report

## A.1 Introduction

9.15.1.1 A Preliminary Environmental Information Report (PEIR) 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 individuals. Underwater sound modelling was undertaken to predict the potential spatial scale of the impact.

9.15.1.2 Two foundation types, monopiles and pin piles, were assessed in the EIA with monopiles leading to the greatest number of animals affected at any one time (Table 9.14). Whilst the number of days on which piling could occur was greater for pin piles than monopiles (i.e. 112 days and 70 days respectively) monopile foundations represented the maximum adverse scenario due to the higher hammer energies. In particular, for behavioural disturbance, the assessment predicted that the elevations in underwater sound leading to disturbance could extend over a considerable area and potentially affect a large number of individuals of the key species identified within the Morgan marine mammal study area.

9.15.1.3 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, to result in long term population level effects on any species. The interim Population Consequences of Disturbance (iPCoD) model (developed by Sea Mammal Research Unit (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 explained within this appendix.

### A.1.1 iPCoD modelling

9.15.1.4 The iPCoD model simulates the changes in a population over time, for both a disturbed and an undisturbed population. This provides a comparison of the type of changes that could occur resulting 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, such as Awel y Môr Offshore Wind Farm Environmental Statement (2022), and consented projects (e.g. Hornsea Project Three Offshore Wind Farm).

9.15.1.5 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 Permanent Threshold Shift (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). 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 a 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).

9.15.1.6 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-dependant 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-dependant factors become limiting again (i.e. population remains at carrying capacity). The limitations for assuming a simple linear ratio between the maximum net productivity level and carrying capacity have been highlighted by Taylor and Master (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.

## A.2 Methodology

### A.2.1 Piling parameters

#### A.2.1.1 Maximum design scenario

9.15.1.7 The maximum design scenario (MDS) for piling at Morgan Generation Assets assumes installation of up to 68 wind turbines each with one monopile and one OSP with two monopile foundations, and a maximum hammer energy of up to 5,500kJ, totalling up to 70 days of piling.

9.15.1.8 For monopiles the largest hammer energy and maximum spacing between concurrent piling events 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.

9.15.1.9 The maximum temporal scenario was assessed on the greatest number of days on which piling could occur based on the number of piles that could be installed within a 24-hour period. For monopiles, this is a maximum of up to 9.5 hours of piling for a monopile with a cumulative total of up to 665 hours. One monopile is installed per 24 hours per vessel, leading to 70 days for a single vessel (maximum temporal) or 35 days for two vessels (maximum spatial).

9.15.1.10 It is estimated that piling activity Morgan Generation Assets will take place within a two year timeframe (2027 and 2028). Piling could potentially take place at any point within the foundation installation phase, however, for the purposes of developing the piling spreadsheet programme 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, given in Table A.1.

**Table A.1: Indicative piling construction programme (2027 and 2028) Morgan Generation Assets project within the four year offshore construction phase (2026 to 2029).**

| Year | Month | Days piling per month | |
|---|---|---|---|
| | | Monopile Single | Monopile Concurrent |
| 2026 | No piling | | |
| 2027 | Jan | 4 | 2 |
| | Feb | 2 | 1 |
| | Mar | 4 | 2 |
| | Apr | 2 | 1 |
| | May | 4 | 2 |
| | Jun | 2 | 1 |
| | Jul | 4 | 1 |
| | Aug | 2 | 2 |
| | Sep | 2 | 1 |
| | Oct | 4 | 2 |
| | Nov | 2 | 1 |
| | Dec | 4 | 2 |
| 2028 | Jan | 2 | 1 |
| | Feb | 4 | 1 |
| | Mar | 2 | 2 |
| | Apr | 4 | 1 |
| | May | 2 | 2 |
| | Jun | 2 | 1 |
| | Jul | 4 | 2 |
| | Aug | 2 | 1 |
| | Sep | 4 | 2 |
| | Oct | 2 | 1 |
| | Nov | 4 | 1 |
| | Dec | 2 | 2 |
| 2029 | | No piling | |
| **Total piling days** | | **70** | **35** |

## A.3 Model inputs

### A.3.1 Key species

9.15.1.11 Key species included in the population modelling were:

- Harbour porpoise *Phocoena phocoena*
- Bottlenose dolphin *Tursiops truncatus*
- Minke whale *Balaenoptera acutorostrata*
- Grey seal *Halichoerus grypus*.

9.15.1.12 Inclusion of these species will be discussed with the marine mammal EWG.

### A.3.2 Demographic parameters

9.15.1.13 The iPCoD model v5.2[3] was set up using the program R v4.1.2 (2021) with RStudio 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.

9.15.1.14 Demographic parameters for the key species in the population model are presented in Table A.2, chosen from both Sinclair *et al*. (2020) and using parameters from sources as recommended by Natural Resources Wales (NRW) following consultation (Leonie Richardson, *pers. comm.* 21.10.22). Values included survival and reproductive rates for harbour porpoise (Murphy *et al* 2015; 2020), calf survival (Pesante *et al.*, 2008; Feingold & Evans, 2014) and fertility rate (Arso Civil, 2017) for bottlenose dolphin.

[3] https://smruconsulting.com/?page_id=13194

**Table A.2: Demographic parameters recommended for each species for the relevant reference population (Sinclair *et al.,* 2020 and consultation with NRW).**

a parameter taken from Sinclair *et al.,* 2020 - Review of demographic parameters

b parameter recommended in NRW personal communication.

c Population estimates for SMUs are taken from Sinclair et al. (2022) report, Ireland regions from Duck and Morris, 2019 and Isle of Man population from Howe (2018).

| Species | Management Unit /Seal Management Unit | Population | Age Calf/Pup Becomes Independent | Age of First Birth | Calf/Pup Survival | Juvenile Survival | Adult Survival | Fertility | Growth Rate |
|---|---|---|---|---|---|---|---|---|---|
| Harbour porpoise | Irish and Celtic Seas | 62,517 | 1[a] | 5[a] | 0.60 (0.85)[b] | 0.85[b] | 0.90 (0.85/0.925)[b] | 0.5 (0.68)[b] | 1 |
| Bottlenose dolphin | Irish Sea (IS) | 293 | 2 [a] | 9 [a] | 0.87[b] | 0.93 (0.96)[b] | 0.94 (0.96)[b] | 0.22 (0.16/0.30)[b] | 1 |
| | IS plus Offshore Channel and South West (OCSW) | 293 + 10,947 = 11,240 | | | | | | | |
| Minke whale | Celtic and Greater NS | 20,118 | 1[a] | 9[a] | 0.7[a] | 0.77[a] | 0.96[a] | 0.91 [a] | 1 |
| Grey seal | OSPAR Region III | 60,780 | 1[a] | 5[a] | 0.22[a] | 0.94[a] | 0.94[a] | 0.9 [a] | 1.01 |
| | Grey Seal Reference population = Four SMUS (Sinclair and Wright, 2022) plus SE and E Ireland survey regions (Duck and Morris, 2019) plus Isle of Man estimate (Howe, 2018). | 13,563[c] | | | | | | | |

## A.3.3 Reference populations

9.15.1.15 Populations based upon Management Units (MUs) were specified in the model as the reference populations against which the effects (i.e. number of animals suffering PTS/disturbed) were assessed. The MUs were agreed during the Marine Mammals Expert Working Group process (EWG Meeting 02, Table 9.6). Table A.3 provides the reference populations used in the iPCoD.

9.15.1.16 During consultation multiple reference populations were suggested for pinniped species, to allow assessment to be conducted over different spatial scales. 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 two reference populations: OSPAR Region III area (west coast of UK + Ireland) and the four SMUs which cover the Irish Sea (12: Wales, 13: NW England, 14: Northern Ireland, 1: SW Scotland) plus the 'South-east' and 'East' survey regions in the Republic of Ireland which border the Irish Sea and the Isle of Man population, hereafter known as the 'Grey Seal Reference Population'. Population estimates for the SMUs are from SCOS (2021) reported in Sinclair *et al.* (2022), from Duck and Morris (2019) for the two Irish survey regions and from Howe (2018) for the Isle of Man estimate.

**Table A.3: Reference Populations use in the iPCoD modelling.**

<table>
<tr><th>Species</th><th>MU</th><th colspan="2">Population</th><th>Reference</th></tr>
<tr><td>Harbour porpoise</td><td>Celtic and Irish Seas (CIS)</td><td colspan="2">62,517</td><td>IAMMWG 2015, 2021</td></tr>
<tr><td rowspan="2">Bottlenose dolphin</td><td>Irish Sea MU (IAMMWG, 2021)</td><td>293</td><td rowspan="2">Total: 11,240</td><td>SCANS-III estimate from IAMMWG (2021)</td></tr>
<tr><td>Offshore Channel and South West (OCSW)</td><td>10,947</td><td>SCANS-III estimate from IAMMWG (2021)</td></tr>
<tr><td>Minke whale</td><td>Celtic and Greater North Seas MU</td><td colspan="2">20,118</td><td>IAMMWG (2021)</td></tr>
<tr><td rowspan="2">Grey seal</td><td>OSPAR III</td><td colspan="2">60,780</td><td>OSPAR Region III area (west coast of UK + Ireland) as outlined in NRW position statement (NRW, 2022)</td></tr>
<tr><td>Grey Seal Reference Population consisting of:<br>• Four SMUS (12 Wales, 13 NW England, 14 Northern Ireland, 1 SW Scotland)<br>• South-east Ireland and East Ireland survey Regions<br>• Isle of Man estimate</td><td colspan="2">13,563:<br>• 9,088 Four SMUs<br>• 4,075 Ireland regions<br>• 400 Isle of Man</td><td>• Four SMUs from SCOS (2021), reported in Sinclair et al (2022).<br>• Duck and Morris, 2019<br>• Howe (2018)</td></tr>
</table>

## A.3.4 Residual days disturbance

9.15.1.17 Empirical evidence from constructed offshore wind farms (e.g. 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. Due to the potential duration of piling occurring at the Morgan Generation Assets (e.g. 9.5 hours per 24 hours for monopile or 19 hours per 24 hours for pin pile), piling could occur for most of the 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.

## A.3.5 Years of simulation

9.15.1.18 Whilst the operational lifetime of the Morgan Generation Assets is 35 years, the iPCoD file suggests users should be aware that the predictions of the model become increasingly uncertain as the number of years to be simulated is increased and suggests values in excess of 25 years are not usually recommended, therefore this iPCoD parameter ('years') was set for 25 years.

## A.3.6 Number of animals (PTS/disturbance)

9.15.1.19 The number of animals predicted to experience PTS and/or disturbance was based on the density values provided as part of the baseline assessment in volume 4, annex 9.1: Marine mammal technical report of the PEIR.

9.15.1.20 Where a range has been used for densities, maximum values were taken forward to the assessment in a conservative approach. For harbour porpoise, the maximum density is based upon the aerial digital surveys for the Morgan marine mammal study area. For bottlenose dolphin, the maximum density uses comparable coastal (6km region from coast) high densities from outer Cardigan Bay (Lohrengel et al., 2018). For pinnipeds, offshore densities are given for average and inshore densities are used for maximum, both taken from Carter *et al*. (2022) maps.

9.15.1.21 When assessing disturbance, the highest densities were also used for harbour porpoise and minke whale. For bottlenose dolphin, it can be reasonably assumed that most bottlenose dolphins will be located within a 6km region from the coastline, and those coastal areas may be comparable to other high use areas in the regional marine mammal study area (such as in outer Cardigan Bay which has higher densities, as described in Lohrengel *et al*., 2018). The assessment for bottlenose dolphin therefore considered the overlap of the ensonified area with the coastal areas; applying the higher density value of 0.035 animals per km$^2$ (as compared to the offshore density of 0.008 animals per km$^2$ given by SCANS-III). Proportional response was again applied for the predicted $SEL_{ss}$ levels which overlapped the coastal areas as per Graham *et al*., (2019).

9.15.1.22 For grey seal 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 5x5km grid cell was summed for each isopleth and corrected using the proportional response as per Whyte *et al.* (2020).

9.15.1.23 For all scenarios, primary and tertiary mitigation was applied (section 9.7). 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 PEIR) as well as use of ADD.

9.15.1.24 Currently the model for project alone assumes one animal experiencing PTS for harbour porpoise and minke whale only (Table A.4).

**Table A.4: Estimated number of animals predicted to be injured (PTS) or disturbed at any one time during piling based on the dual metric approach.**

| Species | Piling scenario | Animals disturbed | Animals injured (PTS) |
|---|---|---|---|
| Harbour porpoise | Single | 979 | 0 |
| | Concurrent | 1370 | 1 |
| Bottlenose dolphin | Single | 11 | 0 |
| | Concurrent | 16 | 0 |
| Minke whale | Single | 69 | 0 |
| | Concurrent | 96 | 1 |
| Grey seal | Single | 31 | 0 |
| | Concurrent | 48 | 0 |

## A.3.7 Piling Schedule

9.15.1.25 The piling schedule was developed from the project design envelope which provided an estimate of the number of days piling for the wind turbine and OSP foundations within a defined piling phase, which is scheduled to run for two years from 2027 to 2028, within a four year construction phase.

9.15.1.26 A total of 70 days for monopiles was estimated for single piling as per the MDS table (Table 9.15), assuming one monopile installed per 24 hours per vessel, and 35 days for concurrent piling of wind turbines with two vessels.

9.15.1.27 The first two time points in the model were selected to coincide with key periods of the piling schedule. Subsequent time points were selected up to year 25 as follows:

- Time point 2: end of the first year of piling
- Time point 3: end of the two year piling phase
- Time point 6: 5 years after the start of the piling phase (5 year impact)
- Time point 11: 10 years after the start of the piling phase
- Time point 21: 20 years after the start of the piling phase
- Time point 26: 25 years after the start of the piling phase.

## A.3.8 Cumulative projects

9.15.1.28 Cumulative projects for marine mammals were considered across the regional marine mammal study area, which encompasses the Irish Sea and Celtic Seas. A summary of the cumulative projects is provided in Table A.5 and indicative offshore construction schedules in Table A. 6Table A.5

9.15.1.29 The assessment carried forward to the cumulative assessment for Morgan Generation Assets was for concurrent piling of monopiles (5,500kJ) as this represented the highest numbers of animals injured and disturbed.

9.15.1.30 The number of animals injured (PTS) for Morgan Generation Assets when primary mitigation is applied is included in the models as precautionary approach, however the application of standard offshore wind industry construction methods (which include soft starts, visual and acoustic monitoring of marine mammals and activation of an acoustic deterrent device) are anticipated to reduce magnitude of impact with respect to auditory injury in marine mammals. Therefore, no potential for significant cumulative impacts for injury from elevated underwater sound during pilling is anticipated (i.e. the parameter for PTS for other cumulative projects is given as zero) and the cumulative assessment focuses on disturbance only.

**Table A.5: Indicative offshore piling scenarios and schedules for cumulative projects.**

| Project | Max. no. of foundations | Scenario | Piling Duration (days) | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 onward | Operational end date |
|---|---|---|---|---|---|---|---|---|---|---|
| Morgan Generation Assets | 70 | Monopile (concurrent) | 35 | | | Piling | Piling | | Operational | 2064 |
| Awel y Môr | 50 | Monopile | 201 | | | | Piling | | Operational | 2064 |
| Erebus | 35 | Pin-pile | 18 | Piling | | | | | Operational | 2055 |

9.15.1.31 The iPCoD model was set up as described above in terms of the demographic parameters (section A.3.2), reference populations (section A.3.3) and with the same days of residual disturbance specified (section A.3.4). 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 projects and has been referenced in the following sections. As piling schedules were unknown, the piling days were spread evenly throughout the offshore construction phases shown in Table A. 6. The model start period was 2025.

9.15.1.32 Time points in the model were selected to coincide with the following periods:

- time point 1: start of 2025, piling commences at Project Erebus
- time point 2: start of 2026, construction period of Project Erebus finishes and construction periods of Morgan Generation Assets and Awel y Môr Offshore Wind Farm begins
- time point 3: 2027, piling begins at Morgan Generation Assets
- time point 4: 2028, piling continues at Morgan Generation Assets and begins at Awel y Môr Offshore Wind Farm
- time point 5: 2029, piling has ended at Morgan Generation Assets and Awel y Môr Offshore Wind Farm
- time point 6: 2030, all projects operational
- time point 11: 2035, ten years since piling commencement of Project Erebus
- time point 21: 2045, 20 years since piling commencement of Project Erebus
- time point 26: 2049, 25 years since piling commencement of Project Erebus.

9.15.1.33 Cumulative projects for marine mammal species were considered across the regional marine mammal study area. A summary of the number of animals for each species affected and number of piling days for each of cumulative projects is provided below (Table A. 6). For bottlenose dolphin, two iPCoD models were run for cumulative projects located within the boundary of separate MUs, and full details are presented in section A.4.2.2.

9.15.1.34 Table A.7 presents a summary of the scenarios modelled through iPCoD for each species for Morgan Generation Assets alone and for cumulative projects.

**Table A. 6: Summary of cumulative projects included in iPCoD for marine mammal species. Where multiple populations have been modelled for a species, values refer to the percentage of the smaller population.**

| Species | Awel y Môr | | Project Erebus | | Morgan Generation Assets | | Mona Offshore Wind Project | |
|---|---|---|---|---|---|---|---|---|
| | Animals Disturbed | % Ref. Population | Animals Disturbed | % Ref. Population | Animals Disturbed | % Ref. Population | Animals Disturbed | % Ref. Population |
| Harbour porpoise | 2,112 | 3.38 | 1,967 | 3.15 | 1,370 | 2.19 | 587 | 0.94 |
| Bottlenose dolphin | 23 | 7.9 | 310 | 2.8 | 16 | 5.46 | 17 | 5.80 |
| Minke whale | 36 | 0.18 | 55 | 0.3 | 96 | 0.48 | 105 | 0.52 |
| Grey seal | 81 | 1.6 | 18 | 0.3 | 48 | 0.35 | 92 | 0.68 |

**Table A.7: Summary of scenarios modelled for each species in iPCoD for Morgan Generation Assets.**

| Scenario | | Population size | Population unit | Calf/Pup Survival | Juvenile Survival | Adult Survival | Fertility | Growth Rate | Age1 | Age2 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Harbour porpoise** | | | | | | | | | | |
| 1a | Monopile single – precautionary parameters from Table A.2 | 62517 | CIS | 0.6 | 0.85 | 0.9 | 0.5 | 1 | 1 | 5 |
| 1b | Monopile single - parameters with highest values for reproductive rate/calf survival/reproductive rate as given in NRW note. | 62517 | CIS | 0.85 | 0.85 | 0.925 | 0.68 | 1 | 1 | 5 |
| 2 | Monopile concurrent - parameters from Table A.2 | 62517 | CIS | 0.6 | 0.85 | 0.9 | 0.5 | 1 | 1 | 5 |
| C1 | Cumulative scenario | 62517 | CIS | 0.6 | 0.85 | 0.9 | 0.5 | 1 | 1 | 5 |
| C2 | Cumulative scenario with Tier 2 Project (Mona Offshore Wind Project) | 62517 | CIS | 0.6 | 0.85 | 0.9 | 0.5 | 1 | 1 | 5 |
| **Bottlenose dolphin** | | | | | | | | | | |
| 1a | Monopile single - parameters from Table A.2 | 293 | IS | 0.87 | 0.93 | 0.94 | 0.22 | 1 | 2 | 9 |
| 1b | Monopile single - with higher 0.3 fertility rate from Sinclair et al (2020) as given in NRW note. | 293 | IS | 0.87 | 0.93 | 0.94 | 0.3 | 1 | 2 | 9 |
| 2a | Monopile concurrent - parameters from Table A.2 | 293 | IS | 0.87 | 0.93 | 0.94 | 0.22 | 1 | 2 | 9 |
| 2b | Monopile concurrent - with higher 0.3 fertility rate from Sinclair et al (2020) as given in NRW note. | 293 | IS | 0.87 | 0.93 | 0.94 | 0.3 | 1 | 2 | 9 |
| C1a | Cumulative scenario: projects within boundary of Irish Sea MU (Morgan Generation Assets and Awel y Môr) | 293 | IS | 0.87 | 0.93 | 0.94 | 0.22 | 1 | 2 | 9 |
| C1b | Cumulative scenario: projects within boundary of Irish Sea MU (Morgan Generation Assets and Awel y Môr) with 0.3 fertility rate. | 293 | IS | 0.87 | 0.93 | 0.94 | 0.3 | 1 | 2 | 9 |
| C2a | Cumulative scenario: projects within boundary of Irish Sea and OCSW MUs (all cumulative projects) | 11,240 | IS + OCSW | 0.87 | 0.93 | 0.94 | 0.22 | 1 | 2 | 9 |
| C2b | Cumulative scenario: projects within boundary of Irish Sea and OCSW MUs (all cumulative projects) with higher 0.3 fertility rate from Sinclair et al (2020) as given in NRW note. | 11,240 | IS + OCSW | 0.87 | 0.93 | 0.94 | 0.3 | 1 | 2 | 9 |
| C3a | Scenario C3a - Cumulative projects in IS MU with Tier 2 project (Mona Offshore Wind Project) | 293 | IS | 0.87 | 0.93 | 0.94 | 0.3 | 1 | 2 | 9 |
| C3b | Scenario C3b - Cumulative projects in IS and OCSW MUs with Tier 2 project (Mona Offshore Wind Project) | 11,240 | IS + OCSW | 0.87 | 0.93 | 0.94 | 0.3 | 1 | 2 | 9 |
| **Minke whale** | | | | | | | | | | |
| 1 | Monopile single - parameters from Table A.2 | 20118 | CGNS | 0.7 | 0.77 | 0.96 | 0.91 | 1 | 1 | 9 |
| 2 | Monopile concurrent - parameters from Table A.2 | 20118 | CGNS | 0.7 | 0.77 | 0.96 | 0.91 | 1 | 1 | 9 |

| Scenario | | Population size | Population unit | Calf/Pup Survival | Juvenile Survival | Adult Survival | Fertility | Growth Rate | Age1 | Age2 |
|---|---|---|---|---|---|---|---|---|---|---|
| C1 | Cumulative scenario | 20118 | CGNS | 0.7 | 0.77 | 0.96 | 0.91 | 1 | 1 | 9 |
| C2 | Cumulative scenario with Tier 2 Project (Mona Offshore Wind Project) | 20118 | CGNS | 0.7 | 0.77 | 0.96 | 0.91 | 1 | 1 | 9 |
| **Grey seal** | | | | | | | | | | |
| 1a | Monopile single - parameters from Table A.2 with OSPAR region III as reference population | 60780 | OSPARIII | 0.22 | 0.94 | 0.94 | 0.9 | 1.01 | 1 | 5 |
| 1b | Monopile single - parameters from Table A.2 with Grey Seal Reference Population as reference population | 13,563 | Grey Seal Reference Population | 0.22 | 0.94 | 0.94 | 0.9 | 1.01 | 1 | 5 |
| 2a | Monopile concurrent - parameters from Table A.2 with OSPAR region III as reference population | 60780 | OSPARIII | 0.22 | 0.94 | 0.94 | 0.9 | 1.01 | 1 | 5 |
| 2b | Monopile concurrent - parameters from Table A.2 with Grey Seal Reference Population as reference population | 13,563 | Grey Seal Reference Population | 0.22 | 0.94 | 0.94 | 0.9 | 1.01 | 1 | 5 |
| C1a | Cumulative scenario - OSPAR region III as reference population | 60780 | OSPARIII | 0.22 | 0.94 | 0.94 | 0.9 | 1.01 | 1 | 5 |
| C1b | Cumulative scenario – Grey Seal Reference population | 13,563 | Grey Seal Reference Population | 0.22 | 0.94 | 0.94 | 0.9 | 1.01 | 1 | 5 |
| C2a | Cumulative scenario - OSPAR region III as reference population with Tier 2 Project (Mona Offshore Wind Project) | 60780 | OSPARIII | 0.22 | 0.94 | 0.94 | 0.9 | 1.01 | 1 | 5 |
| C2b | Cumulative scenario - all four SMUs as reference population with Tier 2 Project (Mona Offshore Wind Project) | 13,563 | Grey Seal Reference Population | 0.22 | 0.94 | 0.94 | 0.9 | 1.01 | 1 | 5 |

# A.4 Results

## A.4.1 Harbour porpoise

### A.4.1.1 Project alone

9.15.1.35 Results of the iPCoD modelling for harbour porpoise using the MDS (monopiles) for single and concurrent scenarios are presented in Table A.8 and Figure A.1 to Figure A.4.

9.15.1.36 For piling of monopiles using a single vessel (Scenario 1a), the results show there appears to be a very small difference in the growth trajectory of harbour porpoise between the un-impacted population and impacted population (Figure A.1). At all time points there was a difference in the size of the impacted and unimpacted populations. For example at time point 3 after the end of piling, there were 33 fewer animals in the impacted population compared to the unimpacted population and at time point 26 this difference was 23 animals (Table A.8). The median counterfactual of population size was 1 at a time point of the start of year two (coinciding with the end of the first year of the Morgan Generation Assets piling phase) onwards until the maximum 25-year time point. Therefore, given that the differences in disturbed to undisturbed populations approaches a ratio of one there is not considered to be a potential for a long-term effect on this species.

9.15.1.37 There is a decline in both populations presented, but there has been a suggested 4% per annum declining trend in the CIS MU (IAMMWG, 2021) and thus this is not unexpected. However, the model is very sensitive to the parameters chosen, and this is reflected in population trajectories. For example, if the highest possible values for calf/pup survival (0.85) adult survival (0.925) and fertility (0.68) given by NRW are used in modelling for piling of monopiles using a single vessel (Scenario 1b), the population trajectory changes and appears to increase over time. There remains, however, very little difference between the impacted and unimpacted populations (Figure A.2).

9.15.1.38 For concurrent piling of monopiles with two vessels (Scenario 2), the results show a similar population decline but again with little difference between un-impacted and impacted populations (Figure A.3)Figure A.3 Harbour porpoise scenario 2: unimpacted versus impacted scenario for monopiles concurrent piling scenario.. The results show that for concurrent piling of monopiles, the median counterfactual of population size was 1 at a time point of the start of year two (coinciding with the end of the first year of the Morgan Generation Assets phase), onwards until the maximum 25-year time point. As described for the single piling scenario, there are differences in the number of animals between impacted and unimpacted population sizes, e.g. 15 animals at time point 26. Therefore, given that the differences in disturbed to undisturbed populations approaches a ratio of one there is not considered to be a potential for a long-term effect on this species.

### A.4.1.2 Cumulative

9.15.1.39 For the cumulative scenario (C1, Figure A.4) assessed against the MU population (CIS = 62,517), where multiple projects may be piling either sequentially or concurrently within the regional marine mammal study area, the population modelling suggested a median ratio of 1 until time point 4, where there was a slight decrease in the median counterfactual of population size with a median ratio 99 at time point 5 (the year after piling finishes at Morgan Generation Assets and Awel y Môr) to time point 26 (Table A.8, Figure A.4). The difference in the number of animals between impacted and unimpacted population sizes at time point 25 was 260 animals.

9.15.1.40 When quantitative information for the Tier 2 Project (Mona Offshore Wind Project) is included (Scenario C2, Figure A.5), the median counterfactual remains at a ratio of 1 until year 5, where there was a slight decrease in the median counterfactual of population size with a median ratio 99 at time point 4 to time point 26 (Table A.8). The difference in the number of animals between impacted and unimpacted population sizes at time point 25 was 220 animals, thus adding the Mona Offshore Wind Project into the models does not have an additional cumulative impact.

**Table A.8: Population trajectory of harbour porpoise in piling scenarios (single, concurrent, cumulative) showing the mean and upper and lower confidence limits at different time points (years after start of offshore construction phase).**

A ratio of less than 1 indicates population decline due to impacted population, equal to 1 indicates no impact, and a ratio of higher than one indicates population growth due to the impact.

| Time point (Years following commencement of piling) | Un-impacted population | | | Impacted population | | | Median Ratio of Population Size |
|---|---|---|---|---|---|---|---|
| | Mean | Lower 2.5% | Upper 95.5% | Mean | Lower 2.5% | Upper 95.5% | |
| **Scenario 1a - single, monopile** | | | | | | | |
| Time point 2 | 61598 | 56079 | 65822 | 61589 | 56078 | 65798 | 1 |
| Time point 3 | 60617 | 53651 | 66305 | 60584 | 53651 | 66215 | 1 |
| Time point 6 | 57595 | 48842 | 66372 | 57566 | 48805 | 66362 | 1 |
| Time point 11 | 53066 | 42661 | 65242 | 53037 | 42661 | 64972 | 1 |
| Time point 21 | 44722 | 32637 | 58842 | 44697 | 32615 | 58819 | 1 |
| Time point 26 | 41296 | 28828 | 55311 | 41273 | 28827 | 55278 | 1 |
| **Scenario 1b- single, monopile, higher calf/pup survival and adult survival value/fertility rate** | | | | | | | |
| Time point 2 | 65563 | 59034 | 70225 | 65549 | 59031 | 70164 | 1 |
| Time point 3 | 68857 | 60250 | 75943 | 68808 | 60239 | 75919 | 0.999971 |
| Time point 6 | 79947 | 65511 | 94128 | 79901 | 65509 | 94124 | 0.999978 |
| Time point 11 | 106569 | 81075 | 134274 | 106501 | 81073 | 134260 | 1 |
| Time point 21 | 163650 | 112712 | 222836 | 163546 | 112462 | 222835 | 1 |
| Time point 26 | 209203 | 140702 | 302965 | 209069 | 140689 | 302614 | 1 |
| **Scenario 2 - concurrent, monopile** | | | | | | | |
| Time point 2 | 61519 | 56154 | 65746 | 61511 | 56152 | 65742 | 1 |
| Time point 3 | 60511 | 54254 | 66032 | 60489 | 54217 | 66026 | 1 |
| Time point 6 | 57604 | 49171 | 66728 | 57584 | 49171 | 66643 | 1 |
| Time point 11 | 53123 | 42748 | 65055 | 53104 | 42713 | 64944 | 1 |
| Time point 21 | 44882 | 33023 | 59002 | 44866 | 32978 | 58904 | 1 |
| Time point 26 | 41266 | 29157 | 56620 | 41251 | 29162 | 56620 | 1 |
| **Scenario C1 - Cumulative projects** | | | | | | | |
| Time point 1 | 62514 | 62514 | 62514 | 62514 | 62514 | 62514 | 1 |
| Time point 2 | 61479 | 56408 | 65594 | 61471 | 56408 | 65594 | 1 |
| Time point 3 | 60427 | 53822 | 66034 | 60408 | 53722 | 65997 | 1 |
| Time point 4 | 59363 | 51939 | 66332 | 59339 | 51939 | 66287 | 1 |
| Time point 5 | 58443 | 50494 | 65904 | 58225 | 50330 | 65688 | 0.998 |
| Time point 6 | 57548 | 49343 | 65899 | 57096 | 49066 | 65380 | 0.995 |
| Time point 11 | 53105 | 43245 | 63762 | 52773 | 42848 | 63012 | 0.996 |
| Time point 21 | 45326 | 33242 | 58887 | 45042 | 33082 | 58534 | 0.996 |
| Time point 26 | 41767 | 29529 | 55332 | 41507 | 29076 | 55001 | 0.996 |

| Time point (Years following commencement of piling) | Un-impacted population | | | Impacted population | | | Median Ratio of Population Size |
|---|---|---|---|---|---|---|---|
| | Mean | Lower 2.5% | Upper 95.5% | Mean | Lower 2.5% | Upper 95.5% | |
| **Scenario C2 - Cumulative projects with Tier 2 Project (Mona Offshore Wind Project)** | | | | | | | |
| Time point 1 | 62514 | 62514 | 62514 | 62514 | 62514 | 62514 | 1 |
| Time point 2 | 61637 | 56310 | 66103 | 61632 | 56310 | 66087 | 1 |
| Time point 3 | 60719 | 53875 | 66622 | 60705 | 53875 | 66571 | 1 |
| Time point 4 | 59599 | 52321 | 66815 | 59574 | 52321 | 66704 | 0.999 |
| Time point 5 | 58706 | 50974 | 66549 | 58503 | 50664 | 66154 | 0.998 |
| Time point 6 | 57758 | 49141 | 66273 | 57360 | 48915 | 65767 | 0.995 |
| Time point 11 | 53187 | 42187 | 64322 | 52903 | 41965 | 64134 | 0.997 |
| Time point 21 | 44881 | 32541 | 59567 | 44641 | 32450 | 59302 | 0.997 |
| Time point 26 | 41337 | 29710 | 57745 | 41117 | 29469 | 57685 | 0.997 |

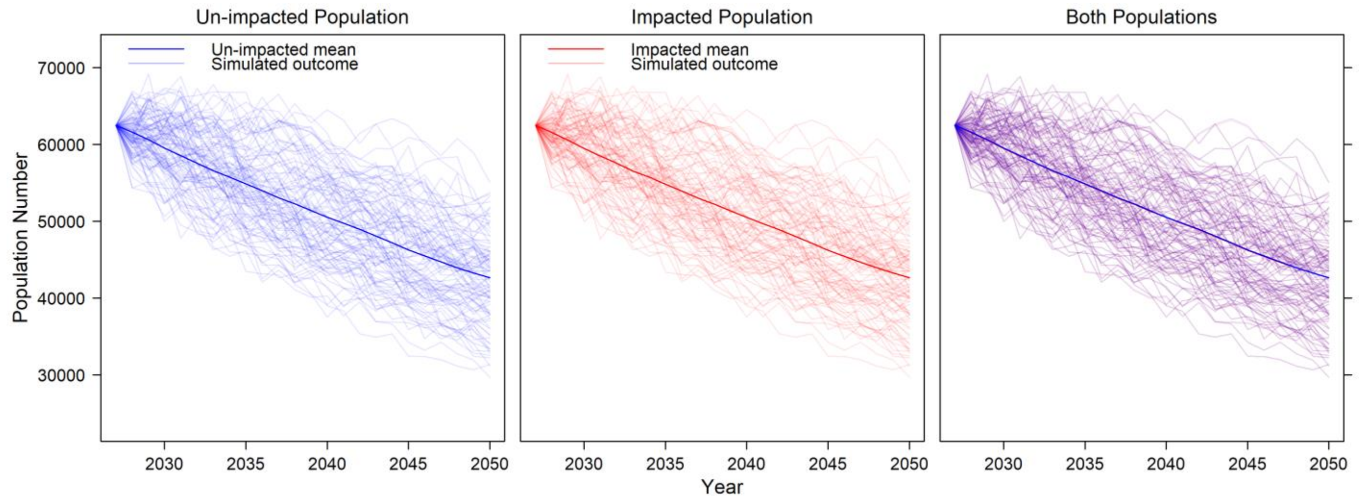


**Figure A.1 Harbour porpoise scenario 1a: unimpacted versus impacted scenario for monopiles, single piling scenario (conservative parameters).**

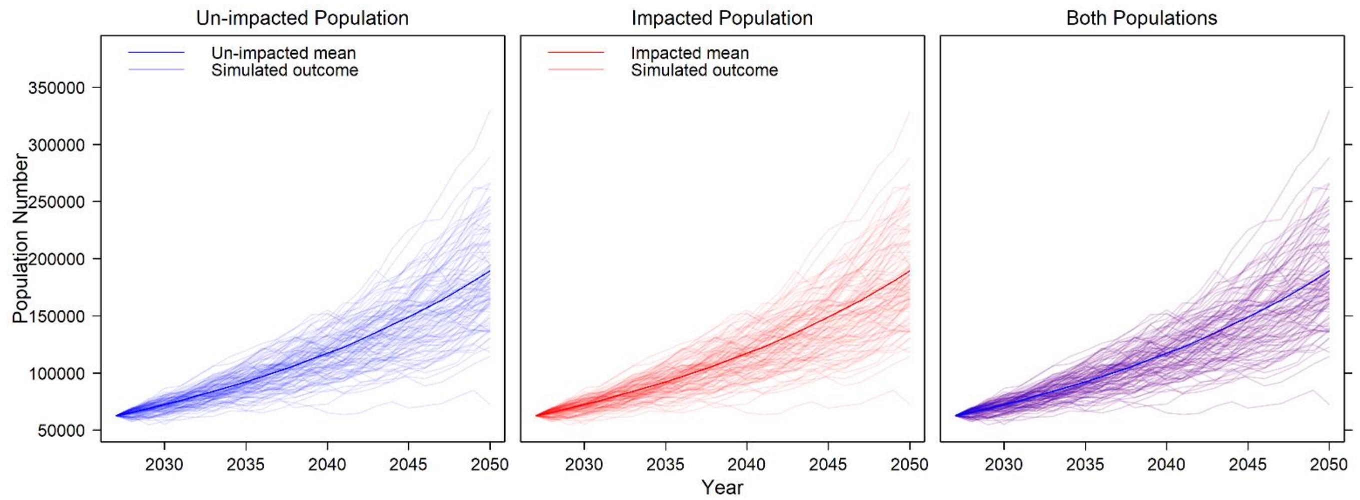


**Figure A.2 Harbour porpoise scenario 1b: unimpacted versus impacted scenario for monopiles, single piling scenario with highest adult survival (0.925) and fertility rates (0.68) from NRW.**

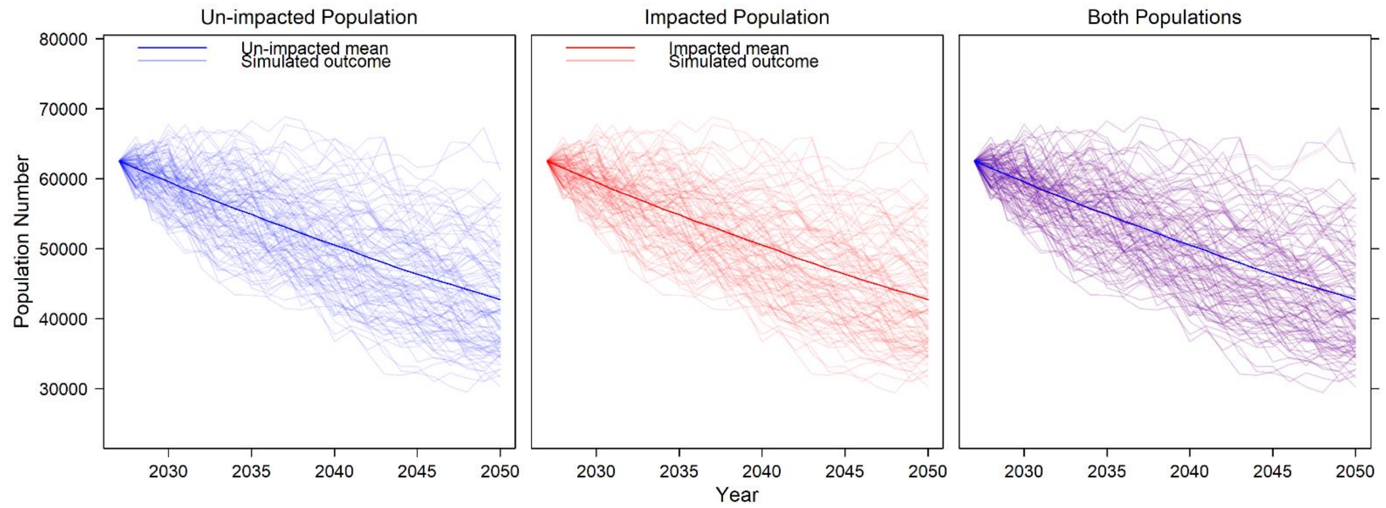


**Figure A.3 Harbour porpoise scenario 2: unimpacted versus impacted scenario for monopiles concurrent piling scenario.**

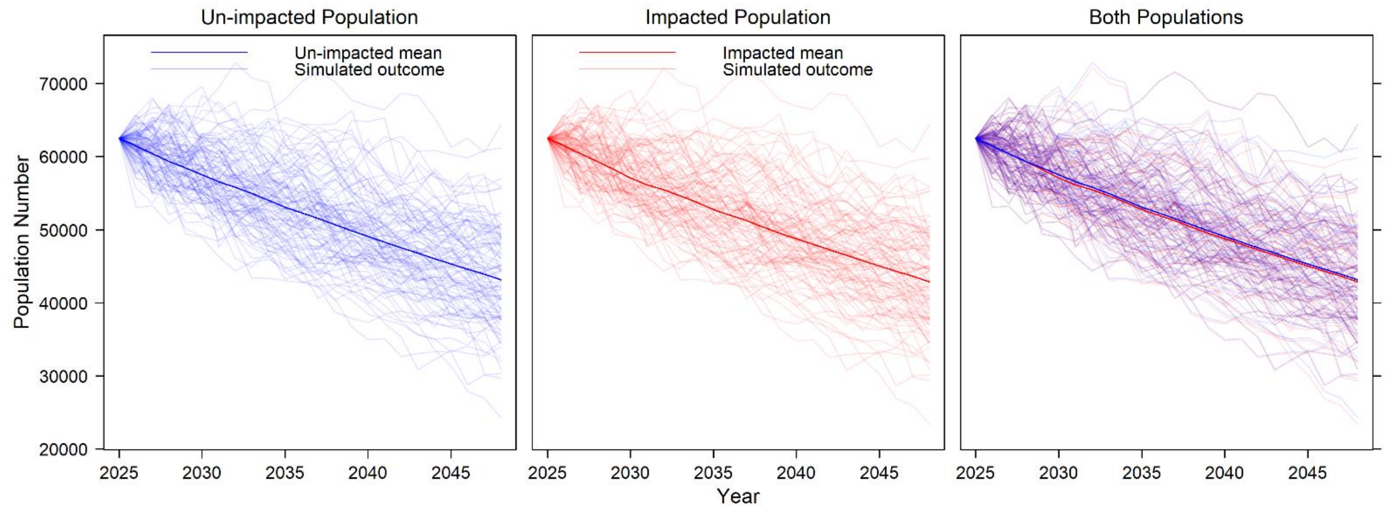


**Figure A.4 Harbour porpoise scenario C1: Cumulative projects unimpacted versus impacted scenario.**

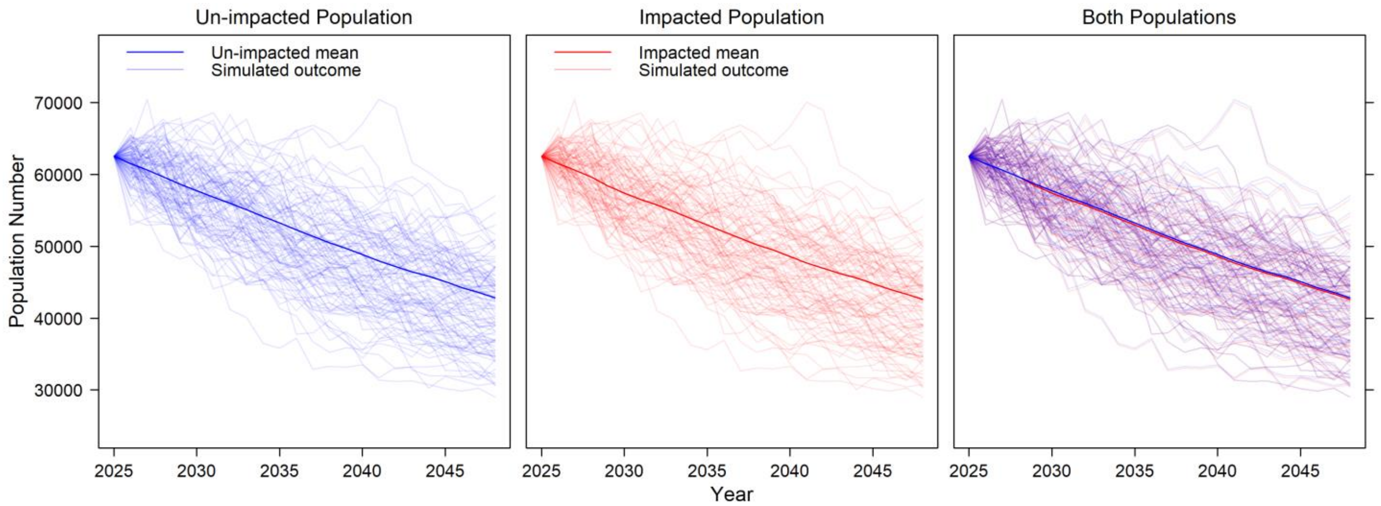


**Figure A.5 Harbour porpoise scenario C2: Cumulative projects unimpacted versus impacted scenario, with Tier 2 project (Mona Offshore Wind Project).**

## A.4.2 Bottlenose dolphin

### A.4.2.1 Project alone

9.15.1.41 Results of the iPCoD modelling for bottlenose dolphin using the maximum design scenario (monopiles) for single and concurrent piling scenarios are presented in Table A.9 and Figure A.6 to Figure A.8.

9.15.1.42 For piling of monopiles using a single vessel (Scenario 1a), the results show there appears to be a very small difference in the growth trajectory of bottlenose dolphin between the un-impacted population and impacted population. The trajectory reflects a decline in both, unimpacted and impacted populations (Figure A.6). The median counterfactual of population size was 1 at a time point of the start of year two (coinciding with the end of the first year of the Morgan Generation Assets piling phase) onwards until the maximum 25-year time point. At all time points there was very little difference in the size of the impacted and unimpacted populations. For example, at time point 3 after the end of piling, there was one fewer animal in the impacted population compared to the unimpacted population which remained at time point 25 (Table A.13). Therefore, given that the differences in disturbed to undisturbed populations approaches a ratio of one there is not considered to be a potential for a long-term effect on this species.

9.15.1.43 However, the model is highly dependent on the parameters chosen and can influence the population trajectory for both unimpacted and impacted populations. When a higher fertility rate of 0.3 (taken from Sinclair *et al.* 2020) is used in combination with the same parameters as bottlenose dolphin scenario 1a, the population trajectory appears to show a growing population (Figure A.7), leading to a population of 334 animals in the IS MU at time point 26. Whilst there remains a small difference in the unimpacted versus impacted population as in the Scenario 1a model (one less dolphin in the impacted population at time point 26), the population trajectory changes. Given the differences in disturbed to undisturbed populations remains as a ratio of one there is not considered to be a potential for a long-term effect on this species in this scenario either.

9.15.1.44 For concurrent piling (Figure A.8) of monopiles, the results present a declining population trajectory but with little difference between un-impacted and impacted populations. The results show that for concurrent piling of monopiles, the median counterfactual of population size was 1 at a time point of the start of year two (coinciding with the end of the first year of the Morgan Generation Assets piling phase) onwards until the maximum 25-year time point. At time point 25, there was just one fewer animal in the impacted population compared to the unimpacted population (0.3% of the IS MU). Therefore, given that the differences in disturbed to undisturbed populations approaches a ratio of one there is not considered to be a potential for a long-term effect on this species.

9.15.1.45 As discussed in paragraph 9.15.1.43, adjusting the fertility rate to 0.3 changes the population trajectory (from 290 to 328 animals in the IS MU, Figure A.9), but there remains one less animal in the impacted population to the unimpacted population. Given the differences in disturbed to undisturbed populations remains as a ratio of one, there is not considered to be a potential for a long-term effect on this species in this scenario either.

### A.4.2.2 Cumulative

9.15.1.46 For cumulative scenario C1a assessed against the Irish Sea MU population (IS = 293) (Figure A.10), where the Morgan Generation Assets and Awel y Môr project may be piling either sequentially or concurrently, the population modelling suggested a median ratio of 1 from year two onwards until the maximum 25-year time point (Table A.9), suggesting that the cumulative effect of piling for these projects is not expected to lead to a deleterious effect upon the bottlenose dolphin population. However, at the 25-year time point, there were predicted to be five fewer animals in the impacted population (n = 240) than in the unimpacted population (n = 245). If the higher fertility rate (0.3) is used (Scenario C1b, Figure A.11) there is predicted to be eight less animals in the impacted population than the unimpacted, but the IS MU population is 322 animals at time point 25 (compared to 290 at time point one) therefore is a growing population, highlighting the sensitivity of the model to the parameters chosen.

9.15.1.47 The cumulative scenario C2a, which assessed the population of the Irish Sea and Offshore Channel and South West MUs (IS + OCSW = 11,240) (Figure A.12) where the Morgan Generation Assets Project, Awel y Môr and Project Erebus projects may be piling either sequentially or concurrently. As for scenario C1, however, the impacted population (n = 9,389) is smaller than the unimpacted population (n = 9,380) by nine animals. The population modelling indicated a median ratio of 1 for impacted and unimpacted populations, from time point 2 (one year after commencement of piling for Project Erebus) and time point 26 (the maximum of the 25-year model) (Table A.9). In the context of a large population within the Irish Sea and Offshore Channel and South West MUs, there is not considered to be a potential for a long-term effect on this species. If the higher fertility rate is used (Scenario C2b, Figure A.12) there is predicted to be 13 less animals in the impacted population than the unimpacted, but the IS and OCSW MUs population is still 12,932 animals at time point 25 (compared to 11,242 at time point 1) therefore is a growing population, highlighting the sensitivity of the model to the parameters chosen.

9.15.1.48 When quantitative information for the Tier 2 Project Mona Offshore Wind Project is included when assessing against the Irish Sea MU (Scenario C3a, Figure A.13), the median counterfactual remains at a ratio of 1 at time point 26 (the maximum of the 25-

year model) (Table A.9). The difference in the number of animals between impacted and unimpacted population sizes at time point 26 was five animals, thus adding the Mona Offshore Wind Project into the models does not have an additional cumulative impact to Scenario 2Ca.

9.15.1.49 When quantitative information for the Tier 2 Project (Mona Offshore Wind Project) is included when assessing the population of the Irish Sea and Offshore Channel and South West MUs (Scenario C3b, Figure A.14), the median counterfactual remains at a ratio of 1 at time point 26 (the maximum of the 25-year model) (Table A.9). The difference in the number of animals between impacted and unimpacted population sizes at time point 26 was eight animals, thus adding the Mona Offshore Wind Project into the models does not have an additional cumulative impact.

**Table A.9: Population trajectory of bottlenose dolphin in monopile scenarios (single, concurrent, cumulative piling) showing the mean and upper and lower confidence limits at different time points (years after start of offshore construction phase) and median ratio of population size.**

A ratio of less than 1 indicates population decline due to impacted population, equal to 1 indicates no impact, and a ratio of higher than one indicates population growth due to the impact.

| Time point (Years following commencement of piling) | Un-impacted population | | | Impacted population | | | Median Ratio of Population Size |
|---|---|---|---|---|---|---|---|
| | Mean | Lower 2.5% | Upper 95.5% | Mean | Lower 2.5% | Upper 95.5% | |
| **Scenario 1a- single, monopile** | | | | | | | |
| Time point 2 | 288 | 256 | 314 | 288 | 256 | 312 | 1 |
| Time point 3 | 286 | 246 | 320 | 285 | 242 | 320 | 1 |
| Time point 6 | 280 | 224 | 334 | 278 | 222 | 334 | 1 |
| Time point 11 | 270 | 198 | 348 | 269 | 198 | 346 | 1 |
| Time point 21 | 251 | 160 | 360 | 250 | 158 | 358 | 1 |
| Time point 26 | 242 | 148 | 360 | 241 | 148 | 358 | 1 |
| **Scenario 1b- single, monopile, higher fertility rate** | | | | | | | |
| Time point 2 | 292 | 260 | 320 | 292 | 260 | 318 | 1 |
| Time point 3 | 294 | 250 | 330 | 292 | 248 | 328 | 1 |
| Time point 6 | 299 | 238 | 360 | 297 | 236 | 358 | 1 |
| Time point 11 | 306 | 222 | 396 | 305 | 222 | 394 | 1 |
| Time point 21 | 326 | 214 | 452 | 325 | 214 | 452 | 1 |
| Time point 26 | 335 | 200 | 496 | 334 | 200 | 496 | 1 |
| **Scenario 2a - concurrent, monopile** | | | | | | | |
| Time point 2 | 289 | 258 | 314 | 288 | 256 | 314 | 1 |
| Time point 3 | 286 | 246 | 318 | 285 | 246 | 318 | 1 |
| Time point 6 | 280 | 226 | 330 | 279 | 224 | 330 | 1 |
| Time point 11 | 270 | 198 | 350 | 269 | 198 | 346 | 1 |
| Time point 21 | 252 | 170 | 352 | 251 | 168 | 352 | 1 |
| Time point 26 | 244 | 150 | 352 | 243 | 150 | 350 | 1 |
| **Scenario 2b – concurrent monopile, higher fertility rate** | | | | | | | |
| Time point 2 | 292 | 260 | 316 | 292 | 260 | 316 | 1 |
| Time point 3 | 294 | 252 | 328 | 293 | 250 | 328 | 1 |
| Time point 6 | 298 | 234 | 356 | 297 | 232 | 356 | 1 |
| Time point 11 | 305 | 220 | 386 | 305 | 218 | 386 | 1 |
| Time point 21 | 320 | 204 | 454 | 319 | 202 | 454 | 1 |
| Time point 26 | 329 | 202 | 478 | 328 | 200 | 478 | 1 |
| **Scenario C1a- Cumulative projects in IS MU** | | | | | | | |
| Time point 1 | 290 | 290 | 290 | 290 | 290 | 290 | 1 |

| Time point (Years following commencement of piling) | Un-impacted population | | | Impacted population | | | Median Ratio of Population Size |
|---|---|---|---|---|---|---|---|
| | Mean | Lower 2.5% | Upper 95.5% | Mean | Lower 2.5% | Upper 95.5% | |
| Time point 2 | 289 | 262 | 316 | 289 | 262 | 316 | 1 |
| Time point 3 | 287 | 250 | 324 | 282 | 240 | 320 | 1 |
| Time point 4 | 285 | 240 | 330 | 276 | 224 | 326 | 1 |
| Time point 5 | 284 | 234 | 336 | 276 | 222 | 332 | 1 |
| Time point 6 | 281 | 228 | 338 | 274 | 218 | 334 | 1 |
| Time point 11 | 273 | 204 | 346 | 268 | 198 | 342 | 1 |
| Time point 21 | 253 | 164 | 354 | 247 | 160 | 346 | 1 |
| Time point 26 | 245 | 156 | 354 | 240 | 150 | 348 | 1 |
| **Scenario C1b - Cumulative projects in IS MU, higher fertility rate** | | | | | | | |
| Time point 1 | 290 | 290 | 290 | 290 | 290 | 290 | 1 |
| Time point 2 | 291 | 256 | 316 | 291 | 256 | 316 | 1 |
| Time point 3 | 292 | 246 | 330 | 286 | 240 | 328 | 1 |
| Time point 4 | 295 | 242 | 340 | 284 | 220 | 334 | 1 |
| Time point 5 | 297 | 238 | 350 | 288 | 222 | 344 | 1 |
| Time point 6 | 299 | 238 | 358 | 290 | 222 | 352 | 1 |
| Time point 11 | 306 | 220 | 394 | 300 | 214 | 388 | 1 |
| Time point 21 | 321 | 208 | 450 | 313 | 196 | 450 | 1 |
| Time point 26 | 330 | 198 | 484 | 322 | 192 | 482 | 1 |
| **Scenario C2a - Cumulative projects in IS and OCSW MUs** | | | | | | | |
| Time point 1 | 11238 | 11238 | 11238 | 11238 | 11238 | 11238 | 1 |
| Time point 2 | 11179 | 10156 | 11912 | 11176 | 10156 | 11912 | 1 |
| Time point 3 | 11096 | 9790 | 12156 | 11089 | 9773 | 12156 | 1 |
| Time point 4 | 11030 | 9591 | 12250 | 11024 | 9591 | 12250 | 1 |
| Time point 5 | 10945 | 9332 | 12322 | 10936 | 9332 | 12322 | 1 |
| Time point 6 | 10855 | 9164 | 12471 | 10843 | 9154 | 12470 | 1 |
| Time point 11 | 10471 | 8376 | 12721 | 10462 | 8370 | 12697 | 1 |
| Time point 21 | 9734 | 7112 | 12838 | 9725 | 7110 | 12821 | 1 |
| Time point 26 | 9389 | 6589 | 12754 | 9380 | 6588 | 12753 | 1 |
| **Scenario C2 - Cumulative projects in IS and OCSW MUs higher fertility rate** | | | | | | | |
| Time point 1 | 11242 | 11242 | 11242 | 11242 | 11242 | 11242 | 1 |
| Time point 2 | 11290 | 10150 | 12044 | 11287 | 10150 | 12028 | 1 |
| Time point 3 | 11353 | 9806 | 12437 | 11343 | 9805 | 12426 | 1 |

| Time point (Years following commencement of piling) | Un-impacted population | | | Impacted population | | | Median Ratio of Population Size |
|---|---|---|---|---|---|---|---|
| | Mean | Lower 2.5% | Upper 95.5% | Mean | Lower 2.5% | Upper 95.5% | |
| Time point 4 | 11410 | 9750 | 12702 | 11401 | 9750 | 12702 | 1 |
| Time point 5 | 11474 | 9554 | 13026 | 11463 | 9554 | 13016 | 1 |
| Time point 6 | 11526 | 9649 | 13244 | 11511 | 9600 | 13240 | 1 |
| Time point 11 | 11838 | 9019 | 14420 | 11826 | 8960 | 14420 | 1 |
| Time point 21 | 12560 | 8950 | 16934 | 12547 | 8950 | 16934 | 1 |
| Time point 26 | 12945 | 8900 | 18106 | 12932 | 8892 | 18106 | 1 |
| **Scenario C3a - Cumulative projects in IS MU with Tier 2 project (Mona Offshore Wind Project)** | | | | | | | |
| Time point 1 | 290 | 290 | 290 | 290 | 290 | 290 | 1 |
| Time point 2 | 288 | 256 | 314 | 287 | 254 | 314 | 1 |
| Time point 3 | 286 | 246 | 322 | 280 | 234 | 320 | 1 |
| Time point 4 | 284 | 236 | 328 | 275 | 218 | 326 | 1 |
| Time point 5 | 282 | 234 | 334 | 274 | 216 | 328 | 1 |
| Time point 6 | 280 | 226 | 336 | 272 | 216 | 330 | 1 |
| Time point 11 | 271 | 198 | 348 | 265 | 190 | 342 | 1 |
| Time point 21 | 251 | 162 | 352 | 245 | 156 | 344 | 1 |
| Time point 26 | 241 | 148 | 352 | 236 | 142 | 350 | 1 |
| **Scenario C3b - Cumulative projects in IS MU and OCSW with Tier 2 project (Mona Offshore Wind Project)** | | | | | | | |
| Time point 1 | 11238 | 11238 | 11238 | 11238 | 11238 | 11238 | 1 |
| Time point 2 | 11184 | 10088 | 11926 | 11181 | 10088 | 11926 | 1 |
| Time point 3 | 11093 | 9671 | 12108 | 11087 | 9671 | 12106 | 1 |
| Time point 4 | 11011 | 9438 | 12226 | 11006 | 9438 | 12226 | 1 |
| Time point 5 | 10955 | 9241 | 12421 | 10947 | 9241 | 12421 | 1 |
| Time point 6 | 10888 | 9092 | 12598 | 10878 | 9088 | 12598 | 1 |
| Time point 11 | 10538 | 8392 | 12707 | 10530 | 8392 | 12707 | 1 |
| Time point 21 | 9835 | 7254 | 13022 | 9828 | 7254 | 13022 | 1 |
| Time point 26 | 9519 | 6728 | 12806 | 9511 | 6716 | 12796 | 1 |

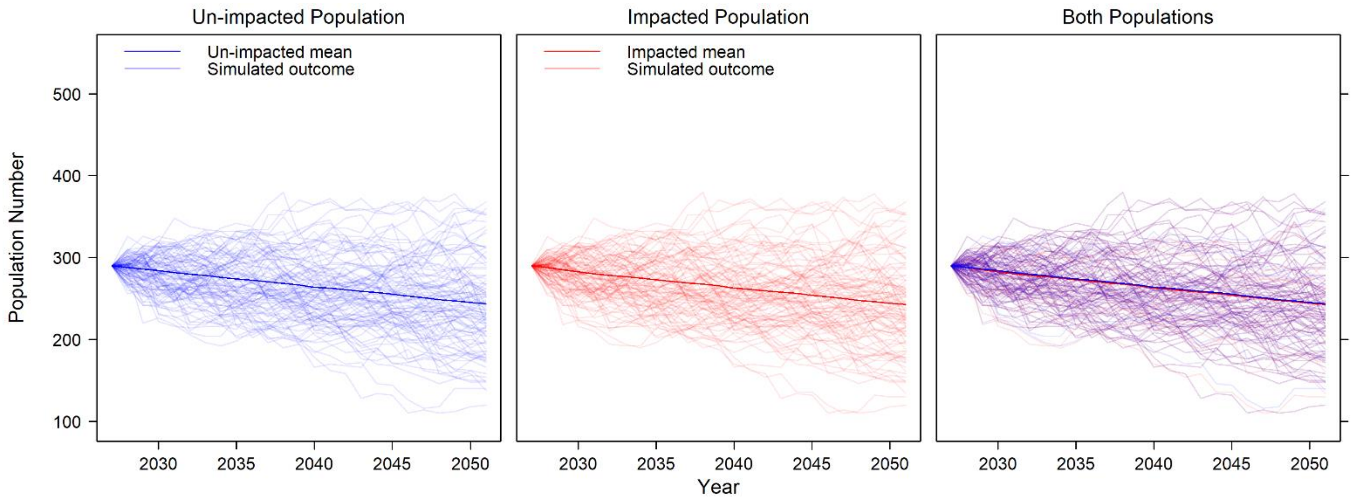


**Figure A.6 Bottlenose scenario 1a: unimpacted versus impacted scenario for monopiles single piling scenario.**

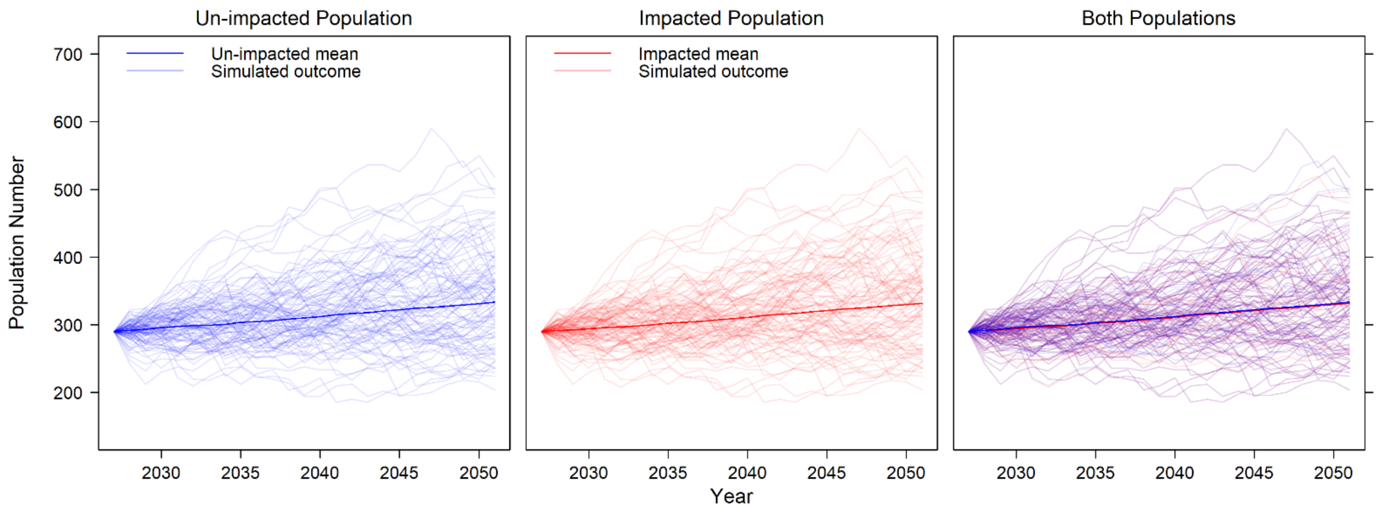


**Figure A.7 Bottlenose scenario 1b: unimpacted versus impacted scenario for monopiles single piling scenario, with higher 0.3 fertility rate.**

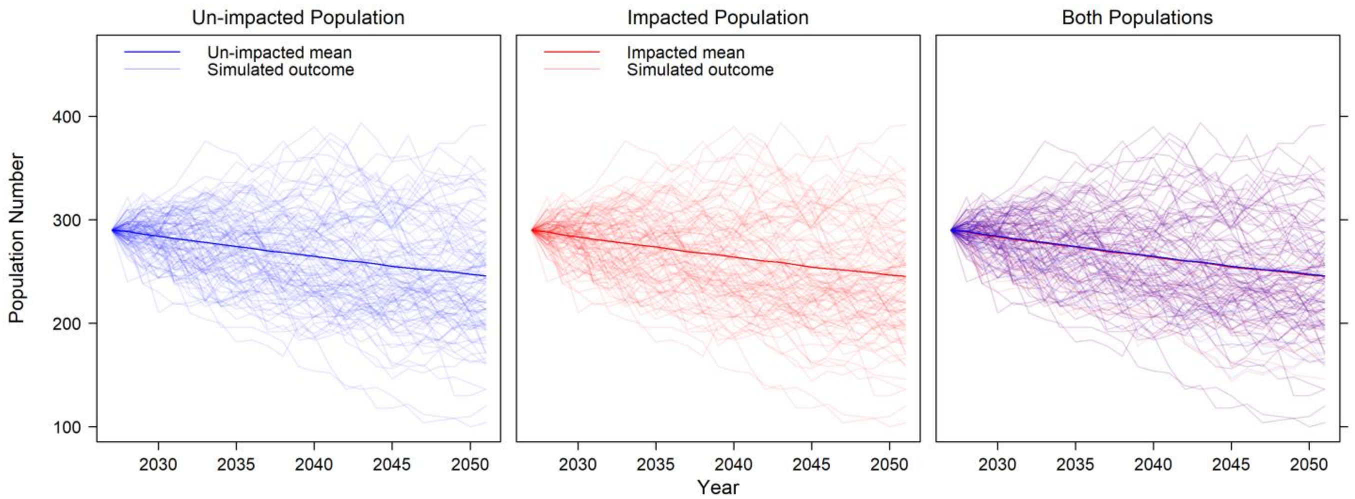


**Figure A.8 Bottlenose dolphin scenario 2a: unimpacted versus impacted scenario for monopiles concurrent piling scenario.**

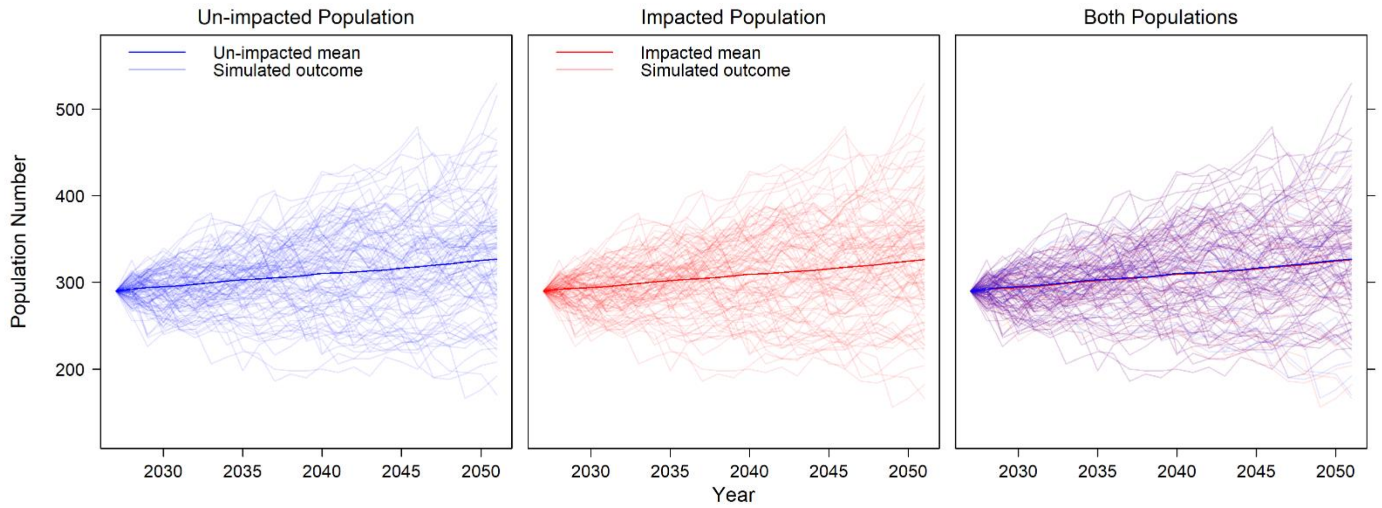


**Figure A.9 Bottlenose dolphin scenario 2b: unimpacted versus impacted scenario for monopiles concurrent piling scenario, with higher 0.3 fertility rate.**

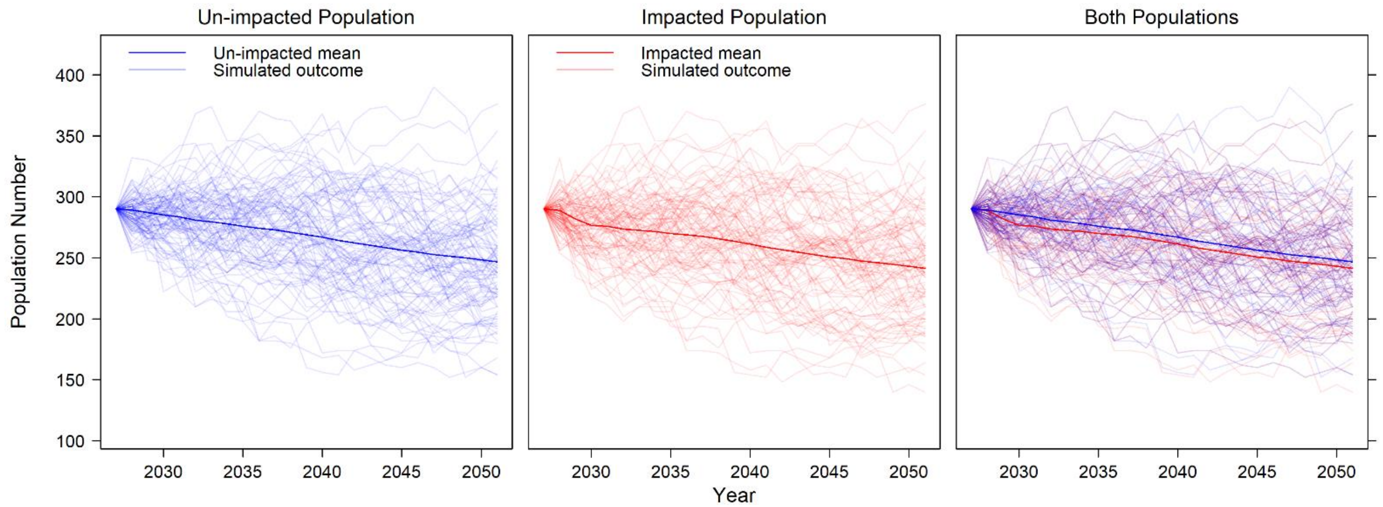


**Figure A.10 Bottlenose dolphin scenario C1a: cumulative projects unimpacted versus impacted scenario, for projects located within the boundary of the ‘Irish Sea’ Management Unit.**

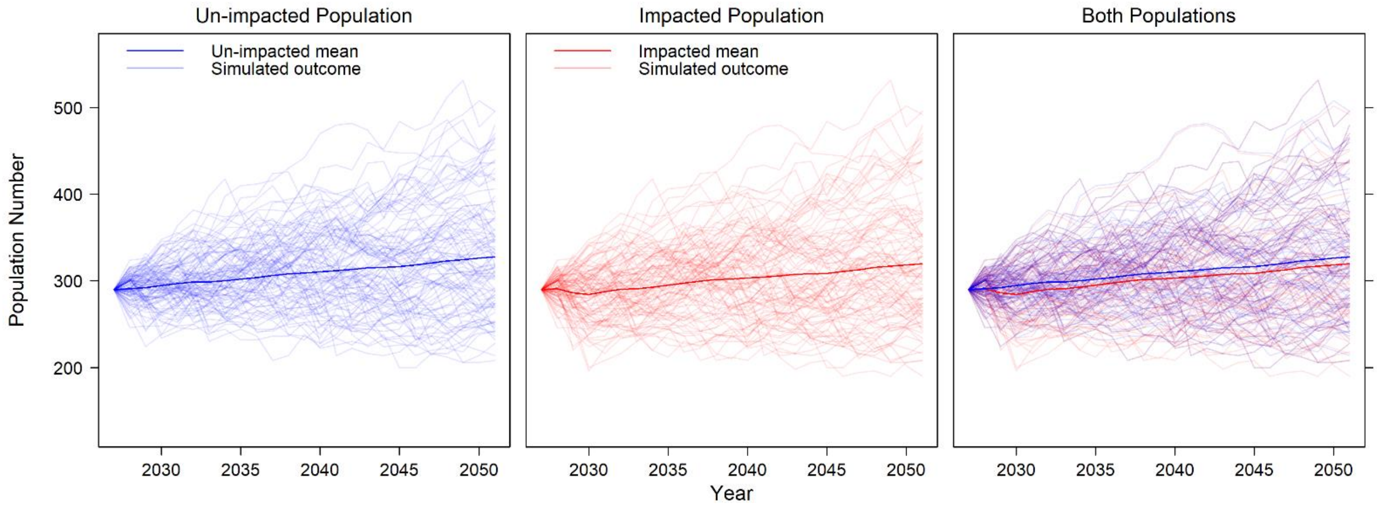


**Figure A.11 Bottlenose dolphin scenario C1b: cumulative projects unimpacted versus impacted scenario, for projects located within the boundary of the Irish Sea with higher 0.3 fertility rate.**

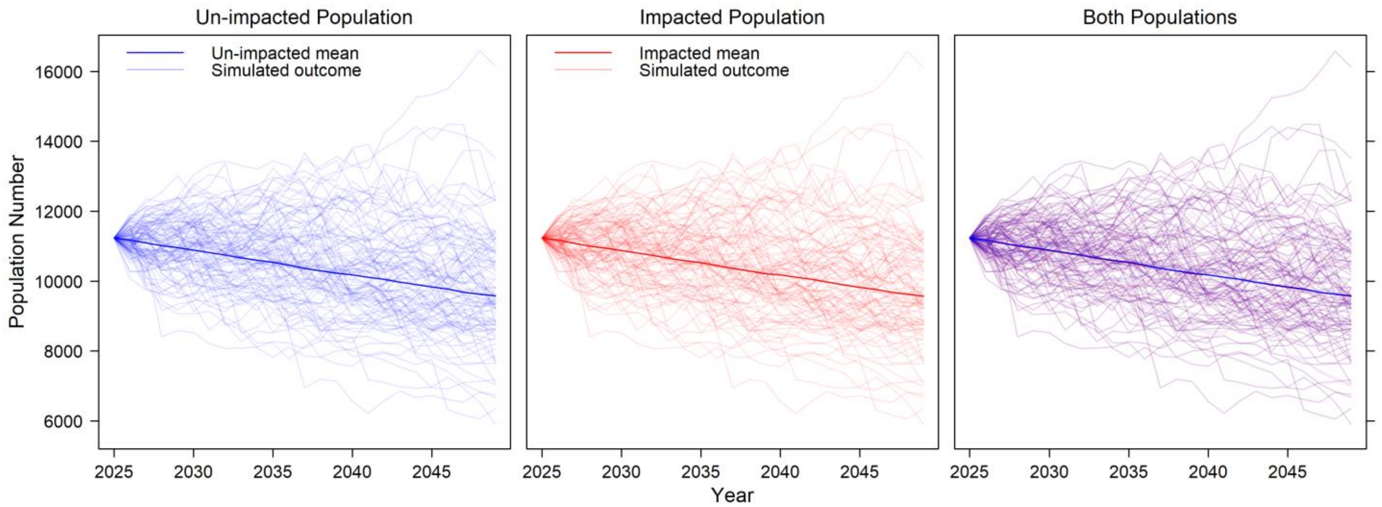


**Figure A.12 Bottlenose dolphin scenario C2a: cumulative projects unimpacted versus impacted scenario, for projects located within the boundary of the Irish Sea and Offshore Channel and South West Management Units.**

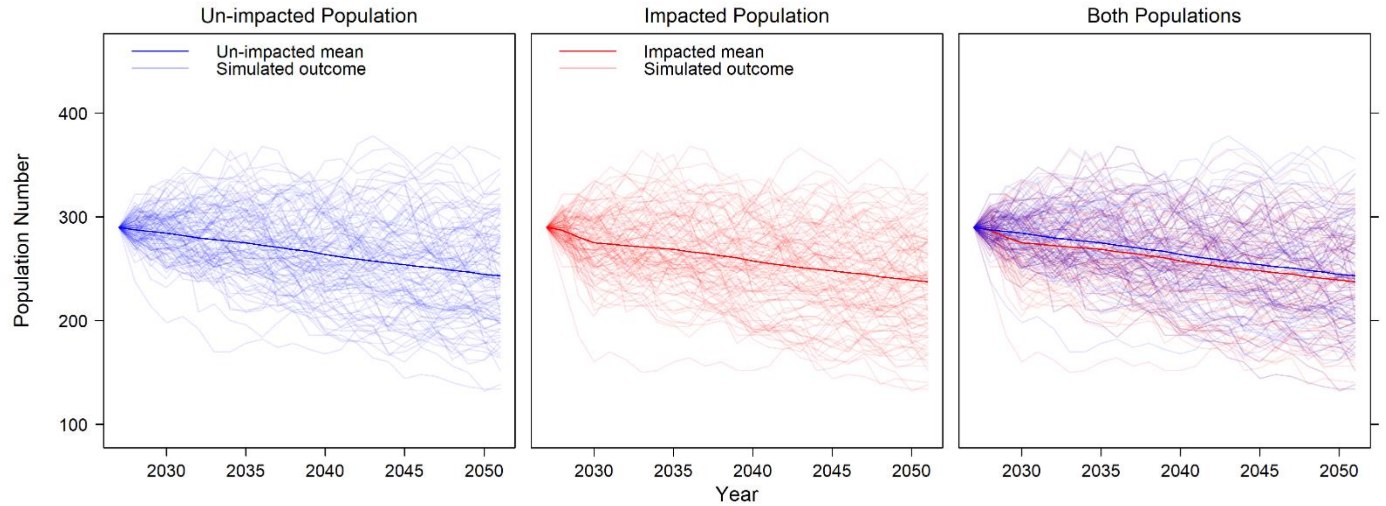


**Figure A.13 Bottlenose dolphin scenario C3a: cumulative projects unimpacted versus impacted scenario, for projects located within the boundary of the 'Irish Sea' Management Unit with Tier 2 project (Mona Offshore Wind Project).**

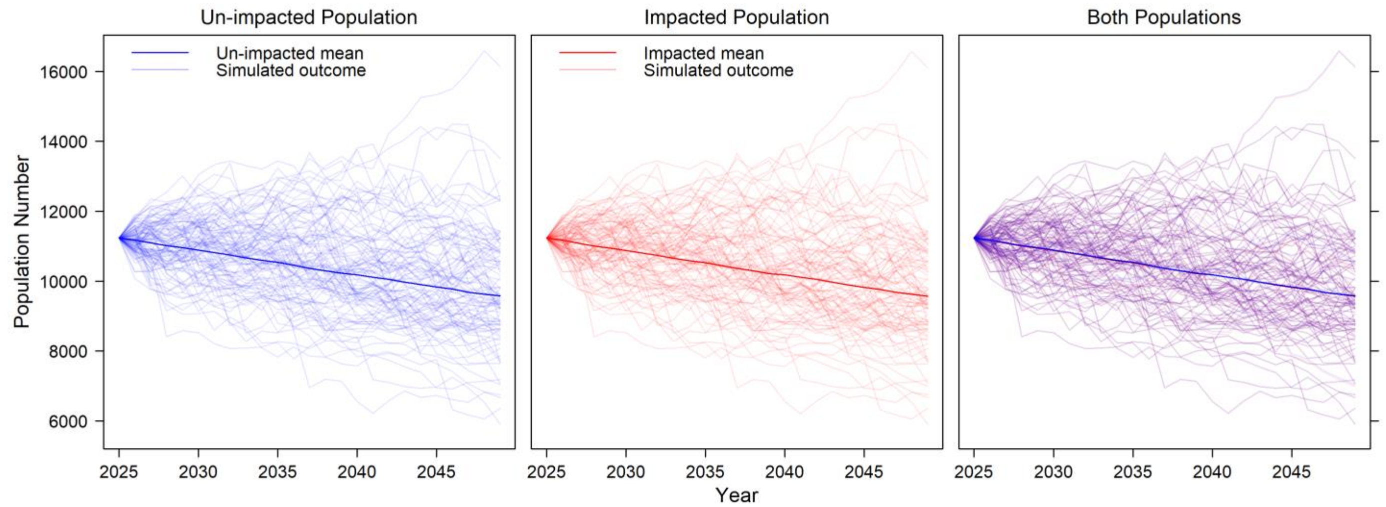


**Figure A.14 Bottlenose dolphin scenario C3b: cumulative projects unimpacted versus impacted scenario, for projects located within the boundary of the Irish Sea and Outer Channel and South West Management Units with Tier 2 project (Mona Offshore Wind Project).**

## A.4.3 Minke whale

### A.4.3.1 Project alone

9.15.1.50 Results of the iPCoD modelling for minke whale using the maximum design scenario (monopiles) for single and concurrent scenarios are presented in Table A.10 and Figure A.15 to Figure A.17.

9.15.1.51 For piling of monopiles using a single vessel, the results show there is a very small decline in both populations presented with very little difference between the impacted and unimpacted populations (Figure A.15, Scenario 1). The median counterfactual of population size was 1 at a time point of the start of year two (coinciding with the end of the first year of the Morgan Generation Assets piling phase) onwards until the maximum 25-year time point. At time point 25, there was the same number of animals in the impacted population as unimpacted (and this was the case throughout all time points). Therefore, given that the differences in disturbed to undisturbed populations approaches a ratio of one there is not considered to be a potential for a long-term effect on this species.

9.15.1.52 For concurrent piling of monopiles using two vessels, the results showed a population decline but with no difference between un-impacted and impacted populations (Figure A.16, Scenario 2). The median counterfactual of population size was 1 at a time point of the start of year two (coinciding with the end of the first year of the Morgan Generation Assets piling phase) onwards until time point 6, where it was 0.99 until the maximum 25-year time point. At time point 25, there were 25 less animals in the impacted population as unimpacted (and this was the case throughout all time points), however given that the differences in disturbed to undisturbed populations approaches a ratio of one there is not considered to be a potential for a long-term effect on this species.

### A.4.3.2 Cumulative

9.15.1.53 For the cumulative scenario assessed against the MU population (CGNS = 20,118) (Figure A.17, Scenario C1), where multiple projects may be piling either sequentially or concurrently within the regional marine mammal study area, the population modelling suggested a median ratio of 1 from year two onwards until the maximum 25-year time point (Table A.10). At time point 25, there were 26 less animals in the impacted population compared to the unimpacted population (n = 19. 951).

9.15.1.54 When quantitative information for the Tier 2 Project (Mona Offshore Wind Project) is included (Scenario C2, Figure A.18), the median counterfactual remains at a ratio of 1 until to time point 26 (). There 24 less animals in the impacted population versus unimpacted population sizes at time point 25 (n = 0), thus adding the Mona Offshore Wind Project into the models does not have any additional cumulative impact.

**Table A.10: Population trajectory of minke whale in monopile scenarios (single, concurrent, cumulative piling) showing the mean and upper and lower confidence limits at different time points (years after start of offshore construction phase) and median ratio of population size.**

A ratio of less than 1 indicates population decline due to impacted population, equal to 1 indicates no impact, and a ratio of higher than one indicates population growth due to the impact.

| Time point (Years following commencement of piling) | Un-impacted population | | | Impacted population | | | Median Ratio of Population Size |
|---|---|---|---|---|---|---|---|
| | Mean | Lower 2.5% | Upper 95.5% | Mean | Lower 2.5% | Upper 95.5% | |
| **Scenario 1- single, monopile** | | | | | | | |
| Time point 2 | 20160 | 17988 | 21902 | 20160 | 17988 | 21902 | 1 |
| Time point 3 | 20135 | 17294 | 22790 | 20135 | 17294 | 22790 | 1 |
| Time point 6 | 20069 | 16908 | 23700 | 20069 | 16908 | 23700 | 1 |
| Time point 11 | 20026 | 15978 | 24350 | 20026 | 15978 | 24350 | 1 |
| Time point 21 | 19829 | 14665 | 26097 | 19829 | 14665 | 26097 | 1 |
| Time point 26 | 19779 | 14255 | 26440 | 19779 | 14255 | 26440 | 1 |
| **Scenario 2 - concurrent, monopile** | | | | | | | |
| Time point 2 | 20076 | 17782 | 21814 | 20075 | 17778 | 21814 | 1 |
| Time point 3 | 20108 | 17313 | 22436 | 20104 | 17313 | 22436 | 1 |
| Time point 6 | 20056 | 16873 | 23636 | 20043 | 16846 | 23608 | 0.99 |
| Time point 11 | 20056 | 16169 | 24486 | 20035 | 16168 | 24462 | 0.99 |
| Time point 21 | 20081 | 14814 | 27001 | 20055 | 14804 | 26955 | 0.99 |
| Time point 26 | 19951 | 14246 | 27909 | 19926 | 14232 | 27866 | 0.99 |
| **Scenario C1 - Cumulative projects** | | | | | | | |
| Time point 1 | 20120 | 20120 | 20120 | 20120 | 20120 | 20120 | 1 |
| Time point 2 | 20056 | 17816 | 21731 | 20056 | 17816 | 21731 | 1 |
| Time point 3 | 20072 | 17328 | 22446 | 20072 | 17328 | 22446 | 1 |
| Time point 4 | 20042 | 17210 | 22908 | 20041 | 17212 | 22908 | 1 |
| Time point 5 | 20041 | 16826 | 23317 | 20037 | 16820 | 23313 | 0.99 |
| Time point 6 | 20103 | 16820 | 23576 | 20094 | 16818 | 23570 | 0.99 |
| Time point 11 | 20061 | 16650 | 23773 | 20049 | 16638 | 23773 | 0.99 |
| Time point 21 | 20062 | 16416 | 24079 | 20048 | 16415 | 24093 | 0.99 |
| Time point 26 | 20049 | 16445 | 24327 | 20033 | 16449 | 24288 | 0.99 |
| **Scenario C2 - Cumulative projects with Tier 2 Project (Mona Offshore Wind Project)** | | | | | | | |
| Time point 1 | 20120 | 20120 | 20120 | 20120 | 20120 | 20120 | 1 |
| Time point 2 | 20131 | 17992 | 21866 | 20131 | 17992 | 21866 | 1 |
| Time point 3 | 20079 | 17558 | 22476 | 20079 | 17558 | 22476 | 1 |
| Time point 4 | 20057 | 17249 | 23027 | 20056 | 17249 | 23027 | 1 |
| Time point 5 | 20078 | 17003 | 23011 | 20073 | 16999 | 22991 | 1 |
| Time point 6 | 20032 | 16888 | 23519 | 20024 | 16888 | 23508 | 0.99 |

| Time point (Years following commencement of piling) | Un-impacted population | | | Impacted population | | | Median Ratio of Population Size |
|---|---|---|---|---|---|---|---|
| | Mean | Lower 2.5% | Upper 95.5% | Mean | Lower 2.5% | Upper 95.5% | |
| Time point 11 | 20015 | 16625 | 23680 | 20005 | 16614 | 23657 | 0.99 |
| Time point 21 | 20005 | 16448 | 24288 | 19992 | 16448 | 24256 | 0.99 |
| Time point 26 | 20008 | 16638 | 24368 | 19994 | 16638 | 24346 | 0.99 |

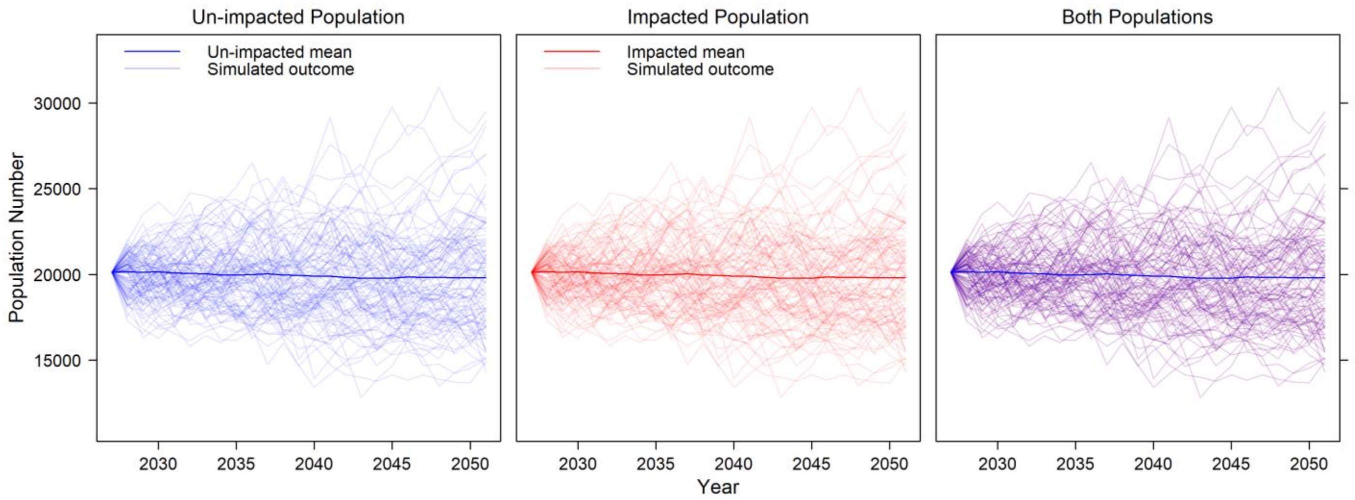


**Figure A.15 Minke whale scenario 1: unimpacted versus impacted scenario for monopiles single piling scenario.**

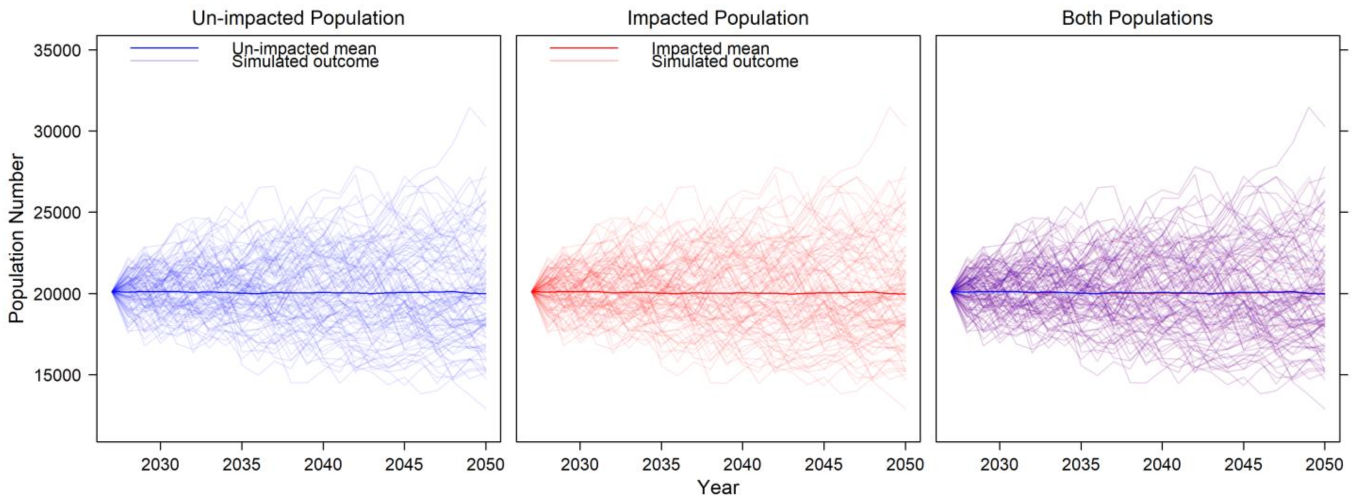


**Figure A.16 Minke whale scenario 2: unimpacted versus impacted scenario for monopiles concurrent piling scenario.**

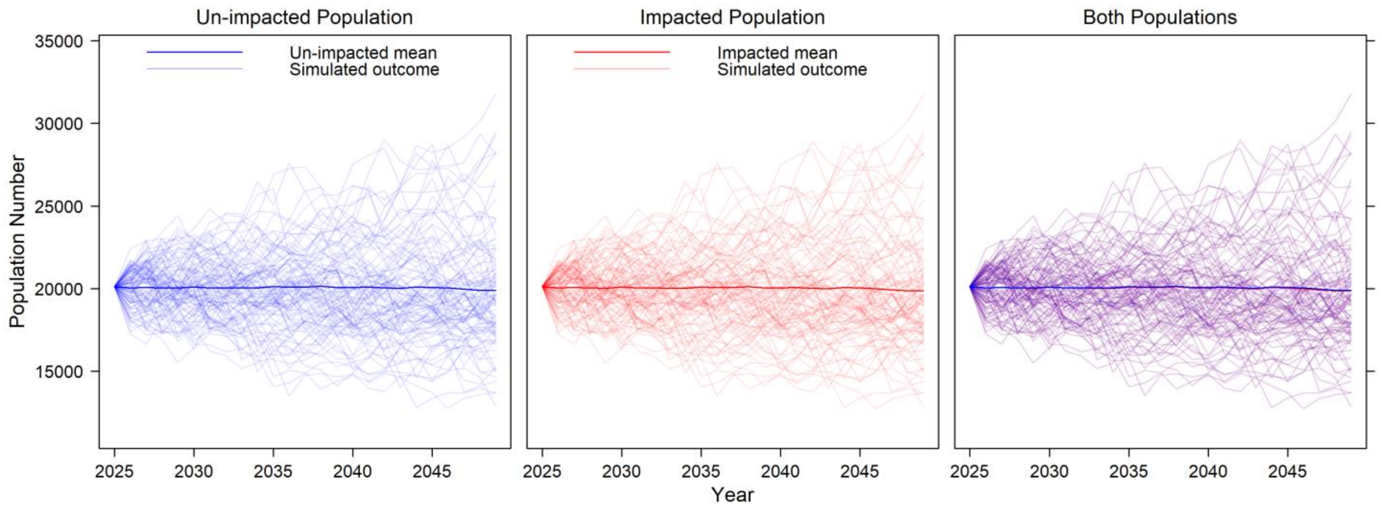


**Figure A.17 Minke whale scenario C1: cumulative projects unimpacted versus impacted scenario.**

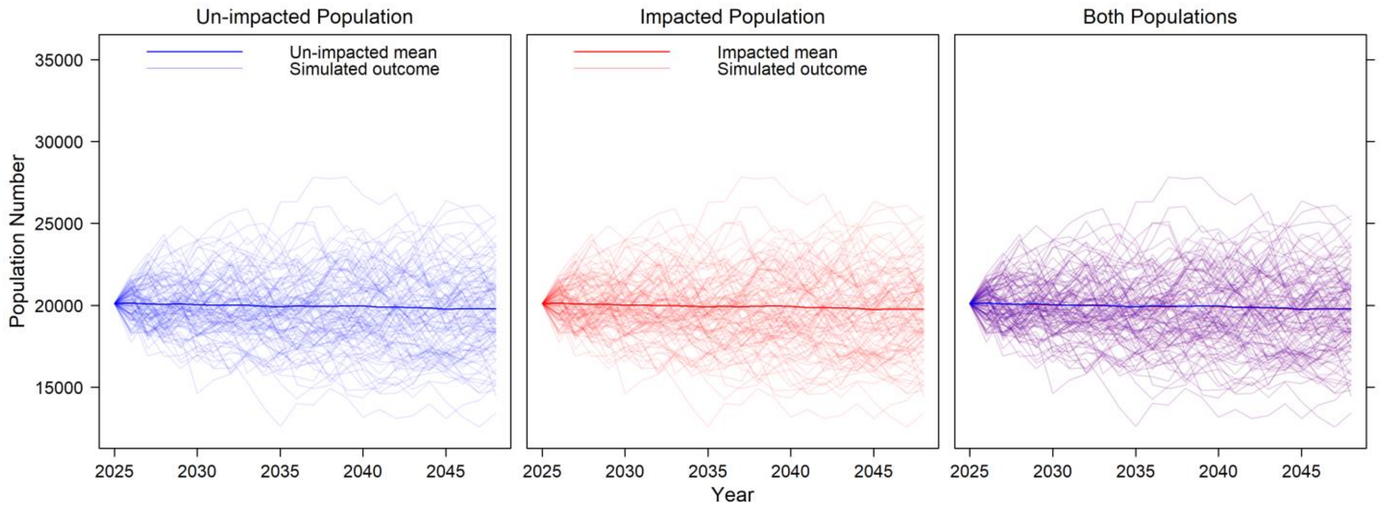


**Figure A.18 Minke whale scenario C2: cumulative projects unimpacted versus impacted scenario with Tier 2 Project (Mona Offshore Wind Project).**

## A.4.4 Grey seal

### A.4.4.1 Project alone

9.15.1.55 Results of the iPCoD modelling for grey seals using the maximum design scenario (monopiles) for single and concurrent scenarios are presented in Table A.11 and Figure A.19 to Figure A.24. Consecutive scenarios are not presented as the numbers of animals for both the disturbance and PTS is zero.

9.15.1.56 For piling of monopiles using a single vessel and applying the OSPAR region III reference population (Scenario 1a), the results show there appears to be no discernible difference in the growth trajectory of grey seal between the un-impacted population and impacted population (Figure A.19). The median counterfactual of population size was 1 at a time point of the start of year two (coinciding with the end of the first year of the Morgan Generation Assets piling phase) until the maximum 25-

year time point. There was no difference in the number of animals in the impacted population compared to the unimpacted at the 25 year time point (or any other time points). Therefore, given that the differences in disturbed to undisturbed populations is equal to a ratio of one there is not considered to be a potential for a long-term effect on this species.

9.15.1.57 Similarly, when using the Grey Seal Reference Population (Figure A.20, Scenario 1b), the median counterfactual of population size was one at a time point of the start of year two until the maximum 25-year time point. There was no difference in the number of animals in the impacted population compared to the unimpacted population at the 25 year time point (or any other time points). As such, in the context of the Grey Seal Reference Population, the differences in disturbed compared to undisturbed populations is equal to a ratio of one and therefore there is not considered to be a potential for a long-term effect on this species.

9.15.1.58 For concurrent piling of monopiles using two vessels, the results show a population increase with very little difference between un-impacted and impacted populations. Using OSPAR region III as a reference population (Scenario 2a, Figure A.21), the median counterfactual of population size was 1 at a time point of the start of year two (coinciding with the end of the first year of the Morgan Generation Assets piling phase) onwards until the maximum 25-year time point. There was no difference in the number of animals in impacted population compared to the unimpacted at the 25 year time point (n = 85,007) (or any other time points). Similarly, when using the Grey Seal Reference population (Scenario 2b, Figure A.22), there was no difference in numbers of animals between the impacted and unimpacted population (n = 18,949) with median counterfactual of population equal to 1 throughout all investigated time points.

### A.4.4.2 Cumulative

9.15.1.59 The cumulative scenario was assessed against the OSPAR Region III population (Figure A.23, Scenario C1a) and Grey Seal Reference Population as a reference populations (Figure A.24, Scenario C1b), where multiple projects may be piling either sequentially or concurrently within the regional marine mammal study area. The population modelling suggested a median ratio of 1 from time point two onwards until the maximum 25-year time point for both populations (Scenarios C1a and C1b). There was no difference in the number of animals in impacted population compared to the unimpacted at the 25 year time point (n = 84,454 for OSPAR Region III, n = 18,837 for Grey Seal Reference Population) (or any other time points). Therefore, given that the differences in disturbed to undisturbed populations approaches a ratio of one for all scenarios, there is not considered to be a potential for a long-term effect on this species.

9.15.1.60 When quantitative information for the Tier 2 Project Mona Offshore Wind Project is included (Scenario C2a Figure A.25, Scenario C2b Figure A.26) the median counterfactual remains at a ratio of 1 until to time point 26 (Table A.11Table A.11: Population trajectory of grey seal in monopile scenarios (single, concurrent, cumulative piling) showing the mean and upper and lower confidence limits at different time points (years after start of offshore construction phase) and median ratio of population size.). There was no difference in the number of animals between impacted and unimpacted population sizes at time point 25 (n = 84,706 for OSPAR Region III, n = 18,895 for Grey Seal Reference Population), thus adding the Mona Offshore Wind Project into the models does not have any additional cumulative impact.

**Table A.11: Population trajectory of grey seal in monopile scenarios (single, concurrent, cumulative piling) showing the mean and upper and lower confidence limits at different time points (years after start of offshore construction phase) and median ratio of population size.**

A ratio of less than 1 indicates population decline due to impacted population, equal to 1 indicates no impact, and a ratio of higher than one indicates population growth due to the impact

| Time point (Years following commencement of piling | Un-impacted population | | | Impacted population | | | Median Ratio of Population Size |
|---|---|---|---|---|---|---|---|
| | Mean | Lower 2.5% | Upper 95.5% | Mean | Lower 2.5% | Upper 95.5% | |
| **Scenario 1a - single, monopile, OSPAR region III reference population** | | | | | | | |
| Time point 2 | 61680 | 56280 | 65564 | 61680 | 56280 | 65564 | 1 |
| Time point 3 | 62509 | 55785 | 67588 | 62509 | 55785 | 67588 | 1 |
| Time point 6 | 65138 | 55570 | 73870 | 65138 | 55570 | 73870 | 1 |
| Time point 11 | 69801 | 55845 | 84389 | 69801 | 55845 | 84389 | 1 |
| Time point 21 | 79651 | 56928 | 103459 | 79651 | 56928 | 103459 | 1 |
| Time point 26 | 85011 | 60041 | 113101 | 85011 | 60041 | 113101 | 1 |
| **Scenario 1b- single, monopile, Grey Seal Reference Population** | | | | | | | |
| Time point 2 | 13739 | 12561 | 14596 | 13739 | 12561 | 14596 | 1 |
| Time point 3 | 13931 | 12494 | 15136 | 13931 | 12494 | 15136 | 1 |
| Time point 6 | 14481 | 12348 | 16371 | 14481 | 12348 | 16371 | 1 |
| Time point 11 | 15483 | 12363 | 18491 | 15483 | 12363 | 18491 | 1 |
| Time point 21 | 17669 | 12792 | 22610 | 17669 | 12792 | 22610 | 1 |
| Time point 26 | 18819 | 13224 | 24838 | 18819 | 13224 | 24838 | 1 |
| **Scenario 2a - concurrent, monopile OSPAR region III reference population** | | | | | | | |
| Time point 2 | 61671 | 56972 | 65424 | 61671 | 56972 | 65424 | 1 |
| Time point 3 | 62404 | 56144 | 67658 | 62404 | 56144 | 67658 | 1 |
| Time point 6 | 64968 | 55434 | 73563 | 64968 | 55434 | 73563 | 1 |
| Time point 11 | 69665 | 56423 | 84365 | 69665 | 56423 | 84365 | 1 |
| Time point 21 | 79497 | 58317 | 105996 | 79497 | 58317 | 105996 | 1 |
| Time point 26 | 85007 | 60114 | 115958 | 85007 | 60114 | 115958 | 1 |
| **Scenario 2b- concurrent, monopile, Grey Seal Reference Population** | | | | | | | |
| Time point 2 | 13745 | 12542 | 14640 | 13745 | 12542 | 14640 | 1 |
| Time point 3 | 13941 | 12448 | 15087 | 13941 | 12448 | 15087 | 1 |
| Time point 6 | 14508 | 12309 | 16489 | 14508 | 12309 | 16489 | 1 |
| Time point 11 | 15534 | 12534 | 18812 | 15534 | 12534 | 18812 | 1 |
| Time point 21 | 17702 | 13020 | 23740 | 17702 | 13020 | 23740 | 1 |
| Time point 26 | 18949 | 13109 | 26325 | 18949 | 13109 | 26325 | 1 |
| **Scenario C1a - Cumulative projects - OSPAR reference population** | | | | | | | |
| Time point 1 | 60780 | 60780 | 60780 | 60780 | 60780 | 60780 | 1 |
| Time point 2 | 61632 | 56379 | 65488 | 61632 | 56379 | 65488 | 1 |

| Time point (Years following commencement of piling | Un-impacted population | | | Impacted population | | | Median Ratio of Population Size |
|---|---|---|---|---|---|---|---|
| | Mean | Lower 2.5% | Upper 95.5% | Mean | Lower 2.5% | Upper 95.5% | |
| Time point 3 | 62432 | 55888 | 67628 | 62432 | 55888 | 67628 | 1 |
| Time point 4 | 63206 | 54926 | 69559 | 63206 | 54926 | 69559 | 1 |
| Time point 5 | 64157 | 55469 | 71767 | 64157 | 55469 | 71767 | 1 |
| Time point 6 | 64991 | 55421 | 73970 | 64991 | 55421 | 73970 | 1 |
| Time point 11 | 69490 | 56467 | 83956 | 69490 | 56467 | 83956 | 1 |
| Time point 21 | 79305 | 59257 | 104047 | 79305 | 59257 | 104047 | 1 |
| Time point 26 | 84454 | 60739 | 112209 | 84454 | 60739 | 112209 | 1 |
| **Scenario C1b - Cumulative projects – Grey Seal Reference Population** | | | | | | | |
| Time point 1 | 13568 | 13568 | 13568 | 13568 | 13568 | 13568 | 1 |
| Time point 2 | 13745 | 12524 | 14644 | 13745 | 12524 | 14644 | 1 |
| Time point 3 | 13939 | 12542 | 15076 | 13939 | 12542 | 15076 | 1 |
| Time point 4 | 14102 | 12316 | 15476 | 14102 | 12316 | 15476 | 1 |
| Time point 5 | 14292 | 12392 | 15904 | 14292 | 12392 | 15904 | 1 |
| Time point 6 | 14459 | 12276 | 16285 | 14459 | 12276 | 16285 | 1 |
| Time point 11 | 15502 | 12448 | 18752 | 15502 | 12448 | 18752 | 1 |
| Time point 21 | 17687 | 13042 | 23138 | 17687 | 13042 | 23138 | 1 |
| Time point 26 | 18837 | 13242 | 25050 | 18837 | 13242 | 25050 | 1 |
| **Cumulative scenario - OSPAR region III as reference population with Tier 2 Project (Mona Offshore Wind Project)** | | | | | | | |
| Time point 1 | 60780 | 60780 | 60780 | 60780 | 60780 | 60780 | 1 |
| Time point 2 | 61552 | 56182 | 65508 | 61552 | 56182 | 65508 | 1 |
| Time point 3 | 62383 | 55723 | 67595 | 62383 | 55723 | 67595 | 1 |
| Time point 4 | 63212 | 55754 | 69791 | 63212 | 55754 | 69791 | 1 |
| Time point 5 | 63965 | 55010 | 71420 | 63965 | 55010 | 71420 | 1 |
| Time point 6 | 64874 | 55479 | 74164 | 64874 | 55479 | 74164 | 1 |
| Time point 11 | 69316 | 55408 | 83533 | 69316 | 55408 | 83533 | 1 |
| Time point 21 | 79163 | 57722 | 103508 | 79163 | 57722 | 103508 | 1 |
| Time point 26 | 84706 | 59787 | 113903 | 84706 | 59787 | 113903 | 1 |
| **Cumulative scenario - all Grey Seal Reference population with Tier 2 Project (Mona Offshore Wind Project)** | | | | | | | |
| Time point 1 | 13568 | 13568 | 13568 | 13568 | 13568 | 13568 | 1 |
| Time point 2 | 13756 | 12520 | 14646 | 13756 | 12520 | 14646 | 1 |
| Time point 3 | 13906 | 12378 | 15141 | 13906 | 12378 | 15141 | 1 |
| Time point 4 | 14110 | 12266 | 15600 | 14110 | 12266 | 15600 | 1 |

| Time point (Years following commencement of piling | Un-impacted population | | | Impacted population | | | Median Ratio of Population Size |
|---|---|---|---|---|---|---|---|
| | Mean | Lower 2.5% | Upper 95.5% | Mean | Lower 2.5% | Upper 95.5% | |
| Time point 5 | 14333 | 12349 | 16046 | 14333 | 12349 | 16046 | 1 |
| Time point 6 | 14542 | 12202 | 16648 | 14542 | 12202 | 16648 | 1 |
| Time point 11 | 15502 | 12440 | 18693 | 15502 | 12440 | 18693 | 1 |
| Time point 21 | 17693 | 13300 | 23035 | 17693 | 13300 | 23035 | 1 |
| Time point 26 | 18895 | 13628 | 25685 | 18895 | 13628 | 25685 | 1 |

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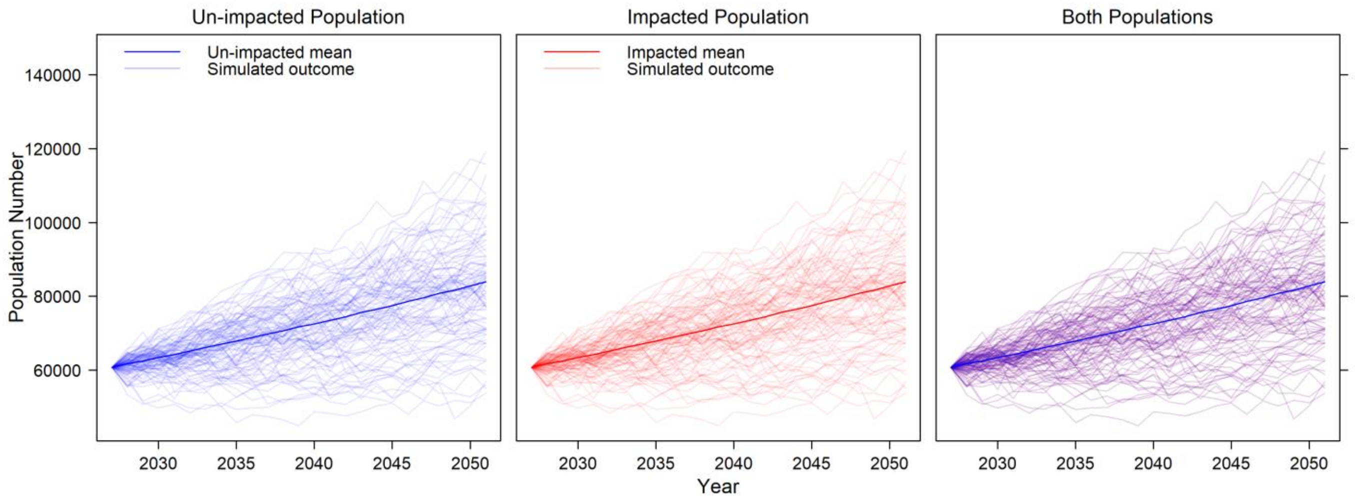


**Figure A.19 Grey seal scenario 1a: unimpacted versus impacted scenario for monopiles single piling scenario, using OSPAR region III as reference population.**

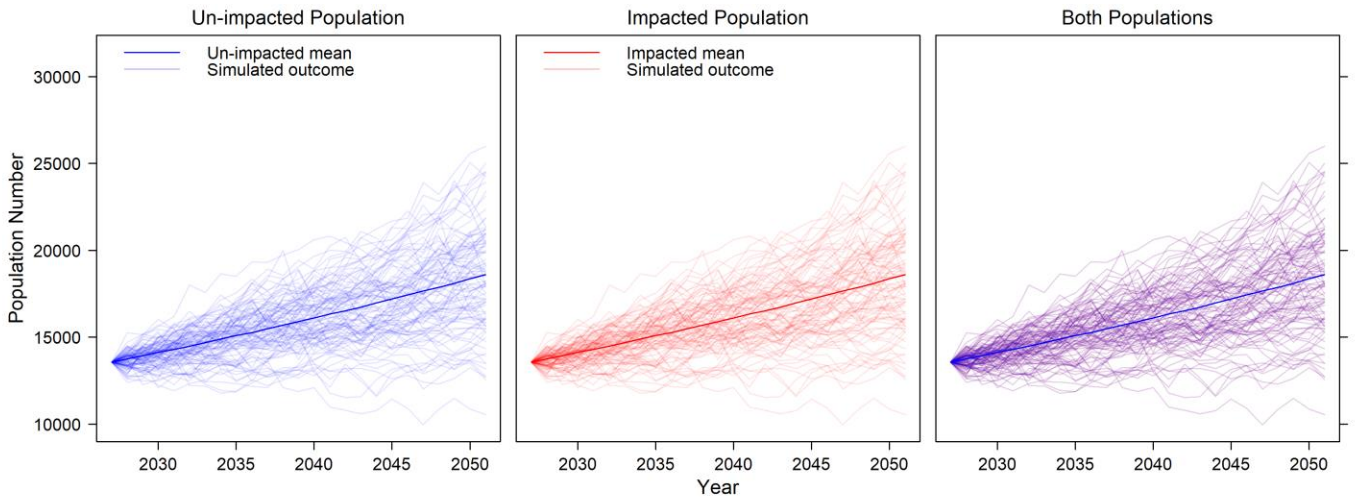


**Figure A.20 Grey seal scenario 1b: unimpacted versus impacted scenario for monopiles single piling scenario, using Grey Seal Reference Population.**

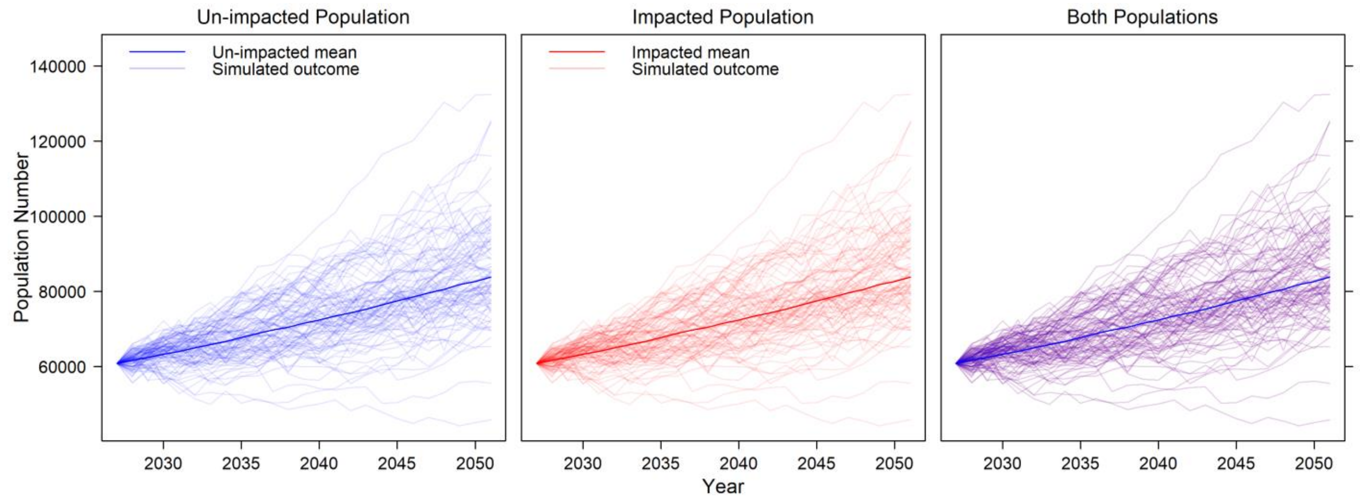


**Figure A.21 Grey seal scenario 2a: unimpacted versus impacted scenario for monopiles concurrent piling scenario using OSPAR region III as reference population.**

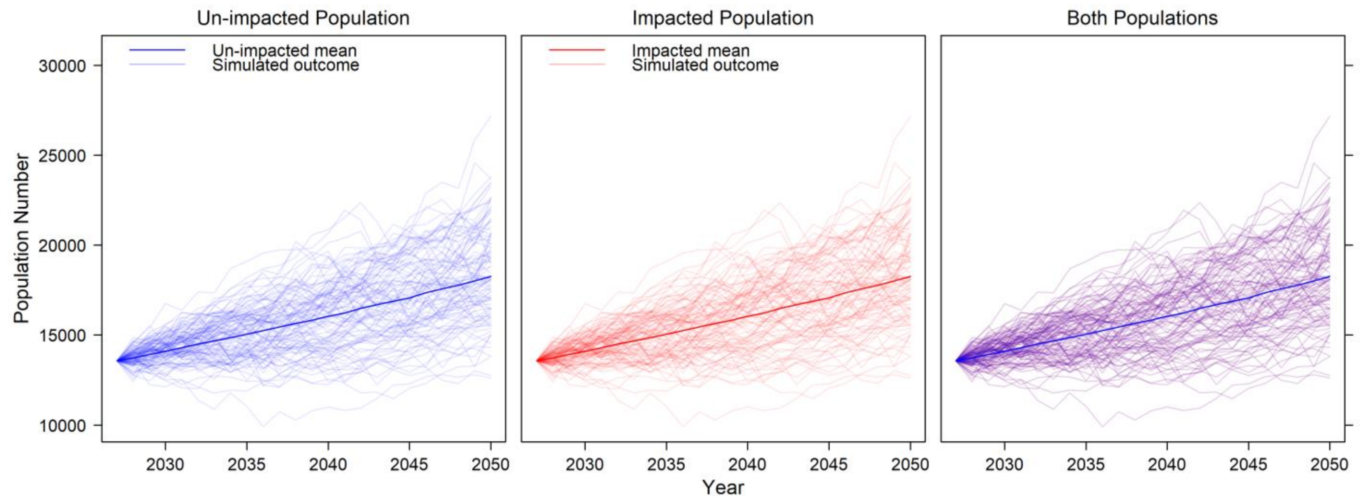


**Figure A.22 Grey seal scenario 2b: unimpacted versus impacted scenario for monopiles concurrent piling scenario using Grey Seal Reference Population.**

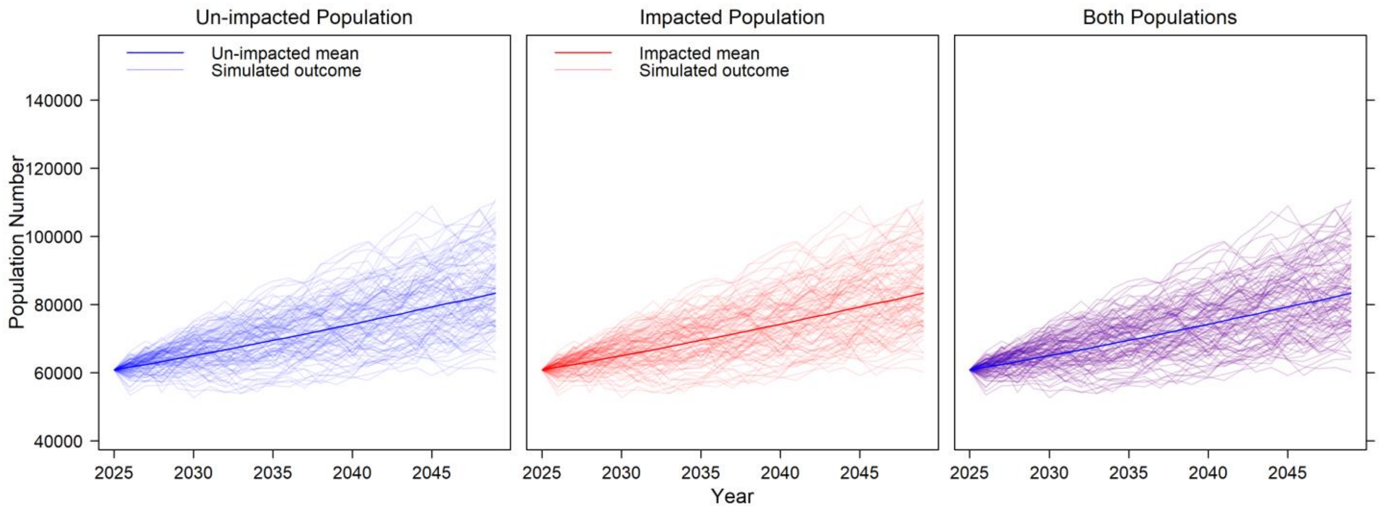


**Figure A.23 Grey seal scenario C1a: cumulative projects unimpacted versus impacted scenario, using OSPAR Region III as reference population.**

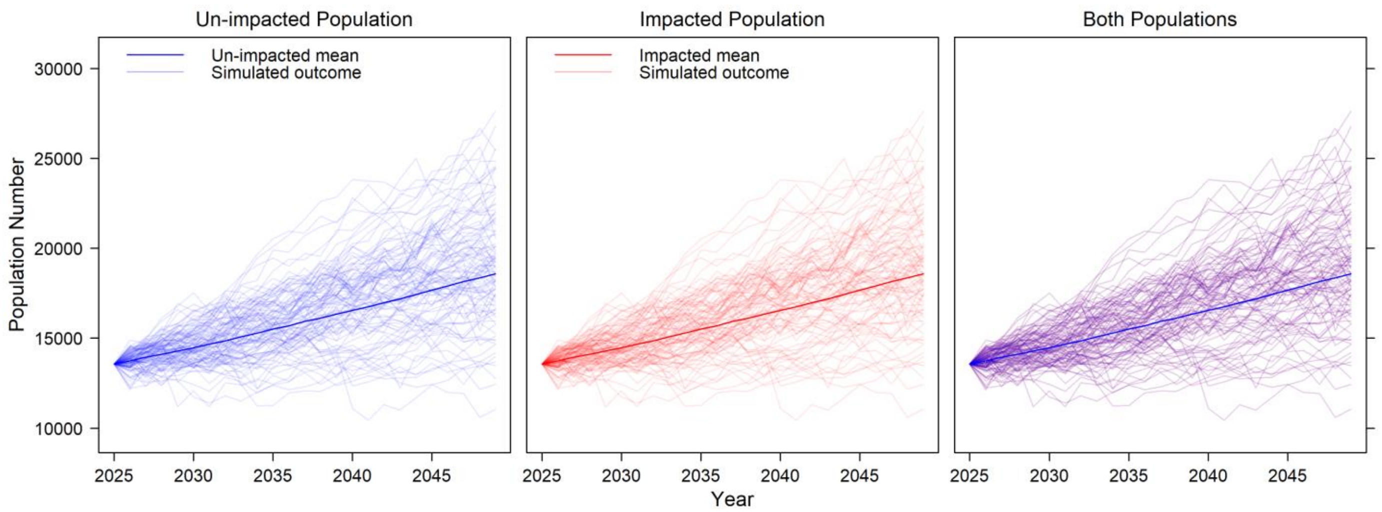


**Figure A.24 Grey seal scenario C1b: cumulative projects unimpacted versus impacted scenario, using Grey Seal Reference Population.**

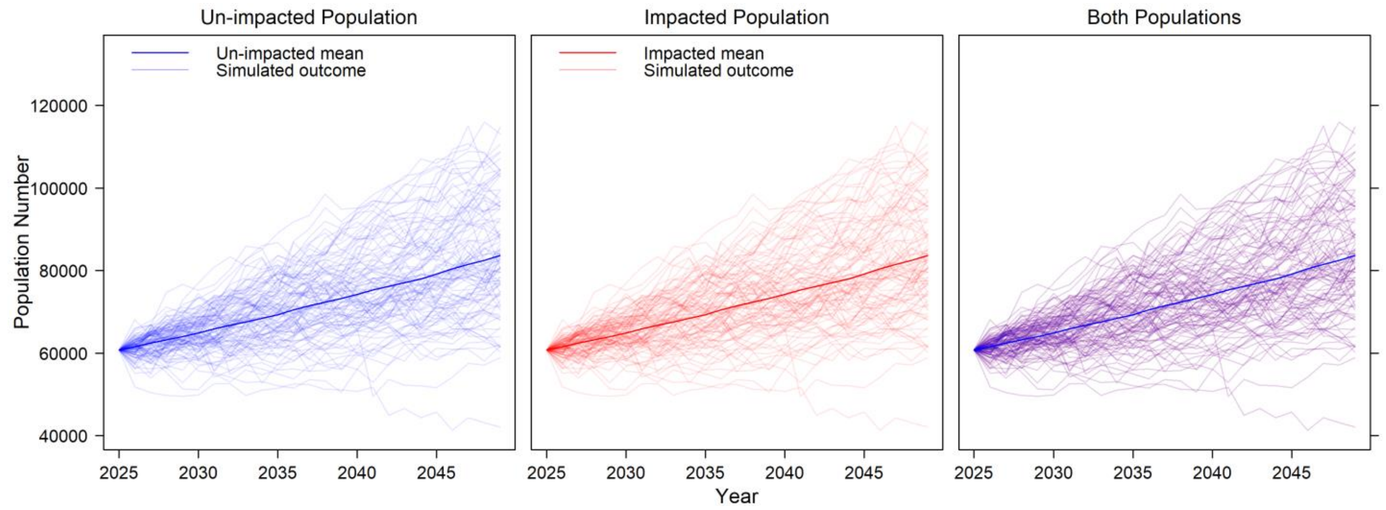


**Figure A.25 Grey seal scenario C2a: cumulative projects unimpacted versus impacted scenario, using OSPAR Region III as reference population with Tier 2 Project (Mona Offshore Wind Project).**

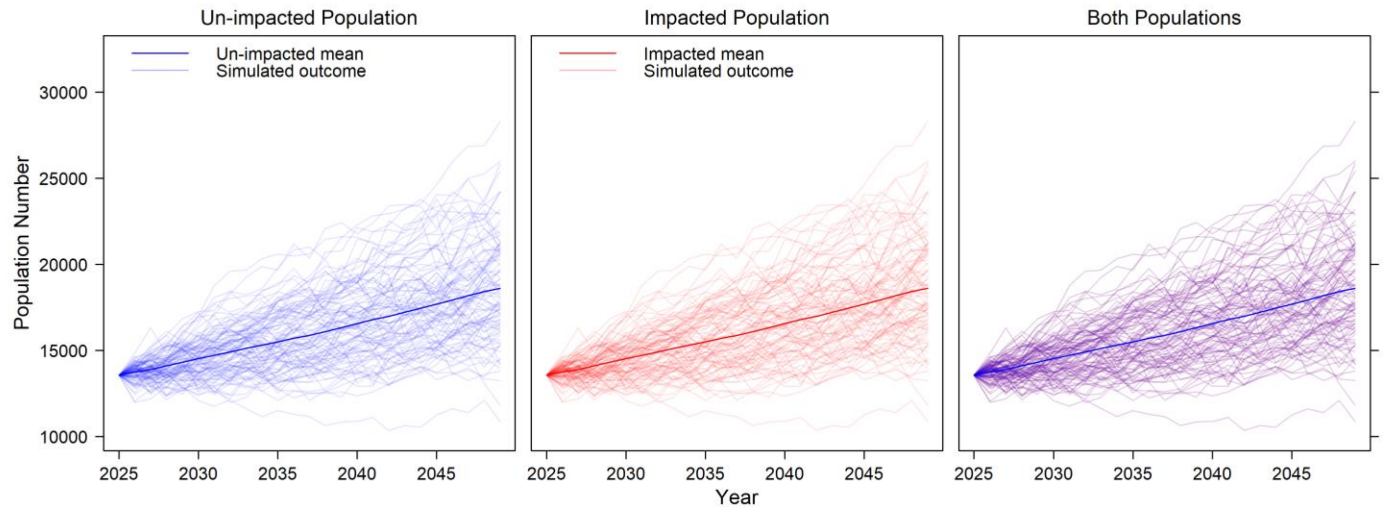


**Figure A.26 Grey seal scenario C2b: cumulative projects unimpacted versus impacted scenario, using Grey Seal Reference Population with Tier 2 Project (Mona Offshore Wind Project).**

## A.5 Summary

9.15.1.61 This report 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 within relevant study areas.

9.15.1.62 The population models were run to predict potential changes in population size as a result of piling at the wind turbine locations and offshore substation platforms associated with Morgan Generation Assets. Reference populations were based on the latest estimates of population size for the relevant species' Management Units or reference populations suggested by NRW. The numbers of animals disturbed were based on the MDS of a 5,000 kJ hammer energy only on the assumption that any population changes would be smaller considering the realistic hammer energy would affect smaller numbers of animals.

9.15.1.63 The modelling for Morgan Generation Assets alone demonstrated that for harbour porpoise, minke whale and grey seal there was predicted to be no long-term decline in the population with negligible to very small differences between the unimpacted to impacted population size. Even where there were notable differences in the number of animals within the undisturbed compared to the disturbed population (i.e. for harbour porpoise and bottlenose dolphin) it is considered likely that this variation will fall within the natural stochasticity of the population and therefore would not represent a measurable (and significant) difference.

9.15.1.64 Conservative parameters were used for the scenarios, following a precautionary approach. Using higher values for survival rates and fertility rates would change population trajectories. Other precautionary assumptions have been made including that animals are disturbed both on the day of piling and for 24 hours the following day leading to additional conservatism in the model.

9.15.1.65 Similarly, for cumulative projects where piling could occur sequentially and concurrently with the Morgan Generation Assets, there would be no long term differences between impacted and unimpacted populations of harbour porpoise, bottlenose dolphin in the context of wider population within the Irish Sea and Offshore Channel and South West MUs, minke whale and grey seal. For bottlenose dolphin population of the Irish Sea MU, the results for cumulative scenario shown a median ratio of 1 from year two onwards until the maximum 25-year time point, suggesting no long-term impacts on the population in terms of iPCoD modelling alone. However, the size of the population, its trajectory and ecology with respect to cumulative piling is further considered in section 9.10.1. The assessment was based on the maximum design scenario 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. Results should, however, be interpreted with caution as there were no details on the actual piling schedules for cumulative projects.

9.15.1.66 Though the iPCoD model attempts to model major sources of uncertainty, results will always vary greatly due to environmental and demographic stochasticity in the model. Whilst the model shows no evidence of population change from the Morgan Generation Assets alone, there are sources of uncertainty. Variation in demographic rates among years may exist as a result of changes in environmental conditions, or as a result of random processes or chance events which impact vital rates (e.g. survival, fertility, etc.). In two, otherwise identical populations that experience exactly the same sequence of environmental conditions, demographic stochasticity will mean populations will follow slightly different trajectories over time. The model assumes 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 data around the mean trajectories in Figure A.1 to Figure A.24). In addition, the model assumes that survival and fertility rates are not affected by population size (i.e. that there is no density dependent response).

9.15.1.67 In summary, whilst it is understood that iPCoD is a relatively simple population model (which links days of disturbance to changes in individual vital rates), the most obvious sources of uncertainty have been captured in the model development. 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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