Morven South Offshore Wind Array Project

Environmental Impact Assessment Report

Volume 2, Chapter 10: Marine Mammals

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Table of contents

List of tables

List of figures

10 Marine Mammals

10.1 Introduction

10.1.1.1 This chapter of the Morven South Offshore Wind Array Project (hereafter 'Morven South') Environmental Impact Assessment (EIA) Report (hereafter, the EIA Report) presents the assessment of the Likely Significant Effects (LSE[1]) (as per the EIA Regulations as defined in Volume 1, Chapter 2: Policy and Legislation) on marine mammals. Specifically, this chapter considers the potential impacts of Morven South seaward of Mean High Water Springs during the construction, Operations and Maintenance (O&M) and decommissioning phases. Where relevant, this chapter also assesses the LSE[1] of Morven South on receptors landward of Mean Low Water Springs (MLWS) during the construction, O&M and decommissioning phases.

10.1.1.2 The assessment presented in this chapter has relied upon, or informed by the following technical chapters and reports:

- Volume 2, Chapter 7: Physical Processes;
- Volume 2, Chapter 9: Fish and Shellfish Ecology;
- Volume 2, Chapter 13: Shipping and Navigation;
- Volume 3, Annex 10.1: Marine Mammals Shared Baseline Technical Report;
- Volume 3, Annex 10.2: Underwater Sound Shared Technical Report;
- Volume 3, Annex 10.3: Marine Mammals Shared Digital Aerial Survey Report;
- Volume 3, Annex 10.4: Marine Mammals Shared Seal Telemetry and Haul-out Data Study Technical Report;
- Volume 3, Annex 10.5: Marine Mammals Interim Population Consequences of Disturbance (iPCoD) Modelling Report.

10.1.1.3 Marine mammals were reported on in the Scoping Report for the Morven Option Lease Agreement Site (hereafter, 'the Morven Site Scoping Report'). (Morven Offshore Wind Limited (MvOWL), 2023). As described in Volume 1, Chapter 4: Site Selection and Consideration of Alternatives, the Morven Site has since been divided into two smaller projects, Morven North and Morven South.

10.1.1.4 The potential impacts to marine mammals are considered to generally be the same (or less) for Morven South as identified in the Morven Site Scoping Report. Consequently, there has been no change in the methodology or impacts that were scoped in or out in the Morven Site Scoping Report for marine mammals. The advice provided by the Marine Directorate Licensing Operations Team (MD-LOT) in the Morven Site Scoping Opinion (MD-LOT, 2023) relevant to Morven South, has therefore been considered for the development of this chapter.

10.1.1.5 This chapter presents and assesses up-to-date parameters for Morven South and explains if and how any assessment aspects differ from the information set out in the Morven Site Scoping Report.

10.2 Study Areas

10.2.1.1 Study areas have been defined for marine mammals:

- the Morven South Marine Mammal Study Area;
- the Morven Site Marine Mammal Study Area;
- the Morven North and Morven South Regional Marine Mammal Study Area.

10.2.1.2 The study areas defined for marine mammals are shown in Figure 10.1 defined as follows:

- The Morven South Marine Mammal Study Area includes the Morven South Boundary, plus a buffer extending 4km from the Morven South Boundary.
- The Morven Site Marine Mammal Study Area. This is the area over which Digital Aerial Survey (DAS) flights were undertaken between January 2021 and September 2023. It incorporates the Morven North Boundary and the Morven South Boundary, plus an approximate 4km buffer.
- The Morven North and Morven South Regional Marine Mammal Study Area (hereafter the Morven Regional Marine Mammal Study Area) extends over the North Sea geographic region

(Figure 10.1). Marine mammals are highly mobile and may range over large distances and, therefore, the Morven Regional Marine Mammal Study Area provides wider context. The desktop review will consider the ecology, distribution, and abundance of marine mammals within the Morven Regional Marine Mammal Study Area and will inform the assessment where the Zone of Influence (ZoI) for a given impact (e.g. underwater sound) may extend beyond the Morven Regional Marine Mammal Study Area. The Morven Regional Marine Mammal Study Area will also be applied as the initial screening area for the Cumulative Effects Assessment (CEA).

10.2.1.3 Other areas of importance in the context of the marine mammals are the regional marine mammal management units (MUs), which differ between species (Figure 10.2). The marine mammal MUs will be used as reference populations for the quantitative assessment (i.e. comparing the number of animals affected by a given impact against the species-specific MU and the percentage of the MU population impacted). The area for SCANS-IV survey block NS-D (Gilles *et al.*, 2023) is also shown in Figure 10.2 for additional context as published data on densities and abundance of key species is available for this survey area which overlaps Morven South.

10.2.1.4 The study areas for marine mammals for the Morven Option Lease Agreement Site (hereafter 'Morven Site') were presented and agreed during the scoping process for the Morven Site. The underlying principles used to define the study area(s) for Morven South have not changed, other than the limits have been applied relative to the Morven South Boundary, rather than the Morven Site. The study areas for Morven South for marine mammals were presented to and confirmed by the Marine Directorate Licensing Operations Team (MD-LOT) via a 'Targeted Consultation Exercise' undertaken in Quarter 1, 2025 and as detailed in Table 10.15.

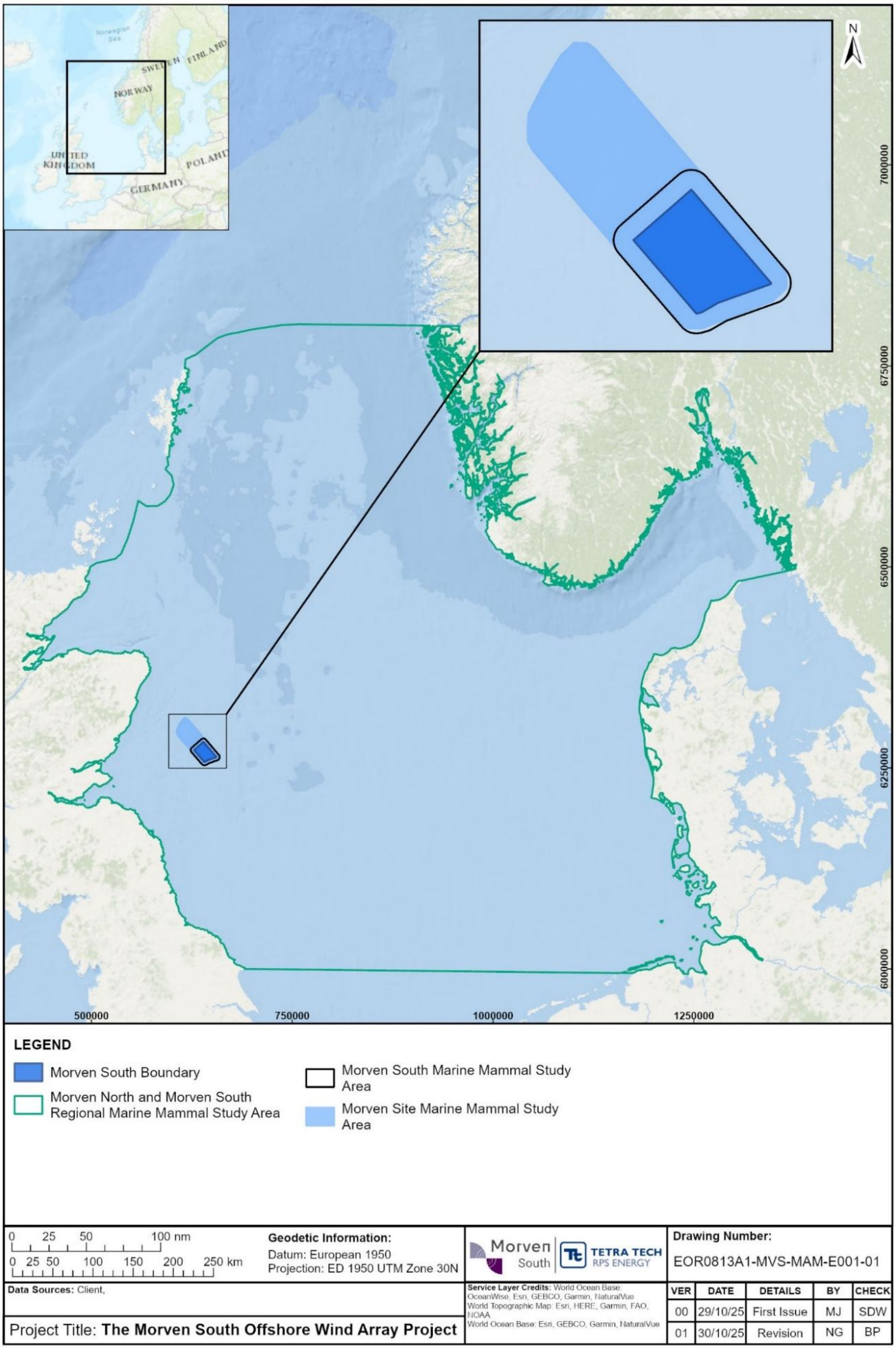

Figure 10.1: Marine mammal study areas for Morven South

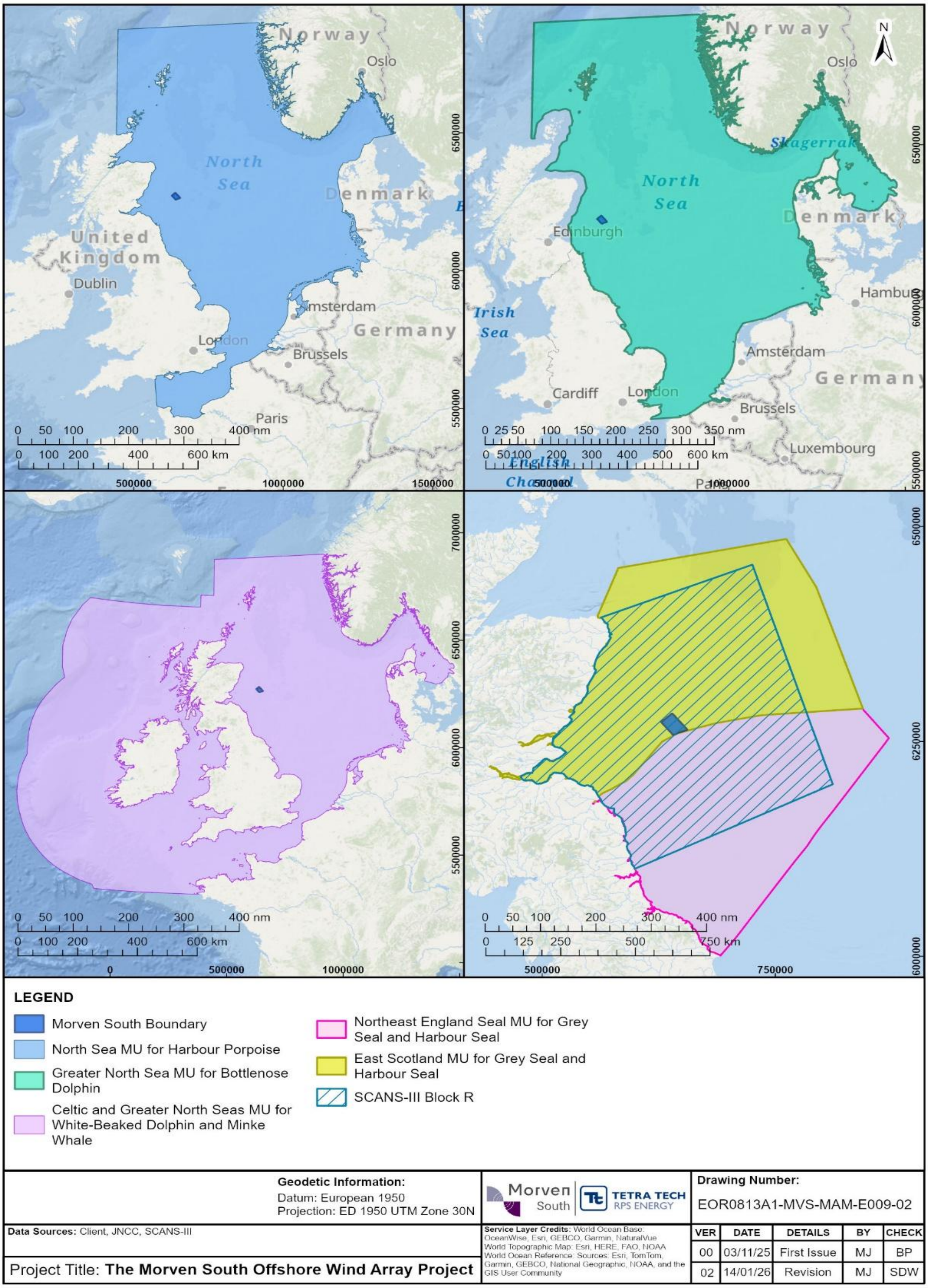

Figure 10.2: Marine mammal Management Units of relevance to Morven South

10.3 Legislative and Policy Context

10.3.1.1 Policy and legislation on renewable energy infrastructure is presented in Volume 1, Chapter 2: Policy and Legislation. A summary of the legislative provisions relevant to marine mammals is provided in Table 10.1 to Table 10.13 below.

Table 10.1: Summary of provisions within the Wildlife and Countryside Act 1981 (as amended) of relevance to marine mammals

Summary of relevant legislation	How and where considered in the EIA Report
The Wildlife and Countryside Act 1981 implements the Bern Convention and offers protection to species listed in Schedule 5, including all cetaceans and basking sharks, making it an offence to intentionally or recklessly disturb, kill, injure or take these species	The assessment of the environmental impacts of Morven South on the marine mammals is presented in Section 10.8, along with mitigation measures adopted to prevent, minimise, reduce or offset potential impacts.

Table 10.2: Summary of provisions within the Marine and Coastal Access Act 2009 of relevance to marine mammals

Summary of relevant legislation	How and where considered in the EIA Report
Marine Protected Areas (MPA) in Scottish Waters, beyond 12nm are designated under the MCAA 2009. These sites are areas that have been designated for the purpose of conserving marine flora and fauna; marine habitat or types of marine habitat; or features of geological or geomorphological interest.	All relevant MPAs within the Morven South Marine Mammal Study Area are listed in section 10.7.3 and further described in Volume 3, Annex 10.1: Marine Mammal Shared Technical Report, and potential effects on these are considered in Section 10.11.

Table 10.3: Summary of provisions within the Wildlife and Natural Environment (Scotland) Act 2011 of relevance to marine mammals

Summary of relevant legislation	How and where considered in the EIA Report
The Wildlife and Natural Environment (Scotland) Act 2011 strengthens the framework for species protection by introducing new wildlife offences, including vicarious liability, and improving licensing and enforcement mechanisms. It updates the Wildlife and Countryside Act 1981, under which all cetaceans are protected, and enhances the regulatory tools available for managing impacts on marine mammals, including through improved oversight of activities that may cause disturbance or harm.	The assessment of the environmental impacts of Morven South on the marine mammals is presented in Section 10.8, along with mitigation measures adopted to prevent, minimise, reduce or offset potential impacts.

Table 10.4: Summary of provisions within the Marine Strategy Regulations 2010 of relevance to marine mammals

Summary of relevant legislation	How and where considered in the EIA Report
The Regulations transpose the Marine Strategy Framework Directive (2008) into UK law and require	The assessment of the environmental impacts of Morven South on the marine mammals is presented

the UK to develop and implement a marine strategy to achieve or maintain Good Environmental Status (GES) in UK marine waters GES is defined through 11 descriptors, with the following particularly relevant to marine mammals: • Descriptor 1 - Biodiversity: Marine biodiversity must be maintained. This includes the abundance and distribution of marine mammals, ensuring populations are healthy and habitats are not degraded. • Descriptor - 4 Food Webs: Food webs must be abundant, sufficiently diverse and at levels capable of ensuring the long-term abundance to support marine mammal populations and reproductive capacity. Disruption to prey availability or trophic interactions could affect marine mammals. • Descriptor 11 - Underwater Noise: Introduction of energy, especially underwater noise, must not adversely affect the marine environment. Marine mammals are highly sensitive to noise, which can interfere with communication, navigation, and foraging, and may lead to displacement or physical harm.	in Section 10.8. Biodiversity, food webs and underwater noise are all considered in the impacts assessed.

Table 10.5: Summary of provisions within the Marine (Scotland) Act 2010 of relevance to marine mammals

Summary of relevant legislation	How and where considered in the EIA Report
Habitat Health	
The Scottish Ministers, and public authorities must act in the way best calculated to further the achievement of sustainable development, including the protection and, where appropriate, enhancement of the health of that area.	The assessment of the environmental impacts of Morven South on marine mammals is presented in Section 10.11 to best inform ministers of the sustainability of the development.
Protection of Seals	
The Act provides improved protection for seals. Certain haul-out sites have been designated here seals are protected from intentional or reckless harassment. The Act seeks to balance seal conservation with other pressures and requirements (such as species conservation). Part 6 prohibits the killing, injuring or taking of seals except under specific licence	The designated haul-out sites located in vicinity to Morven South are described in Volume 3, Annex 10.1: Marine Mammal Shared Technical Report and effects on these are considered in Section 10.11. No licence is required as there will be no killing or taking of seals in any phase of Morven South.

Summary of relevant legislation	How and where considered in the EIA Report
Nature Conservation Marine Protected Areas	
The Marine (Scotland) Act 2010 provides for the development of a marine spatial planning system, creating a framework for marine developments and enables the creation of Nature Conservation Marine Protected Area (ncMPA).	The Southern Trench ncMPA, designated for minke whale, is in Scottish inshore waters (within 12nm) and is discussed in section 10.7.3. Potential effects on this are considered in Section 10.11.
The Marine (Scotland) Act 2010 provides the legal basis for designating Marine Protected Areas (MPAs) within 12nm. These inshore MPAs can be designated to protect important marine habitats, species, and features of geological or geomorphological interest.	All relevant MPAs within the Morven South Marine Mammal Study Area are listed in section 10.7.3 and further described in Volume 3, Annex 10.1: Marine Mammal Shared Technical Report, and potential effects on these are considered in Section 10.11.

Table 10.6: Summary Habitats Regulations relevant to marine mammals

Summary of relevant legislation	How and where considered in the EIA Report
Overview	
The Conservation of Offshore Marine Habitats and Species Regulations 2017, the Conservation of Habitats and Species Regulations 2017, and The Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019 collectively transpose the requirements of the EU Habitats Directive into UK law. These regulations apply to offshore waters beyond 12 nautical miles and govern the assessment and protection of European sites in relation to applications made under the Electricity Act 1989	Morven South falls beyond 12 nautical miles of the coast and therefore the offshore Habitats Regulations apply to this project.
European sites	
Before deciding to undertake, or give any consent, permission or other authorisation for, a plan or project which is likely to have a significant effect on a European offshore marine site or a European site (either alone or in-combination with other plans or projects) and is not directly connected with or necessary to the management of the site, a competent authority must make an Appropriate Assessment of the implications of the plan or project for that site in view of that site's conservation objectives. If the competent authority is satisfied that, there being no alternative solutions, the plan or project must be carried out for imperative reasons of over-riding public interest it may agree to the plan or project notwithstanding a negative assessment of the implications for the European site and if compensatory measures can be secured.	All European sites with marine mammals as protected features, relevant to Morven South, are listed in section 10.7.3 and effects on the features of these are considered in Section 10.11. European sites are further assessed in accordance with the Habitats Regulations, as presented in the Habitats Regulations Appraisal (Chapter 2.1: Report to Inform Appropriate Assessment Part 2: SAC Assessments).

Summary of relevant legislation	How and where considered in the EIA Report
Species protection	
A person is guilty of an offence if they deliberately capture, injure, or kill any wild animal of a European Protected Species (EPS). In Scottish offshore waters (beyond 12 nautical miles from the coast), offences relating to the protection of marine EPS are provided for under the Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2017. In this context, disturbance is considered an offence only where it is non-trivial and has the potential to affect the conservation status of the species, rather than disturbance to individual animals.	An EPS licence will be applied for in relation to any activity which has potential to result in an offence and this application would be informed by the assessments presented in Section 10.11.

Table 10.7: Summary of the Nature Conservation (Scotland) Act 2004 relevant to marine mammals

Summary of relevant legislation	How and where considered in the EIA Report
General Principles	
Places duties on public bodies in relation to the conservation of biodiversity and strengthens wildlife enforcement legislation. The Act amends section 9 of the Wildlife and Countryside Act 1981 to extend wild animal protection to include reckless as well as intentional acts. The Act makes it an offence to disturb or harass cetaceans and amends the provisions for enforcement. (Inserted as section 9(4A).)	Section 10.11 presents an assessment of the significance of the effects of Morven South on marine mammal receptors along with mitigation measures adopted to prevent, minimise, reduce or offset potential impacts.

Table 10.8: Summary of Scotland's National Marine Plan (2015) relevant to marine mammals

Summary of relevant policy	How and where considered in the EIA Report
General Policies	
GEN 5 Climate Change: Marine planners and decision makers must act in the way best calculated to mitigate, and adapt to, climate change.	The impact of climate change on the baseline environment and how this may influence the assessment of effects is considered as part of the future baseline in Section 10.7.4. A climate change assessment has been undertaken that considers Morven South in the context of climate change in Volume 2, Chapter 12: Climate Change.
GEN 9 section of the Plan refers to Natural Heritage and provides that "Development and use of the marine environment must:	Marine mammal protected species and PMFs are identified in Section 10.7.3. Section 10.11 presents an assessment of the significance of the effects of Morven South on marine mammals, along with

Summary of relevant policy	How and where considered in the EIA Report
• comply with legal requirements for protected areas and protected species; • not result in significant impacts on the national status of Priority Marine Features (PMFs); • protect and, where appropriate, enhance the health of the marine area". Includes consideration of risks to achieving objectives of a ncMPA and includes consideration of legally protected species and licensing requirement.	mitigation measures adopted to prevent, minimise, reduce or offset potential impacts. This includes consideration of the features of designated sites, including the Southern Trench ncMPA. In respect of legally protected species, an EPS licence will be applied for in relation to any activity which has potential to result in an offence and this application would be informed by assessment presented in Section 10.11.
GEN 13 Noise: Development and use in the marine environment should avoid significant adverse effects of man-made noise and vibration, especially on species sensitive to such effects. Where avoidance is not possible, mitigation must be applied.	Underwater noise impacts from construction activities (e.g. piling) are assessed in Section 10.11. Development on marine mammals, along with mitigation measures, are adopted to prevent, minimise, reduce or offset potential impacts. Impulsive noise will be monitored at four foundations and detail provided to Marine Noise Registry (MNR).

Table 10.9: Summary of Priority Marine Features in Scotland's Seas (NatureScot, 2020) relevant to marine mammals

Summary of relevant policy	How and where considered in the EIA Report
Marine Mammal Species	
PMFs are habitats and species that have been identified as being conservation priorities in Scottish waters. These include 16 species of marine mammals.	Most of the marine mammal features identified as key species for this assessment are also Scottish PMFs (see Section 10.7.2) and the conservation status assigned to them reflects their national and international importance.

Table 10.10: Summary of the Sectoral Marine Plan[1] for Offshore Wind Energy 2020 relevant to marine mammals

Summary of relevant policy	How and where considered in the EIA Report
General Policies	
Minimise the potential adverse effects on other marine users, economic sectors and the environment resulting from further commercial scale offshore wind development. (Marine Spatial Planning, Section 2.1)	Section 10.11 presents assessments of the significance of the effects as a result of the construction, O&M and decommissioning phases of Morven South on marine mammal receptors.

[1] At the time this document was prepared, the Sectoral Marine Plan (SMP) was based on the 2020 version. A revised SMP is currently available in draft form for consultation (Draft SMP, 2025), and the updated plan is expected to be formally published in summer 2026.

Offshore Wind and Marine Renewable Energy Policies	
Regional cumulative effects include the potential for negative effects on bird populations, benthic habitats, cetaceans, navigational safety, seascape/landscape and commercial fisheries. The Sectoral Marine Plan includes measures to mitigate potential impacts at various scales. (Environmental Effects, Section 4.1)	A consideration of impacts on the relevant European sites from Morven South cumulatively with other plans and projects is provided in Habitats Regulations Appraisal Report to Inform Appropriate Assessment Part 2: SAC Assessments, alongside relevant mitigation measures (see Section 10.10).

Table 10.11: Summary of the United Kingdom Marine Policy Statement relevant to marine mammals

Summary of relevant policy	How and where considered in the EIA Report
General Policies	
Ensure a sustainable marine environment which promotes healthy, functioning marine ecosystems and protects marine habitats, species and our heritage assets. (Introduction)	The assessment for Morven South (Section 10.11) takes a holistic approach that considers potential impacts on the functioning of ecosystems relevant to marine mammals including indirect effects from changes in prey availability or habitat-associated effects that may displace animals from important areas.
The marine environment plays an important role in mitigating climate change. (Achieving the Vision Through Marine Planning, Section 2.2)	The impact of climate change on the baseline environment and how this may influence the assessment of effects is considered as part of the future baseline in 10.7.4. A climate change assessment has been undertaken that considers Morven South in the context of climate change in Volume 2, Chapter 18: Climate Change.
Biodiversity is protected, conserved and where appropriate recovered and loss has been halted. (Achieving the Vision Through Marine Planning, Section 2.2)	All marine mammals are PMFs with exception of humpback whale as presented in Table 10.23 (Section 10.7). Conservation value is considered as part of the sensitivity evaluation of marine mammals.
Offshore Wind and Marine Renewable Energy Policies	
Marine businesses are acting in a way which respects environmental limits and is socially responsible. (Achieving the Vision Through Marine Planning, Section 2.2)	As part of the Morven South design process, a number of designed-in measures and mitigation have been proposed to reduce the potential for impacts on marine mammals (see Section 10.10). They are considered at every stage of Morven South through a commitment to implementing environmentally responsible design and best practice measures.

Table 10.12: Summary of the Scottish Government Planning Guidance: Biodiversity relevant to marine mammals

Summary of relevant policy	How and where considered in the EIA Report
General Principles	
The guidance sets out the Scottish ministers' expectations for implementing NPF4 policies which support the cross-cutting NPF4 outcome 'improving biodiversity'. Policy 3b requires development proposals to demonstrate that: • they are informed by a clear understanding of the site's ecological characteristics and wider context; • nature-based solutions have been used wherever feasible; • all negative effects are fully mitigated following the mitigation hierarchy; • they deliver meaningful biodiversity enhancements, including strengthening nature networks and habitat connectivity, secured and managed for the long term; and These requirements ensure that developments assess and address potential impacts on marine habitats and protected species while contributing to wider ecological resilience.	Morven South is being developed with designed-in measures and mitigation (Section 10.10) to reduce any short- to medium term risks to marine mammal receptors throughout the lifetime of Morven North.

Table 10.13: Summary of the Scottish Biodiversity Strategy to 2045 (Scottish Government 2023) relevant to marine mammals

Summary of relevant policy	How and where considered in the EIA Report
General Principles	
Sets out a vision for 2045 explaining how the government will conserve biodiversity for the people of Scotland now and in the future with the objective to halt the loss of biodiversity.	Reducing the risk of climate change via renewable developments contributes to the long-term vision for protection of biodiversity. Morven South is being developed with designed-in measures and mitigation (Section 10.10) to reduce any short- to medium term risks to marine mammal receptors throughout the lifetime of Morven South.

Table 10.14: Summary of the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) 1992, Relevant to Marine Mammals

Summary of relevant policy	How and where considered in the EIA Report
General Principles	
The OSPAR Convention (1992) provides a framework for international cooperation to protect the marine environment of the North-East Atlantic. It is particularly important for marine mammals, as it includes provisions to reduce pollution, manage human activities, and conserve biodiversity through Annex V. The Convention supports the designation of Marine Protected Areas (MPAs), promotes ecosystem-based management, and addresses threats such as underwater noise, contaminants, and habitat degradation factors known to impact cetaceans and pinnipeds.	Sites designated for the protection of marine mammals are detailed in Section 10.7.3 and have been considered as part of the impact assessment.

10.4 Consultation

10.4.1.1 The approach to consultation for Morven South is set out in Chapter 5: Consultation. A summary of the issues raised during consultation activities undertaken to date specific to marine mammals is presented in Table 10.15, together with how these issues have been considered in the production of this marine mammals EIA Report chapter. Further detail is presented within Volume 1, Chapter 5: Consultation and Volume 3, Annex 5.1: Consultation Annex.

Table 10.15: Summary of key consultation issues raised during consultation activities undertaken for Morven South of relevance to marine mammals

Date	Consultee and type of consultation	Summary of issue(s) raised	Applicant's response to issue raised and, if applicable, where considered in this chapter
18 April 2023	Nature Scot, Scoping Workshop session	Confirmation of proposed data sources for the Marine Mammal chapter.	Data sources outlined in Section 10.6.3.
18 April 2023	MSS (now MD-SEDD), Scoping Workshop session	Recommend use of Hague *et al.* (2020) and Lacey *et al.* (2022) to inform the EIA Report marine mammal chapter.	Hague *et al.* (2020) and Lacey *et al.* (2022) were used to inform the ecological baseline. Provided in Volume 3, Annex 10.1: Marine Mammals Shared Baseline Technical Report.
18 April 2023	NatureScot, Scoping Workshop session	SCANS IV survey campaign taking place during summer 2023. Outputs to be used in EIA Report if feasible. Final SCANS IV report expected in Q4 2023.	SCANS IV (Gilles *et al.*, 2023, Gilles *et al.*, 2025) was used to inform the ecological baseline for potential impacts to marine mammal receptors (Section 10.6).
18 April 2023	NatureScot, Scoping Workshop session	NatureScot agree with proposed approach to scope out injury to marine mammals due to collision with vessels during the O&M phase of the Array Project.	NatureScot agreement noted and collision risk was not considered within this EIA chapter.
18 April 2023	NatureScot, Scoping Workshop session	Outlined expected approach to marine mammal underwater sound assessment: both Sound Pressure Level (SPL_{pk}) and cumulative Sound Exposure Level over 24 hours (SEL_{24h}) should be used for assessment. SPL_{pk} should be used to determine distances from the source for which nominal measures will be implemented, such as marine mammal observers and passive acoustic monitoring (PAM) to mitigate potential injury effects from instantaneous sound (i.e. SPL_{pk}) of piling first strike. Maximum hammer energy should be used to model injury ranges. If modelled SEL_{24h} ranges are greater than those predicted for SPL_{pk}, then additional mitigation measures	A dual metric approach using both peak SPL (PK) and SEL_{24h} has been applied based on underwater so (Volume 3, Annex 10.2: Underwater Sound Shared Technical Report und assessment). The assessment found that injury could be mitigated with standard industry measures and therefore no additional mitigation measures were considered necessary (Section 10.10)

Date	Consultee and type of consultation	Summary of issue(s) raised	Applicant's response to issue raised and, if applicable, where considered in this chapter
		should be considered, such as Acoustic Deterrent Device (ADD) or sound emission reduction/abatement systems.	
18 April 2023	NatureScot, Scoping Workshop session	NatureScot agree with the suggested approach to modelling of SEL_{24h} ranges both with and without ADD.	ADD is a standard industry mitigation measure and the modelling of injury ranges both with and without an ADD (Section 0)., has been undertaken to demonstrate the efficacy of an ADD to reduce the risk of injury.
18 April 2023	NatureScot, Scoping Workshop session	With regard to incorporation of ADD into modelling, recommended 30 minutes as an appropriate duration of active ADD. Beyond this duration, recommend consideration of additional mitigation measures such as sound emission reduction technologies.	Modelling was undertaken for 30 minutes of ADD activation (Volume 3, Annex 10.2: Underwater Sound Shared Technical Report und assessment), however, the final mitigation (including duration of ADD) will be agreed post-consent subject to any design modifications
18 April 2023	NatureScot, Scoping Workshop session	Agreed modelling of unexploded ordnance (UXO) approach: Temporary Threshold Shift (TTS) as a proxy to model disturbance (TTS represents a temporary change in hearing sensitivity and is also the onset of a moving away response; therefore, is used as a proxy for behavioural disturbance for UXO).	TTS has been used as a proxy for disturbance for UXO clearance (Section 0).
18 April 2023	MSS, Scoping Workshop session	Confirmed support of approach to assessment of population-level effects via Interim Population Consequences of Disturbance Model (iPCoD) and the new Cumulative Effects Framework (CEF) tool.	CEF tool was not available at time of writing, however, iPCoD was used to model population-level effects of underwater sound during piling (Section 10.11.1)
18 April 2023	NatureScot, Scoping Workshop session	NatureScot agree with approach to selecting the species to be modelled via iPCoD, with a caveat that decisions are to be informed by the results of underwater sound	Species modelled and results of iPCoD were presented and agreed with NatureScot at subsequent meeting on 22/10/25.

Date	Consultee and type of consultation	Summary of issue(s) raised	Applicant's response to issue raised and, if applicable, where considered in this chapter
		modelling. Proposed further engagement is undertaken to discuss at the relevant point.	
18 April 2023	NatureScot, Scoping Workshop session	NatureScot agree with the approach suggested for the Regional Marine Mammal Study Area.	The Morven Regional Marine Mammal Study Area is described in Section 10.2.
18 April 2023	NatureScot and MSS, Scoping Workshop session	Approach to assessment of unidentified species and allocation to species groups (e.g. unidentified seal to grey seal group) to be discussed further following analysis of site specific survey data.	Response on this point was made further to NatureScot's written representation (see below).
18 April 2023	NatureScot, Scoping Workshop session	NatureScot request consideration of humpback whale (qualitatively) in the Marine Mammal chapter.	Humpback whale has been included qualitatively in this chapter (Section 10.11).
25 May 2023	NatureScot, Written Advice	NatureScot agree with the Regional Marine Mammal Study Area.	The Morven Regional Marine Mammal Study Area comprises the North Sea Marine Natural Area (MNA) extended towards the European coastline, as shown in Figure 10.1.
25 May 2023	NatureScot, Written Advice	NatureScot are content with the baseline data sources presented. SCANS IV is taking place over the summer and should be available soon. This should be included in the baseline data sources if available.	SCANS IV data was published and was presented in Volume 3, Annex 10.1: Marine Mammals Shared Baseline Technical Report
25 May 2023	NatureScot, Written Advice	NatureScot advise that humpback whale should be scoped in using a qualitative approach due to a recent increase in sightings along the East coast. Otherwise, NatureScot agree with the impacts to be scoped in and out.	The Applicant has included humpback whale in the marine mammal baseline adopting a qualitative approach to the assessment (Table 10.20).

Date	Consultee and type of consultation	Summary of issue(s) raised	Applicant's response to issue raised and, if applicable, where considered in this chapter
25 May 2023	NatureScot, Written Advice	Given this is a fixed foundation project in a 'busy' area, NatureScot reiterate the importance of the use of the CEF. NatureScot encourage collaboration (particularly with neighbouring developers) when planning piling schedules to reduce potential cumulative impacts of noise. Consideration of noise abatement systems may also be necessary.	Development of the CEF tool has been paused and therefore was not available at the time of writing, however, the tool is underpinned by iPCoD and this assessment included modelling of potential population consequences during piling at cumulative projects using the iPCoD software.
25 May 2023	NatureScot, Written Advice	With regards to the DAS marine mammal data, NatureScot note that unidentified species will be allocated to identified species proportionally. NatureScot have concerns about this approach due to the introduction of bias and the underestimation of rarer species. NatureScot would welcome the presentation of data both with and without unidentified species to be included, and request further consultation on the marine mammal DAS data and the proposed allocations so that NatureScot can provide more specific advice.	The analyses was done both with and without the allocation. However, allocation of unidentified species provides a more precautionary approach to estimating site specific densities. Density estimates from the DAS data could only be generated for the more abundant species and, therefore, allocating unidentified animals to these more abundant species have increased the density estimates, where otherwise data may have been disregarded.
25 May 2023	NatureScot, Written Advice	Underwater sound modelling should be undertaken at maximum hammer as a worst case. Although there will be a soft start, there is still uncertainty about how the noise levels will change during ramping up, so NatureScot would recommend taking a precautionary approach by using the maximum hammer energy. Further discussion on this during the pre-application stage maybe helpful.	Modelling considered the peak sound pressure level (PK) at discrete points along the piling sequence from soft start, through ramp up, and up to the maximum hammer energy and maximum penetration depth. The maximum peak level for a given piling operation, excluding varying geological considerations, is a function of the hammer energy and pile stick-up length. To adopt a conservative approach the assessment has considered the maximum value at any point during the piling sequence to define the mitigation zone (MZ).

Date	Consultee and type of consultation	Summary of issue(s) raised	Applicant's response to issue raised and, if applicable, where considered in this chapter
25 May 2023	NatureScot, Written Advice	NatureScot support the use of the dual metric approach for impulsive noise, as described in Southall *et al.* (2019).	Both metrics (SEL_{24h} and PK) were modelled. Whilst TTS will also be modelled and ranges presented in Volume 3, Annex 10.2: Underwater Sound Shared Technical Report, this is not taken forward to the marine mammal assessment for predicting injury ranges. The focus will instead be on Permanent Threshold Shift (PTS) as a permanent (non-recoverable) injury).
25 May 2023	NatureScot, Written Advice	For non-impulsive noise, accumulated noise metrics (SEL) should be used.	Volume 3, Annex 10.2: Underwater Sound Shared Technical Report provides the PTS and TTS criteria for non-impulsive noise from Southall *et al.* (2019) and is based on hearing-weighted SEL_{24h} thresholds.
25 May 2023	NatureScot, Written Advice	All geophysical equipment should be treated as producing impulsive sound as a precautionary measure and geophysical surveys should be considered as a standalone impact	Geophysical equipment has been modelled using impulsive thresholds as per (NMFS, 2024).
25 May 2023	NatureScot, Written Advice	In terms of mitigating the injurious noise sources, NatureScot recommend using the pre-piling instantaneous impact to inform mitigation measures. However, there is also the risk of injury accruing over time, and, therefore, the accumulated noise dose should also be considered in assessment. There are many uncertainties with the accrual of a noise dose, from the uncertainty in any behavioural response, to recovery between noise exposures, and the effect of a pulse noise signal losing the impulsiveness over distance. Currently there is no framework to assess this transition to a non-impulsive signal, and so the accumulated risk is assessed using the worst case impulsive noise thresholds. It is	Assessment has modelled peak SPL (PK) to define the MZ as recommended by NatureScot.

Date	Consultee and type of consultation	Summary of issue(s) raised	Applicant's response to issue raised and, if applicable, where considered in this chapter
		because of this high level of uncertainty that NatureScot recommend the use of predictions of instantaneous injury (SPL(pk)) rather than accumulated injury (SEL(cum)) to determine pre-piling mitigation.	
25 May 2023	NatureScot, Written Advice	NatureScot agree with the dose response approach for all species.	Dose response adopted for all species for assessment of piling (Section 10.11.1).
25 May 2023	NatureScot, Written Advice	NatureScot agree with the NMFS criteria of non-trivial (strong) disturbance (160 dBrms) for impulsive sound sources.	Metrics used in the assessment, including NMFS criteria are presented in Table 10.31.
25 May 2023	NatureScot, Written Advice	NatureScot agree with the approach to the UXO assessment (modelling a range from low order clearance to high order detonation). Noting that NatureScot wish to see low order clearance techniques as recommended in the Joint Position Statement on UXO clearance (UK Government, 2025).	Morven South has committed to the use of low order clearance of UXOs (Table 10.33). The assessment presents the results for both low order clearance and high order detonation for completeness (Section 0)
25 May 2023	NatureScot, Written Advice	NatureScot agree with TTS being used as a proxy for behavioural effects for UXO only.	TTS has been used as a proxy for disturbance for UXO clearance (Section 0).
25 May 2023	NatureScot, Written Advice	NatureScot do not agree on the long periods of ADD use for mitigation. Their duration of use should be limited to ensure their efficacy and to reduce the overall noise entering the marine environment. If modelling predicts that ADDs are required for greater than about 30 minutes in order to clear an ensonified area, then other mitigation, such as noise abatement systems, should be considered.	Feedback noted, agreed that minimising the use of ADD will be important to reduce the overall noise introduced into the marine environment. The duration of ADD will be determined by the radius of the MZ to allow animals to flee safely beyond this area, and appropriate use will be agreed with SNCBs in developing the final Marine Mammal Mitigation Protocol (MMMP) post-consent and covering three impacts: piling, UXO and site investigation surveys. Further details are available in the Version 1 MMMP

Date	Consultee and type of consultation	Summary of issue(s) raised	Applicant's response to issue raised and, if applicable, where considered in this chapter
			submitted with this Application and are summarised in Table 10.33
03 March 2025	MD-LOT: Targeted Consultation on Morven North and Morven South and approach to CEA	On 21 July, MD-LOT responded to the targeted consultation letter on the revised consenting strategy. This included the new study areas for Marine Mammals. MD-LOT noted that there are no additional aspects requiring consideration following the revision to the proposed approach to consenting and advised discussing the CEA approach further with NatureScot.	The following revised study areas have been used in assessment: • Morven South Marine Mammal Study Area; • Morven Site Marine Mammal Study Area • Morven Regional Marine Mammal Study Area. Please see Section 10.2.
21 July 2025	MD-LOT, Quarterly Meeting	MD-LOT is content with MvOWL's proposed approach to mitigation and post-consent plans and would request that the appropriate level of detail is provided at the application stage, such that would enable stakeholders to have early sight of the plans and the opportunity to comment at that stage. MD-LOT would also highlight the new guidance on mitigation and monitoring plans which must be submitted at application stage as previously highlighted to MvOWL during quarterly update meetings.	An MMMP, covering three topics (piling, UXO and site investigation surveys) will be developed and submitted with each application. Additional details on the Version 1 MMMP and are presented in Table 10.33.
15 September 2023	Natural England	NE cannot agree with NatureScot's advice to scope out the Southern North Sea Special Area of Conservation (SNS SAC). NE believes that a potential impact pathway exists between the proposed Morven South and the SNS SAC for harbour porpoise.	Information on the SNS SAC is presented in Section 10.7.3 and has been screened into the Report to Inform Appropriate Assessment (RIAA).
23 October 2025	MD-LOT, NatureScot, Underwater sound and marine mammal workshop	Summary of the following elements of the marine mammal assessment: • Underwater sound modelling approach and results,	Results were presented to NatureScot together with a detailed note on the CEA. NatureScot have provided specific feedback on the CEA and the approach is provided in Section 10.12 of this Chapter.

Date	Consultee and type of consultation	Summary of issue(s) raised	Applicant's response to issue raised and, if applicable, where considered in this chapter
		• Presentation of the species densities to be taken through to assessment, • Approach and results of the project alone population modelling • Approach to UXO sound modelling and results • Approach to vessel sound modelling, results and assessment • Approach to cumulative effects assessment	
17 November 2025	NatureScot email response to CEA note submitted to NatureScot on 14th October as well as response to Underwater Sound (UWS) workshop on 13 October (see above)	For the CEA consider screening of MUs where extent of impact pathways overlaps	The relevant MU where there is a receptor-impact pathway has been considered (Section 10.7).
		Time period should consider up to a year on either side of construction	Projects screened in where the timelines fall a year either side of Morven North and Morven South combined (Section 10.12.3).
		Do not advise that all impacts that are non-significant for project alone should be scoped out of CEA; example is disturbance from piling	Disturbance from piling and disturbance from vessels is taken through to the CEA even though there is no impact from project alone; all other impacts were scoped out with detailed justification provided in Table 10.77.
		NatureScot acknowledge that the EDRs have been updated in 2025 but advise that for quantitative assessment of Tier 2 and 3 projects the most precautionary EDRs between the 2020 and new 2025 EDRs should be applied.	Assessment is based on the most up-to-date published guidance; selecting on the basis only of the largest EDR is not scientifically justified if this is in contrast to the most recent publication.

Date	Consultee and type of consultation	Summary of issue(s) raised	Applicant's response to issue raised and, if applicable, where considered in this chapter
		Advise that assessment considers the UK portion of the MU for inferring the percentage population with the potential to be impacted as well as the input reference population used in iPCoD modelling, both for project alone and cumulative assessments. Since the Scoping Opinion for Morven North and Morven South was published in 2023, NatureScot have now consistently recommended using the UK portion of the MU.	It is highlighted that NatureScot advice in the Scoping Opinion for Morven North and Morven South did not recommend the use of the UK MU although Applicant notes that projects since this time have received that advice. Subsequently, the quantitative assessment presented here shows the % of the UK portion of each MU that may be impacted although noting that it is more ecologically justified to present the full MU population within the iPCoD model and therefore the full MU has been applied to iPCoD (Volume 3, Annex 10.5).
		NS defer to MD-LOT to comment further on projects included within the shortlist, noting from our own understanding of build schedules that there is likely to be overlap with Buchan (if consented) as well Seagreen IA (for the Offshore Substation Platforms (OSPs))	The CEA shortlist was developed on the basis of the latest published information at the time of writing. Build schedules at this time led to both Buchan and Seagreen 1A (variation to original Seagreen project) being screened out for construction-related impacts to marine mammals as construction was expected to fall out with the 1-year buffer. For vessel disturbance during operation Buchan was screened out as it fell outside the screening distance (see comment below) and Seagreen 1A was screened out on the basis that there was project-related vessel disturbance associated with the Seagreen project at the time of compiling the Morven North baseline and therefore this was considered as part of the existing baseline.
		The 50 km screening buffer may not be the most appropriate method of screening in projects for vessel noise, both during construction and operation, as the most likely transit routes to and from port should be included within the assessment.	The screening buffer has been increased to 86km on the basis of NatureScot advice: this is the furthest distance between either the Morven North or Morven South boundary and the UK coast to capture transit

Date	Consultee and type of consultation	Summary of issue(s) raised	Applicant's response to issue raised and, if applicable, where considered in this chapter
			to/from ports. Aberdeen port lies ~63km from Morven North and Morven South.
		During the Underwater Noise workshop (22nd October 2025) you stated that you will be applying a 140 dB SELss cap to the harbour porpoise dose-response curve for disturbance predictions. NS consider a plateau or truncation at 140 dB SELss as an intermediate step between the original Graham et al (2017) dose-response curve and the deterrence (distance based) approach. After recent discussion with MD-SEDD, NatureScot advise that you present both the full dose-response predictions and the deterrence function, as well as the capped 140dB dose-response for comparison.	NatureScot have agreed that the dose-response capped at 140 dB SEL_{ss} can be used within the assessment for all species except low-frequency cetaceans. For low-frequency cetaceans, NatureScot and MD-SEDD recommend using the full dose-response approach for these receptors, due to their high sensitivity to low-frequency sound and uncertainties around their behavioural response to underwater noise. Paragraph 10.8.3.18 gives a detailed justification as to why the approach of applying the full dose response would be incorrect, for all hearing groups, including low-frequency cetaceans, with evidence provided by multiple sources.

10.5 Scope of the assessment

10.5.1 Impacts scoped into the assessment

10.5.1.1 The scope of this EIA Report has been developed in consultation with relevant statutory and non-statutory consultees as detailed in Table 10.15. The scope of this assessment is to determine if any impacts, whether direct or indirect, could have a significant effect on the marine mammal species which have been identified in the Morven Regional Marine Mammal Study Area. Taking into account the scoping and consultation process, Table 10.16 summarises the potential impacts which have been scoped into this assessment.

Table 10.16: Potential impacts scoped into the marine mammal assessment

C= Construction, O= Operations and Maintenance (O&M), D= Decommissioning phases

"✓" is used to denote the phase the potential impact can occur, "✗" outlines there is no impact within this project phase

Potential impact	Phase			Activity
	C	O	D	
Injury and disturbance from underwater sound generated from piling.	✓	×	×	Piling of foundations for wind turbines and offshore substation platform
Injury and disturbance from underwater sound generation from UXO clearance.	✓	×	×	UXO clearance prior to commencement of construction
Injury and disturbance to marine mammals from vessel use and other (non-piling) sound-producing activities.	✓	✓	✓	Vessel traffic and other sound producing activities (e.g. vessels associated with sand wave clearance, installation vessel, construction vessel, rock placement vessel and cable installation vessels, boulder clearance, jack-up rig, tug/anchor handlers, guard vessels, survey vessel and support vessels crew transfer vessel (CTV), scour/cable protection/seabed preparation/installation vessels) Vessel traffic associated with O&M (e.g. CTVs, jack-up vessels, cable repair vessels, service operations vessels, excavator/backhoe dredger).
Injury to marine mammals due to collision with vessels.	✓	×	✓	
Effects on marine mammals due to changes in prey availability.	✓	✓	×	Potential effects from temporary habitat loss/disturbance, long-term habitat loss, increased Suspended Sediment Concentrations (SSCs) and associated deposition, colonisation of hard structures and associated fish aggregation, EMF and injury/disturbance to fish and shellfish receptors from underwater sound from piling and UXO clearance on fish assemblages, which could result in changes in the availability or distribution of prey species and, as a result, could affect the foraging ability of marine mammal species.
Injury and disturbance to marine mammals from pre-	✓	✓	×	Site investigation surveys – geophysical and geotechnical surveys

Potential impact	Phase			Activity
	C	O	D	
construction site investigation surveys.				

10.5.2 Impacts scoped out of the assessment

10.5.2.1 A summary of the effects scoped out, supported with justification and whether the approach has been agreed with key stakeholders through either scoping or consultation, is presented in Table 10.17.

Table 10.17: Impacts scoped out of the assessment for marine mammals

C= Construction, O= O&M, D= Decommissioning phases

"✓" denotes the impact has been scoped in for this phase, "✗" denotes the impact has been scoped out for this phase

Potential impact	Phase			Justification
	C	O	D	
Accidental release of pollutants.	✓	✓	✓	There is a risk of pollution (e.g. fuel or oil) being accidentally released during the construction, O&M and decommissioning phases from sources including vessels/vehicles and equipment/machinery. This may lead to direct mortality of marine mammals or a reduction in prey availability, either of which may affect species' survival rates. However, the risk of such events will be managed for Morven South by the implementation of measures set out in standard post-consent plans (e.g. Environmental Management Plan (EMP), including a Marine Pollution Contingency Plan (MPCP)). These plans include planning for accidental spills, address all potential contaminant releases and include key emergency contact details. They also set out industry good practice and Oslo-Paris Convention for the Protection of the Marine Environment (OSPAR), International Maritime Organisation (IMO) and International Convention for the Prevention of Pollution from Ships (MARPOL) guidelines for preventing pollution at sea. Therefore, the likelihood of an accidental spill occurring is very low and, in the unlikely event that such events did occur, the magnitude of these will be minimised through measures such as the MPCP. As such, this impact has been scoped out of further consideration within the marine mammal EIA chapter, and this has been agreed upon with consultees as part of the Morven Site Scoping Opinion (Table 10.15).
Increased SSCs and associated sediment deposition	✓	✓	✓	Disturbance to water quality as a result of construction operations can have both direct and indirect Impacts on marine mammals. Indirect impacts would include effects on prey species (which is scoped in). Direct impacts include the impairment of visibility and, therefore, foraging ability, 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 (*Phocoena phocoena*) and harbour seal (*Phoca vitulina*) in the UK have been documented foraging in areas with high tidal flows (Pierpoint, 2008, Marubini *et al.*, 2009); 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

Potential impact	Phase			Justification
	C	O	D	
				are able to sense the environment in other ways, for example, seals can detect water movements and hydrodynamic trails with their mystacial vibrissae; while odontocetes primarily use echolocation to navigate and find food in darkness. Whilst elevated levels of SSCs arising during construction of Morven South may decrease light availability in the water column and produce turbid conditions, the maximum impact range is expected to be localised with sediments rapidly dissipating over one tidal excursion. In addition, there is a large natural variability in the SSCs within the Morven South Marine Mammal Study Area, so marine mammals living here will be tolerant of any small-scale increases, such as those associated with the construction activities. As such, this impact has been scoped out of further consideration within the marine mammal EIA chapter, and this has been agreed upon with consultees as part of the Morven Site Scoping Opinion (Table 10.15).
Impact of Electromagnetic Fields (EMF) (from surface laid or buried cables)	×	✓	×	Based on the data available to date, there are uncertainties around EMF from marine renewable devices having an impact (either positive or negative) on marine mammals (Copping, 2018). Threshold values for EMF effects are only available for a few species (mainly elasmobranchs), leaving major uncertainties in several important taxonomic groups (cetaceans, pinnipeds, fish, crustaceans, etc.). There is currently no evidence that seals can detect or respond to EMF but some species of cetaceans may be able to detect variations in magnetic fields (Normandeau Associates Inc *et al.*, 2011). To date, the only marine mammal known to show any response to EMF is the Guiana dolphin (*Sotalia guianensis*) which has been shown to possess an electroreceptive system that uses the vibrissal crypts on their rostrum to detect electrical stimuli similar to those generated by small to medium sized fish (Czech-Damal *et al.*, 2012). However, this has not been shown in any other of marine mammal and this species does not occur within the Morven South Marine Mammal Study Area. Furthermore, magnetic fields from alternating current (AC) cables are only detectible within a few metres of the cable and decrease with distance from the cable (Hutchison *et al.*, 2020), so the lack of sensitivity combined with extremely small scale of emissions means there will be no likely effect on marine mammals.

Potential impact	Phase			Justification
	C	O	D	
				As such, this impact has been scoped out of further consideration within the marine mammal EIA chapter, and this has been agreed upon with consultees as part of the Morven Site Scoping Opinion (Table 10.15).
Disturbance to marine mammals from operational sound from wind turbine operation	×	✓	×	The Marine Management Organisation (MMO) (MMO, 2014) review of post-consent monitoring at Offshore Wind Farms (OWFs) found that available data on the operational wind turbine sound from the UK and abroad, in general, showed that sound levels from operational wind turbines are low and the spatial extent of the potential impact of the operational wind turbine sound on marine receptors is generally estimated to be small, with behavioural response only likely at ranges close to the wind turbines. This is supported by several published studies, which provide evidence that marine mammals are not displaced from operational wind farms. At the Horns Rev and Nysted OWFs in Denmark, long term monitoring showed that both harbour porpoise and harbour seal were sighted regularly within the operational OWFs and, within two years of operation, the populations had returned to levels that were comparable with the wider area (Diederichs *et al.*, 2008) . Similarly, a monitoring programme at the Egmond aan Zee OWF in the Netherlands reported that significantly more porpoise activity was recorded within the OWF compared to the reference area during the operational phase (Scheidat *et al.*, 2011). Other studies at Dutch and Danish OWFs (Lindeboom *et al.*, 2011) also suggest that harbour porpoise may be attracted to increased foraging opportunities within operating OWFs. Indeed, tagging work by (Russell and McConnell, 2014) found that some tagged harbour and grey seals demonstrated grid-like movement patterns as these animals moved between individual wind turbines, which is strongly suggestive of these structures being used for foraging. A number of reviews have concluded that operational wind farm sound will have negligible effects (Madsen *et al.*, 2006, Teilmann *et al.*, 2006). As such, this impact has been scoped out of further consideration within the marine mammal EIA chapter, and this has been agreed upon with consultees as part of the Morven Site Scoping Opinion (Table 10.15).

Potential impact	Phase			Justification
	C	O	D	
Injury to marine mammals due to collision with vessels	×	✓	×	The impact pathway of injury to marine mammals due to collision with vessels during the O&M phase has been scoped out of further consideration within the marine mammals EIA chapter. O&M vessels will transit slowly through Morven South, and Morven South will adhere to the Scottish Marine Wildlife Watching Code. This approach has been discussed and confirmed by NatureScot via the Morven Offshore Wind Farm Scoping Workshop (18 April 2023, see Table 10.15).

10.6 Approach to baseline characterisation

10.6.1.1 The marine mammal baseline environment has been characterised through site specific data and a literature review of key desktop datasets and reports (see Table 10.18). This list is not exhaustive; further datasets and reports are covered in more detail within Volume 3, Annex 10.1: Marine Mammals Shared Baseline Technical Report.

10.6.2 Relevant guidance

10.6.2.1 The following publications have been consulted throughout this assessment for marine mammal ecology:

- Guidelines for Ecological Impact Assessment (EcIA) in the UK and Ireland (Chartered Institute for Ecology and Environmental Management (CIEEM, 2024));
- Good Practice Guide No. 133 – Underwater Noise Measurement (NPL, 2014);
- Marine environment: UXO Joint Position Statement (UK Government, 2025);
- Joint Nature Conservation Committee (JNCC) guidelines for minimising the risk of injury to marine mammals from UXO clearance in the marine environment (JNCC, 2025a);
- Scaling laws for unmitigated pile driving: Dependence of underwater noise on strike energy, pile diameter, ram weight, and water depth (von Pein *et al.*, 2022);
- Guidelines for minimising the risk of injury to marine mammals from piling sound (JNCC, 2024);
- Reducing marine noise: Outlines strategic commitments to reduce underwater noise from human activities and protect marine life (UK Government, 2025e);
- Joint position on noise abatement and quieter piling methods: Guidance from JNCC, Natural England, and Cefas on the use of noise abatement systems and quieter piling technologies to reduce impacts on marine mammals (JNCC, 2025f);
- EU Guidance on Wind Energy Developments and Natura 2000 legislation (European Commission, 2010);
- Oslo Paris Convention (OSPAR) Guidance on Environmental Considerations for OWF Development (OSPAR, 2008);
- Marine mammal sound exposure criteria: Updated scientific recommendations for residual hearing effects (Southall *et al*., 2019);
- Marine mammal sound exposure criteria: assessing the severity of marine mammal behavioural response to human sound (Southall *et al*., 2021);
- Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling sound (JNCC, 2010);
- JNCC guidelines for minimising the risk of disturbance and injury to marine mammals whilst using explosives (JNCC, 2021);
- JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys (JNCC, 2017);
- Guidance on sound management in harbour porpoise SACs (JNCC, 2020);
- Department for Business, Energy and Industrial Strategy (BEIS) Policy Statement Marine environment: unexploded ordnance clearance joint interim position statement (BEIS , 2022).

10.6.3 Desktop study

10.6.3.1 Information on marine mammals within the Morven Regional Marine Mammal Study Area was collected through a detailed desktop review of existing studies and datasets. These are summarised in Table 10.18 below.

Table 10.18: Summary of key desktop reports used to characterise the marine mammal baseline

Title	Source	Year	Author
Updated Habitat-Based At-Sea Distribution Maps for Harbour and Grey Seals in Scotland	SMRU/Scottish Government	2025	Carter *et al.*
Spatial models of cetacean density in European Atlantic waters based on SCANS-IV summer 2022 survey data	Small Cetaceans in European Atlantic waters and the North Sea (SCANS)	2025	Gilles *et al.*
Winter SCANS: Estimates of cetacean abundance in the southern North Sea in winter 2024	SCANS	2025	Ramirez-Martinez *et al.*
Estimates of cetacean abundance in European Atlantic waters in summer 2022 from the SCANS-IV aerial and shipboard surveys	SCANS	2023	Gilles *et al.*
Morven North and Morven South Seal Telemetry and Haul-out Data Study.	SMRU Consulting	2023	Stevens
Sympatric Seals, Satellite Tracking and Protected Areas: Habitat-Based Distribution Estimates for Conservation and Management.	Frontiers in Marine Science	2022	Carter *et al.*
JNCC Report 680: Updated abundance estimates for Cetacean MUs in UK waters (Revised 2022).	JNCC	2022	Inter-Agency Marine Mammal Working Group (IAMMWG)
Modelled density surfaces of Cetaceans in European Atlantic waters in summer 2016 from the SCANS-III surveys.	SCANS	2022	Lacey *et al.*
Scientific advice on matters related to the management of seal populations: 2024.	SCOS	2025	SCOS
Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys.	SMRU, University of St Andrews	2021	Hammond *et al.*
Regional baselines for marine mammal knowledge across the North Sea and Atlantic areas of Scottish waters. Scottish Marine and Freshwater Science.	Marine Scotland Science	2020	Hague *et al.*

Title	Source	Year	Author
Distribution maps of Cetacean and seabird populations in the North-East Atlantic.	Journal of Applied Ecology	2020	Waggitt *et al*.
JNCC MPA mapper.	JNCC	2025	JNCC
Seasonal and diel acoustic presence of North Atlantic minke whale in the North Sea.	Nature Scientific Reports	2019	Risch *et al*.
Seagreen Alpha and Bravo OWFs EIA Report.	Seagreen Wind Energy	2018	Seagreen Wind Energy
Revised Phase III Data Analysis of Joint Cetacean Protocol Data Resource.	JNCC	2016	Paxton *et al*.
JNCC Report 544: Harbour Porpoise Density.	JNCC	2015	Heinänen and Skov
Background information on marine mammals for SEA 6.	Sea Mammal Research Unit (SMRU), University of St Andrews	2005	Hammond *et al*.

10.6.4 Identification of designated sites

10.6.4.1 All designated sites within the Morven Regional Marine Mammal Study Area and qualifying interest features that could be affected by the construction, O&M and decommissioning phases of Morven South were identified using the three-step process described below:

- Step 1: All designated sites of international, national and local importance within the Morven Regional Marine Mammal Study Area were identified using a number of sources, including the JNCC MPA Mapper (JNCC, 2025c) and the JNCC SACs with marine components dataset (JNCC, 2023);
- Step 2: Information was compiled on the relevant marine mammal features for each of these sites using data in the public domain (JNCC, 2023);
- Step 3: Using the above information and expert judgement, sites were included for further consideration if:
  - a designated site directly overlaps with the Morven South Boundary;
  - designated sites and/or qualifying features were located within an area where impacts associated with Morven South could affect marine mammals directly or indirectly;
  - a designated site and/or qualifying features are located within the Morven Regional Marine Mammal Study Area and have a potential for connectivity with Morven South (see Section 10.7.3) for all sites identified.

10.6.5 Site-specific surveys

10.6.5.1 A summary of the surveys undertaken to inform the marine mammal assessment of effects is outlined in

10.6.5.2 Table 10.19 and further detail of the survey methodologies and results is included within Volume 3, Annex 10.1: Marine Mammals Shared Baseline Technical Report.

Table 10.19: Summary of site specific surveys

Title	Extent of survey	Overview of survey	Survey contractor	Date	Reference to further information
Aerial marine mammal surveys	Morven Site Marine Mammal Study Area	Marine mammal survey to characterise the marine mammal environment at Morven South	APEM	January 2021 to September 2023	Volume 3, Annex 10.1: Marine Mammals Shared Baseline Technical Report

10.7 Baseline environment

10.7.1 Overview of baseline environment

10.7.1.1 The following sections provide a summary of the marine mammal baseline environment. The marine mammal technical report includes full details of the analysis undertaken to develop the marine mammal baseline and information on species ecology, distribution, seasonality as well as density and abundance.

10.7.1.2 There are five species of cetaceans and two species of pinnipeds that are regularly encountered within the Morven Regional Marine Mammal Study Area (Hammond *et al.*, 2013, Hammond *et al.*, 2021). The distribution and abundance of marine mammals is highly correlated with the distribution of prey (NatureScot, 2019, Weir *et al.*, 2001).

10.7.1.3 Although some species may occasionally occur within the Morven Marine Mammal Study Area, e.g. killer whale (*Orcinus orca*), Atlantic white-sided dolphin *Lagenorhynchus acutus,* short-beaked common dolphin *Delphinus delphis,* Risso's dolphin *Grampus griseus*, long-finned pilot whale *Globicephala melas*, fin whale *Balaenoptera physalus* and sowerby's beaked whale *Mesoplodon bidens* these are unlikely to travel through or use the Morven South Marine Mammal Study Area as important foraging grounds. The DAS of marine mammals commenced in January 2021 and continued monthly up to and including September 2023. The 33 months of data collection allowed identification of the most common species likely to be encountered within the Morven South Marine Mammal Study Area. More details on the DAS data analysis can be found in Volume 3, Annex 10.1: Marine Mammals Shared Baseline Technical Report.

10.7.1.4 Data from the DAS conducted within the Morven South Marine Mammal Study Area demonstrated that several marine mammal species occurred regularly within the Morven South Marine Mammal Study Area. Harbour porpoise was the most identified species across the 33 months of DAS data (n = 594), followed by white-beaked dolphin (n = 85). Low numbers of short-beaked common dolphin (*Delphinus delphis*) (n = 8), grey seal (n = 11), minke whale (n = 6) and humpback whale (n = 1) were also observed. No other species were recorded, including bottlenose dolphin and harbour seal, and all other individuals observed were assigned to broader categories (e.g. 'dolphin/porpoise').

10.7.1.5 The summary of the marine mammal baseline within the Morven South Marine Mammal Study Area, in the context of the Morven Regional Marine Mammal Study Area, is presented in Table 10.20. Densities and reference populations taken forward to assessment for each species are presented in Table 10.21. Further detail can be found in Volume 3, Annex 10.1: Marine Mammals Shared Baseline Technical Report. The relevant MUs are presented in Figure 10.2.

Table 10.20: Summary of marine mammal baseline

Species	Baseline Summary
Harbour porpoise	Harbour porpoise is widespread throughout the cold and temperate seas of Europe, including the North Sea. Harbour porpoise accounted for the highest number of sightings identified to species level (based on raw count data) during the DAS and was recorded in all but four survey months. It was the most commonly identified cetacean during historic aerial surveys in the wider Firth of Forth and Tay region (Grellier and Lacey, 2011). The Inter-Agency Marine Mammal Working Group (IAMMWG) (2023) estimated abundance for the North Sea MU as 346,601 individuals with 159,632 individuals in the UK portion of this MU. Density estimates reported by Gilles *et al.* (2023) are considered the most appropriate to use to reflect densities of harbour porpoise in offshore waters where Morven South is located and a density of 0.599 animals/km^2 has been taken forward to the assessment.
Bottlenose dolphin (*Tursiops truncatus*.)	Bottlenose dolphin is present within the northern North Sea and comprises discrete offshore and inshore population ecotypes. Morven South is located in the offshore region and will therefore predominantly overlap with the offshore population represented by the Greater North Sea (GNS) MU, with an estimated abundance of 2,022 in the full MU and 1,885 in the UK portion. However, only the coastal population, distributed within the 2m to 20m depth contour and approximately 2km from the shore, is well studied (Geelhoed *et al.*, 2022). The main distributional range of the Coastal East Scotland (CES) MU population is from Moray Firth to Firth of Forth, although ongoing citizen science projects suggest that some individuals of this population are relocating southwards into waters off the coast of eastern England (as far as south of Scarborough) (Hackett, 2022). The most recent abundance estimate for the CES MU is 226 animals (Cheney *et al.*, 2024). Morven South lies 61.4km away from the CES MU, which is linked to the Moray Firth SAC population. No bottlenose dolphin were recorded during the DAS of the Morven South Marine Mammal Study Area. Density estimates reported by (Lacey *et al.*, 2022) based on SCANS III surveys (Hammond *et al.*, 2021) are considered the most appropriate to reflect densities of bottlenose dolphin in offshore waters where Morven South is located and a density of 0.005 animals/km^2 has been taken forward to the assessment.
White-beaked dolphin (*Lagenorhynchus albirostris*)	White-beaked dolphin is considered the second most abundant cetacean in the North Sea, with the highest rates of sightings off the east coast of Scotland during summer months (Weir *et al.*, 2001). White-beaked dolphin accounted for the second highest number of sightings during the DAS and was recorded in 14 months over the 33-month survey period. The summer mean design-based density (corrected for availability bias) was estimated at 0.174 animals/km^2. However, several studies have suggested that the abundance of white-beaked dolphin in the UK waters is declining as a result of increases in local water temperature (Lambert *et al.*, 2014) (MacLeod *et al.*, 2007, MacLeod *et al.*, 2005) . Findings from SCANS IV surveys conducted in 2022 also suggest a decline in the number of white-beaked dolphin (Gilles *et al.*, 2023). IAMMWG (2022) estimated white-beaked dolphin abundance for the Celtic and Greater North Seas (CGNS) MU as 43,951 animals (Coefficient of Variation (CV)=0.22) and 34,025 animals in the UK portion of the MU. SCANS IV Density estimates reported by Gilles *et al.* (2023) are considered the most appropriate to use to reflect densities of white-beaked dolphin in offshore waters where Morven South is located and a density of 0.080 animals/km^2 has been taken forward to the assessment.

Species	Baseline Summary
Minke whale (*Balaenoptera acutorostrata*)	Minke whale is widely distributed in northern North Sea. In Scotland, minke whale display seasonal occurrence patterns with inshore movements during summer, as dictated by increased availability of key prey species (usually sandeel *Ammodytes marinus* during summer months)(Robinson *et al.*, 2023, Robinson *et al.*, 2009), returning to offshore waters in winter. The data from the DAS as well as historic surveys within the wider Firth of Forth and Tay areas suggest that minke whale presence is highly seasonal with most encounters during summer months (SSE Renewables, 2022, Mainstream Renewable Power, 2019). IAMMWG (2022) presented estimated abundance for the CGNS MU of 20,118 individuals, and 10,288 individuals in the UK portion of the MU. Minke whale were recorded in five months only during the DAS of the Morven South Marine Mammal Study Area. It is considered that density estimates based on Gilles *et al.* (2023) are the most appropriate to use and a density of 0.042 animals/km^2 has been taken forward to the assessment.
Humpback whale (*Megaptera novaeangliae*)	Humpback whale travel long annual migration distances and individuals in Scottish waters have been matched with both recovering (western North Atlantic) and non-recovering (Cape Verde) breeding populations. There are no density estimates currently available for humpback whale in Scottish waters. However, there has been an increased recording of this species in Scotland in recent years (Hague, 2023, O'Neil *et al.*, 2019) . Observations have been recorded mostly within the Firth of Forth during winter months (December to March), which may represent a migratory stopover, or a feeding or recovery opportunity en route of a longer migration between high and low latitude areas (O'Neil *et al.*, 2019). One humpback whale was recorded during DAS of the Morven South Marine Mammal Study Area, in May 2022.
Grey seal (*Halichoerus grypus*)	The east coasts of Scotland and northern England provide important breeding and haul-out habitats for grey seal (Volume 3, Annex 10.4: Marine Mammals Shared Seal Telemetry and Haul-out Data Study Technical Report). The UK total grey seal population size at the start of the 2022 breeding season was estimated to be 168,400 grey seals of which 129,100 (approximately 80%) were in Scotland (Stevens, 2023). The most recent August grey seal counts took place in 2021 in both the East Scotland Seal MU (SMU) and Northeast England SMU, resulting in scaled August population estimates of 10,783 and 25,913 grey seals, respectively (SCOS, 2023; Stevens, 2023). The closest designated haul-out site is Ythan River Mouth located approximately 99.9km northwest from the Morven South Marine Mammal Study Area. Based on Carter *et al.* (2022; 2025) maps, mean grey seal at-sea usage within the Morven South Marine Mammal Study Area is low, as the hotspots are located closer to the shore and in the vicinity of the Berwickshire and North Northumberland Coast SAC, Firth of Forth, Tay and Eden Estuary and north of Aberdeen. Grey seal were the most identified pinniped species during the monthly site specific DAS, with 11 animals recorded in ten months out of the 33-month DAS campaign. The annual mean design-based density (corrected for availability bias) was estimated as 0.014 animals/km^2. Tagging data has illustrated a high-level of connectivity between the Morven South Marine Mammal Study Area and Berwickshire and North Northumberland Coast SAC, with approximately 10% of tagged individuals being tracked within the Morven South Marine Mammal Study Area and this SAC (Stevens, 2023). Given the uncertainty associated with identification of seals to species level based on the DAS, density estimates reported by Carter *et al*. (2022) are considered the most appropriate to use and a density of 0.252 animals/km^2 has been taken forward to the assessment.
Harbour seal	Harbour seal is widespread around the west coast of Scotland and the Hebrides and Northern Isles (Volume 3, Annex 10.4: Marine Mammals Shared Seal Telemetry and

Species	Baseline Summary
	Haul-out Data Study Technical Report). On the east coast of the UK, however, the distribution of this species is more restricted with concentrations in the major estuaries of the Thames, The Wash, the Firths of Forth and Tay, and the Moray Firth (SCOS, 2023). The most recent August haul-out count for the whole of Scotland is for the count period 2016 to 2019 and 2021, where a total of 26,378 harbour seals were counted (Stevens, 2023). The current scaled population estimate (based on the 2021 count) for the East Scotland seal MU is 364 harbour seals (Stevens, 2023). The closest designated haul-out site is Ythan River Mouth located approximately 65.5km northwest from the Morven Site Marine Mammal Study Area. Based on Carter *et al.* (2022; 2025) maps, mean harbour seal at-sea usage within the Morven South Marine Mammal Study Area is low, as the hotspots are located closer to the shore and in the vicinity of the Firth of Forth, Tay and Eden Estuary and north of Aberdeen. No harbour seals were recorded during the DAS and as such, design- or model-based density and abundance estimates for this species were not available. Telemetry data confirmed that harbour seal habitat usage within the Morven South Marine Mammal Study Area is very limited (Stevens, 2023). In total, 50 harbour seals were tracked within the East Scotland and Northeast England seal MUs, and of these animals, four (8%) were recorded within the Morven North and South Regional Marine Mammal Study Area (Stevens, 2023). All four of these were tagged within the Firth of Tay and Eden Estuary SAC, and although this site lies approximately 100km from the Morven North and South Regional Marine Mammal Study Area (i.e. beyond the typical 50km foraging range for harbour seal), the data suggests some degree of connectivity between these two areas. Given the uncertainty associated with identification of seals to species level based on DAS, density estimates reported by Carter *et al.* (2022) are considered the most appropriate to use and a density of 1.20×10^{-7} animals/km^2 has been taken forward to the assessment.

Table 10.21: Densities and reference populations for each species taken forward in the assessment (NA= Not Applicable)

Species	Density (animals per km^2)	Management Unit	Population in MU	UK portion of MU
Harbour porpoise	0.599	North Sea	346,601	159,632
Bottlenose dolphin	0.005	GNS	2022	1,885
White-beaked dolphin	0.080	CGNS	43,951	34,025
Minke whale	0.042	CGNS	20,118	10,288
Humpback whale	Density estimates and were not available for this species and there was no defined MU; therefore, this species was assessed qualitatively.			
Grey seal	0.252	East Scotland seal MU + northeast England seal MU	36,696	NA

Species	Density (animals per km^2)	Management Unit	Population in MU	UK portion of MU
Harbour seal	1.20 x 10^{-7}	East Scotland seal MU + northeast England seal MU	488	NA

10.7.2 Important Ecological Features

10.7.2.1 In accordance with CIEEM guidelines (2024), Important Ecological Features (IEF) have been identified for assessment within this chapter. Ecological features (habitats, species, ecosystems and functions/processes) recorded within the Morven Regional Marine Mammal Study Area have been evaluated and a nature conservation value assigned based on the criteria set out in Table 10.22.

10.7.2.2 All marine mammal IEFs have been assessed as being of international importance and justifications for this provided in Table 10.23.

Table 10.22: Defining criteria for Important Ecological Features

Value of IEF	Defining Criteria
International	Internationally designated sites and protected species. Species protected under international law that are listed as a qualifying feature of an internationally designated site within the Morven Regional Marine Mammal Study Area (e.g. Annex II species). Species protected under international law (including the Bonn Convention, the Bern Convention, or the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)).
National	Species protected under national law (e.g. listed on the Scottish Biodiversity List (SBL), species listed as qualifying features of MPAs, or under the Wildlife and Countryside Act 1981). Annex II species which are not listed as qualifying interests of SACs in the Morven Regional Marine Mammal Study Area. Oslo Paris Convention (OSPAR) List of Threatened and/or Declining Species, and International Union for the Conservation of Nature (IUCN) Red List species that have nationally important populations within the Morven Regional Marine Mammal Study Area, particularly in the context of species/habitat that may be rare or threatened in Scottish waters. Species that are listed as PMFs as they have been deemed features characteristic of Scottish marine environment and are likely to be one of the characteristic species within the Morven Regional Marine Mammal Study Area. Species that have breeding or nursery areas within or within Morven South Marine Mammal Study Area that are important nationally (e.g. may be primary breeding/nursery area for that species).
Regional	OSPAR List of Threatened and/or Declining Species, and IUCN Red List species that have regionally important populations within the Morven Regional Marine Mammal Study Area (i.e. are locally widespread and/or abundant).

Value of IEF	Defining Criteria
	Species that are of commercial and/or cultural value to the communities which operate within the Morven Regional Marine Mammal Study Area. Species that have breeding or nursery areas within or within Morven South Marine Mammal Study Area that are important regionally (i.e. species may breed in other parts of Scottish waters, but this may be a key nursery area).
Local	Species that are of commercial and/or cultural importance but do not form a key component of the marine mammal assemblages within or within Morven South Marine Mammal Study Area. Species which are common throughout Scottish waters but forms a component of the marine mammal assemblages in the Morven Regional Marine Mammal Study Area.

Table 10.23: Important Ecological Features within the Morven Regional Marine Mammal Study Area

IEF	Importance within the Marine Mammal Study Area	Justification
Harbour porpoise	International	• Annex II species that is a designated feature of the Southern North Sea SAC; • EPS; • Scottish PMF; • OSPAR protected species; • IUCN Red List Least Concern; • UK Biodiversity Action Plan (BAP) priority species.
Bottlenose dolphin	International	• Annex II species that is a designated feature of Moray Firth SAC; • EPS; • Scottish PMF; • IUCN Red List Least Concern; • UK BAP priority species.
White-beaked dolphin	International	• EPS; • Scottish PMF; • IUCN Red List Least Concern; • UK BAP priority species.
Minke whale	International	• Annex II species that is a designated feature of Southern Trench ncMPA; • EPS; • Scottish PMF; • IUCN Red List Least Concern;

IEF	Importance within the Marine Mammal Study Area	Justification
		• UK BAP priority species.
Humpback whale	International	• EPS; • IUCN Red List Least Concern; • UK BAP priority species.
Grey seal	International	• Annex II species that is a designated feature of Berwickshire and North Northumberland Coast SAC and Isle of May SAC; • IUCN Red List Least Concern; • Scottish PMF.
Harbour seal	International	• Annex II species that is a designated feature of Dornoch Firth and Morrich More SAC and Firth of Tay and Eden Estuary SAC; • IUCN Red List Least Concern; • Scottish PMF.

10.7.3 Designated sites

10.7.3.1 Designated sites identified for the marine mammal chapter are described in Table 10.24.

Table 10.24: Designated sites and relevant qualifying interest features for the marine mammal chapter

Designated sites	Closest distance to Morven South (km)	Closest distance to Morven South Marine Mammal Study Area (km)	Relevant qualifying interest feature (s)
Southern Trench ncMPA	90.8	86.7	Minke whale
Firth of Tay and Eden Estuary SAC	109.3	105.3	Harbour seal
Berwickshire and North Northumberland Coast SAC	97.2	93.3	Grey seal
Isle of May SAC	108.6	104.7	Grey seal
Southern North Sea SAC	135.1	131.2	Harbour porpoise
Moray Firth SAC	215.8	211.7	Bottlenose dolphin

Designated sites	Closest distance to Morven South (km)	Closest distance to Morven South Marine Mammal Study Area (km)	Relevant qualifying interest feature (s)
Dornoch Firth and Morrich More SAC	253.5	249.5	Harbour seal

10.7.4 Future baseline scenario

10.7.4.1 The EIA Regulations (The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017 and The Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2007), require the following to be included within the EIA Report: "a description of the relevant aspects of the current state of the environment (baseline scenario) and an outline of the likely evolution thereof without 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."

10.7.4.2 In the event that Morven South does not come forward, an assessment of the future baseline conditions has been carried out and is described within this section.

10.7.4.3 Marine mammal abundance and distribution is impacted by various anthropogenic activities (Avila *et al.*, 2018), including offshore developments and associated subsea noise, together with fisheries and increased rates of vessel activity. According to Avila *et al.* (2018) almost all global marine mammal species (98%) were documented to be affected by at least one threat between 1991 and 2016. Bycatch in active fishing gear was the most prevalent threat for odontocetes and mysticetes, followed by pollution (solid waste), commercial hunting, and boat collisions. Pinnipeds were documented as primarily threatened by ghost-net entanglements, solid and liquid wastes, and infections (Avila *et al.,* 2018). As discussed in Volume 2, Chapter 9: Fish and Shellfish Ecology, fisheries management measures will affect marine mammal prey species, such as the recent closure of sandeel fisheries in Scottish waters (i.e. The sandeel (Prohibition of Fishing) (Scotland) Order 2024)) which banned the fishing for sandeel from March 2024 within the Scottish zone. It is anticipated that this closure will provide wider potential benefits to the marine ecosystem, including direct benefits to sandeel populations (through reduction of pressures from fishing) and indirect benefits to marine mammal species through potential increased prey availability, as sandeel is an important prey species for many marine mammal species.

10.7.4.4 Beyond the direct anthropogenic impacts, marine mammals are susceptible to non-direct effects from human activities (Avila *et al.,* 2018), such as climate change and global warming leading to rising sea temperatures. A common response of marine mammals to temperature changes is shifts in their spatial distribution, potentially modifying the ranges of certain species (e.g. white-beaked dolphin). Changes in water temperatures may also impact the life cycles of marine mammal prey species, creating discrepancies in prey abundance that affect migratory marine mammal species and those exhibiting site fidelity. Additionally, global warming could influence marine mammal survival rates by impacting reproductive success, increasing stress, and promoting pathogen infections (Albouy *et al.,* 2020).

10.7.4.5 Given that climatic changes now compound anthropogenic pressures, predicting future trajectories of marine mammal populations without comprehensive data is challenging. Monitoring is not consistently in place at relevant temporal or spatial scales for some species, especially minke whale. SCANS surveys for cetaceans are conducted infrequently, approximately every decade, leading to significant temporal gaps in data (Gilles, *et al.,* 2023). Additionally, not all areas are covered in each survey, resulting in spatial gaps. Similarly, SCOS surveys for seals do not monitor every site annually, creating both spatial and temporal gaps in the data (SCOS, 2024). Some sites may be monitored more frequently than others, leading to inconsistencies in data coverage. Therefore, information presented in this section provides a summary of current and anticipated pressures. Where data are available, information about population dynamics is presented.

10.7.4.6 Any changes that may occur during the design life span of Morven South have been considered in the context of both greater variability and sustained trends occurring on national and international scales in the marine environment. Whilst there is an indication that some populations are increasing (i.e. bottlenose dolphin, grey seal), remaining stable (harbour porpoise, minke whale, white-beaked dolphin) or exhibiting regional declines (e.g. harbour seal), it is challenging to define a future trajectory of marine mammal populations. Some UK marine mammal populations have undergone periods of significant change in parts of their range, with a limited understanding of the driving factors responsible. For example, there is uncertainty about whether a reduction in pup mortality or an increase in fecundity is the cause of the recent exponential growth of grey seals in the North Sea (Russell & Hastie., 2017). Additionally, there is no appropriate monitoring at the right temporal or spatial scales to fully understand the baseline dynamics of some marine mammal populations, including all marine mammal species included in this assessment. Therefore, it is difficult to predict what marine mammal populations would look like in the future. For humpback whale there is limited data so the population trajectory for this species is unknown.

10.7.4.7 The results of the most recent UK assessment of Favourable Conservation Status (FCS),(relevant to marine mammals as EPS), for each marine mammal species included in the assessment are outlined in Table 10.25.

Table 10.25: Summary of the conservation status of each marine mammal species in UK waters (FV = Favourable, XX = Unknown, + = improving, U1 = Unfavourable – Inadequate, S = Stable, NA = Not Available)

Species	Range	Population	Habitat	Future Prospects	Overall Assessment of Conservation Status	Overall trend in Conservation Status	Reference
Harbour porpoise	FV	XX	XX	FV	XX	XX	JNCC, 2019a
Bottlenose dolphin	FV	XX	XX	XX	XX	XX	JNCC, 2019b
White-beaked dolphin	FV	XX	XX	XX	XX	XX	JNCC, 2019d
Minke whale	FV	XX	XX	XX	XX	XX	JNCC, 2019h
Humpback whale	NA	NA	NA	NA	NA	NA	NA
Grey seal	FV	FV	FV	FV	FV	+	JNCC, 2019i
Harbour seal	FV	U1	XX	U1	U1	XX	JNCC, 2019j

10.7.5 Data limitations and assumptions

10.7.5.1 Morven South was developed on the basis of the best available information at the time of writing. Baseline data used to underpin the assessment were drawn from a thorough desktop review of broadscale sources and site specific surveys which are subject to temporal and spatial variability which in turn is likely to influence marine mammal distribution and abundance.

10.7.5.2 The assessment of marine mammal species abundance and density is not straightforward. Primarily because they are wide-ranging and spend most of their time underwater. Each type of survey method has advantages and disadvantages, but one key consideration is that the observations made are specific to the location and the time of survey. Often, these observations need to be extrapolated to understand the likely usage of the area. Observations are subject to bias and the ability of individual observers to accurately count and identify animals on the transect may be affected by a range of factors, including prior experience, observer fatigue and technical limitations. Further, because animals are underwater, they are not always available to be observed. Correction factors can be used to account for time underwater, however, there are limited data upon which to base these correction factors.

10.7.5.3 Numerical models are relied on to extrapolate the observations, and each model used is subject to a number of assumptions and choices. The compilation of a wide range of data sources where the information can be compared allows for the baseline data to characterise the region of interest. More information on uncertainty and assumptions made during the site specific surveys can be found in Volume 3, Annex 10.3. Marine Mammals Shared Digital Aerial Survey Report.

10.7.5.4 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.

10.8 Methodology for assessment of effects

10.8.1 Overview

10.8.1.1 The Marine Mammal assessment of effects has followed the methodology set out in Volume 1, Chapter 6: EIA Methodology with reference to specific guidance listed in Section 10.6.2 and with reference to legislative and policy context given in Section 10.3.

10.8.2 Assessment criteria

10.8.2.1 The approach for determining the significance of effects is determined by consideration of the magnitude of impact alongside the sensitivity of each receptor/receptor group, in accordance with the defined significance criteria. 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 6: EIA Methodology.

10.8.2.2 The criteria for defining magnitude in this chapter are outlined in Table 10.26 below. Each assessment considered the spatial extent, duration, frequency, and reversibility of impact when determining magnitude, which are outlined within the magnitude section of each impact assessment (e.g. a duration of hours or days would be considered for most receptors to be of short-term duration, which is likely to result in a low magnitude of impact).

Table 10.26: Definition of terms relating to the magnitude

Magnitude of impact	Definition
High	**Extent:** The impact could lead to large scale changes to behaviour and distribution, that are extensive in the context of the relevant geographic frame of reference (area/proportion of MU). **Duration:** The impact is long-term in the context of the life-history (life-span/reproductive cycles) of the species. Typically >7 years (species dependant). **Frequency**: The impact will occur repeatedly or constantly throughout the project phase and/or at high intensity.
	Consequence (adverse): The effect, which may be either reversible or irreversible in individuals, would be of sufficient severity to affect the long-term viability of the relevant population over a generational scale. **Consequence (beneficial):** Long term benefits to many individuals within the population (e.g. long-term improvement of key habitats) such that there is an increase in the relevant population trajectory over a generational scale.
Medium	**Extent:** The impact could lead to large scale changes to behaviour and distribution, that are moderate in the context of the relevant geographic frame of reference (area/proportion of MU). **Duration:** The impact is medium-term in the context of the life-history (life-span/reproductive cycles) of the species. Typically 1-7 years (species dependant). **Frequency:** The impact is anticipated to occur repeatedly or continuously for a moderate length of time within a relevant project phase, and/or at moderate intensity, or occurring intermittently for short periods of time, but at a moderate to high intensity.
	Consequence (adverse): The effect, which may be either reversible or irreversible in individuals, could result in some population-level effects, but not a level that would alter the relevant population trajectory over a generational scale. **Consequence (beneficial):** Lifetime benefits to some individuals although not enough to affect the relevant population trajectory over a generational scale.
Low	**Extent:** The impact could lead to changes to behaviour and distribution in individuals, but which are relatively small in the context of the relevant geographic frame of reference (area/proportion of MU). **Duration:** The impact is short-term within the context of the life-history (life-span/reproductive cycles) of individuals. Typically <1 year (species dependant). **Frequency:** The impact is anticipated to occur at low frequency (occurring occasionally/intermittently) for short periods within relevant project phase at low intensity.
	Consequence (Adverse): Whilst there may be effects at an individual level which may be either reversible or irreversible, these would not be at a scale that would lead to any population-level effects. **Consequence (Beneficial):** Minor benefit, or positive addition to individuals over a localised scale.
Negligible	**Extent:** The impact is anticipated to occur over a highly localised scale within the relevant geographical frame of reference. **Duration**: The impact is anticipated to be momentary/very brief.

Magnitude of impact	Definition
	Frequency: The impact will occur once or infrequently throughout a relevant project phase.
	Consequence (Adverse): Very short-term, recoverable impact on the behaviour and/or distribution in a very small proportion of the population. No potential for the any negative changes in the individual reproductive success or survival therefore no changes to the population size or trajectory. **Consequence (Beneficial):** Very minor benefit, or positive addition to individuals but not at a level that would be measurable.

10.8.2.3 The criteria for defining sensitivity for marine mammal receptors are outlined in Table 10.27 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 (resilience and adaptability), and its ability to recover back to pre-impact conditions (recoverability).

- resilience is the ability to withstand a perturbation or disturbance by resisting damage;
- adaptability is the ability of an individual to adapt its behaviour to sustain ecological functioning and allow survival;
- 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. Recoverability is dependent on the ability of the individuals to recover following cessation of the activity that causes the impact and is defined as the susceptibility of a species to disturbance, damage or death, from a specific external factor.

10.8.2.4 Information on these aspects of sensitivity of the marine mammal IEFs to given impacts has been informed by the best available robust evidence from scientific research and published literature 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 OWFs (and analogous activities such oil and gas surveys) has been used to inform this assessment. The review of resilience 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 10.27.

Table 10.27: Definition of terms relating to the sensitivity of the receptor

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

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

10.8.2.5 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 10.28.

10.8.2.6 In cases where a range is suggested for the significance of effect, there remains the possibility that this may span the significance threshold (i.e. the range is given as minor to moderate). 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.

10.8.2.7 For the purposes of this assessment:

- a level of effect of moderate or more will be considered a 'significant' effect in terms of the EIA Regulations;
- a level of effect of minor or less will be considered 'not significant' in terms of the EIA Regulations.

10.8.2.8 Effects of moderate significance or above are therefore considered important in the decision-making process, whilst effects of minor significance or less warrant little, if any, weight in the decision-making process.

Table 10.28: Matrix used for the assessment of the significance of the effect

Sensitivity of receptor	Magnitude of impact			
	Negligible	Low	Medium	High
Negligible	Negligible	Negligible to minor	Negligible to minor	Minor
Low	Negligible to minor	Negligible to minor	Minor	Minor to moderate
Medium	Negligible to minor	Minor	Moderate	Moderate to major
High	Minor	Minor to moderate	Moderate to major	Major
Very high	Minor	Moderate to major	Major	Major

10.8.3 Approach for underwater sound assessment

10.8.3.1 There is potential for sound emissions from all phases of Morven South to adversely affect marine mammals. The underwater sound modelling assessment (Volume 3, Annex 10.2: Underwater Sound Shared Technical Report) applied peer-reviewed models to calculate impact ranges to marine mammal species from a range of activities that could lead to elevated sound at different phases of Morven South. The modelled sources are:

- impact piling;
- UXO clearance;
- pre-construction site investigation surveys (geophysical/geotechnical);
- vessel activity.

10.8.3.2 Marine mammals, in particular cetaceans, are capable of generating and detecting sound. They are dependent on sound for many aspects of their life, including prey identification, predator avoidance, communication and navigation (Bailey *et al.*, 2010). Increases in anthropogenic sound may consequently lead to a potential effect within the marine environment (Bailey *et al.*, 2010, Parsons *et al.*, 2008). Underwater sound influence may then subsequently affect marine mammals in a number of ways and vary with the distance from the sound source (Marine Mammal Commission, 2007). It can compete with important signals (masking) and alter behaviour (by inducing changes in foraging or habitat-use patterns, separation of mother-calf pairs). Underwater sound can also cause temporary hearing loss or, if the exposure is prolonged or intense, permanent hearing loss. It can also cause damage to tissues other than the ear if the sound is sufficiently intense (Marine Mammal Commission, 2007).

10.8.3.3 Given that there is sparse scientific evidence to properly evaluate masking (e.g. no relevant threshold criteria to enable a quantitative assessment), the assessment of effects associated with underwater sound on marine mammals presented in this section will consider auditory injury (temporary and permanent hearing loss) and behavioural responses.

Injury

10.8.3.4 Auditory injury in marine mammals can be either temporary (TTS), wherein an animal's auditory system recovers over time, or a PTS, whereby hearing does not recover. The 'onset' of non-trivial TTS corresponds to a 6dB shift in a hearing threshold, defined by NMFS (2024) as "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".

10.8.3.5 The acoustic threshold that would result in PTS onset in marine mammals has not been directly measured (given the ethical implications of experimentally inducing permanent auditory injury and must therefore be extrapolated from available TTS onset measurements. The extrapolated PTS threshold of 40dB of TTS is conservatively thought to require a longer recovery time than smaller shifts (e.g. of 6 dB), with a higher probability of irreversible damage (Southall *et al.*, 2007).

10.8.3.6 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 duration of impulsive sounds. If a shift occurs within a frequency band 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 presented later in this assessment. Potential auditory injury is assessed in terms of PTS given the irreversible nature of the effect. TTS is considered to be impairment rather than injury because an animal's auditory system can recover. (Hastie *et al.*, 2019)

10.8.3.7 Auditory injury criteria are used to assess potential impacts to marine mammals. In an update to the previously applied Southall *et al.* (2019) criteria NMFS (2024) has compiled, interpreted and synthesized the scientific literature to produce criteria for the onset of permanent auditory injury (expressed as 'AUD INJ'), which includes (but is not limited to) PTS. The new guidance also provides thresholds for the onset of temporary hearing damage (based on a TTS). This updated guidance is considered to reflect the current state of knowledge regarding the characteristics of sound exposure that has the potential to affect marine mammal hearing sensitivity. AUD INJ thresholds are based on both unweighted peak sound pressure levels (PK) and hearing-weighted cumulative sound exposure levels (SEL_{24h}) (NMFS, 2024) (Table 10.29). Weighting functions are defined using the frequency characteristics (bandwidth and sound level) for each hearing group within which acoustic signals can be perceived, and therefore, assumed to have potential auditory effects. The weighting functions used in sound modelling act as filters, to de-prioritise frequency content that is less relevant for the species group (Table C-1 in Volume 3, Annex 10.2: Underwater Sound Shared Technical Report). Underwater sound modelling also assumes continuous exposure during piling with animals moving away horizontally from the sound source at a steady speed (Table 10.30). A degree of conservatism was built into the method in that the assessment presumes receivers swim solely at the depth of the maximum sound level. This discounts the effect of animals coming up to the surface to breathe, where sound levels are demonstrably much lower.

Table 10.29: Summary of acoustic thresholds for Temporary Threshold Shift and Auditory Injury onset in relevant hearing groups

Hearing Group (NMFS, 2024)	Generalised hearing range	Indicative species	Sound characteristic	Acoustic threshold			
				PK (dB re 1µPa)		SEL_{24h} (dB re 1µPa²s)	
				TTS	AUD INJ	TTS	AUD INJ
Low Frequency (LF) cetaceans	7Hz to 36kHz	Minke whale; Humpback whale	Impulsive	216	222	168	183
			Non-impulsive	-	-	177	197
High Frequency (HF) cetaceans	150Hz to 160kHz	Bottlenose dolphin; White-beaked dolphin	Impulsive	224	230	178	193
			Non-impulsive	-	-	181	201
Very High Frequency (VHF) cetaceans	200Hz to 165kHz	Harbour porpoise	Impulsive	196	202	144	159
			Non-impulsive	-	-	160	181
Phocid pinnipeds (in water) (PW)	40Hz to 90kHz	Grey seal; Harbour seal	Impulsive	217	223	168	183
			Non-impulsive	-	-	175	195

Table 10.30: Swim speeds used in the underwater sound modelling

Species	NMFS Hearing Group	Swim Speed (m/s)	Source Reference
Minke whale	LF	2.3	Boisseau *et al.* (2021)
Humpback whale[2]			
Bottlenose dolphin	HF	1.52	Bailey *et al.* (2010)
White-beaked dolphin			
Harbour porpoise	VHF	1.5	Otani *et al.* (2000)
Grey seal	PW	1.8	Thompson *et al.* (2015)
Harbour seal			

[2] There is no information for humpback whale and therefore minke whale is used as proxy for this species.

Disturbance

10.8.3.8 As sound intensity decreases beyond the injury threshold zone, sound levels have the potential to disrupt the behavioural patterns of marine mammals. Behavioural reactions can vary in severity, from sustained vigilance to interruptions in foraging, to active avoidance or displacement (NRW, 2023). Responses may not necessarily directly scale with received sound level (Gomez *et al.*, 2016). The reaction of a marine mammal to disturbance is dependent upon individual factors and contextual considerations (Southall *et al.*, 2021), with prior experience and acclimatisation playing crucial roles in determining whether an individual will manifest an aversive response to sound (Ellison *et al.*, 2012, Popper *et al.*, 2014), especially in regions characterised by elevated underwater sound levels associated with human activities.

10.8.3.9 Non-trivial disturbance may occur when there is a risk of animals incurring sustained or chronic disruption of behaviour. The determination of the likelihood and extent of disturbance is difficult. There are no agreed-upon disturbance criteria, primarily because there are no clear threshold criteria that can be used due to the variability of documented animal responses to similar levels of noise. The NMFS Level B harassment is defined as: "having the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioural patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild" (NMFS, 2005). This definition is similar to the JNCC *et al.* (2010) description of non-trivial (significant) disturbance. For impulsive sound the Level B harassment thresholds for all marine mammals is 160 dB re 1 μPa (rms) whilst for continuous sound the threshold is given as 120 dB re 1 μPa (rms). Considering the paucity and high-level variation of data relating to onset of behavioural effects due to continuous sound, any ranges predicted using this number are likely to be probabilistic and potentially over precautionary.

10.8.3.10 This NMFS (2005) guidance is based on thresholds above which disturbance could occur and has been widely applied to UK offshore wind farm assessments. Further, an unweighted sound threshold value of 143 dB re 1μPa^{2}s SEL_{ss} based on the work by Tougaard (2021) was recently recommended in the position statement on assessing behavioural disturbance of harbour porpoise from impulsive underwater sound published by (NRW, 2023). Such thresholds represent an area-based approach which assumes that all animals out to these thresholds could experience a disturbance effect. In the context of HRA, area-based thresholds are useful in understanding the potential for a significant disturbance where elevated underwater sound overlaps an SAC.

10.8.3.11 An alternative approach is to apply the concept of a dose-response. There is empirical evidence from data gathered in the field during impact piling activity, which demonstrates a proportional disturbance response of animals corresponding to decreasing levels of received sound moving further away from the source (Brandt *et al.*, 2011, Graham *et al.*, 2019, Whyte *et al.*, 2020). Further detail on the dose-response approach is provided in paragraphs 10.8.3.13 to 10.8.3.28.

10.8.3.12 This assessment has applied several disturbance thresholds considered to be most appropriate relative to the noise generating activities assessed for Morven South (Table 10.31). The risk of disturbance from impact piling has been assessed using a dose-response (D/R) approach, as supported in the Morven Site Scoping Opinion (MD-LOT, 2023).

Table 10.31: Summary of criteria used in the impact assessment of behavioural disturbance for different marine mammal species

Species	Impulsive source: Piling	Intermittent (impulsive/non-impulsive) source: geophysical surveys	Impulsive source: UXO Clearance	Continuous source: Vessels
Harbour porpoise	143dB re 1μPa2s SEL_{ss} (Dose response out to 140dB SEL_{ss})	160dB re 1μPa SPL_{rms}	TTS onset for VHF: • PK 196dB re 1 μPa; • SEL 178dB re 1μPa₂s	120dB re 1μPa SPLrms
Bottlenose dolphin, white-beaked dolphin, minke whale, humpback whale[1]	160dB re 1μPa SPL_{rms} (Dose response out to 140dB SEL_{ss})	160dB re 1μPa SPL_{rms}	TTS onset for HF: • PK 224dB re 1μPa; • SEL 178dB re 1μPa₂s	120dB re 1μPa SPLrms
Harbour seal, grey seal	160dB re 1μPa SPL_{rms} (Dose response out to 145dB SEL_{ss})	160dB re 1μPa SPL_{rms}	TTS onset for PCW: • PK 216dB re 1μPa; • SEL 168dB re 1μPa₂s	120dB re 1μPa SPLrms

Dose response

10.8.3.13 The application of a D/R function allows for a more realistic assessment of the risk of disturbance as this takes into account the likelihood of a response, in comparison to a fixed noise threshold, as this assumes all individuals within the fixed sound threshold respond, whereas outside the contour there is no response.

10.8.3.14 Southall *et al.* (2019) stated that "Apparent patterns in response as a function of received noise level (sound pressure level) highlighted a number of potential errors in using all or nothing "thresholds" to predict whether animals will respond. Tyack and Thomas (2019) subsequently and substantially expanded upon these observations. The clearly evident variability in response is likely attributable to a host of contextual factors, which emphasises the importance of estimating not only a dose-response function but also characterising response variability at any dosage"

Approach for cetacean species

10.8.3.15 Current D/R functions used for assessment regarding cetacean disturbance are based on Graham *et al.* (2017) (Figure 10.3) and were developed using monitoring data obtained in the Moray Firth as part of the Beatrice Offshore Wind Farm monitoring programme and these data have been regularly applied as industry standard across UK offshore wind farm marine mammal assessments. Graham *et al.* (2019) presented updated information (Figure 10.4) gathered from further monitoring of piling in the Moray Firth. Analysis of the PAM data showed a 50% probability of response to piling within 7.4km for the first location piled, which reduced to within 1.3km by the final piling location, suggesting that the use of the D/R functions from 2017 is precautionary.

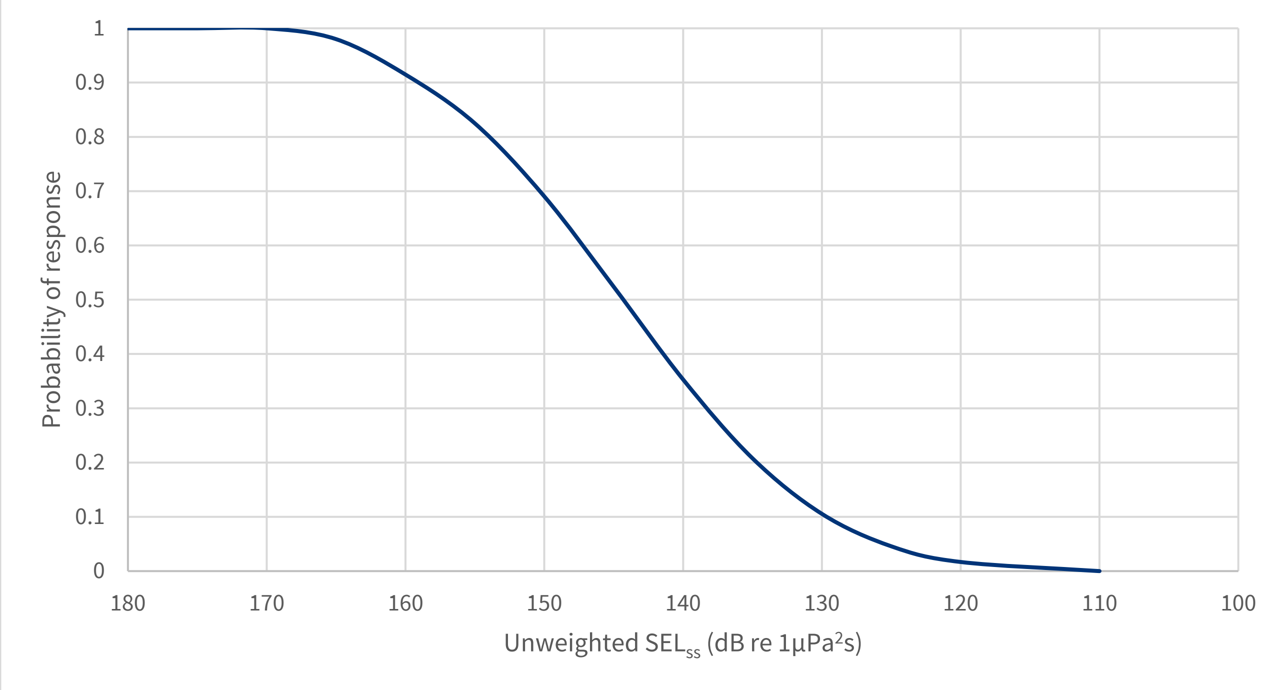

Figure 10.3: Relationship between the proportion of harbour porpoise responding and the received single strike sound exposure level, from Graham *et al.* (2017)

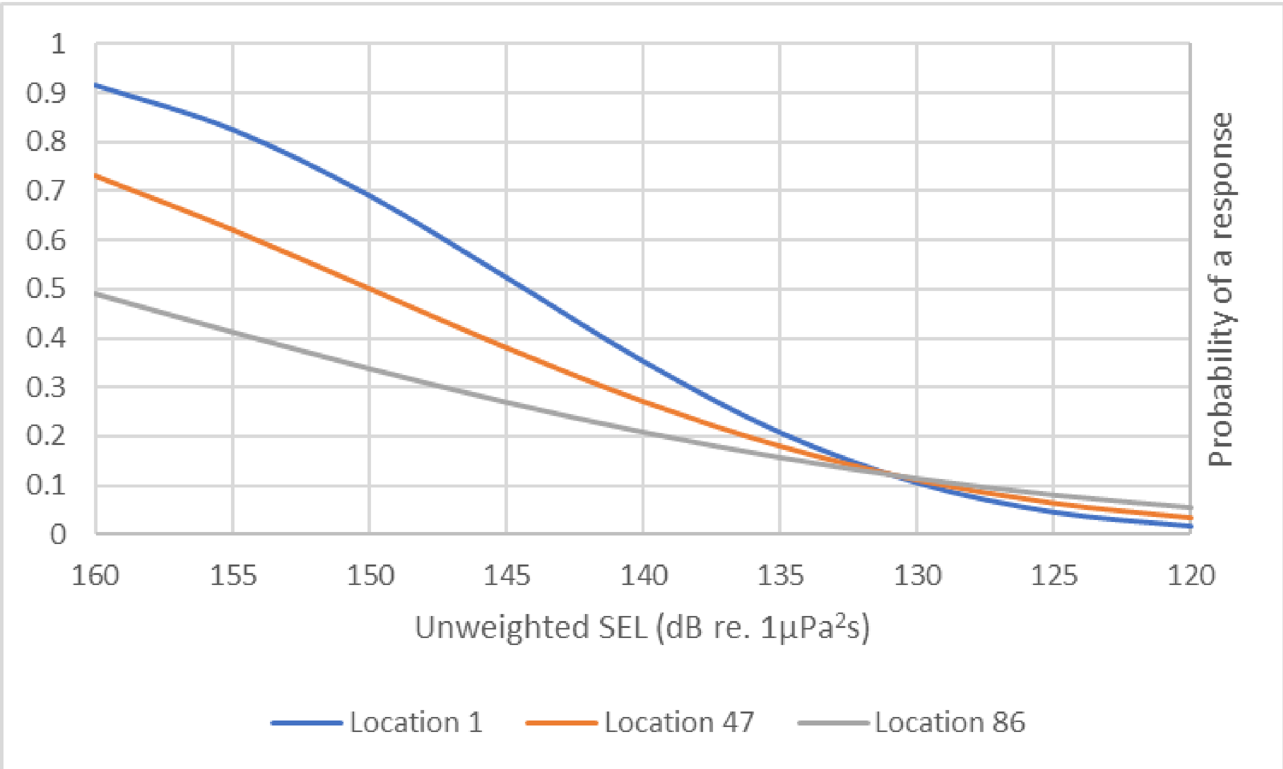

Figure 10.4: The probability of a harbour porpoise response (24 hour) in relation to the unweighted received single-strike sound exposure level for the first location piled (blue line), the location piled halfway through construction (orange line) and the final location piled (grey line), from Graham *et al.* (2019)

10.8.3.16 The recent PrePARED paper (Thompson *et al.,* 2025) highlights the over precaution relating to the use of the Graham *et al.* (2017) dose-response functions. One issue is that received levels of sound may not be the key driver of disturbance. Further, that the use of an unweighted metric may overestimate sound levels for harbour porpoise, because sound propagation with distance alters the frequency content due to quick attenuation of HF sound. This means for porpoise, a VHF cetacean, that the impact piling sound may not be audible at the further ranges covered by the D/R noise contours.

10.8.3.17 The case study presented in Thompson *et al.* (2025) stated that the monitoring data indicated that around 150 harbour porpoise would have been at risk of disturbance by each piling event. When compared to the worst-case prediction (using the Graham *et al.* (2017) D/R functions) of 4,681 harbour porpoise, the prediction is approximately 30 times more than the number estimated from monitoring information. Thompson *et al.* (2025) highlights that the potential for significant disturbance to occur in the far field are biologically implausible.

10.8.3.18 The emerging evidence strongly suggests that the use of the Graham *et al.* (2017) is highly over precautionary. In the absence of any alternative approach, we have used the Graham *et al.* (2017) D/R functions, but the assessment caps the likely response at the 140 dB SEL_{ss} contour to derive an estimate of the number of animals at risk of disturbance (this approach was accepted by NatureScot, for all species with the exception of minke whale, which remains a matter of disagreement Table 10.15). The following was considered in order to define this approach:

- Graham *et al*. (2017) considered that harbour porpoise responded to piling when the proportional decrease in occurrence exceeded the threshold of 0.5, therefore, anything below a 50% chance was not considered to be a significant behavioural response;
- Graham *et al*. (2019) found that there was a greater than or equal to a 50% chance of porpoises responding in the 24-hour period after piling to an unweighted SEL of 144.3 dB re 1 mPa^2 s (95% Confidence Intervals (CI) 142.1–146.8) at the first location piled;
- The 140 dB SEL_{ss} aligns with (or is more conservative than) other published thresholds that have been used for impact piling assessment including 143 dB SEL_{ss} (Tougaard, 2021); 145 dB SEL_{ss} (Lucke *et al.*, 2009); or 140 dB SEL_{ss} ((ASCOBANS, 2014);
- Whilst fixed thresholds represent an all or nothing response areas and are therefore not necessarily equivalent to a D/R approach, the examples above are detailed for context as to noise levels considered to elicit a behavioural response;
- The D/R functions described in Graham *et al.* (2017) indicate that there is less than a 20% probability of a response at noise levels below 140 dB SEL_{ss}. A 20% probability is not considered to be a significant behavioural response, together with the emerging data published in Thompson *et al.* (2025) suggests therefore that capping the Graham *et al*. (2017) D/R curves at the 140 dB SEL_{ss} contour will capture those individuals most at risk of non-trivial disturbance, whilst retaining sufficient precaution;
- In the absence of species-specific data for other cetacean species, the same dose-response curve was assumed to apply to all cetacean species in this assessment and represents a precautionary approach to assessment as other cetacean species are likely to be less sensitive than harbour porpoise to behavioural disturbance as noted in the literature (Tougaard, 2021).

<u>Approach for seal species</u>

10.8.3.19 Whyte *et al.* (2020) used tracking data from 24 harbour seal to estimate the effects of pile driving sounds on this species. The study used predictions of seal density during pile driving made by Russell *et al.* (2016), predicted seal density significantly decreased within 25km or above 145dB re 1 μPa^2 SEL_{ss} (averaged across depths and pile installations). Other studies have reported similar avoidance reactions for both grey seal and harbour seal to the same sound source (Aarts *et al*., 2018; Götz & Janik, 2010) and therefore harbour seal dose-response curve is considered as appropriate to be used as a proxy for grey seal. As such, the dose-response curve derived from Whyte *et al*. (2020) (Figure 10.5) was applied to the grey seal assessment to determine the number of animals that may potentially respond behaviourally to received sound levels during piling.

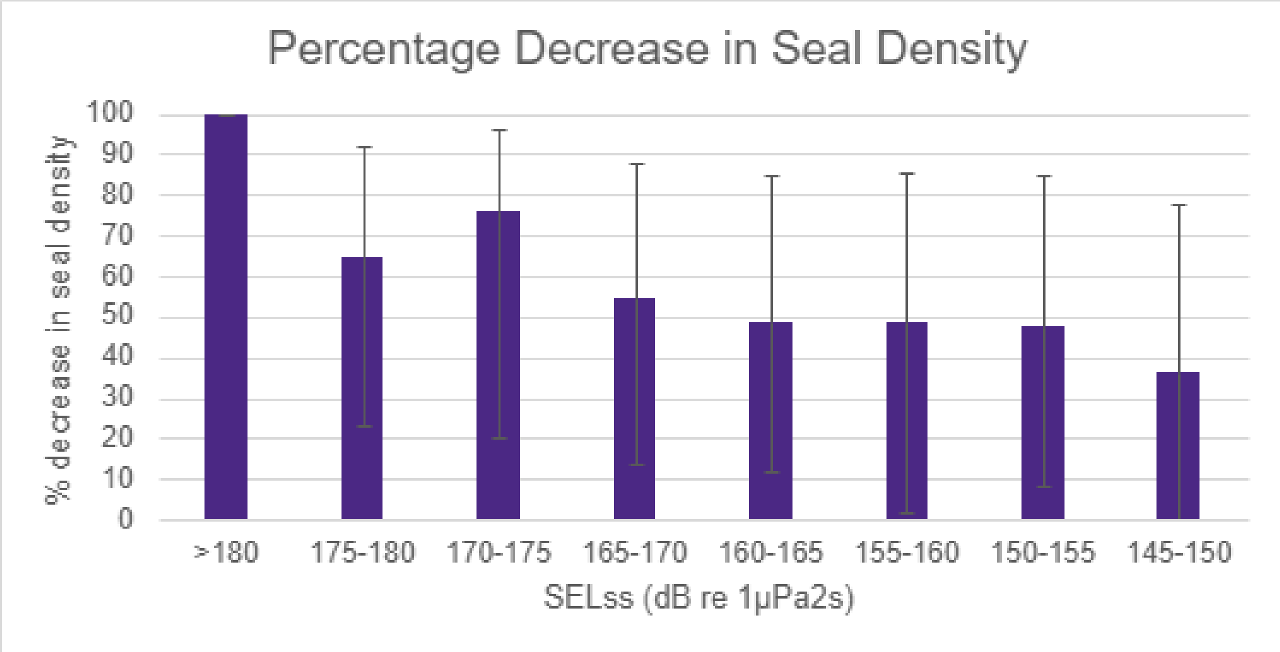

Figure 10.5: Predicted decrease in seal density as a function of estimated sound exposure level. Error bars show 95% confidence interval (from Whyte *et al.*, 2020)

Geographic Information System mapping for dose-response

10.8.3.20 To obtain the numbers of animals (cetaceans and seals) disturbed during piling, SEL_{ss} contours from underwater sound modelling were plotted by 5dB contours in Geographic Information System (GIS) for all modelled locations. The areas within each contour were calculated from the spatial GIS map and a proportional expected response (derived from the dose-response curve for each contour area) was used to calculate the number of animals potentially disturbed. These numbers were subsequently summed across all contours to estimate the total number of animals disturbed during piling at any given time. The number of animals predicted to respond are based on species-specific densities derived from site specific surveys and desktop data. For seal species animals were counted where >50% of each 5 x 5km grid cell fell within a 5dB isopleth and the total number of animals were summed across all grid cells.

Assumptions and limitations

10.8.3.21 By applying the fixed-threshold based and dose-response criteria, the magnitude of impact can be quantified with respect to the spatial extent of disturbance, and subsequently the number of animals potentially disturbed based on available density information. However, Southall *et al*. (2021) noted that it is challenging to develop a comprehensive set of empirically derived criteria for such a diverse group of animals. The study identified data gaps, as for example, measurements of the effects of elevated sound on mysticetes have never been conducted and extrapolation from other species has been necessary. Since there are broad differences in hearing across the frequency spectrum for different marine mammal hearing groups, sounds that disturb one species may be irrelevant or inaudible to other species. Variance in responses even across individuals of the same 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).

10.8.3.22 As such, the recent recommendations by Southall *et al*. (2021) steer away from a single overarching approach. Instead, the study proposes a framework for developing probabilistic response functions for future studies (Southall *et al.,* 2021). 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.

10.8.3.23 Although some 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 in paragraph 10.11.1.7 to 10.11.1.21and in Volume 3, Annex 10.5: Marine Mammals Interim Population Consequences of Disturbance (iPCoD) Modelling Report.

10.8.3.24 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 as 'capital breeders' accumulate energy in their feeding grounds and transfer it to calves in their breeding ground, whilst other species such as harbour porpoise, bottlenose dolphin and harbour seal are 'income breeders' as 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).

10.8.3.25 Marine mammal ability to compensate for chronic exposure to sound will also depend on a range of ecological factors, including the relative importance of the disturbed area and prey availability within their wider home range, the distance to and quality of other suitable sites, the relative risk of predation or competition in other areas, individual exposure history, and the presence of concurrent disturbances in other areas of their range (Gill *et al.*, 2001). Animals may be able to compensate for short term disturbances by feeding in other areas, for example, which would reduce the likelihood of longer-term population consequences. Booth (2019) reported that although minimising the anthropogenic disturbance is an important factor to animal's health, if animals can find suitable high-energy-density prey they may be capable of recovering from some lost foraging opportunities. Christiansen and Lusseau (2015) studied the effect of whale-watching on minke whale in Faxafloi Bay, Iceland and found no significant long-term effects on vital rates, although years with low sandeel density led to increased exposure to whale-watching as whales were forced to move into disturbed areas to forage. Odontocetes 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. Studies of changes in abundance as a result of disturbance should be considered in light of findings presented in Gill *et al.* (2001) who reported that if 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.

10.8.3.26 The marine mammal receptors 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 marine mammals identified as key biological receptors in the baseline. Humpback whale and grey seals are capital breeders and store energy for reproduction and survival, while harbour porpoise (and other cetaceans whose ecology is well studied, e.g. bottlenose dolphin) are income breeders and they use energy that is acquired on a continual basis, including during the reproductive period (Stephens *et al.*, 2009).

10.8.3.27 Recognising the inherent uncertainty in the quantification of effects using threshold and dose-response approaches, this assessment has adopted a precautionary approach at all stages of assessment, including additional conservative assumptions in the:

- marine mammal baseline (e.g. use of seasonal density peaks for harbour porpoise densities);
- Maximum Design Scenario (MDS) for the project parameters (Table 10.32, e.g. use of high order UXO detonation as the MDS);

- underwater sound modelling (see paragraphs 10.8.3.29 to 10.8.3.34 for summary and Volume 3, Annex 10.2: Underwater Sound Shared Technical Report for more details).

10.8.3.28 These assumptions have been referred to throughout this chapter, illustrating that the systematic incorporation of layers of conservatism is likely to result in a very precautionary assessment.

Conservatism in the underwater sound modelling

10.8.3.29 To ensure that the assessment is precautionary, a number of conservative assumptions were adopted in the underwater sound model. These measures of conservatism are summarised in this section and highlight that both PTS (and TTS onset ranges) predicted using the SEL_{24h} threshold are likely to lead to overestimates in the ranges and therefore should be interpreted with caution. For more details refer to Volume 3, Annex 10.2: Underwater Sound Shared Technical Report.

10.8.3.30 The underwater sound 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 OWFs, e.g. Beatrice Offshore Wind Farm, where the mean actual hammer energy averages were considerably lower than the maximum assessed in the EIA Report and only six out of 86 asset locations reached maximum hammer energy (Beatrice OWF Limited, 2018).

10.8.3.31 Additionally, the piling procedure simulated in the model does not allow for short pauses in piling (e.g., for realignment) and therefore the modelled SEL_{24h} is likely to be an overestimate since, in reality, these pauses would reduce the sound exposure that animals experience whilst moving away.

10.8.3.32 The underwater sound modelling assessment also 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, 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) reported horizontal speed for harbour porpoise can be significantly faster than vertical speed and cite a maximum speed of 4.3m/s (compared to 1.5m/s used in the underwater noise model). Similarly, McGarry *et al.* (2017) reported minke whale speeds of up to 4.2m/s during acoustic deterrent exposure experiments on free-ranging animals, compared to swim speed of 2.3m/s used in the underwater sound model.

10.8.3.33 The underwater sound model accounts for the SEL_{24h} metric 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. Since for intermittent sound (such as piling) the quiet periods between sound exposures will allow some recovery of hearing compared to continuous sound, the equal-energy rule is likely to overestimate the extent of impact. Additionally, modelling of concurrent piling assumed 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.

10.8.3.34 The impulsive sound is likely to undergo transition into non-impulsive sound at distance from the sound source due to a combination of factors (e.g. dispersion of the waveform, multiple reflections from sea surface and seafloor, and molecular absorption of HF energy). The empirical evidence suggests that such shifts in impulsivity could occur within 10km from the sound source (Hastie *et al.*, 2019). However, since the precise range at which this transition occurs is unknown, the underwater sound model adopted the impulsive thresholds at all ranges. This is likely to lead to an overly precautionary estimate of injury ranges at larger distances (tens of kilometres) from the noise source. The Offshore Renewables Joint Industry Programme (ORJIP) RaDIN study (ORJIP, 2024) concluded that "there was a marked decrease in impulsiveness as sounds travel away from the source within 5km of the piling location" and that, "there is still insufficient evidence to establish a range of distances from which these sounds are no longer impulsive".

10.8.4 Designated sites

10.8.4.1 This chapter makes an assessment of the LSE[1] in EIA terms on the qualifying interest feature(s) of the European sites described within Section 10.7.3 of this chapter. The full assessment of the potential impacts on the designated sites deferred to the Report to Inform Appropriate Assessment (RIAA) for Morven South). A summary of the outcomes reported in the RIAA is provided in Section 10.16.

10.8.4.2 With respect to locally designated sites and national designations (other than European sites), where these sites fall within the boundaries of a European site and where qualifying interest features are the same, only the European site has been taken forward for assessment. This is because potential impacts on the integrity and conservation status of the locally or nationally designated site are assumed to be inherent within the assessment of the European site (i.e., a separate assessment for the local or national site is not undertaken). However, where a local or nationally designated site falls outside the boundaries of a European site, but within the Morven South Marine Mammal Study Area, an assessment of the Likely Significant Effects (LSE[1]) on the overall site is made in this chapter using the EIA methodology (Volume 1, Chapter 6: EIA Methodology).

10.9 Parameters for assessment

10.9.1 Maximum Design Scenario

10.9.1.1 The MDSs identified in Table 10.32 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 details provided in Volume 1, Chapter 3: Project Description. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the Project Design Envelope (PDE) (e.g. different infrastructure layout), to that assessed here, be taken forward in the final design scheme.

Table 10.32: Maximum Design Scenario considered for the assessment of potential impacts on marine mammals

Potential Impact	Phase			Maximum Design Scenario	Justification
	C	O	D		
Injury and disturbance from underwater sound generated from piling	✓	×	×	**Construction Phase** ***Spatial MDS*** Concurrent piling with up to two vessels, at a minimum distance of 1.1km and a maximum distance of 27.65km, piling at 73 foundations comprising: • 67 wind turbines: – 16m diameter monopiles; – Maximum hammer energy of 6,600kJ; – Maximum duration of 24h piling per monopile, with a maximum of one foundation per day; – Total of 34 days of concurrent piling. • Four High Voltage Alternating Current (HVAC) collector OSPs (OSP Type I): – 16m diameter monopiles; – Maximum hammer energy of 6,600kJ; – Maximum duration of 24h piling per monopile, with a maximum of one foundation per day; – Total of two days of concurrent piling. • One bridge-linked (= two foundations) high-voltage direct current (HVDC) converter OSP (OSP Type II): – Two six-legged jacket foundations (bridge-linked) – 24 x5m diameter pin pile (modelled as 5.3m) per foundation, equals 48 pin piles for two bridge-linked foundations; – Maximum hammer energy of 4,000kJ;	***Spatial MDS*** The spatial MDS assumes that concurrent piling of the largest diameter monopiles (16m) using the greatest hammer energy (6,600kJ) would lead to the largest spatial extent of ensonification at any one time. The spatial MDS assumes the maximum number of piles would be installed per day. Minimum spacing between concurrent piling (1km) represents the highest risk of injury to animals as sound from adjacent foundations could combine to produce a greater radius of effect compared to a single piling event. Maximum spacing between concurrent piling (27.65km) represents the highest risk of behavioural effects to marine mammals as a larger area would be ensonified at any one time. ***Temporal MDS*** The temporal MDS assumes that the greatest number of piles (524) would be installed and that piling would be undertaken at only one location at a time. The temporal MDS assumes the minimum number of piles would be installed per day

Potential Impact	Phase			Maximum Design Scenario	Justification
	C	O	D		
				– Maximum duration of 9h piling per pin pile, with an average of two piles per day. – Total of 12 days of piling (based on four piles per day). Total duration of piling = 34 + 2 + 12 = 48 days ***Temporal MDS*** Single-vessel piling at 101 locations comprising: • 95 wind turbines: – 3.7m diameter pin piles per foundation = 380 piles; – Maximum hammer energy of 4,000kJ; – Maximum duration of 9h piling per pile, with a minimum of two piles per day; – Maximum of 190 days of piling. • Four HVAC collector OSPs: – 4.5m diameter pin piles (modelled as 5.3m) per foundation = 96 piles; – Maximum hammer energy of 4,000kJ; – Maximum duration of 9h piling per pile, with a minimum of two pile per day; – Maximum of 48 days of piling. • One bridge-linked (=two foundations) HVDC converter OSP: – Two six-legged jacket foundations (bridge-linked); – 24 x 5m (modelled as 5.3m) diameter pin piles per foundation, equals 48 piles for two bridge-linked foundations; – Maximum hammer energy of 4,000kJ;	(one pile), leading to the greatest number of piling days.

Potential Impact	Phase			Maximum Design Scenario	Justification
	C	O	D		
				– Maximum duration of 9h piling per pin pile, with a minimum of two pile per day. – Maximum of 24 days of piling. Total duration of piling = 190 + 48 + 24 = 262 days Piling phased over 12 months (start Q4 2034)	
Injury and disturbance from underwater sound generation from UXO clearance	✓	×	×	**Construction Phase** • Clearance of up to 15 UXOs within the Morven South Boundary; • maximum charge weight of 554kg Net Explosive Quantity (NEQ); • most likely charge weight of 132kg NEQ; • maximum donor charge of 10kg (2 x 5kg); • maximum of one detonation within 24 hours; • total duration of UXO clearance campaign 15 days (excluding downtime for e.g. weather); • clearance during daylight hours only.	Maximum number and maximum realistic size of UXOs encountered is based on the UXO Hazard Assessment undertaken for Morven South.
Injury and disturbance to marine mammals from site investigation surveys	✓	✓	×	**Construction Phase** Geophysical surveying is expected to include the following equipment, operating within the following indicative frequency range and source levels: • Multibeam Echo-Sounder (MBES) – 200-500kHz, 180-240dB re 1μPa re 1m(rms); • Sidescan Sonar (SSS) – 200-700kHz, 216-228dB re 1μPa re 1m(rms); • Single Beam Echosounder (SBES)	The range of geophysical and geotechnical survey activities likely to be undertaken, using equipment and parameters typically employed for these types of surveys, will result in the greatest potential impact.

Potential Impact	Phase			Maximum Design Scenario	Justification
	C	O	D		
				– 120-400kHz, 180-240dB re 1μPa re 1m(rms); • Sub-Bottom Profilers (SBP) – 0.2-14kHz chirp, 200-240dB re 1μPa re 1m(rms). – 2-7 kHz pinger, 200-235dB re 1μPa re 1m(rms); • Ultra High Resolution Seismic (UHRS) – 0.05-4kHz, 182dB re 1μPa re 1m (rms). • Geotechnical surveys will include: – boreholes; – cone penetration tests; – seismic cone penetration tests; – vibrocores Geophysical and geotechnical surveys will involve the use of up to two vessels on site at any one time, with up to 156 survey vessel movements in total. **O&M Phase** The type of site investigation surveys, and the corresponding indicative frequencies and source levels, are assumed to be the same as for the construction phase. Routine geophysical surveys would typically be undertaken every three years except for the inter-array cables and interconnectors where surveys would occur annually for the first five years, and every four years thereafter. Up to four survey vessels will be on site at any one time, involving 60 vessel return trips per year.	

Potential Impact	Phase			Maximum Design Scenario	Justification
	C	O	D		
				There would be no geotechnical surveys undertaken post construction.	
Injury and disturbance to marine mammals from vessel use and other (non-piling) sound-producing activities	✓	✓	✓	**Construction Phase** • Up to a total of 41 construction vessels on site at any one time (15 main installation and support vessels, 8 tug/anchor handlers, four cable lay installation & support vessels, 2 guard vessels, 2 survey vessels, 3 seabed preparation vessels for boulder removal, grapnel, pre-sweep/levelling, six crew transfer vessels and one scour protection installation vessel). • Up to 3,060 installation vessel movements (return trips) during the entire construction phase (488 main installation and support vessels, 416 tug/anchor handlers, 162 cable lay installation & support vessels, 172 guard vessels, 156 survey vessels, 50 seabed preparation vessels for boulder removal, grapnel, pre-sweep/levelling, 1,460 crew transfer vessels, and 156 scour protection installation vessels). • **Other activities:** Drilling, ploughing, trenching and jetting, cable burial and rock dumping. Maximum offshore construction duration of up to 4.5 years (includes pre-construction surveys). **O&M Phase** • Up to a total of 19 vessels on site at any one time (8 crew transfer vessels/workboats), 2twojack-up vessels, 2 cable repair vessels, 4 survey vessels (unmanned surface vehicles), and three other vessels,. • For foundations (wind turbine); up to 702 annual return trips (143 routine inspections including scour protection inspection and geophysical surveys, 96 repairs and replacements of navigational equipment, 382 removal of	The MDS considers the maximum number of vessels on site at any one time and the greatest number of return trips during each phase of Morven South. This represents the broadest range of vessel types and therefore sound signatures within the marine environment that may affect marine mammal receptors. The MDS considers the maximum durations for which activities could be conducted.

Potential Impact	Phase			Maximum Design Scenario	Justification
	C	O	D		
				marine growth including guano removal, 15 replacement of corrosion protection anodes, 51 painting, 5 replacement of access ladders and boat landings, and 10 modifications to/replacement of J-tubes). • For wind turbines; up to 1,165 annual return trips (382 routine inspections, 764 minor repairs and replacements within the wind turbine, three major component replacements, and 16 painting or other coatings). • For foundations (OSP): up to 35 annual return trips (11 removal of marine growth including guano removal, 6 replacement of corrosion protection anodes, 6 painting, 6 replacement of access ladders and boat landings, and six modifications to/replacement of J-tubes; scour protection inspection included in routine inspections and geophysical surveys). • For offshore substation: Up to a total of 101 annual return trips (66 routine inspections, 26 replacements of consumables and minor components, three major component replacements, and six painting or other coatings; guano removal included in removal of marine growth). 232 routine inspections including scour protection inspection and geophysical surveys, 116 geophysical surveys, 2 inter-array cable repairs, and one inter-array cable reburial). 20 routine inspections including scour protection inspection and geophysical surveys, 10 geophysical surveys, 2 interconnector cable repairs, and one interconnector cable reburial; modifications to/replacement of J-tubes counted in 'Foundations' above). **Decommissioning Phase**	

Potential Impact	Phase			Maximum Design Scenario	Justification
	C	O	D		
				Vessel traffic during the decommissioning phase is expected to be of similar magnitude (or lower) to that for the construction phase, and is, therefore, not discussed in its own right.	
Injury to marine mammals due to collision with vessels	✓	×	✓	**Construction Phase** As described for disturbance due to vessel use above. **Decommissioning Phase** As described for disturbance due to vessel use above.	Maximum numbers of vessels on site at any one time, and largest numbers of round trips during each phase, will result in the greatest potential impact.
Effects on marine mammals due to changes in prey availability	✓	✓	✓	**Construction Phase** A total of up to 62,596,300m^2 of temporary habitat loss and/or disturbance due to: • boulder removal; • sand wave clearance; • installation of foundations; • installation of inter-array and interconnector cables; • jack-up vessel feet during piling and infrastructure installation. Effects on fish and shellfish receptors due to underwater noise from piling and UXO clearance and also from increased SSCs. **O&M Phase** A total of up to 7,967,400m^2 of temporary habitat loss and/or disturbance due to jack-up vessel usage and disturbance caused by reburial of inter-array and interconnector cables. A total of up to 1,820,664m^2 of long-term subtidal habitat loss due to infrastructure installed in the construction phase, which will persist into the O&M phase.	The MDS is as defined in Volume 2, Chapter 9: Fish and Shellfish Ecology, and summarised here.

Potential Impact	Phase			Maximum Design Scenario	Justification
	C	O	D		
				Up to 3,074,239m^2 of hard substrate will be installed in the construction phase which will persist into the O&M phase and could have fish aggregation effects. Up to 684km of subsea electrical cables will be present across the Morven South Boundary, which could impact fish and shellfish receptors due through the release of EMFs. These cables will be buried to a target depth of 1m, with minimum and maximum burial depths of 0.5m and 3m, respectively. Where burial is not possible, cable protection will be installed. **Decommissioning Phase** Temporary habitat loss and/or disturbance will occur due to the footprint area of jackup vessel use for decommissioning activities, although a footprint was not able to be calculated at this stage of development. Up to 1,649,807m^2 of long term subtidal habitat loss due to infrastructure left *in situ* following the decommissioning phase (all scour protection and cable protection). This may have fish aggregation effects.	

C= construction, O= O&M, D= decommissioning phases

10.10 Designed-in measures and mitigation

10.10.1.1 As part of the project design process, a number of measures (primary and tertiary) have been adopted to reduce the potential for impacts on marine mammals (see Table 10.33). For the purposes of the EIA process, the term 'designed-in measure' is used to include the following measures (adapted from IEMA, 2016 and IEMA, 2024):

- measures included as part of the design of Morven South. These include modifications to the location or design of Morven South, which are integrated into the application for consent. These measures are considered standard industry practice for this type of development and are referred to as primary mitigation in IEMA, 2016 and IEMA 2024;
- measures required to meet legislative requirements, or actions that are generally standard practice used to manage commonly occurring environmental effects. These measures are secured through the conditions of the marine licences and referred to as tertiary mitigation in IEMA, 2016 and IEMA, 2024.

10.10.1.2 As there is a commitment to implementing these measures, they are considered inherently part of the design of Morven South and have therefore been considered in the assessment presented in Section 10.11 (i.e. the determination of magnitude and therefore significance assumes implementation of these measures).

10.10.1.3 The requirement for any additional mitigation measures is dependent on the significance of the effects on marine mammals. Where significant effects have been identified, further mitigation measures (referred to as secondary mitigation in IEMA, 2016 and IEMA, 2024) 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, where relevant, in Section 10.11.

10.10.1.4 All designed-in measures and secondary mitigation measures are detailed in Volume 3, Annex 6.3: Morven South EIA Commitments Register.

Table 10.33: Designed-in (primary and tertiary) measures adopted as part of Morven South

Reference number	Designed-in measures adopted as part of Morven South	Justification	Primary or tertiary
MM-5	Development of and adherence to an Invasive Non-Native Species Management Plan, and Biosecurity Plan.	To reduce the risk of introduction and spread of INNS during all phases of the Morven North and Morven South projects, as far as practicable. The Biosecurity Plan and an Invasive Non-Native Species Management Plan will control invasive non-native species and their potential impact on marine ecology receptors.	Tertiary
MM-6	Development and adherence to a Marine Pollution Contingency Plan (MPCP).	To reduce the potential for release of pollutants from construction, operation and maintenance and decommissioning, a MPCP will be developed. The Marine Pollution Contingency Plan will include planning for accidental spills, addressing all potential contaminant releases and include key emergency details, and will be in line with appropriate regulations and guidelines.	Primary

Reference number	Designed-in measures adopted as part of Morven South	Justification	Primary or tertiary
MM-7	Development of and adherence to a Navigation Safety Plan and Vessel Management Plan (NSPVMP).	A NSPVMP will be developed to reduce the risk introduced due to the presence of project vessels. The Navigation Safety and Vessel Management Plan will describe the measures related to navigational safety, including information on Safety Zones, charting, construction buoyage, temporary lighting and marking and means of notification of Morven South activity to other sea users (e.g. via Notices to Mariners). It will confirm the types and numbers of vessels engaged in Morven South and consider vessel coordination, including indicative transit route planning.	Primary
MM-8	Development of and adherence to a Marine Mammal Mitigation Protocol.	The Marine Mammal Mitigation Protocol (MMMP) will mitigate for risk of injury or disturbance to marine mammals during construction. This will include ensuring that animals are not observed within the marine mammal mitigation zone during piling. The MMMP may include using Marine Mammal Observer(s) and PAM to monitor the Mitigation Zone (MZ, as determined by the underwater sound modelling) to ensure that animals are not observed within the MZ during piling. ADD may be used if required to deter animals from the MZ.	Tertiary
MM-16	UXO clearance using low order disposal techniques where technically feasible	Where reasonably practical, low order techniques will be adopted as mitigation to reduce sound levels and thereby reduce injury and disturbance to sound-sensitive receptors during UXO clearance.	Primary
MM-32	Development of and adherence to an Environmental Management Plan.	The EMP will ensure appropriate environmental controls are in place for Morven North and Morven South, and the agreed procedures to mitigation and potential risk to the receiving environment. Measures will cover a wide range of management measures including environmental awareness training, auditing, reporting procedures and waste management. It is expected that the EMP will include a Marine Pollution Contingency Plan (MPCP) and an Invasive Non-Native Species Management Plan (INNSMP). The EMP is also expected to limit potential environmental damage from small quantities of drill fluids which may be released and as regulated by the UK Registration, Evaluation, Authorisation and Restriction of Chemicals REACH Regulations.	Primary
MM-40	Development of and adherence to a piling strategy which will include a soft-start procedure (including low	To reduce the likelihood of injury from elevated underwater noise to marine receptors in the immediate vicinity of piling operations as much as possible, allowing individuals to move away from	Primary

Reference number	Designed-in measures adopted as part of Morven South	Justification	Primary or tertiary
	hammer initiation and ramp up) to be implemented for pile driving.	the area before sound levels reach a level at which injury may occur.	

10.11 Assessment of significant effects

10.11.1 Injury and disturbance from underwater sound generated from piling

Summary of piling scenarios

10.11.1.1 Piling during the construction phase of Morven South has the potential to result in higher levels of underwater sound when compared to background levels and could result in auditory injury (AUD INJ threshold) and/or potential behavioural effects on marine mammal receptors.

10.11.1.2 The assessment of potential effects on marine mammal receptors from piling considered a temporal MDS and a spatial MDS (Table 10.32). The temporal MDS, leading to the greatest number of days of piling, is based on single piling of pin piles for jacket foundations. The assessment therefore focused on the longest duration of piling and the greatest number of days over which piling could occur and is summarised in Table 10.34.

Table 10.34: Summary of piling parameters for the temporal Maximum Design Scenario

Parameter	Structure			Total
	Wind turbine	AC collector OSP	HVDC converter OSP	
Number of foundations	95	4	2	101
Foundation type	4-legged jacket	6-legged jacket	6-legged jacket	-
Pile diameter (m)	3.7	4.5	5	-
Max hammer energy (kJ)	4,000	4,000	4,000	-
Number of legs	4	6	6	-
Number of piles per leg	1	4	4	-
Total number of piles	380	96	48	524
Minimum piles per day	2	2	2	-
Maximum piling days	190	48	24	262

10.11.1.3 The spatial MDS assumes concurrent piling of 16m diameter monopile foundations, leading to the largest area of effect at any one time (Table 10.35), for which underwater sound modelling was undertaken. The following assumptions were identified for concurrent piling, based on the project description and site bathymetry (see Volume 3, Annex 10.2: Underwater Sound Shared Technical Report):

- minimum separation distance of 1.1km between concurrent piling events as the MDS for potential injury (cumulative exposure metric);
- maximum separation distance of up to 27.65km as the MDS for potential disturbance and injury PK metric.

Table 10.35: Summary of piling parameters for the spatial Maximum Design Scenario

Parameter	Structure			Total
	Wind turbine	AC collector OSP	HVDC converter OSP	
Number of foundations (locations)	67	4	2	73
Foundation type	Monopile	Monopile	6-legged jacket (pin pile)	-
Pile diameter (m)	16	16	5	-
Max hammer energy (kJ)	6,600	6,600	4,000	-
Number of legs	1	1	4	-
Number of piles per leg	1	1	4	-
Total number of piles	67	4	48	119
Number of concurrent piling events	2	2	2	-
Minimum piles per day	1	1	2	-
Maximum piling days	34	2	12	48

10.11.1.4 Note that due to the large number of options presented in Volume 1, Chapter 3: Project Description, the underwater sound modelling selected three conservative pile types to represent the suite of different options available (Table 10.36).

Table 10.36: Details of hammer and helmet weights in the modelling and representations of different foundation types/hammer energies presented in this chapter

Pile	Hammer model	Helmet weight (kN)	Hammer energy (kJ)	Foundation/ hammer Represented	Justification
3.7m pin pile	IHC S-4000	2,255	4,000	3.7m pin pile, 4,000 kJ	Sensitivity testing was undertaken and demonstrated that the 3.7m pin pile could not be represented by the 5.3m diameter pin pile as some frequency components led to larger effect ranges than predicted for the 5.3m pin pile in the far field.
5.3m pin pile	IQIP IQ6	4,000	4,500	5.0m pin pile, 4,000 kJ 4.5m pin piles, 4,000 kJ	The 5.3m pin pile was selected to capture the maximum ranges across all pin pile diameters in the PDE including the 5.0m and 4.5m.
16m monopile	IQIP IQ6	4,400	6,600	16m monopile, 6,600 kJ	16m monopile is the maximum adverse spatial for wind turbines and OSPs Type I

10.11.1.5 Model outputs were provided as Best Estimates (BE) and Upper Bound (UB) to represent the median and maximum geoacoustic profiles respectively. These are described in Volume 3, Annex 10.2: Underwater Sound Shared Technical Report, as realistic and conservative for the BE and UB respectively. Effect ranges were given as R_{max} and $R_{95\%}$. R_{max} corresponds to the maximum horizontal distance from the sound source to the given sound level and is more suited to cases when sound propagation does not radiate in a uniform manner, typically due to interaction with bathymetric features. $R_{95\%}$ corresponds to the equivalent distance after the 5% farthest points have been excluded and is more suited to cases when sound propagation radiates relatively uniformly in all directions from the source.

10.11.1.6 For the assessment of instantaneous injury (based on PK), the greatest predicted ranges, across all penetration depths, have carried forward from the underwater sound modelling (as discussed in Volume 3; Annex 10.1: Underwater Sound Shared Technical Report) since these will underpin the MZ and therefore should be inherently precautionary. These were found to be at penetration depth B and predicted using the BE and R_{max} in all cases. Contrary to expectations, in most cases, it was the BE that produced larger ranges than the UB for the PK metric; most likely as a result of how seabed reflectivity couples with the geoacoustics in the nearfield where sound energy was more effectively transferred to the water column using the BE parameters compared to the UB parameters. However, for pin piles the UB were the largest ranges, and therefore were carried forward.

Table 10.37: Summary of metrics taken forward from the underwater sound modelling to the marine mammal assessment

Metric	Application	Values taken forward	Justification
Unweighted Peak pressure (PK)	Instantaneous auditory injury using AUD INJ criteria	Largest across all penetration depths, Upper bound or Best Estimate and R_{max}	This is the absolute maximum which will determine the maximum injury range at any location and define the size of the MZ.
M-weighted SEL_{24h}	Hearing weighted AUD INJ criteria for accumulated sound for different hearing groups	Best estimate, $R_{95\%}$	Modelling of cumulative SEL makes very conservative assumptions; here we take the realistic values to reduce the potential for overestimating the effect ranges.
Single strike SEL (SEL_{ss})	Unweighted SEL_{ss} to apply either a single threshold of 143dB (harbour porpoise)/ 140dB (all other species) or 5dB isopleths as per dose-response to estimate behavioural effects*	Best estimate, $R_{95\%}$	Realistic values are taken as the results are used in population modelling. It is therefore more representative to understand the maximum averaged over all locations rather than the absolute maximum at a single location which is then assumed across all locations as this could lead to an overestimate.

*140/143dB is a fixed threshold compared to the dose-response which assumes proportional disturbance relating to the level of sound received at different isopleths

Summary of interim Population Consequences of Disturbance modelling

10.11.1.7 To aid with the assessment of magnitude for piling, the potential for population-level consequences of behavioural disturbance has been considered using the iPCoD approach for harbour porpoise, bottlenose dolphin, minke whale, harbour seal, and grey seal. The results of population modelling are presented in the relevant magnitude sections of disturbance for each species, following estimations of the number of animals disturbed.

10.11.1.8 There is limited understanding of how behavioural disturbance and auditory injury affect survival and reproduction in individual marine mammals and how subsequently this translates into potential effects at the population-level.

10.11.1.9 The iPCoD framework was developed by SMRU consulting and the University of St Andrews using a process of expert elicitation (Booth and Heinis, 2018, Booth *et al.*, 2019) 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).

10.11.1.10 The iPCoD framework applies simulated changes in vital rates to infer the number of animals that may be affected by disturbance as a means to iteratively project the size of the population. The expert elicitation process has been undertaken for five key species:

- harbour porpoise;
- bottlenose dolphin;
- minke whale;
- grey seal;
- harbour seal.

10.11.1.11 As such the current version of iPCoD does not allow modelling of population trajectories for other species. Species included in this assessment (either quantitatively or qualitatively) for which the expert elicitation process has not been undertaken include:

- white-beaked dolphin;
- humpback whale.

10.11.1.12 Although the current version of iPCoD does not model population trajectories for these species, this does not affect the robustness of the assessment, as they will still be assessed through qualitative or alternative approaches.

10.11.1.13 Relevant MU and associated reference populations for modelling were informed by the baseline characterisation presented in Volume 3, Annex 10.1: Marine Mammal Shared Baseline Technical Report and summarised in Table 10.38.

10.11.1.14 For bottlenose dolphin, two ecotypes have been identified (coastal and offshore) and in this region two MUs have been delineated, each incorporating either the coastal ecotype (the CES MU, n = 226) (Cheney *et al.,* 2024) or the offshore ecotype (the GNS MU, n = 2,122 (IAMMWG, 2023)). For Morven South the GNS MU (an offshore population) was used as the relevant reference population. This large MU extends the entire length of the east coast of the UK and east to Scandinavia and given this extent it is unlikely that piling within the Morven South Boundary will create significant barrier effects for this offshore ecotype. Due to the large spatial scale of the GNS MU, only the UK portion of the GNS MU population estimate was included (n = 1,885 (IAMMWG, 2023)) for the purpose of increasing conservatism. For bottlenose dolphin the assessment also considered the potential impact pathway with the coastal ecotype within the CES MU. This was due to the importance of the Moray Firth SAC which supports a comparatively small coastal population of bottlenose dolphin whose range extends throughout the CES MU, and further south towards St Andrews Bay and the Tay Estuary, and northeast English waters (Arso Civil *et al.*, 2021, Arso Civil *et al.*, 2019). Modelled underwater noise contours for Morven South alone were not predicted to overlap with the CES MU, and as such piling at Morven South alone was not expected to impact the resident population. However, a number of projects within cumulative study area did predict effects on the coastal ecotype and therefore for the cumulative effects assessment both the GNS MU (UK portion) and CES MU were included.

10.11.1.15 For harbour porpoise and minke whale, only one MU for each species occurs in the vicinity of the Morven South Marine Mammal Study Area (IAMMWG, 2023), and the respective population estimates for these MUs have been used for iPCoD modelling: the North Sea MU for harbour porpoise and the CGNS MU for minke whale. The site boundary coincides with the boundary between two seal MUs, so for grey seal and harbour seal, the reference population comprises the sum of the East Scotland seal MU and the North-east England seal MU (SCOS, 2022).

Table 10.38: Management units and population estimates for species included in the interim Population Consequences of Disturbance models

Species	Management Unit	Population Estimate	Source
Harbour porpoise	North Sea MU	346,601	IAMMWG (2023)
Bottlenose dolphin	GNS MU	1,885 (UK portion of MU)	IAMMWG (2023)
Minke whale	CGNS MU	20,118	IAMMWG (2023)
Grey seal	East Scotland SMU plus North-east England SMU	36,696	Stevens (2023)

Species	Management Unit	Population Estimate	Source
Harbour seal	East Scotland SMU plus North-east England SMU	488	Stevens (2023)

10.11.1.16 The population estimates used to parameterise iPCoD models were taken from IAMMWG (2023) for cetacean species and from Stevens (2023) for seals (summarised in Table 10.38Table 10.39), alongside vital rates taken from Sinclair *et al.* (2020), presented in Table 10.39.

Table 10.39: Marine mammal vital rates used to parameterise the models for Morven South alone

Species	Calf/Pup Survival	Juvenile Survival	Adult Survival	Fertility	Age of independence (years)	Age of First Birth (years)
Harbour porpoise	0.846	0.85	0.925	0.34	1	5
Bottlenose dolphin	0.925	0.96	0.980	0.24	3	9
Minke whale	0.700	0.77	0.960	0.91	1	9
Grey seal	0.222	0.94	0.940	0.84	1	6
Harbour seal	0.400	0.78	0.920	0.85	1	4

10.11.1.17 Estimates of the number of animals of each species that may experience auditory injury considered the hearing group-specific frequency-weighted injury ranges derived from underwater noise modelling (Volume 3, Annex 10.2: Underwater Sound Shared Technical Report) to calculate, using dose response, the maximum numbers of animals predicted to experience auditory injury (based on the PK and SEL_{24h} metrics). As detailed in paragraph 10.8.3.13, use of dose response numbers allows for a more realistic assessment of the risk of disturbance which takes into account the likelihood of a response, rather than a fixed threshold approach. As described in Paragraph 10.8.3.18, the dose-response contour was capped at the 140dB SEL_{ss} contour.

10.11.1.18 The assessment of magnitude aligns with the dual metric approach applied in underwater noise modelling, whereas the MZ for the implementation of standard industry measures, (e.g. marine mammal observers (MMObs), PAM and ADD) has been informed only by the PK metric (see Table 10.15).

10.11.1.19 Note that the use of ADD is a standard industry measure; however, the exact device type and duration will be determined post-consent once the final project parameters have been determined (see Table 10.15). The assessment therefore provides the effect ranges with and without an ADD (using a standard 30 minutes of activation) for the purpose of demonstrating the efficacy of using this tool as a mitigation measure. For the purpose of this assessment calculation of the residual number of animals that may experience PTS has assumed a 30-minute implementation of an ADD, as use of an ADD is standard industry practice, and these residual numbers were also included in the iPCoD modelling.

10.11.1.20 iPCoD models were parameterised to simulate both the temporal MDS (i.e. the single piling scenario with fewer animals impacted per day, but over more days) and the spatial MDS (i.e. the concurrent piling scenario with more animals impacted per day, but over fewer days).

10.11.1.21 Results of iPCoD modelling are presented in full in Volume 3, Annex 10.5: Marine Mammals Interim Population Consequences of Disturbance (iPCoD) Modelling Report, and summarised in the relevant magnitude sections for harbour porpoise, bottlenose dolphin, minke whale, harbour seal and grey seal: key species for which iPCoD functionality is currently available.

Construction phase – Auditory Injury

Magnitude of impact

Single piling

10.11.1.22 For single piling of monopile foundations (i.e. piling undertaken by one vessel at one location on any given day) without activation of ADD the maximum predicted instantaneous injury risk range based on the PK metric (Table 10.40) is 950m for the VHF functional hearing group (e.g. harbour porpoise), and the potential injury range based on the SEL_{24h} metric (Table 10.41) is 4,450m for the LF hearing group (minke whale/humpback whale). The impact ranges, based on the PK metric (Table 10.40) are below 30m for minke whale, grey seal and harbour seal, and were not exceeded for HF cetaceans (bottlenose dolphin and white-beaked dolphin). For all pin pile scenarios (i.e. 5.3m and 3.7m diameter) the ranges were smaller than those presented for monopiles (Table 10.40).

10.11.1.23 As discussed in section 10.10, it is assumed that an ADD will be activated for 30 minutes prior to the commencement of piling (as a tertiary measure). The distance swam by marine mammals during ADD activation has been calculated based upon the conservative swim speeds in Table 10.30, and are summarised in Table 10.42. With 30 minutes of ADD activation as a standard industry mitigation measure, all species are predicted to move beyond PK-based injury ranges (i.e. harbour porpoise can move 2,700m during this time and therefore further than the 950m predicted injury range)(see Table 10.40). For the SEL_{24h} metric there would be no exceedance of the injury threshold, with the exception of LF species (minke whale/humpback whale) residual range of 620m was predicted (for monopiles only). This falls within the range over which MMObs would be effective and therefore it is anticipated that the risk of injury can be fully mitigated with standard industry mitigation applied (Volume 4, Annex 2: Marine Mammal Mitigation Protocol (MMMP) (Version 1).

Table 10.40: Potential marine mammal injury ranges for single installation of wind turbine/Offshore Substation Platform foundations, based on the NMFS (2024) Peak metric (N/E denotes AUD INJ threshold not exceeded) (see Table 10.42).

Hearing Group	Species	AUD INJ Threshold, PK (dB re 1 µPa)	Maximum Range (m)		
			Monopile No ADD	5.3m* Pin Pile No ADD	3.7m Pin Pile No ADD
LF	Minke whale Humpback whale	222	30	N/E	N/E
HF	Bottlenose dolphin White-beaked dolphin	230	N/E	N/E	N/E
VHF	Harbour porpoise	202	950	570	770

Hearing Group	Species	AUD INJ Threshold, PK (dB re 1 µPa)	Maximum Range (m)		
			Monopile No ADD	5.3m* Pin Pile No ADD	3.7m Pin Pile No ADD
PW	Grey seal Harbour seal	223	N/E	N/E	N/E

10.11.1.24 * Captures the 4.5m pin pile (HVAC collector OSP) and the 5m pin pile (HVDC converter OSP), see Table 10.36

Table 10.36.

Table 10.41: Potential marine mammal injury ranges for single installation of monopile foundations, based on the NMFS (2024) SEL_{24h} metric (N/E denotes AUD INJ threshold not exceeded)

Hearing Group	Species	AUD INJ Threshold, SEL_{24h} (dB re 1 μPa^{2}s)	Maximum Range (m)					
			Monopile		5.3m Pin Pile*		3.7m Pin Pile	
			No ADD	ADD	No ADD	ADD	No ADD	ADD
LF	Minke whale Humpback whale	183	4,450	620	1,410	N/E	2,210	N/E
HF	Bottlenose dolphin White-beaked dolphin	193	N/E	N/E	N/E	N/E	N/E	N/E
VHF	Harbour porpoise	159	N/E	N/E	N/E	N/E	N/E	N/E
PW	Grey seal Harbour seal	183	N/E	N/E	N/E	N/E	N/E	N/E

* Captures the 4.5m pin pile (AC collector OSP) and the 5m pin pile (HVDC converter OSP), see Table 10.36.

Table 10.42: Distances swum during 30 minutes of Acoustic Deterrent Device activation by each hearing group

Species	Hearing group	Swim speed (m/s)	Distance swum (m) in 30 minutes
Minke whale Humpback whale	LF	2.3	4,140
Bottlenose dolphin White-beaked dolphin	HF	1.52	2,736
Harbour porpoise	VHF	1.5	2,700
Grey seal Harbour seal	PW	1.8	3,240

10.11.1.25 The estimated numbers of animals potentially experiencing auditory injury from single piling, with and without ADD activation is summarised in Table 10.43 based on the PK metric and Table 10.44 based on the SEL_{24h} metric. Numbers have been presented for the monopile scenario only as this represents the largest spatial extent. Thus, the number of animals potentially at risk of injury during piling of pin piles would be fewer than those presented in Table 10.43 and Table 10.44.

10.11.1.26 For harbour porpoise, in the absence of ADD, potential instantaneous auditory injury (PK metric) is predicted for up to two animals (0.001% of the NS MU) (Table 10.43). With 30 minutes of ADD activation, harbour porpoise can clear the injury range (Table 10.54) and this is expected to reduce to zero animals injured.

10.11.1.27 For minke whale, in the absence of ADD less than one animal is estimated to suffer potential instantaneous auditory injury (PK metric) (equating to 0.005% of the CGNS MU / 0.01% of the UK portion of the CGNS for minke whale) (Table 10.43). With 30 minutes of ADD activation minke whale, can clear the injury range and this is expected to reduce to zero animals injured.

10.11.1.28 For HF cetaceans and pinnipeds (bottlenose dolphin and white-beaked dolphin; grey seal and harbour seal), in the absence of ADD the threshold is not exceeded and therefore zero animals are potentially injured. With 30 minutes of ADD activation, injury ranges are likely to reduce further.

10.11.1.29 Using the SEL_{24h} metric, for harbour porpoise, bottlenose dolphin, white-beaked dolphin, grey seal and harbour seal, the AUD INJ threshold is not exceeded both with and without ADD activation, and therefore zero animals are potentially injured.

10.11.1.30 For minke whale, using the SEL_{24h} AUD INJ metric, auditory inury is potentially predicted for up to three minke whales in the absence of ADD (0.015% of the CGNS MU / 0.03% of the UK portion of the MU). With 30 minutes of ADD activation this is expected to reduce to <1 animal (0.005% of the CGNS MU / 0.01% of the UK portion of the MU).

10.11.1.31 Note that density estimates are not available for humpback whale (an LF species), so an estimate of the number of animals potentially injured is not possible to quantify. However, given the low incidence of the humpback whale in this region, it is likely that fewer individuals would be affected than the minke whale estimate and therefore the risk is very small.

Table 10.43: Numbers of animals at risk of auditory injury from single piling (based on monopiles), using the Peak metric, and equivalent percentage of Management Unit population potentially affected

Hearing Group	Species	Density (animals /km^2)	Ensonified area (km^2)	Number of animals		Percentage of MU		Percentage of UK portion of MU	
				No ADD	30 min ADD	No ADD	30 min ADD	No ADD	30 min ADD
LF	Minke whale	0.042	0.003	<1	0	0.005	-	0.01	-
HF	Bottlenose dolphin	0.005	N/E	-	-	-	-	-	-
	White-beaked dolphin	0.080	N/E	-	-	-	-	-	-
VHF	Harbour porpoise	0.599	2.84	2	0	0.0006	0	0.001	0
PW	Grey seal	0.252	N/E	-	-	-	-	-	-
	Harbour seal	1.20 x 10^{-7}	N/E	-	-	-	-	-	-

Table 10.44: Numbers of animals at risk of auditory injury from single piling (based on monopiles), using the SEL_{24h} metric, and equivalent percentage of Management Unit population potentially affected

Hearing Group	Species	Density (animals/ km^2)	Ensonified area (km^2)	Number of animals		Percentage of Full MU		Percentage of UK portion of MU	
				No ADD	30 min ADD	No ADD	30 min ADD	No ADD	30 min ADD
LF	Minke whale	0.042	62.21	3	<1	0.015	0.005	0.03	0.01
HF	Bottlenose dolphin	0.005	N/E	-	-	-	-	-	-
	White-beaked dolphin	0.080	N/E	-	-	-	-	-	-
VHF	Harbour porpoise	0.599	N/E	-	-	-	-	-	-
PW	Grey seal	0.316	N/E	-	-	-	-	-	-

Hearing Group	Species	Density (animals/ km^2)	Ensonified area (km^2)	Number of animals		Percentage of Full MU		Percentage of UK portion of MU	
				No ADD	30 min ADD	No ADD	30 min ADD	No ADD	30 min ADD
	Harbour seal	4.88 x 10^{-6}	N/E	-	-	-	-	-	-

Concurrent piling

10.11.1.32 For the spatial MDS (see Table 10.35), represented by concurrent piling of monopile foundations (i.e. piling undertaken by two vessels at two locations on any given day), the greatest magnitude for auditory injury (based on the PK metric) was from two closely-spaced (1km) monopiles, compared to two monopiles spaced further away (maximum modelled distance was 27.65km, see Table 10.32).

10.11.1.33 The results are presented as a maximum ensonified area for PK and maximum range for SEL_{24h} metrics (Table 10.45 and Table 10.46 respectively). As detailed in Volume 3, Annex 10.2: Underwater Sound Shared Technical Report, PK sound fields are taken as the maximum over the two fields (from each concurrent pile). Therefore, the maximum distance to any threshold remains the same as the maximum from the single pile case (Table 10.40). In these cases, for PK, it is the ensonified area to a threshold sound level that is presented instead of the maximum distance.

10.11.1.34 For the PK metric, the area in which a risk of instantaneous injury is predicted is 5.67km^2 for the VHF functional hearing group (e.g. harbour porpoise). With 30 minutes of ADD applied, based on conservative swim speeds in Table 10.30, harbour porpoise can clear the area (Table 10.45). For minke whale, humpback whale (minke whale used as proxy), using PK metric, the area in which a risk of instantaneous injury is predicted is less than 0.01km^2. With 30 minutes of ADD applied, based on conservative swim speeds in Table 10.30, animals can clear the area (Table 10.45). For HF cetaceans and pinnipeds (bottlenose dolphin and white-beaked dolphin; grey seal and harbour seal) the AUD INJ threshold (PK metric) is not exceeded.

10.11.1.35 For the SEL_{24h} metric, the potential maximum injury range is 6,600m for the LF hearing group (minke whale/humpback whale). The impact ranges for all other functional groups were not exceeded. With 30 minutes of ADD applied, the potential maximum injury range is reduced to 2,830m.

10.11.1.36 For the SEL_{24h} metric, the potential injury range for the VHF hearing group (e.g., harbour porpoise) is approximately 30m when an ADD is used. Using an ADD changes the acoustic profile by replacing the initial 15 minutes of low-frequency piling sound with high-frequency sound. VHF cetaceans are less sensitive to low-frequency piling noise and typically move away quickly, resulting in a lower cumulative SEL dose when no ADD is used. However, when an ADD is introduced, animals are exposed to the high-frequency sound from the ADD before they have moved away, which they are more sensitive to. Whilst this increases the likelihood of exceeding auditory injury thresholds, modelling demonstrates auditory injury ranges are still small (30m).

Table 10.45: Ensonified area for potential marine mammal injury from concurrent installation of monopile foundations, based on the NMFS (2024) Peak metric (N/E denotes AUD INJ threshold not exceeded)

Hearing Group	Species	AUD INJ Threshold, PK (dB re 1 μPa)	Ensonified Area (km²)			
			Monopile No ADD	5.3m Pin Pile* No ADD	3.7m Pin Pile No ADD	Clear of injury range?
LF	Minke whale Humpback whale	222	<0.01	N/E	N/E	Y
HF	Bottlenose dolphin White-beaked dolphin	230	N/E	N/E	N/E	Y
VHF	Harbour porpoise	202	5.67	1.66	2.42	Y
PW	Grey seal Harbour seal	223	N/E	N/E	N/E	Y

* Captures the 4.5m pin pile (HVAC collector OSP) and the 5m pin pile (HVDC converter OSP), see Table 10.36.

Table 10.46: Potential marine mammal injury ranges for concurrent installation of monopile foundations, based on the NMFS (2024) SEL_{24h} metric (N/E denotes AUD INJ threshold not exceeded)

Hearing Group	Species	AUD INJ Threshold, SEL_{24h} (dB re 1 μPa²s)	Maximum Range (m)					
			Monopile		5.3m Pin Pile*		3.7m Pin Pile	
			No ADD	ADD	No ADD	ADD	No ADD	ADD
LF	Minke whale Humpback whale	183	6,600	2,830	2,560	N/E	3,760	450
HF	Bottlenose dolphin White-beaked dolphin	193	N/E	N/E	N/E	N/E	N/E	N/E
VHF	Harbour porpoise	159	N/E	30	N/E	30	N/E	30
PW	Grey seal Harbour seal	183	N/E	N/E	N/E	N/E	N/E	N/E

* Captures the 4.5m pin pile (HVAC collector OSP) and the 5m pin pile (HVDC converter OSP), see Table 10.36.

10.11.1.37 The estimated numbers of animals potentially experiencing auditory injury from concurrent piling, with and without ADD activation is summarised Table 10.47 based on the PK metric and Table 10.48 based on the SEL_{24h} metric. The number of animals at risk of auditory injury from concurrent piling is estimated by combining the impact area with the species-specific density estimates (Table 10.21). For the PK metric the magnitude of the impact was available as a specific area, while for SEL_{24h} this was calculated as the area of a circle with radius equal to the horizontal distance to respective thresholds (Paragraph 10.8.3.32).

10.11.1.38 In the absence of ADD, instantaneous auditory injury resulting from peak sound pressure (the PK metric) is predicted for up to four harbour porpoise (0.001% of the NS MU / 0.003% of the UK portion of the NS MU). With 30 minutes of ADD activation, harbour porpoise can clear the injury range (Table 10.47) and this is expected to reduce to zero animals injured.

10.11.1.39 For minke whale, in the absence of ADD less than one animal is estimated to potential instantaneous auditory injury (PK metric) (equating to 0.005% of the CGNS MU / 0.01% of the UK portion of the CGNS for minke whale) (Table 10.47). With 30 minutes of ADD activation, minke whale can clear the injury range and this is expected to reduce to zero animals injured.

10.11.1.40 For HF cetaceans and pinnipeds (bottlenose dolphin and white-beaked dolphin; grey seal and harbour seal) using the PK metric, in the absence of ADD the threshold is not exceeded and therefore zero animals are potentially injured.

10.11.1.41 Note that density estimates are not available for humpback whale (an LF species), so an estimate of the number of animals potentially injured is not possible to quantify. However, given the low incidence of the species humpback whale in this region, it is likely that fewer individuals would be affected than the minke whale estimate and therefore the risk is very small.

10.11.1.42 Auditory injury resulting from accumulated sound (the SEL_{24h} metric), in the absence of ADD, is predicted for up to six minke whale (0.03% of the CGNS MU / 0.06% of the UK portion of the CGNS MU). With 30 minutes of ADD activation this is expected to reduce to two animals (0.01% of the CGNS MU / 0.02% of the UK portion of the CGNS MU). For harbour porpoise, with ADD, less than one animal is predicted to experience auditory injury (0.0003% of the NS MU / 0.0006% of the UK portion of the NS MU). For all other species, both in the absence of ADD and with ADD, the threshold is not exceeded and therefore zero animals are potentially injured.

Table 10.47: Numbers of animals at risk of auditory injury from concurrent piling, using the Peak metric, and equivalent percentage of Management Unit population potentially affected

Hearing Group	Species	Density (animals/ km^2)	Ensonified area (km^2)	Number of animals		Percentage of Full MU		Percentage of UK portion of MU	
				No ADD	30 min ADD	No ADD	30 min ADD	No ADD	30 min ADD
LF	Minke whale	0.042	0.01	<1	0	0.005	0	0.01	0
HF	Bottlenose dolphin	0.005	N/E	-	-	-	-	-	-
	White-beaked dolphin	0.080	N/E	-	-	-	-	-	-

Hearing Group	Species	Density (animals/ km^2)	Ensonified area (km^2)	Number of animals		Percentage of Full MU		Percentage of UK portion of MU	
				No ADD	30 min ADD	No ADD	30 min ADD	No ADD	30 min ADD
VHF	Harbour porpoise	0.599	5.64	4	0	0.001	0	0.003	0
PW	Grey seal	0.252	N/E	-	-	-	-	-	-
	Harbour seal	1.20 x 10^{-7}	N/E	-	-	-	-	-	-

Table 10.48: Numbers of animals at risk of auditory injury from concurrent piling, using the SEL_{24h} metric, and equivalent percentage of Management Unit population potentially affected

Hearing Group	Species	Density (animals/ km^2)	Ensonified area (km^2)	Number of animals		Percentage of Full MU		Percentage of UK portion of MU	
				No ADD	30 min ADD	No ADD	30 min ADD	No ADD	30 min ADD
LF	Minke whale	0.042	122.33	6	2	0.0003	0.0002	0.0006	0.0002
HF	Bottlenose dolphin	0.005	N/E	-	-	-	-	-	-
	White-beaked dolphin	0.080	N/E	-	-	-	-	-	-
VHF	Harbour porpoise	0.599	N/E	-	<1	-	0.0003	-	0.0006
PW	Grey seal	0.252	N/E	-	-	-	-	-	-
	Harbour seal	1.20 x 10^{-7}	N/E	-	-	-	-	-	-

10.11.1.43 For minke whale, due to the low numbers of individuals affected with the application of ADD (up to two individuals), and the corresponding proportion of the CGNS MU (0.01%), the impact is predicted to be of highly localised spatial extent, short-term duration, intermittent, and with high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude for minke whale is, therefore, considered to be low.

10.11.1.44 For all other assessed species, due to the calculation that no or less than one individual would be affected with the application of ADD, the impact is predicted to be of highly localised spatial extent, short-term duration, intermittent, and with high reversibility. It is predicted that the impact will affect the receptor directly. For humpback whale, due to the very small numbers likely to be in the Morven North Marine Mammal Study area the risk of injury is deemed to be very low. The magnitude for all other assessed species is, therefore, considered to be negligible.

Sensitivity of the Receptor

10.11.1.45 PTS is a permanent and irreversible shift in hearing, causing hearing impairment with the potential to affect key life functions such as mating, maternal fitness, communication, foraging, predator detection and mortality. The result of these effects could drive chronic (i.e. long-term and persistent) changes in animal health or acute (i.e. short-term and temporary) changes in vital rates (Costa, 2012, Erbe *et al.*, 2018).

10.11.1.46 Scientific understanding of the biological impact of auditory threshold shifts is limited to the results of controlled exposure studies on small numbers of captive animals (Finneran, 2015) where TTS was experimentally induced (given it is unethical to induce auditory injury in animals) and thresholds for auditory injury were extrapolated using TTS growth rates. (Kastelein *et al.*, 2013) demonstrated that hearing impairment as a result of exposure to piling noise is likely to only occur where the source frequencies overlap the range of peak sensitivity for the receptor species, rather than across the whole frequency hearing spectrum. The study demonstrated that for simulated piling sound (broadband spectrum), harbour porpoise hearing around 125 kHz (the key frequency for echolocation) was not affected. Rather, a measurable, but relatively small, threshold shift in hearing was observed at frequencies of 4 kHz to 8 kHz, as most of the energy from the simulated piling occurred in the lower frequencies (Kastelein *et al.*, 2013).

10.11.1.47 The periodicity of underwater sound is also likely to affect the magnitude of a hearing shift, whereby hearing may recover to some extent during inter-pulse intervals (Kastelein *et al.*, 2014), with the suggestion that audible and visual cues may allow animals to predict when injurious sounds will occur (Kastelein *et al.*, 2020). Other studies reported that whilst a threshold shift may 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, Kastelein *et al.*, 2014, Reichmuth *et al.*, 2019).

10.11.1.48 In response to exposure to underwater sound, marine mammals may exhibit behaviours that allow avoidance or a reduction in direct exposure. For instance, the animal may change the orientation of its head so that sound levels reaching the ears are reduced, and some cetacean species may modulate hearing sensitivity by one or more neurophysiological control mechanisms in the middle ear, inner ear, and/or central nervous system (Kastelein *et al.*, 2020). Kastelein *et al.* (2020) demonstrated this self-mitigation in harbour porpoise whereby an animal exposed to repeated airgun sounds, did not consistently experience TTS. Pinnipeds may also simply lift their head above the water to avoid exposure to underwater sound.

10.11.1.49 In comparison to cetaceans, seals are less dependent on hearing for foraging, but may rely on sound for communication and predator avoidance (Deecke *et al.*, 2002). Seals can detect swimming fish with their vibrissae (Schulte-Pelkum *et al.*, 2007) and, in certain conditions, may also use the vocalisations of fish to hunt. The ecological consequences of noise-induced threshold shift in seals may be a reduction in fitness, reproductive output and longevity (Kastelein *et al.*, 2018).

10.11.1.50 One study reported that, based on calculations of SEL during the construction of the Lincs Offshore Wind Farm (Greater Wash, UK), at least half of the tagged harbour seals would have received sound levels from pile driving that exceeded auditory injury thresholds for pinnipeds (Hastie *et al.*, 2015). Nevertheless, population estimates indicated that the trajectory was increasing and, although numerous other ecological factors may influence population health, this study predicted that PTS would not affect a sufficient number of individuals to cause a decline in population trajectory (Hastie *et al.*, 2015). Hastie *et al.*, (2015) noted, however, that the paucity of data around the effects of underwater sound on seal hearing required that the exposure criteria applied Southall *et al.* (2007) are intentionally conservative and consequently predicted numbers of individuals likely to experience auditory injury would also have been highly conservative (Hastie *et al.*, 2015).

10.11.1.51 Despite the uncertainty in the ecological effects of auditory injury on seals, the effect is unlikely to cause a change in either reproduction or survival rates. In addition, seals may be able to self-mitigate (i.e. reduce their hearing sensitivity in the presence of loud sound in order to reduce their perceived sound level).

10.11.1.52 Booth and Heinis (2018) presents the conclusions from the expert elicitation workshop on the effects of an auditory injury on vital rates in marine mammal species. The aim of the workshop was to update the relevant parameters for the iPCoD model and was focused on the potential forinjury from LF broadband sound (i.e. pile driving). Key conclusions were that individuals predicted to be at risk of exceeding the auditory injury thresholds did not mean the animals were deaf, but that there could be a reduction in hearing sensitivity within a specific hearing range.

10.11.1.53 Conclusions were that effects on vital rates were lowest on harbour porpoise (VHF) harbour and grey seals (PCW). Effects there thought to be slightly larger for delphinid species (HF), because dolphin species use lower frequencies for communication, rather than they were more sensitive. However, for both hearing groups, the conclusions were that auditory injury was unlikely to result in an impact to either survival or reproductive rates.

10.11.1.54 LF cetaceans were not assessed in this workshop, however, the generalised hearing range for this hearing group is between 7 Hz to 36 kHz (NMFS, 2024) suggesting a potential greater overlap between frequencies used by LF cetaceans and impact piling than for other cetacean hearing groups.

10.11.1.55 All species are therefore considered to be able to avoid or adapt behaviour (adaptability) have some tolerance (resilience) but with limited ability to recover from any impact as exceeding the AUD INJ threshold is a permanent hearing damage. The sensitivity of the receptor is therefore, conservatively considered to be medium.

<u>Significance of the Effect</u>

10.11.1.56 Overall, for minke whale and humpback whale, the magnitude of the impact is deemed to be low, and the sensitivity is considered to be medium. Given that there remains a very small risk of injury (from cumulative exposure only), the effect will be of **minor adverse** significance, which is not significant in EIA terms.

10.11.1.57 For all other assessed species, the magnitude of the impact is deemed to be negligible, and the sensitivity is considered to be medium. The overall significance of the effect is negligible or minor. Given that there is no residual risk of injury, with designed-in measures (i.e. no likely effect), the effect will be of **negligible adverse** significance, which is not significant in EIA terms.

<u>Secondary Mitigation and Residual Effect</u>

10.11.1.58 No mitigation measures for marine mammals are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 10.33), is not significant in EIA terms.

Construction phase – behavioural disturbance

10.11.1.59 Acoustic disturbance to marine mammals may lead to the interruption of normal behaviours (such as feeding or breeding) and avoidance, leading to displacement and exclusion from critical habitats (Castellote *et al.*, 2010, Castellote *et al.*, 2012, Goold, 1996, Weller *et al.*, 2002). Elevated underwater noise may also cause stress, which in turn can lead to a depressed immune function and reduced reproductive success (Anderson *et al.*, 2011, De Soto *et al.*, 2013). The extent to which an animal will be behaviourally affected, however, is very much context-dependent and varies both inter- and intra-specifically as described previously for auditory injury.

10.11.1.60 Behavioural disturbance has been assessed using two approaches: a D/R approach (applying the Graham *et al.* (2017) and Whyte *et al.* (2020) response functions to cetaceans and pinnipeds, respectively), and by applying an area-based threshold based on the 143db contour for harbour porpoise (Tougaard, 2021) and the 160db contour associated with "strong disturbance" (NMFS, 2005) for all other species.

10.11.1.61 Estimates for the numbers of animals are derived from the dose-response approach, and the percentage of each species' reference population, potentially experiencing behavioural disturbance are presented in Table 10.49 for the temporal MDS and in Table 10.50 for the spatial MDS. These numbers are carried forward into iPCoD modelling whilst the area-based thresholds are used to assess any impact on the species-specific SACs and are carried forward into the RIAA. The areas of effect for both the dose-response and area-based thresholds are illustrated in Figure 10.6 to Figure 10.19.

Table 10.49: Maximum estimate of the number of animals potentially experiencing disturbance from the temporal Maximum Design Scenario, calculated for D/R and maximum % of reference populations disturbed (i.e. based on Offshore Substation Platforms)

Species	Number of animals disturbed			% Reference population	% UK portion of reference population
	wind turbine (3.7m pin pile)	OSP (AC) (5.3m pin pile*)	OSP (DC) (5.3m pin pile*)		
Harbour porpoise	846	866	866	0.25	0.54
Bottlenose dolphin	8	8	8	0.40	0.42
White-beaked dolphin	113	116	116	0.26	0.34
Minke whale	60	61	61	0.30	0.59
Grey seal	153	161	161	0.44	
Harbour seal	<1	<1	<1	0.20	

* Captures the 4.5m pin pile (HVAC collector OSP) and the 5m pin pile (HVDC converter OSP), see Table 10.36.

Table 10.50: Maximum estimate of the number of animals potentially experiencing disturbance from the spatial Maximum Design Scenario, calculated for D/R and maximum % of reference populations disturbed (i.e. based on wind turbine or OSP (AC))

Species	Number of animals disturbed			% Reference population	% UK portion of reference population
	wind turbine (16m monopile)	OSP (AC) (16m monopile)	OSP (DC) (5.3m pin pile*)		
Harbour porpoise	1,739	1,739	1,443	0.50	1.09
Bottlenose dolphin	15	15	13	0.74	0.80
White-beaked dolphin	233	233	193	0.53	0.68
Minke whale	122	122	102	0.61	1.19
Grey seal	408	408	311	1.11	
Harbour seal	<1	<1	<1	0.20	

* Captures the 4.5m pin pile (HVAC collector OSP) and the 5m pin pile (HVDC converter OSP), see Table 10.36.

10.11.1.62 The number of animals potentially experiencing behavioural disturbance for the spatial MDS (Table 10.50) was at least double that estimated for the temporal MDS (Table 10.49). However, the timescale for piling for the temporal MDS was more than five times longer than for the spatial MDS. This would mean that although fewer animals would be affected per day, disturbance from piling would be experienced for a longer period.

Magnitude of impact: harbour porpoise

10.11.1.63 The temporal MDS consists of a total of 101 foundations consisting of up to 524 piles over 262 piling days (Table 10.34), within a construction phase of up to five years (see Volume 1, Chapter 3: Project Description). Based upon a density of 0.599 animals/km^2, for the temporal MDS up to 866 animals (equivalent to approximately 0.25% of the NS MU / 0.55% of the UK portion of the NS MU) were estimated to have the potential to experience disturbance, when calculated using the D/R methodology for cetaceans (Graham *et al.*, 2017) capped at 140db SEL_{ss}.

10.11.1.64 The spatial MDS consists of a total of 73 foundations consisting of up to 119 piles over 48 piling days (Table 10.35), within a construction phase of up to five years (see Volume 1, Chapter 3: Project Description). Up to 1,739 animals (equivalent to approximately 0.50% of the North Sea MU/1.09% of the UK portion of the NS MU) were estimated to have the potential to experience disturbance, when calculated using the 140db SEL_{ss}-capped D/R methodology for cetaceans (Graham *et al.*, 2017).

10.11.1.65 Figure 10.6 illustrates that there is no potential for underwater sound generated by concurrent piling of 16m monopiles (i.e. the spatial MDS) to affect designated sites with harbour porpoise as a qualifying feature (i.e. the Southern North Sea SAC). Similarly, there would be no overlap for underwater sound generated by concurrent piling of pin piles (i.e. the temporal MDS) as this would lead to a smaller ensonified area compared to monopiles and therefore has not been illustrated here. The 143 SEL_{ss} area-based threshold lies a distance of 107.9km from the Southern North Sea SAC (Figure 10.6).

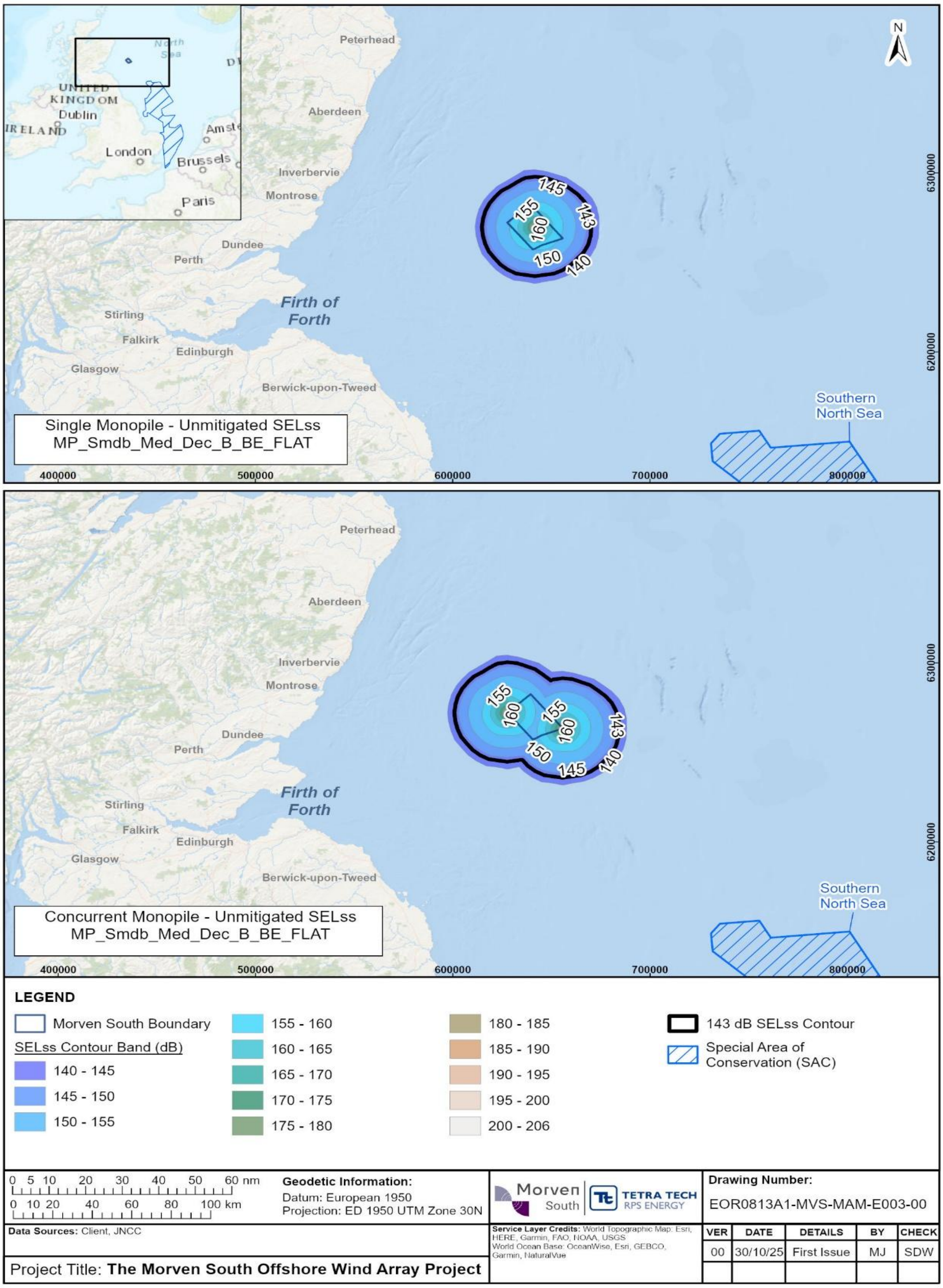

Figure 10.6: Unweighted single strike sound exposure level contours associated with single (top) and concurrent (bottom) piling of 16m monopiles and 143dB SEL_{ss} area-based threshold contour, in relation to designated sites with harbour porpoise as a qualifying feature (inset).

10.11.1.66 As detailed in Volume 3, Annex 10.5: Marine Mammals Interim Population Consequences of Disturbance (iPCoD) Modelling Report, the iPCoD model outputs include the ratio of the simulated impacted population size to the unimpacted population size, termed the "counterfactual" of population size. A counterfactual of one corresponds to a prediction of no difference in size between the impacted and unimpacted populations. Counterfactuals of <1 would correspond to a prediction of the impacted population being smaller than the unimpacted population. Both median counterfactual and mean counterfactual are presented.

10.11.1.67 Results of the iPCoD modelling for harbour porpoise (using the maximum numbers from the D/R approach) against the North Sea MU population (346,601 individuals) for the temporal MDS showed that the median counterfactual of population size was 0.9999 or 1.000 throughout the 25-year model run. The mean counterfactual was one for time-point 1 and 2, and 0.9999 from time point 3 until the end of the 25-year model run. This indicates that there is predicted to be no significant difference between the population trajectories for the impacted population when compared to the un-impacted population (see Volume 3, Annex 10.5: Marine Mammals Interim Population Consequences of Disturbance (iPCoD) Modelling Report). This is illustrated in Figure 10.7, whereby the un-impacted and impacted populations are predicted to follow very similar trajectories.

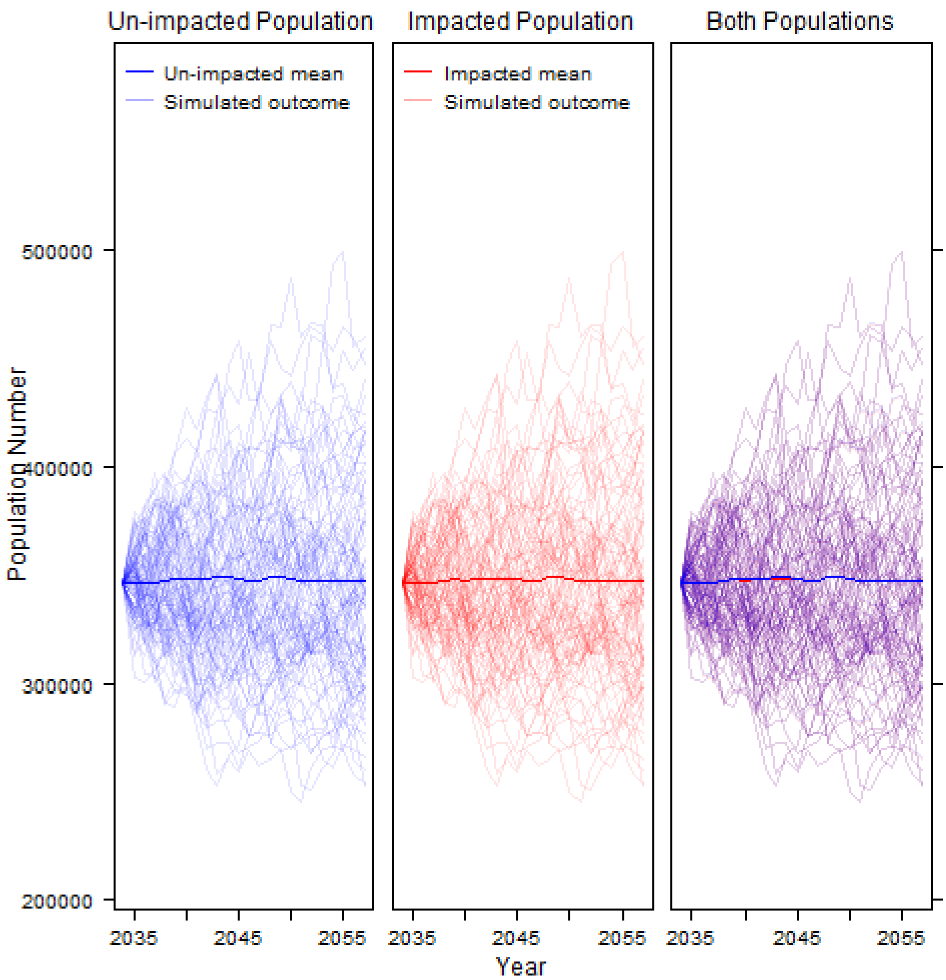

Figure 10.7: Simulated harbour porpoise population trajectories for the un-impacted and impacted populations, modelled against the temporal maximum design scenario (longest duration of impact)

10.11.1.68 Results of equivalent iPCoD modelling for the spatial MDS also showed that the median counterfactual of population size was 1.000 (and mean counterfactual was 1 or 0.99) throughout the 25-year model run, again indicating that there is predicted to be no significant difference between the population trajectories for the impacted and un-impacted populations (Figure 10.8).

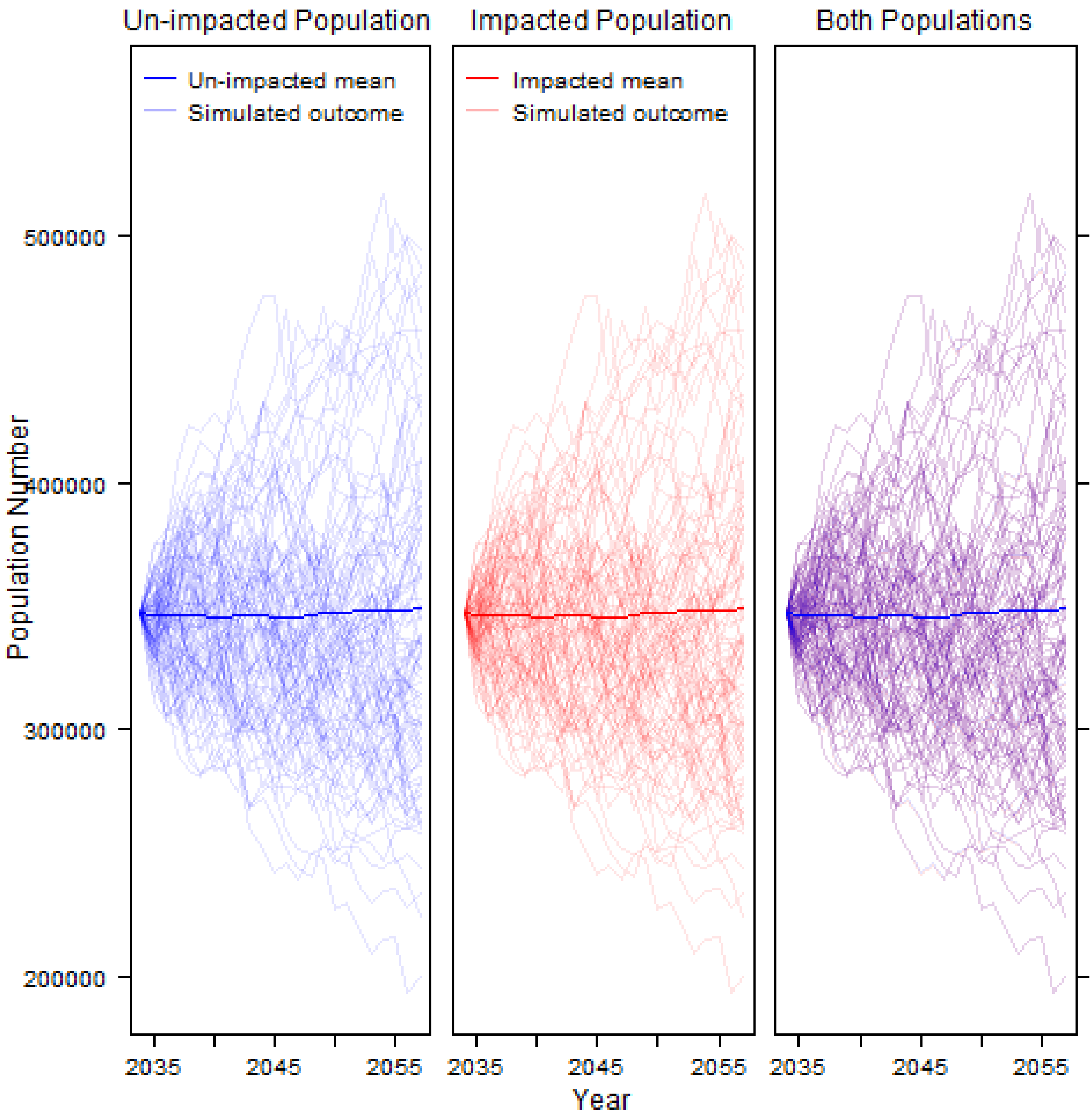

Figure 10.8: Simulated harbour porpoise population trajectories for the un-impacted and impacted populations, modelled against the spatial maximum design scenario (greatest spatial impact)

10.11.1.69 The impact is predicted to be of local spatial extent, short-term duration, intermittent and of high reversibility (as receptors are expected to recover within hours/days). It is predicted that the impact will affect the receptor directly. The impact may 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 proportion of the reference population impacted is predicted to be very small (0.25% to 0.5% of the North Sea MU for temporal and spatial MDS respectively) and there would be no population-level consequences of disturbance. The magnitude for harbour porpoise is, therefore, considered to be low.

Sensitivity of the Receptor: harbour porpoise

10.11.1.70 As a small cetacean species, harbour porpoise is vulnerable to heat loss, and with a high metabolic requirement, needs to forage frequently to lay down sufficient fat reserves for insulation (e.g. between 4% and 9.5% of their body weight in fish is typically required per day (Kastelein *et al.*, 1997)). Wild porpoises forage almost continuously day and night to obtain their required calorific intake, so they are vulnerable to starvation if foraging is interrupted (Wisniewska *et al.*, 2016). Harbour porpoise was recorded year-round (in 28 out of 33 survey months) in the Morven South Marine Mammal Study Area and therefore could be vulnerable to piling at any time of year (Volume 3, Annex 10.3: Marine Mammals Shared Digital Aerial Survey Report).

10.11.1.71 Variation in behavioural responses to increased underwater sound is context-specific and factors such as the activity state of the receiving animal, the nature and novelty of the sound (i.e. previous exposure history), and the distance between sound source and receiving animal are important in determining the likelihood of a behavioural response (Ellison *et al.*, 2012). Empirical evidence from monitoring during construction of OWFs indicates that piling is unlikely to lead to 100% avoidance in all individuals exposed, and that there will be a proportional decrease in avoidance at greater distances from the piling source (Brandt *et al.*, 2011). At Horns Rev Offshore Wind Farm, 100% avoidance was observed in harbour porpoise at up to 4.8km from the piles, whilst at distances beyond 10km this proportion reduced to less than 50% (Brandt *et al.*, 2011).

10.11.1.72 More recently Benhemma-Le Gall *et al.* (2021) studied responses of harbour porpoise to piling at the Beatrice Offshore Wind Farm and suggested that harbour porpoise may adapt to increased noise disturbance over the course of the piling phase, thereby showing a degree of tolerance and behavioural adaptation. The probability of occurrence (measured as porpoise-positive minutes) may increase relative to distance from the sound source (Graham *et al.*, 2019). For example, Brandt *et al*. (2018) demonstrated at OWFs in the German Bight that at maximum effect distances (between 17km and 33km for installation of foundations comprising monopiles, tripiles, tripod foundations and jacket foundations) avoidance occurred only during the hours of piling, when detections were found at sound levels exceeding 143 dB re 1 $\mu Pa^2 s$. However, within the vicinity (<2km) of piling, porpoise detections declined several hours before the start of piling (likely due to increased shipping traffic in-combination with calm weather conditions) and were reduced for one to two days post piling (Brandt *et al*., 2018). Brandt *et al*. (2018) considered that this gradient is a result of more animals reacting, or animals responding more strongly, or quickly, to sound when it is louder and/or when the noise source is closer.

10.11.1.73 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 previously mentioned, (10.11.1.71 *et seq.*), 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.

10.11.1.74 Therefore, harbour porpoise is deemed to have some adaptability (i.e. avoidance) to behavioural disturbance, high recoverability and high international value. Given its metabolic requirement to forage frequently, which may be affected by behavioural disturbance, the sensitivity of the receptor is, therefore, conservatively considered to be medium.

Magnitude: bottlenose dolphin

10.11.1.75 The temporal MDS consists of a total of 101 foundations consisting of up to 524 piles over 262 piling days (Table 10.34), within a construction phase of up to five years (see Volume 1, Chapter 3:

Project Description). Based upon a density of 0.005 animals/km^2, for the temporal MDS up to eight animals (equivalent to approximately 0.42% of the UK portion of the GNS MU/0.40% of the GNS MU) were estimated to have the potential to experience disturbance, when calculated using the D/R methodology for cetaceans (Graham *et al.*, 2017) capped at 140db SEL_{ss},.

10.11.1.76 The spatial MDS consists of a total of 73 foundations consisting of up to 119 piles over 48 piling days (Table 10.35), within a construction phase of up to five years (see Volume 1, Chapter 3: Project Description). Up to 15 animals (equivalent to approximately 0.80% of the UK portion of the GNS MU/0.74% of the GNS MU) were estimated to have the potential to experience disturbance, when calculated using the 140db SEL_{ss}-capped D/R methodology for cetaceans (Graham *et al.*, 2017).

10.11.1.77 Figure 10.9 illustrates that there is no potential for underwater sound generated by concurrent piling of 16m monopiles (spatial MDS) to affect designated sites with bottlenose dolphin as a qualifying feature (i.e. the Moray Firth SAC). The NMFS (2005) 160db rms strong disturbance contour shows no overlap with the SAC, with a distance of 203.7km from the Moray Firth SAC (for concurrent piling). Similarly, the underwater noise contour for the NMFS (2005) for 160db rms (strong disturbance) metrics are not predicted to overlap with the CES MU. Similarly, there would be no overlap for underwater sound generated by concurrent piling of pin piles (i.e. the temporal MDS) as this would lead to a smaller ensonified area compared to monopiles and therefore has not been illustrated here.

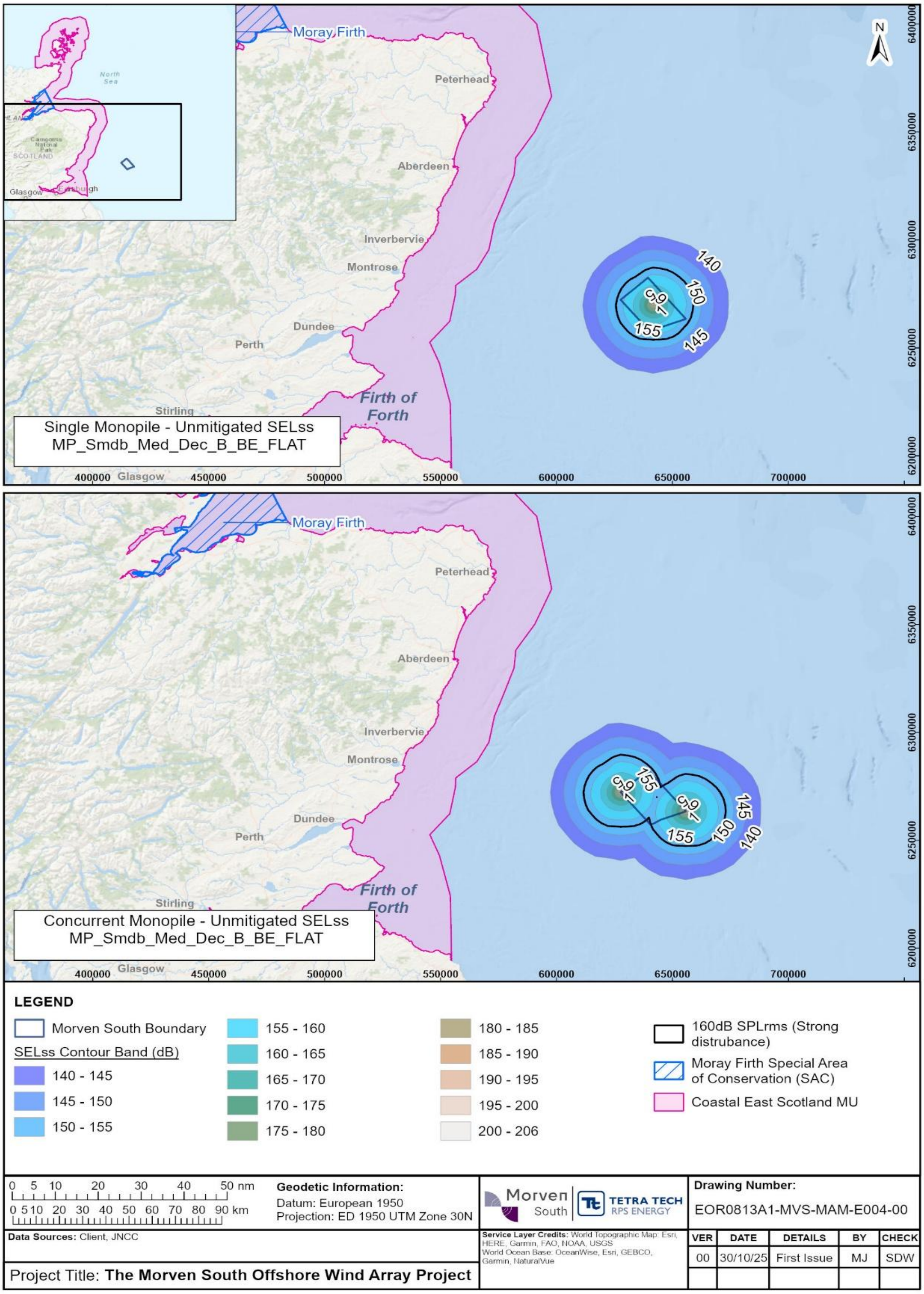

Figure 10.9: Unweighted single strike sound exposure level contours and NMFS (2005) sound pressure level (root mean square) strong disturbance thresholds associated with single (top) and concurrent (bottom) piling of 16m monopiles, in relation to designated sites with bottlenose dolphin as a qualifying feature (inset).

10.11.1.78 Results of the iPCoD modelling for bottlenose dolphin against the UK portion of the GNS MU population (1,885 individuals) for the temporal MDS showed that the median counterfactual of population size was 1.000 throughout the 25-year model run. The mean counterfactual was one for time-point 1 and 2, and 0.99 from time point 3 until the end of the 25-year model run. This indicates that there is predicted to be no significant difference between the population trajectories for the impacted population when compared to the un-impacted population (see Volume 3, Annex 10.5: Marine Mammals Interim Population Consequences of Disturbance (iPCoD) Modelling Report). This is illustrated in Figure 10.10, whereby the un-impacted and impacted populations are predicted to follow very similar trajectories.

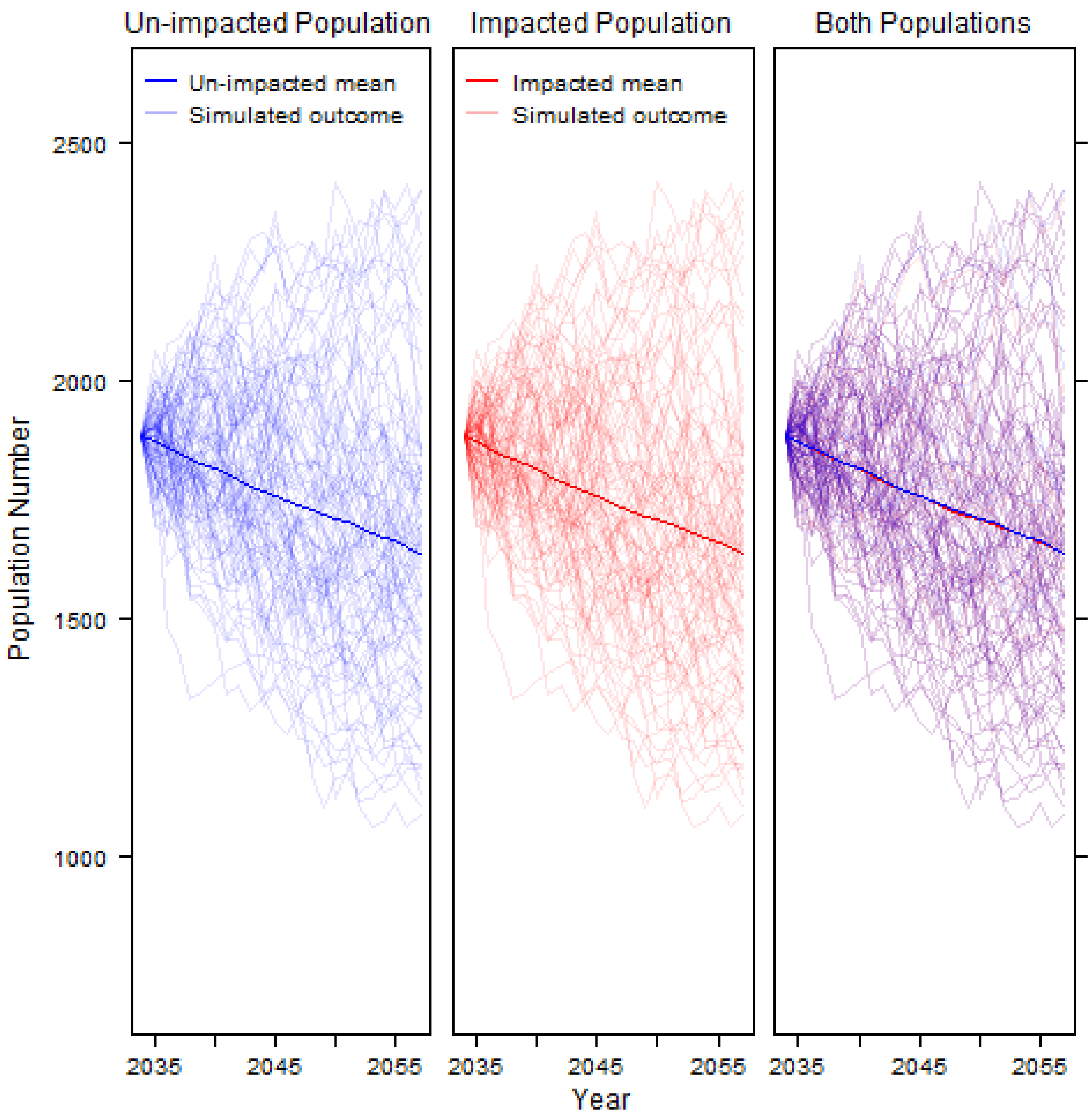

Figure 10.10: Simulated bottlenose dolphin population trajectories for the un-impacted and impacted populations, modelled against the temporal Maximum Design Scenario (longest duration of impact)

10.11.1.79 Results of equivalent iPCoD modelling for the spatial MDS also showed that the median counterfactual of population size was 1.000 (and mean counterfactual was 1 or 0.99) throughout the 25-year model run, again indicating that there is predicted to be no significant difference between the population trajectories for the impacted and un-impacted populations (Figure 10.11).

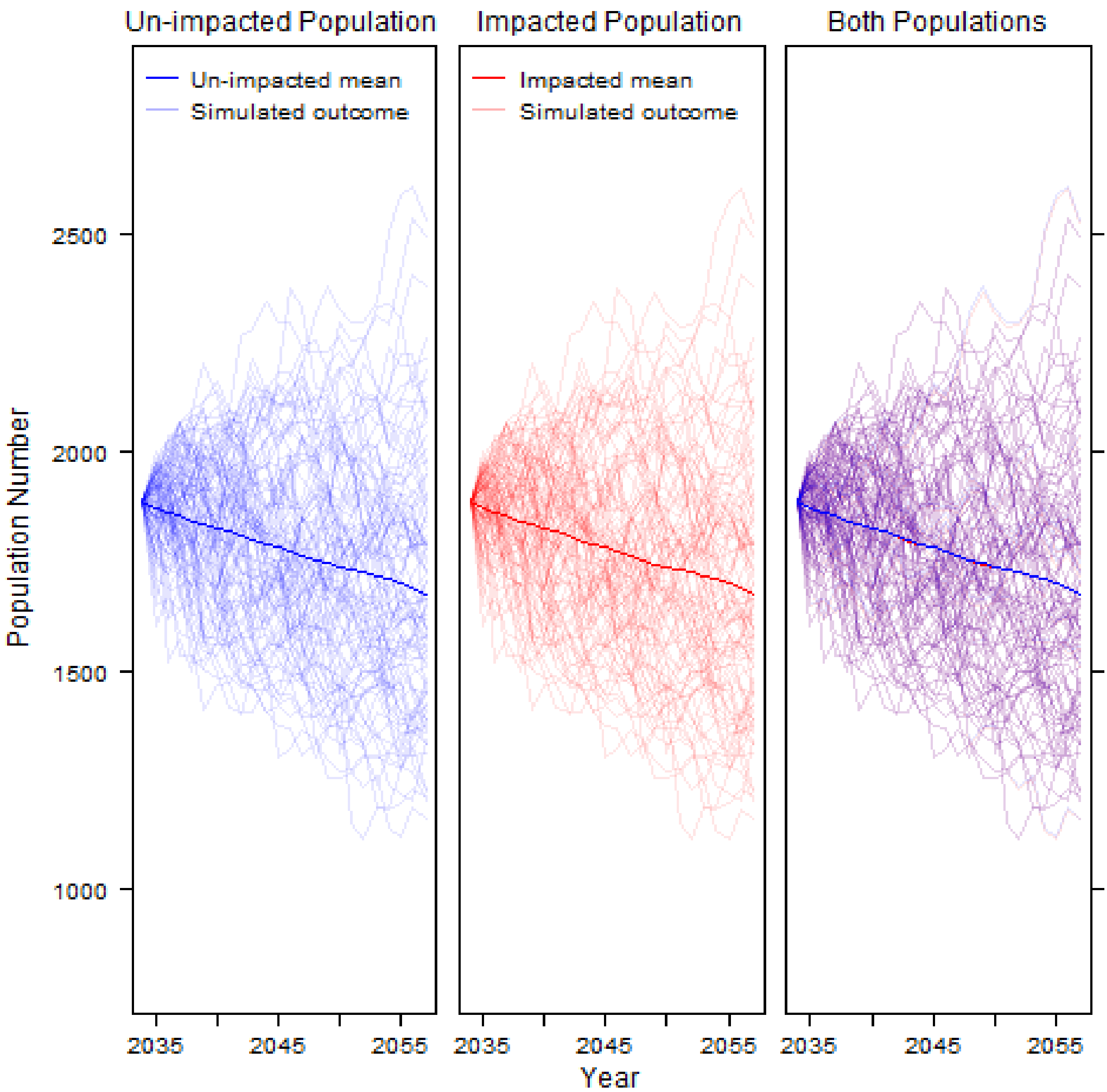

Figure 10.11: Simulated bottlenose dolphin population trajectories for the un-impacted and impacted populations, modelled against the spatial maximum design scenario (greatest spatial impact)

10.11.1.80 The impact is predicted to be of local spatial extent, short-term duration, intermittent and of high reversibility. It is predicted that the impact will affect the receptor directly. The impact may 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 proportion of the reference population impacted is predicted to be very small (0.42% to 0.74% for the temporal and spatial MDS respectively of the GNS MU) and there would be no population-level consequences of disturbance. The magnitude for bottlenose dolphin is, therefore, considered to be low.

Sensitivity: bottlenose dolphin

10.11.1.81 Bottlenose dolphin is considered less vulnerable to disturbance compared to harbour porpoises due to its larger body sizes, lower metabolic rates, and less frequent foraging needs. Bottlenose dolphins is predominantly distributed in coastal habitats and tend to be more abundant during spring and summer months. Across 33 months of site specific surveys in the Morven South Marine Mammal Study Area, no bottlenose dolphins were observed.

10.11.1.82 There is limited information on how bottlenose dolphin responds to piling noise disturbances, as most research has focused on harbour porpoises. A study at the Nigg Energy Park in northeast Scotland found that bottlenose dolphin showed a weak but measurable response to piling activities, spending less time near the construction site (Graham *et al.*, 2017). During offshore wind farm construction in the Moray Firth increased bottlenose dolphin detections were observed on days when piling occurred, suggesting that behavioural changes like increased vocalisations occurred rather than displacement (Fernandez-Betelu *et al.*, 2021).

10.11.1.83 The behavioural response severity spectrum developed by Southall *et al*. (2007, 2021) suggests that strong disturbance near the noise source could lead to displacement, while mild disturbance further away would cause less severe behavioural effects. Bottlenose dolphins is likely capable of avoiding disturbed areas, and while there may be some reproductive impacts close to the source of strong disturbance, survival rates are unlikely to be affected. It is expected that these animals will build some tolerance to the noise over time and resume normal activities once piling ceases.

10.11.1.84 Therefore, bottlenose dolphin is deemed to have some resilience to behavioural disturbance, high recoverability and high international value. The sensitivity of the receptor is therefore considered to be low.

Magnitude: white-beaked dolphin

10.11.1.85 The temporal MDS consists of a total of 101 foundations consisting of up to 524 piles over 262 piling days (Table 10.34), within a construction phase of up to five years(see Volume 1, Chapter 3: Project Description).Based upon a density of 0.080 animals/km^2, for the temporal MDS up to 116 animals (equivalent to approximately 0.26% of the CGNS MU / 0.34% of the UK portion of the CGNS MU) were estimated to have the potential to experience disturbance, when calculated using the D/R methodology for cetaceans (Graham *et al.*, 2017) capped at 140db SEL_{ss}.

10.11.1.86 The spatial MDS consists of a total of 73 foundations consisting of up to 119 piles over 48 piling days (Table 10.35), within a construction phase of up to five years (see Volume 1, Chapter 3: Project Description). The spatial MDS represents the largest contours (compared to pin piles, for the temporal MDS) and is presented in Figure 10.12. Figure 10.12 illustrates the disturbance ranges due to underwater sound generated by single and concurrent piling of 16m monopiles (i.e. the spatial MDS). There are no designated sites within the Morven Regional Marine Mammal Study Area with white-beaked dolphin as a qualifying feature.

10.11.1.87 For the spatial MDS up to 233 animals (equivalent to approximately 0.53% of the total CGNS MU and 0.68% of the UK portion) were estimated to have the potential to experience disturbance, when calculated using the 140db SEL_{ss}-capped D/R methodology for cetaceans (Graham *et al.*, 2017).

10.11.1.88 Expert elicitation within the iPCoD framework has not been undertaken for white-beaked dolphin, so it was not possible to conduct population modelling for this species. Intermittent piling (of both spatial and temporal scenarios) within a 12-month window may coincide with key breeding periods for white-beaked dolphin. However given this short duration of disturbance, the temporal overlap would occur with only one breeding season.

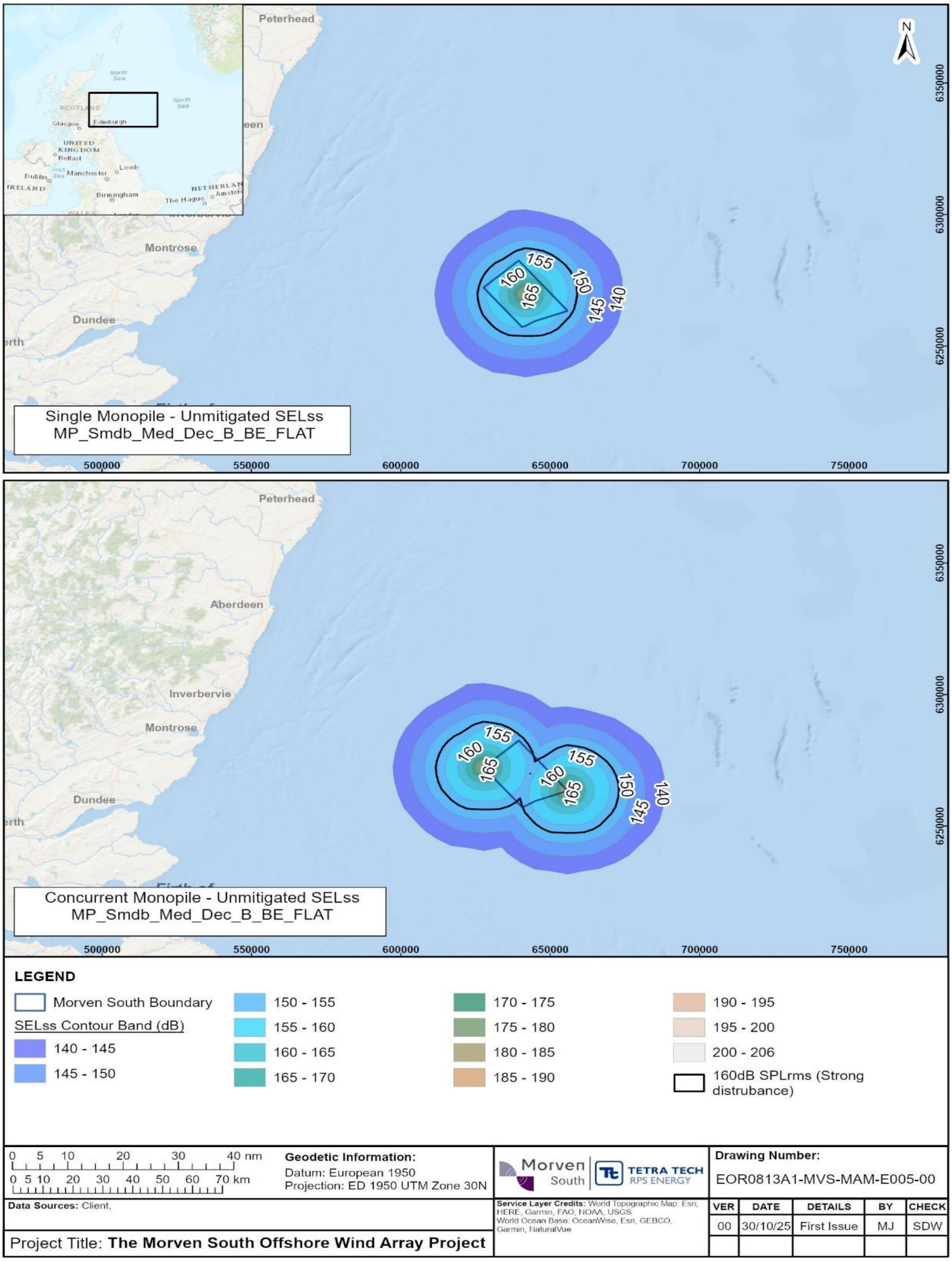

Figure 10.12: Unweighted single strike sound exposure level contours and NMFS (2005) sound pressure level (root mean square) disturbance thresholds associated with single (top) and concurrent (bottom) piling of 16m monopiles

10.11.1.89 The impact is predicted to be of local spatial extent, short-term duration, intermittent and of high reversibility. It is predicted that the impact will affect the receptor directly. The impact may 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 proportion of the reference population impacted is predicted to be very small (0.26% to 0.53% for the temporal and spatial MDS respectively of the whole CGNS MU and 0.34% to 0.68% of the UK portion, respectively) and no population-level consequences of disturbance would be expected. The magnitude for white-beaked dolphin is, therefore considered, to be low.

<u>Sensitivity: white-beaked dolphin</u>

10.11.1.90 As for bottlenose dolphin, white-beaked dolphin is considered less vulnerable to disturbance compared to harbour porpoises due to its larger body sizes, lower metabolic rates, and less frequent foraging needs. However, in contrast to bottlenose dolphin, white-beaked dolphin tends to have a more offshore distribution. White-beaked dolphin exhibits a seasonal presence in the Morven South Marine Mammal Study Area, typically appearing between June and August with a peak in August. White-beaked dolphin accounted for the second highest number of sightings in site specific surveys, recorded in ten out of 33 survey months (see Volume 3, Annex 10.3: Marine Mammals Shared Digital Aerial Survey Report).

10.11.1.91 There is limited information on how white-beaked dolphin responds to piling sound disturbances, as most research has focused on harbour porpoise. However, responses are expected to be similar to those for bottlenose dolphin (see paragraph 10.11.1.81 to 10.11.1.82).

10.11.1.92 White-beaked dolphin is deemed to have some resilience to behavioural disturbance, high recoverability and high international value. The sensitivity of the receptor is therefore considered to be low.

<u>Magnitude: humpback whale</u>

10.11.1.93 Although there have been increased sightings of humpback whale in the Morven Regional Marine Mammal Study Area, there is no density estimate available for this species and therefore the number of animals potentially disturbed could not be quantified. The baseline characterisation suggests that this species primarily occurs within the Firth of Forth during winter months (December to March), which may represent a migratory stopover, or a feeding or recovery opportunity en route of a longer migration between high and low latitude areas. However, very low numbers have been recorded in this area and therefore the magnitude of effects (in terms of numbers disturbed) is anticipated to be very small.

10.11.1.94 Humpback whale are in the same 'LF' functional hearing group as minke whale (NMFS, 2024) and the spatial extent of behavioural effects on humpback whale are therefore as described for minke whale (paragraph 10.11.1.98 *et seq*). The magnitude of impact is assumed to be the same or lower than for minke whale. The magnitude is, therefore, considered to be low.

<u>Sensitivity: humpback whale</u>

10.11.1.95 There is limited information on the sensitivity of humpback whale to impulsive sound from pile driving. A study looking at frequency-dependent response thresholds found that individual humpback whales responded with directed movements and dive changes at frequencies of 0.25kHz, 1kHz, 4kHz and 16kHz suggesting that 0.25kHz is at the lower end of their hearing range whilst 1 to 4kHz is at their peak hearing threshold (Dunlop *et al.*, 2003). This is within the same frequency range for minke whale hearing and therefore the sensitivity of humpback whale is considered to be the same as described below (paragraph 10.11.1.105 *et seq.*).

10.11.1.96 Strong disturbances in the near field could cause humpback whale to be displaced, while mild disturbances over larger areas might lead to less severe behavioural changes (Southall *et al.*, 2021). The Morven South Marine Mammal Study Area experiences relatively high levels of shipping, fishing, and vessel activity (see paragraph 10.11.4.9 et seq.). While displacement or behavioural changes are possible near strong sound sources, humpback whale within the Morven South Marine Mammal Study Area may exhibit some tolerance due to ongoing exposure to anthropogenic noise.

10.11.1.97 Humpback whale is deemed to have some resilience to behavioural disturbance, high recoverability and high international value. The sensitivity of the receptor is therefore considered to be low.

Magnitude: Minke whale

10.11.1.98 The temporal MDS consists of a total of 101 foundations consisting of up to 524 piles over 262 piling days (Table 10.34), within a construction phase of up to five years (see Volume 1, Chapter 3: Project Description). Based upon a density of 0.042 animals/km^2, for the temporal MDS up to 61 animals (equivalent to approximately 0.30% of the whole CGNS MU/0.59% of the UK portion of the MU) were estimated to have the potential to experience disturbance, when calculated using the D/R methodology for cetaceans (Graham *et al.*, 2017) capped at 140db SEL_{ss}.

10.11.1.99 The spatial MDS consists of a total of 73 foundations consisting of up to 119 piles over 48 piling days (Table 10.35), within a construction phase of up to five years (see Volume 1, Chapter 3: Project Description).The spatial MDS represents the largest contours (compared to pin piles, for the temporal MDS) and is presented in Figure 10.15.

10.11.1.100 For the spatial MDS up to 122 animals (equivalent to approximately 0.61% of the CGNS MU/1.19% of the UK portion of the MU) were estimated to have the potential to experience disturbance, when calculated using the 140db SEL_{ss}-capped D/R methodology for cetaceans (Graham *et al.*, 2017). Figure 10.15 illustrates that there is no potential for underwater sound generated by concurrent piling of 16m monopiles (i.e. the spatial MDS) to overlap designated sites with minke whale as a qualifying feature (i.e. the Southern Trench ncMPA). The NMFS (2005) 160db rms strong disturbance contour shows no overlap with the ncMPA, with a distance of 79km (for concurrent piling) from the Southern Trench ncMPA.

10.11.1.101 Results of the iPCoD modelling for minke whale against the CGNS MU population (20,118 individuals) for the temporal MDS showed that the median counterfactual of population size was 1.000 throughout the 25-year model run. The mean counterfactual was one at time points 1 and 2, and 0.99 for all other time points throughout the 25-year model run. This indicates that there is predicted to be no significant difference between the population trajectories for the impacted population when compared to the un-impacted population (see Volume 3, Annex 10.5: Marine Mammals Interim Population Consequences of Disturbance (iPCoD) Modelling Report). This is illustrated in Figure 10.13 whereby the un-impacted and impacted populations are predicted to follow very similar trajectories.

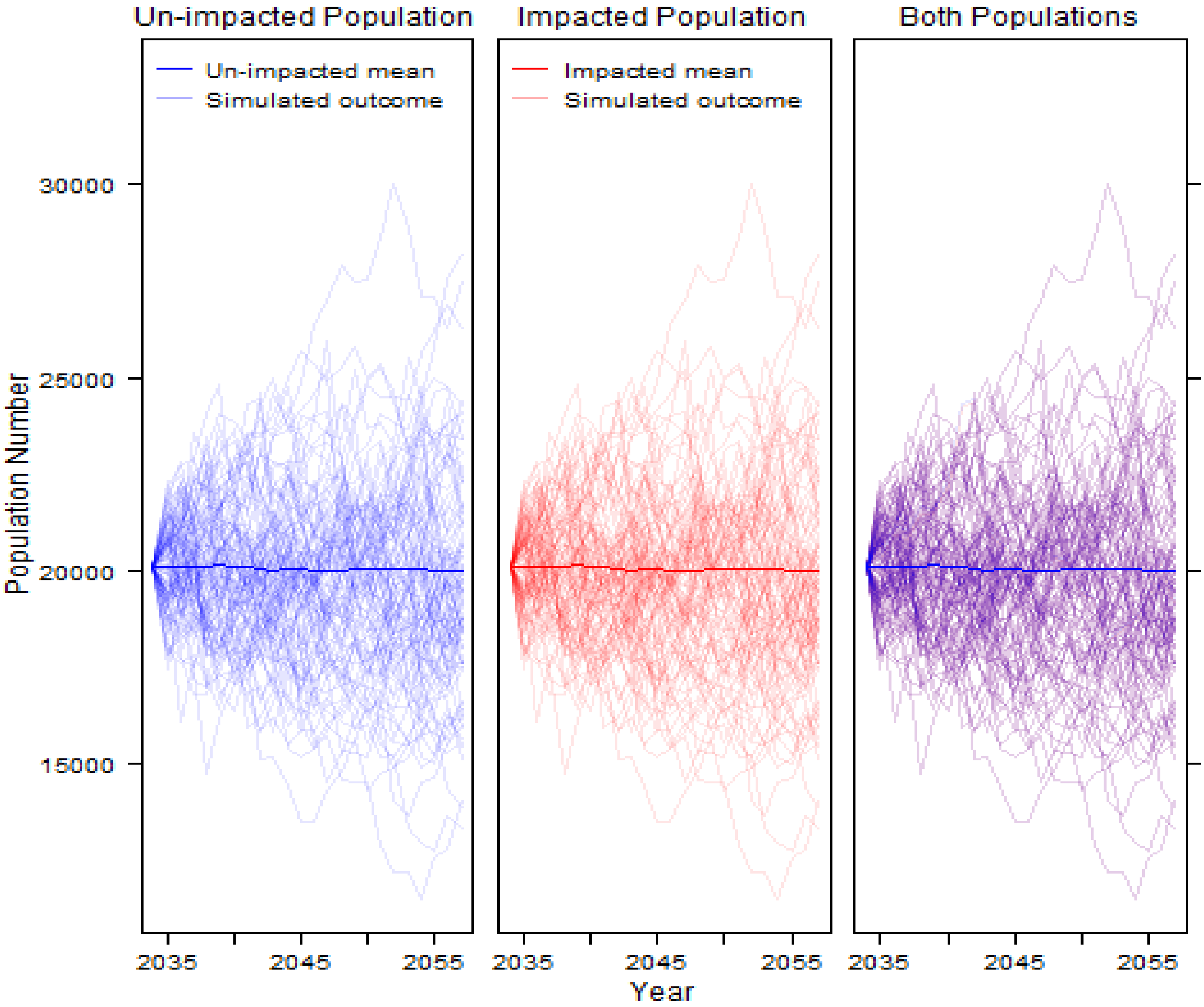

Figure 10.13: Simulated minke whale population trajectories for the un-impacted and impacted populations, modelled against the temporal maximum design scenario (longest duration of impact)

10.11.1.102 Results of equivalent iPCoD modelling for the spatial MDS also showed that the median counterfactual of population size was 1.000 or 0.99 (and mean counterfactual was 1 or 0.99) throughout the 25-year model run, again indicating that there is predicted to be no significant difference between the population trajectories for the impacted and un-impacted populations (Figure 10.14).

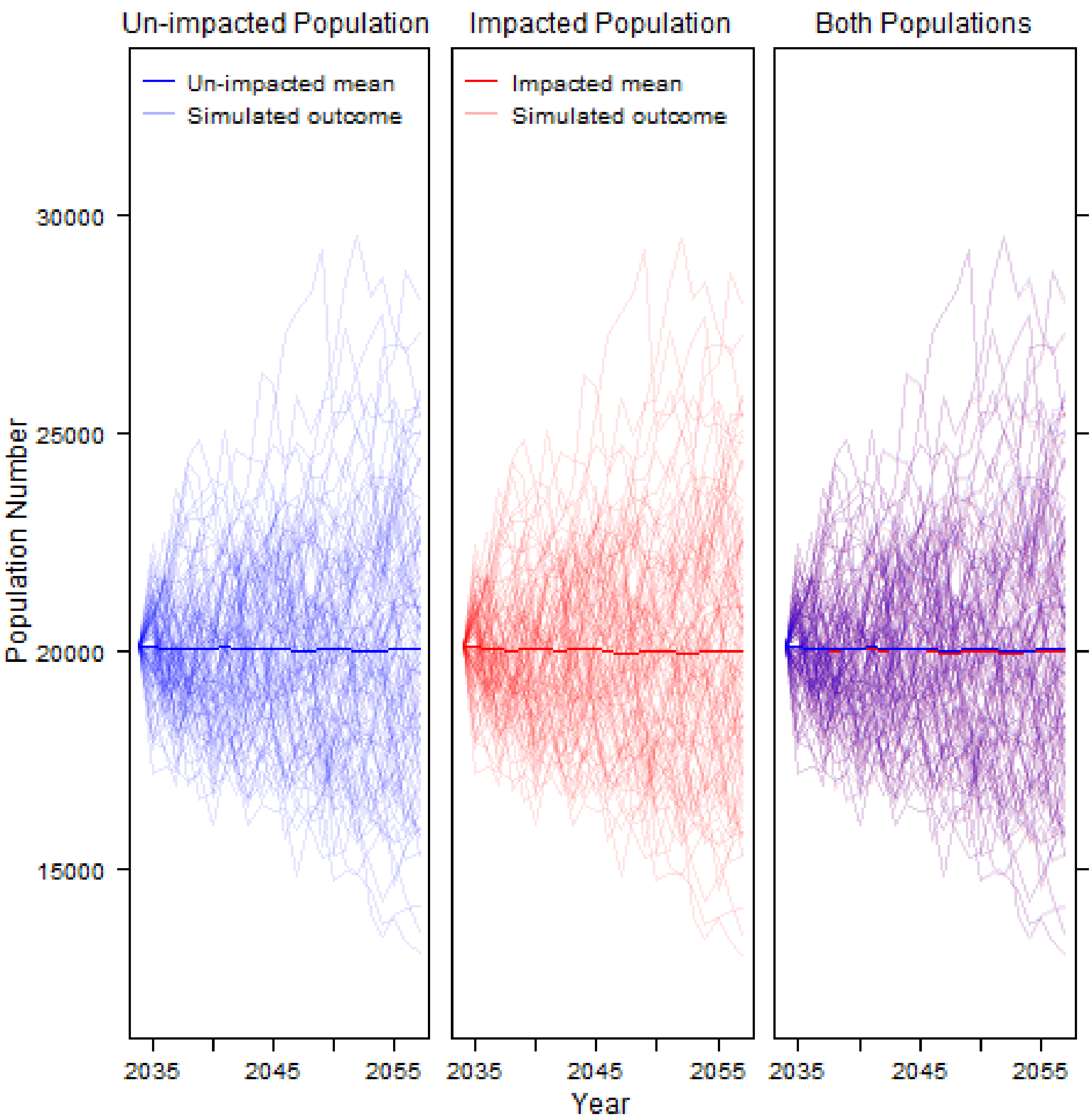

Figure 10.14: Simulated minke whale trajectories for the un-impacted and impacted populations, modelled against the spatial maximum design scenario (greatest spatial impact)

10.11.1.103 Figure 10.15 illustrates that there is no potential for underwater sound generated by concurrent piling of 16m monopiles (i.e. the spatial MDS) to affect designated sites with minke whale as a qualifying feature (i.e. the Southern Trench ncMPA).

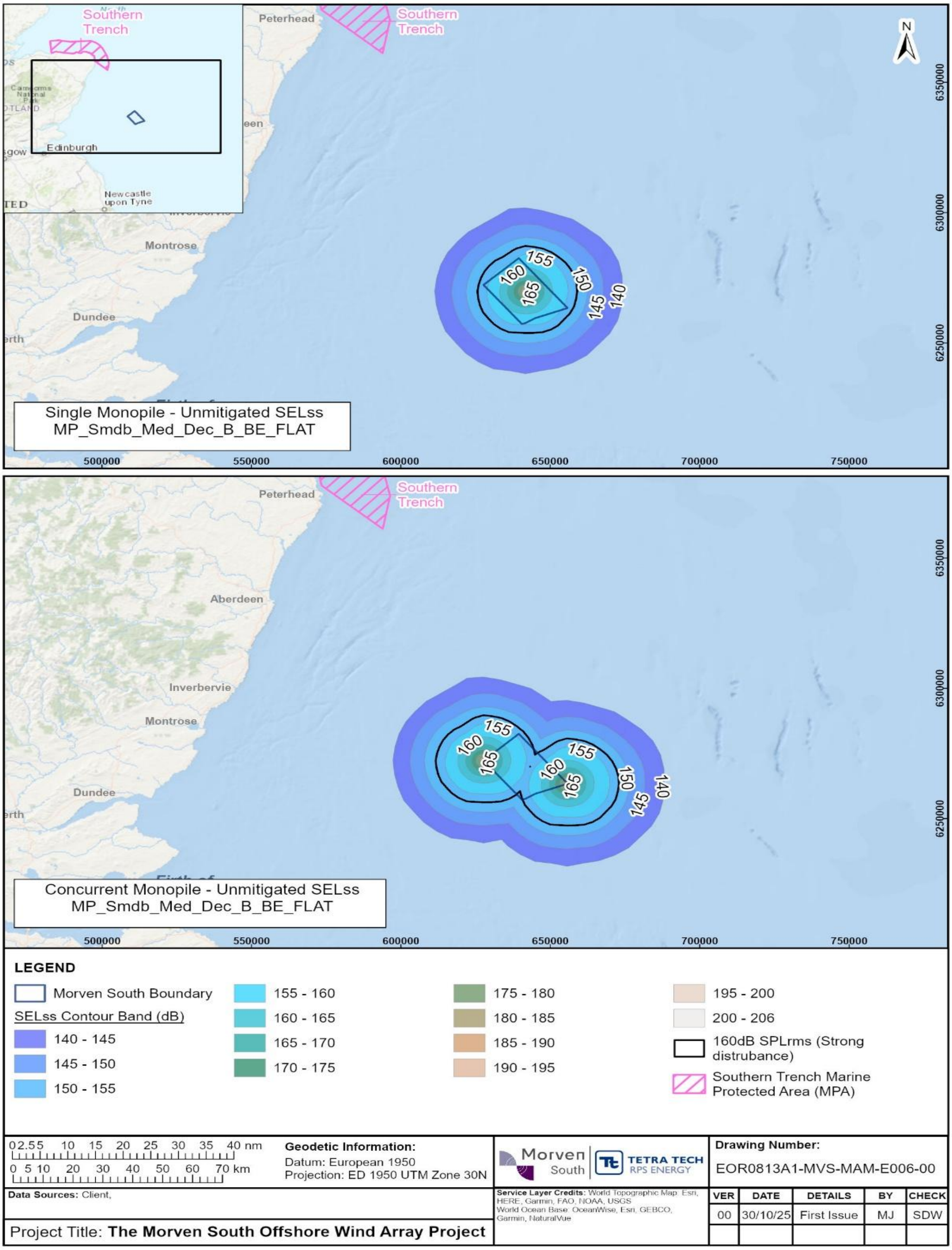

Figure 10.15: Unweighted single strike sound exposure level contours and NMFS (2005) sound pressure level (root mean square) strong disturbance threshold associated with single (top) and concurrent (bottom) piling of 16m monopiles, in relation to designated sites with minke whale as a qualifying feature (inset).

10.11.1.104 The impact is predicted to be of local spatial extent, short-term duration, intermittent and of high reversibility (as receptors are expected to recover within hours/days). It is predicted that the impact will affect the receptor directly. The impact may 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 proportion of the reference population impacted is predicted to be very small (0.30% to 0.61% of the CGNS MU) and there would be no population-level consequences of disturbance. The magnitude for minke whale is, therefore, considered to be low.

Sensitivity: minke whale

10.11.1.105 Minke whale is a seasonal visitor to the Morven South Marine Mammal Study Area, primarily moving into inshore waters during the summer months with peak numbers from June to September. Whilst they are able to adopt a low energy feeding strategy, exploiting prey herded by other species, they rely heavily on sandeel, which comprises up to 70% of their diet in Scotland (Robinson *et al.*, 2009, Tetley *et al.*, 2008). Disturbances in key sandeel habitats could therefore negatively impact the health and survival of minke whale by reducing their foraging success, and whale-watching boats in important feeding areas may reduce foraging activity (Christiansen *et al.*, 2013a, Christiansen *et al.*, 2013b), potentially affecting reproductive success, since female body condition influences foetal growth (Christiansen *et al.*, 2014). However, studies in Iceland, where baseline sound levels are lower than the North Sea, found no significant long-term effects from whale-watching disturbances on whale vital rates, likely because whales shifted their feeding locations when sandeel availability was low (Christiansen and Lusseau, 2015).

10.11.1.106 Strong disturbances in the near field could cause minke whale to be displaced, while mild disturbances over larger areas might lead to less severe behavioural changes (Southall *et al.*, 2021). The Morven South Marine Mammal Study Area experiences relatively high levels of shipping, fishing, and vessel activity (see paragraph 10.11.4.8 *et seq.*). While displacement or behavioural changes are possible near strong sound sources, minke whale within the Morven South Marine Mammal Study Area may exhibit some tolerance due to ongoing exposure to anthropogenic noise.

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

Magnitude: grey seal

10.11.1.108 The temporal MDS consists of a total of 101 foundations consisting of up to 524 piles over 262 piling days (Table 10.34), within a construction phase of up to five years (see Volume 1, Chapter 3: Project Description). Based upon a density of 0.252 animals/km^2, for the temporal MDS up to 161 animals (equivalent to approximately 0.44% of the combined East Scotland and Northeast England seal MUs) were estimated to have the potential to experience disturbance, when calculated using the D/R methodology for seals (Whyte *et al.* 2020).

10.11.1.109 The spatial MDS consists of a total of 73 foundations consisting of up to 119 piles over 48 piling days (Table 10.35), within a construction phase of up to five years (see Volume 1, Chapter 3: Project Description). The spatial MDS represents the largest contours (compared to pin piles, for the temporal MDS) and is presented in Figure 10.18.

10.11.1.110 For the spatial MDS up to 408 animals (equivalent to approximately 1.11% of the combined East Scotland and Northeast England seal MUs) were estimated to have the potential to experience disturbance, when calculated using the D/R methodology for seals (Whyte *et al.* 2020). The (Graham *et al.*, 2017) 160db rms strong disturbance contour shows no overlap with seal haul-out or breeding sites or the Berwickshire and North Northumberland Coast and Isle of May SACs, with a distance of 85.5km and 92.5km from the Berwickshire and North Northumberland Coast and Isle of May SACs respectively (concurrent piling) (Figure 10.18).

10.11.1.111 Results of the iPCoD modelling for grey seal against the combined population of the East Scotland and Northeast England seal MUs (36,696 individuals) for the temporal MDS showed that the mean and median counterfactual of population size was 1.000 throughout the 25-year model run. This indicates that there is predicted to be no significant difference between the population trajectories for the impacted population when compared to the un-impacted population (see Volume 3, Annex 10.5: Marine Mammals Interim Population Consequences of Disturbance (iPCoD) Modelling Report). This is illustrated in Figure 10.16, whereby the un-impacted and impacted populations are predicted to follow very similar trajectories.

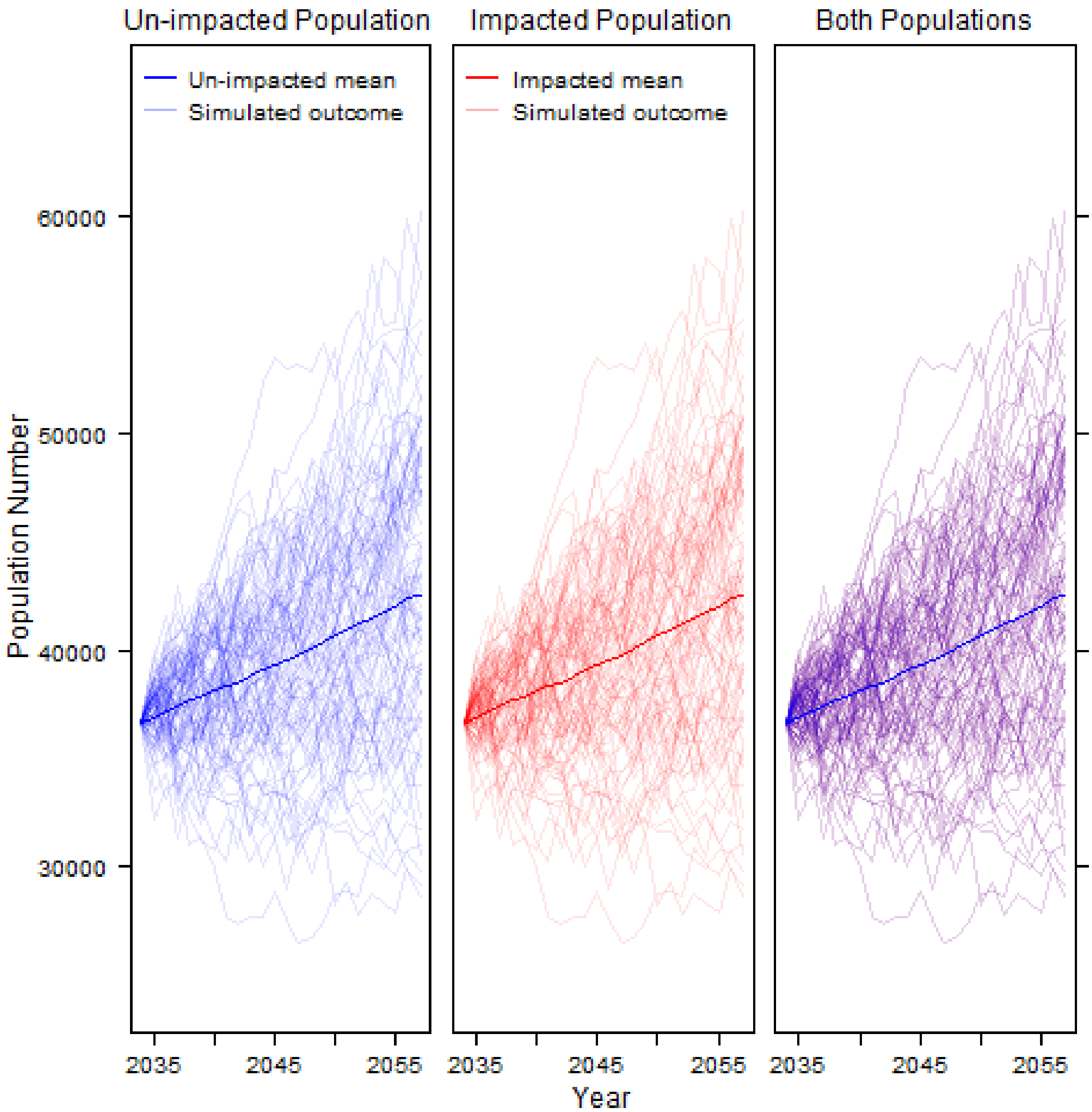

Figure 10.16: Simulated grey seal population trajectories for the un-impacted and impacted populations, modelled against the temporal maximum design scenario (longest duration of impact)

10.11.1.112 Results of equivalent iPCoD modelling for the spatial MDS also showed that the mean and median counterfactual of population size was 1.000 throughout the 25-year model run, again indicating that there is predicted to be no significant difference between the population trajectories for the impacted and un-impacted populations (Figure 10.17).

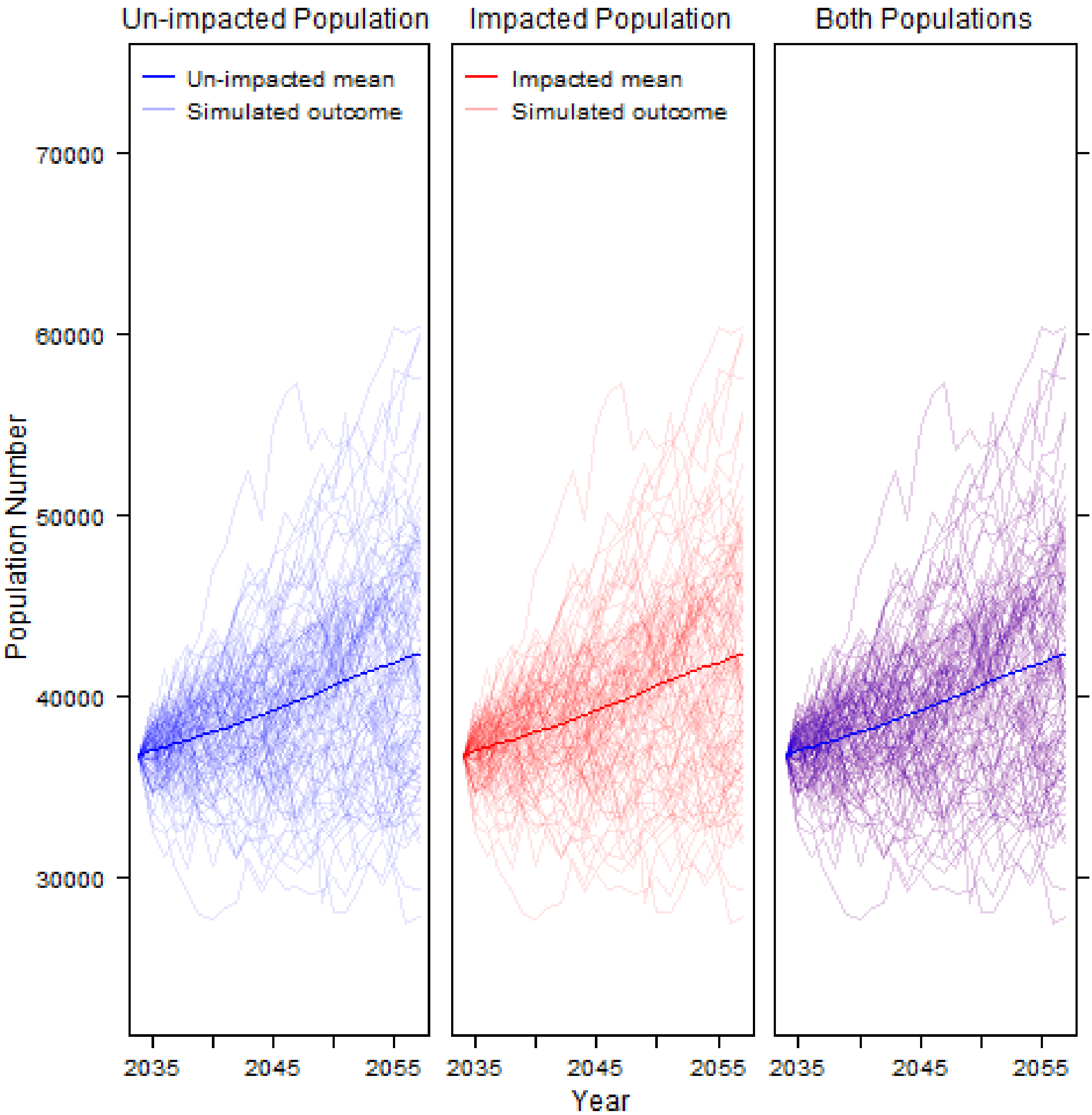

Figure 10.17: Simulated grey seal population trajectories for the un-impacted and impacted populations, modelled against the spatial maximum design scenario (greatest spatial impact)

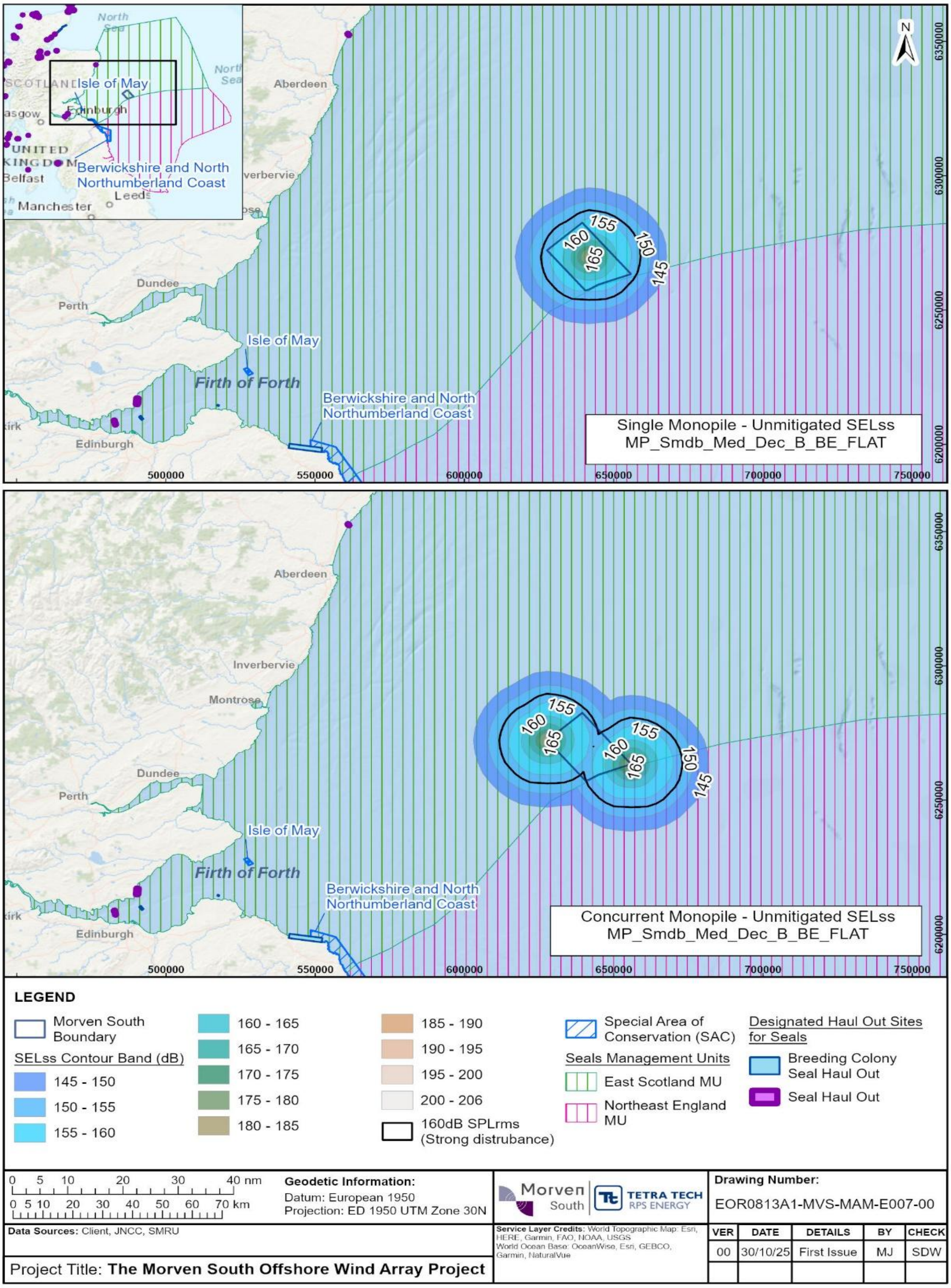

Figure 10.18: Unweighted single strike sound exposure level contours and NMFS (2005) sound pressure level (root mean square) strong disturbance thresholds associated with single (top) and concurrent (bottom) piling of 16m monopiles, in relation to designated sites with grey seal as a qualifying feature (inset)

10.11.1.113 The impact is predicted to be of local spatial extent, short-term duration, intermittent and of high reversibility (as receptors are expected to recover within hours/days). It is predicted that the impact will affect the receptor directly. The impact may 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 proportion of the reference population impacted is predicted to be very small (0.44% to 1.11% of the combined East Scotland and Northeast England seal MUs) and there would be no population-level consequences of disturbance. The magnitude for grey seal is, therefore, considered to be low.

Sensitivity: grey seal

10.11.1.114 There are still limited data on grey seal behavioural responses to pile driving. An experimental study showed that *ex situ* observations suggest that grey seal foraging success depends on both the perceived risk from anthropogenic sounds (scenarios included in the study: silence, piling or tidal turbines), and prey patch quality (low or high density) and foraging context. During the trials, foraging success was found to be highest in silent control periods, and reduced in the presence of anthropogenic noise (piling and tidal turbine sounds), especially when prey density was low, suggesting seals balance risk against foraging profit (Hastie *et al.*, 2021). Importantly, animals showed an initial aversive response to the pile driving playbacks (with a lower proportion of dives spent foraging) but this diminished during each trial. Empirical evidence from a telemetry study on harbour seal at the Lincs Offshore Wind Farm showed harbour seals significantly avoided piling activities within a 25km radius (predicted received levels of between 166 and 178 dB re 1 lPa$_{(p-p)}$), with a notable decrease in seal presence during piling but this was limited to piling activity only. Seal distribution returned to baseline levels less than two hours after piling ceased (Russell *et al.*, 2016),

10.11.1.115 Twenty grey seals tracked during pile driving at the Luchterduinen and Gemini wind farms exhibited varied responses, including altered diving and swimming behaviours, and no changes in behaviour or movement at all (Aarts *et al.*, 2018). The most common reactions were declines in descent speed (observed up to 36km) and reduction in bottom time, and on average grey seal within 33km were more likely to swim away from piling. Response distances varied significantly, however (similar to the risk/profit conclusions presented by Hastie *et al.* (2021)) some seals exposed to pile driving at less than 30km returned to the disturbed areas on subsequent trips, indicating that the attraction to the area may outweigh the deterrent effect of noise.

10.11.1.116 Behavioural changes and barrier effects may impact seals' ability to build necessary energy reserves before reproduction and lactation - critical for capital breeders like grey seal which rely on stored energy for offspring survival (Sparling *et al.*, 2006). Female grey seals are particularly vulnerable during late pregnancy, needing extensive foraging to accumulate energy reserves for milk production (Hall and Thompson, 2009). However, during an expert elicitation workshop in 2018 (Booth *et al.*, 2019), it was concluded that grey seal have a reasonable ability to compensate for lost foraging opportunities due to their generalist diet, mobility, life history and adequate fat stores. Instead survival of 'weaned of the year' animals and fertility were determined to be the most sensitive parameters to disturbance. Experts agreed grey seal would be more robust to the effects of disturbance, due being capital breeders and more generalist adaptable foraging strategy, than harbour seal (Booth *et al.*, 2019). Grey seals are also highly adaptable to environmental changes, capable of adjusting their metabolic rates and foraging strategies to balance varying energy demands and availability (Sparling *et al.*, 2006, Beck *et al.*, 2003) and show wide foraging ranges between haul-out and multiple foraging regions (Russell and McConnell, 2014) (e.g. 448km for grey seal in Carter *et al.* (2022)). Therefore, they are unlikely to be highly sensitive to displacement or barrier effects from foraging grounds during piling and whilst mild disturbances may elicit small behavioural changes in seals (such as altered swimming speed or direction) these are unlikely to lead to populations level effects.

10.11.1.117 Grey seal is deemed to have some resilience to behavioural disturbance, high recoverability and international value. The sensitivity of the receptor to behavioural disturbance is therefore, considered to be low.

Magnitude: harbour seal

10.11.1.118 The temporal MDS consists of a total of 101 foundations consisting of up to 524 piles over 262 piling days (Table 10.34), within a construction phase of up to five years (see Volume 1, Chapter 3: Project Description). Based upon a density of <0.001 animals/km^2, for the temporal MDS up to one animal (equivalent to 0.20% of the combined East Scotland and Northeast England seal MUs) were estimated to have the potential to experience disturbance, when calculated using the D/R methodology for seals (Whyte *et al.*, 2020). When applying the NMFS (2005) 160db rms strong disturbance metric, up to one animal (<0.001% of the combined East Scotland and Northeast England seal MUs) were estimated to have the potential to be affected.

10.11.1.119 The spatial MDS consists of a total of 73 foundations consisting of up to 119 piles over 48 piling days (Table 10.35), within a construction phase of up to five years (see Volume 1, Chapter 3: Project Description). The spatial MDS represents the largest contours (compared to pin piles, for the temporal MDS) and is presented in Table 10.32. For the spatial MDS up to one animal (equivalent to <0.001% of the combined East Scotland and Northeast England seal MUs) were estimated to have the potential to experience disturbance, when calculated using the D/R methodology for seals (Whyte *et al.*, 2020).

10.11.1.120 Figure 10.19 illustrates that there is no potential for underwater sound generated by concurrent piling of 16m monopiles (i.e. the spatial MDS) to affect designated sites with harbour seal as a qualifying feature (i.e. the Firth of Tay and Eden Estuary SAC, the Dornoch Firth and Morrich More SAC and designated seal haul-outs), with a distance of 93.4km from the Firth of Tay and Eden Estuary SAC, and 241.8km from the Dornoch Firth and Morrich More SAC.

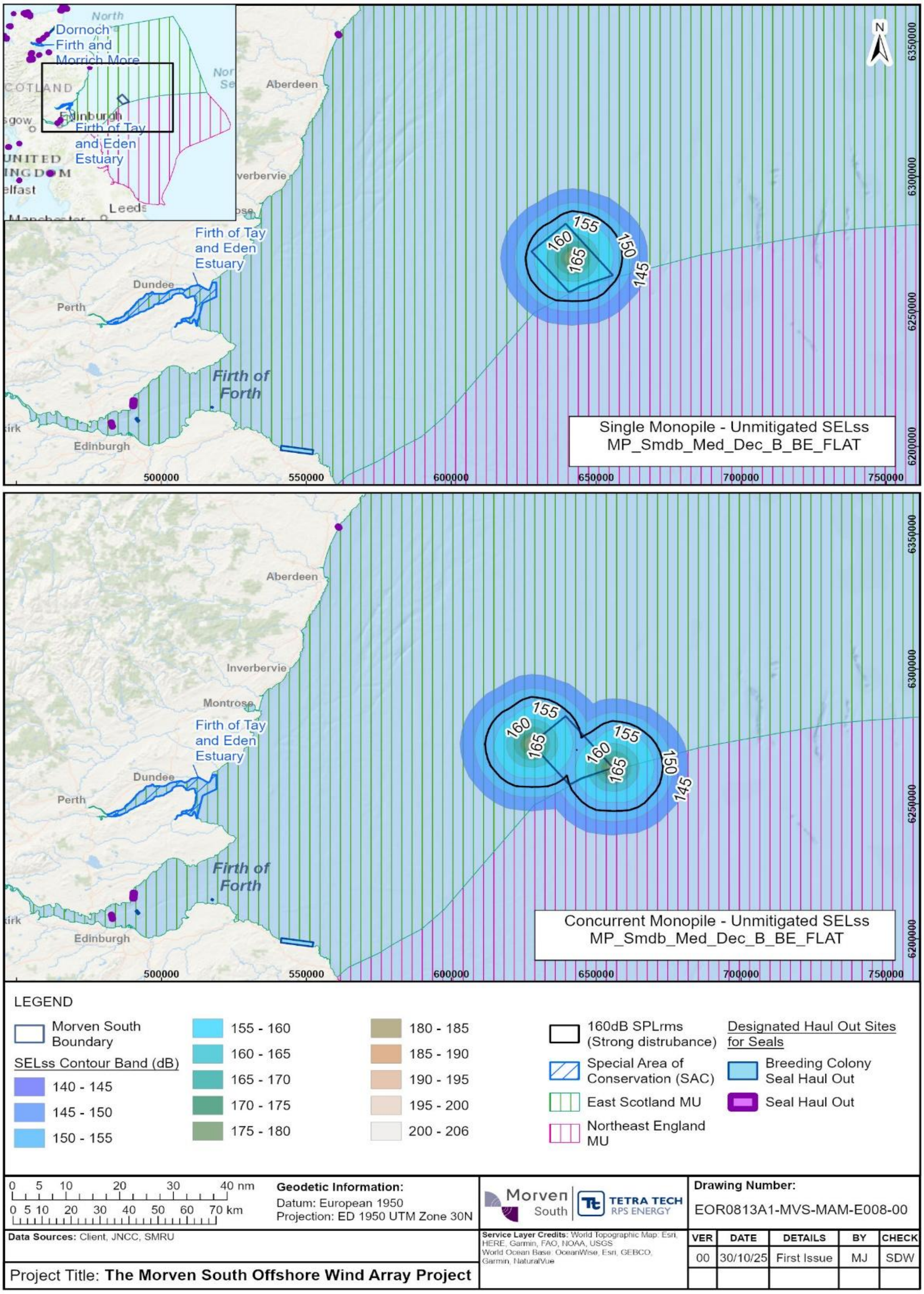

Figure 10.19: Unweighted SEL_{ss} contours associated with single (top) and concurrent (bottom) piling of 16m monopiles, in relation to designated sites with harbour seal as a qualifying feature.

10.11.1.121 Results of the iPCoD modelling for harbour seal against the combined population of the East Scotland and Northeast England seal MUs (488 individuals) for the temporal MDS showed that the median and mean counterfactual of population size was 1.000 throughout the 25-year model run, indicating that there is predicted to be no significant difference between the population trajectories for the impacted population when compared to the un-impacted population (see Volume 3, Annex 10.5: Marine Mammals Interim Population Consequences of Disturbance (iPCoD) Modelling Report). This is illustrated in Figure 10.20, whereby the un-impacted and impacted populations are predicted to follow very similar trajectories.

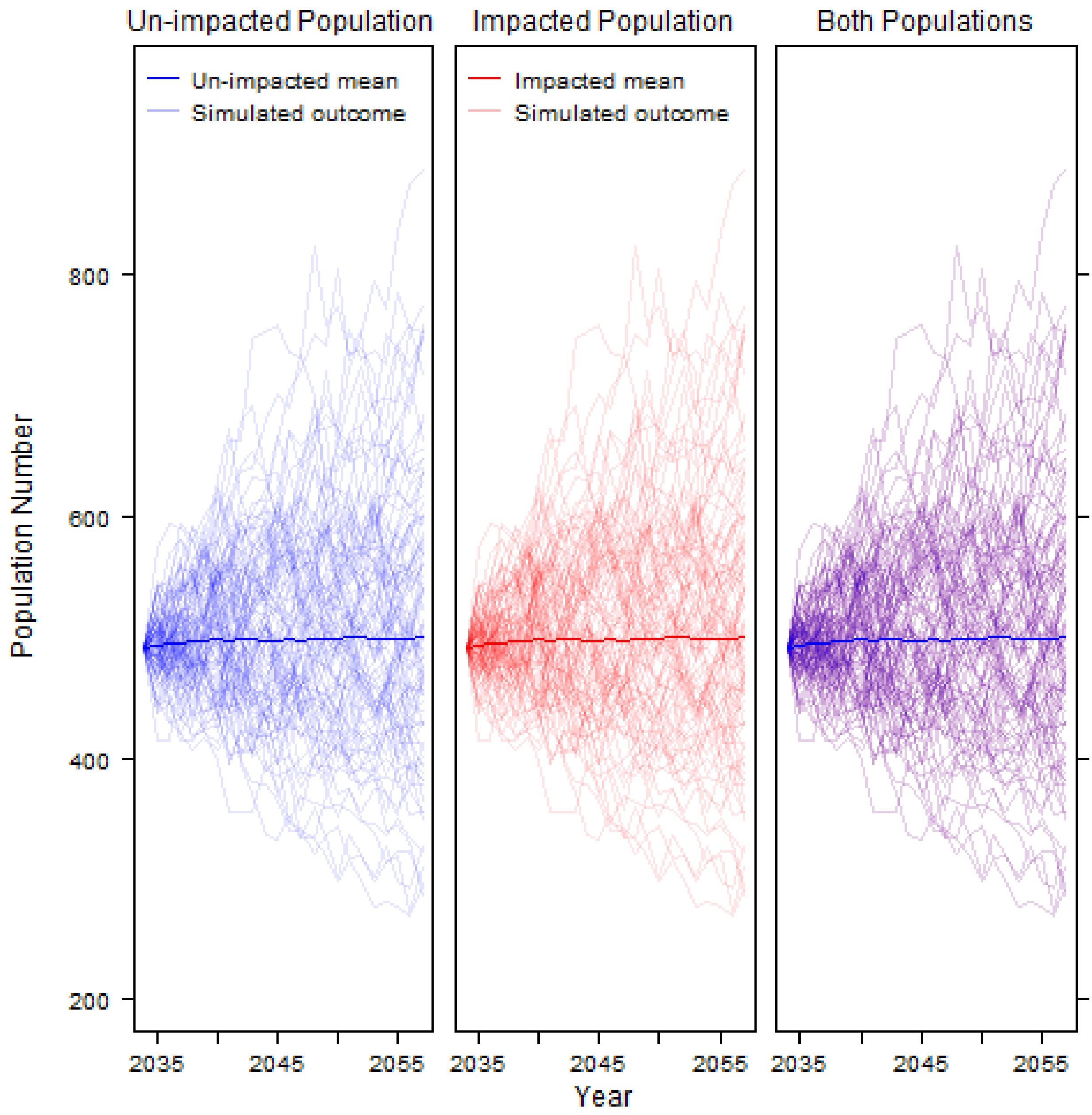

Figure 10.20: Simulated harbour seal population trajectories for the un-impacted and impacted populations, modelled against the temporal Maximum Design Scenario (longest duration of impact)

10.11.1.122 Results of equivalent iPCoD modelling for the spatial MDS also showed that the mean and median counterfactual of population size was 1.000 throughout the 25-year model run, again indicating that there is predicted to be no significant difference between the population trajectories for the impacted and un-impacted populations (Figure 10.21).

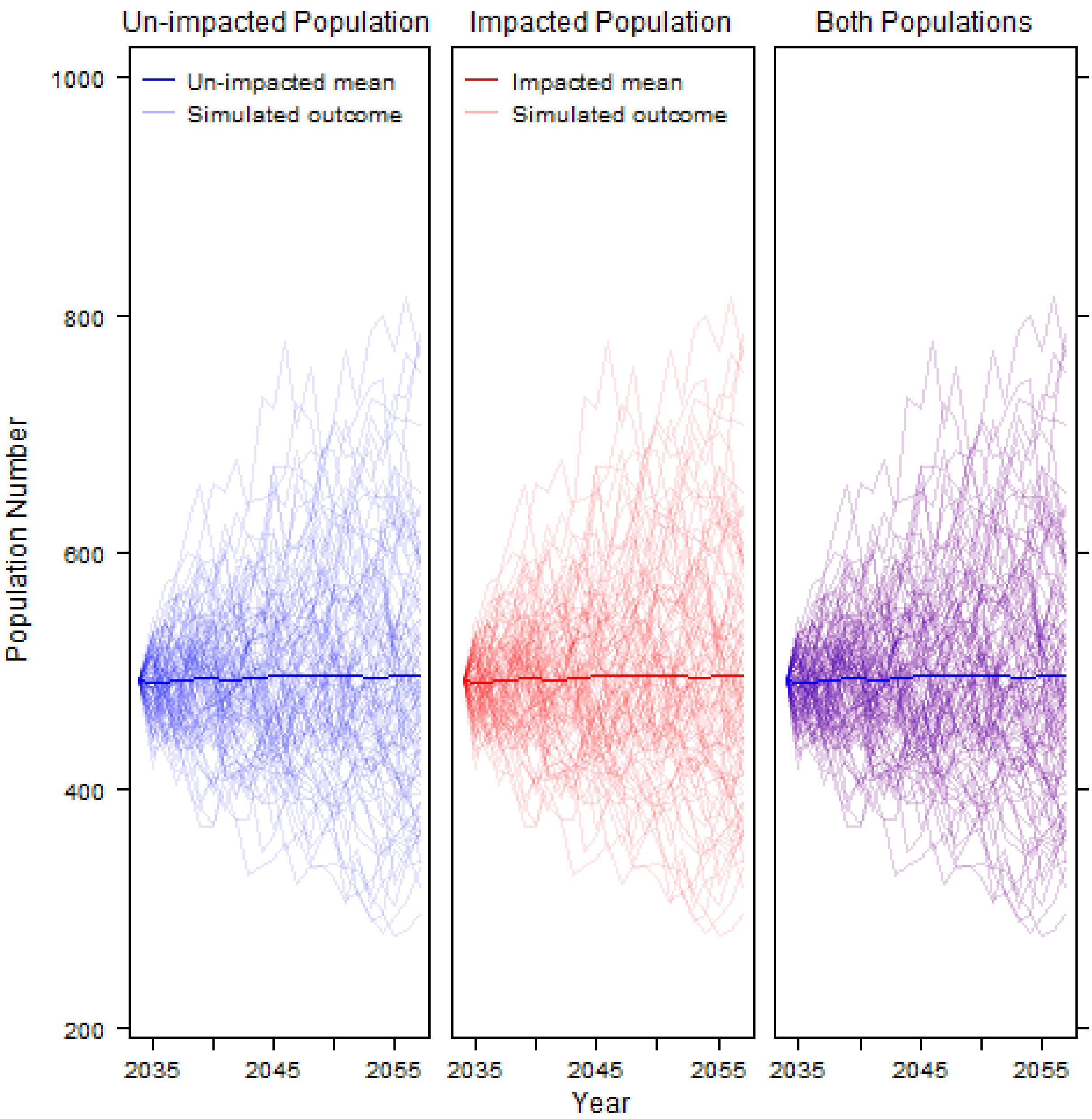

Figure 10.21: Simulated harbour seal population trajectories for the un-impacted and impacted populations, modelled against the spatial Maximum Design Scenario (greatest spatial impact)

10.11.1.123 The impact is predicted to be of local spatial extent, short-term duration, intermittent and of high reversibility (as receptors are expected to recover within hours/days). It is predicted that the impact will affect the receptor directly. The impact may 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 proportion of the reference population impacted is predicted to be very small (<0.001% of the combined East Scotland and Northeast England seal MUs) and there would be no population-level consequences of disturbance. The magnitude for harbour seal is, therefore, considered to be low.

Sensitivity: harbour seal

10.11.1.124 Sensitivity for harbour seal is expected to be similar to that for grey seal. Mild disturbances may elicit behavioural changes, such as altered swimming speed or direction, but these are unlikely to impact populations significantly.

10.11.1.125 Tagged harbour seals in the Wash were found to be displaced during impact piling, with seal abundance dropping by 19–83% within 25kmof active piling sites (Russell *et al.*, 2016). However, this displacement was short-term, as seals returned to typical distribution patterns within two hours after piling ceased. Harbour seals store energy in thick blubber, allowing them to tolerate short-term fasting while hauled out during rest, breeding, or moulting. As a result, they are less likely to be significantly affected by brief disruptions to foraging caused by piling activity (Whyte *et al*., 2020). However, the reproductive strategy of harbour seals is considered to be an intermediate between capital and income breeding (Harwood *et al*. 2022), because females start foraging before the end of lactation, and income breeders must feed much more continuously to support themselves and their pups, and therefore may be more susceptible to disturbance than grey seal (see paragraph 10.11.1.116). In an expert elicitation workshop (Booth, 2019) experts agreed the most likely outcome of a six-hour period without energy intake, due disturbance from low-frequency broadband pulsed noise (e.g., impact piling, airgun pulses) would be a short-term disruption to feeding behaviour. It was agreed that harbour seals were considered to have a reasonable ability to compensate for lost foraging opportunities due to their generalist diet, mobility, life history and adequate fat stores. Foraging ranges are smaller than for grey seal, with harbour seals generally considered to be coastal foragers (Booth, 2019, Vance *et al.*, 2021) (though often journey much further from haul-out sites, e.g. 273km in Carter *et al.* (2022)).

10.11.1.126 Harbour seal is deemed to have some resilience to behavioural disturbance, high recoverability and international value. The sensitivity of the receptor to behavioural disturbance is therefore, considered to be low.

Significance of the effect (behavioural disturbance)

10.11.1.127 Overall, for harbour porpoise the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. There will be some changes at the individual level during piling and due to the sensitivity of this species the effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

10.11.1.128 Overall, for all other marine mammal species (bottlenose dolphin, white-beaked dolphin, minke whale, humpback whale, grey seal, harbour seal), the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The overall significance of the effect is negligible or minor. The effect was concluded to be of **minor adverse** significance (rather than negligible) as there will be some changes at the individual level during piling, with the ZoI most likely extending beyond the Morven Marine Mammal Study Area. However, the impact is not significant in EIA terms.

Secondary mitigation and residual effect

10.11.1.129 No mitigation measures for marine mammals are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 10.33), is not significant in EIA terms.

10.11.2 Injury and disturbance from underwater sound generation from Unexploded Ordnance clearance

10.11.2.1 The Applicant is applying for UXO licence separately; however, potential UXO impacts are still assessed as a more holistic approach.

10.11.2.2 Pre-construction clearance of UXOs could lead to effects from high order detonation of UXO. This activity has the capacity to produce some of the most elevated peak sound pressures among all human-made underwater sound sources and is recognised as a high-energy, impulsive sound source (von Benda-Beckmann *et al.*, 2015). The effects of this impact will vary based on the characteristics of the sound source, the species affected, proximity to the source and the degree of attenuation within the surrounding environment.

10.11.2.3 Further detail on underwater sound modelling of UXO clearance is provided in Volume 3, Annex 10.2: Underwater Sound Shared Technical Report. In the case of high order detonation, acoustic modelling was conducted following the empirical exponentially decaying model for an underwater blast outlined in Gaspin (1983) and Richardson *et al.* (1995), as well as contributions from subsequent bubble expansion-contraction cycles.

10.11.2.4 Low order deflagration yields a considerably lower amplitude of peak sound pressure compared to high order detonations (Robinson *et al.*, 2020). Low order clearance techniques offer a substantial reduction in acoustic output over traditional high order methods, with the PK and SEL_{24h} observed being typically >20dB lower for the deflagration of the same sized munition. In this case, the radiated sound corresponds with the donor charge weight rather than the UXO itself. Therefore, underwater sound modelling for low order clearance has been based on the same methodology as for high order detonation, but with a smaller donor charge size.

10.11.2.5 Volume 3, Annex 10.2: Underwater Sound Shared Technical Report presents two distances relative to the source (e.g. the site of UXO clearance) for each sound level: R_{max} and $R_{95\%}$ (see paragraph).

10.11.2.6 For the purpose of defining the MZ, and based on the PK metric, the assessment has adopted the modelled output for R_{max} as this is the most conservative approach. For SEL_{24h} and disturbance associated with UXO clearance the distances related to $R_{95\%}$ have been applied, as the bathymetry in this region is unlikely to cause underwater sound to propagate irregularly, and the sound source (UXO detonation) is not expected to be directional.

10.11.2.7 As described previously (paragraph 10.8.3.34) the sound from both low order clearance and high order detonation is unlikely to remain impulsive in character at distances beyond a few kilometres (see Volume 3, Annex 10.2: Underwater Sound Shared Technical Report for more details). Predicted injury ranges should therefore be interpreted with caution, as those in the order of tens of kilometres as are likely to be considerably lower.

10.11.2.8 In line with stakeholder advice (Table 10.15) the assessment of significance with respect to auditory injury from UXO clearance will be based on both the unweighted PK and marine mammal hearing weighted SEL metrics. The impulsive sound threshold for AUD INJ for explosives are the same as those defined for piling (NMFS, 2024). The assessment of effect assumes designed-in measures (i.e. MMObs, PAM and 30 minutes of ADD activation prior to clearance) (Table 10.33) and the MMMP will be developed in line with the latest statutory guidance (JNCC, 2025a).

Construction phase – Auditory Injury

Magnitude of impact

10.11.2.9 Potential impacts of underwater sound resulting from UXO clearance on marine mammals could include mortality, physical injury or auditory injury. The assessment focuses on auditory injury as this represents the largest potential effect range that should be mitigated. 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. As such, TTS represents a temporary auditory injury but can be also considered as a threshold for strong behavioural disturbance (for the onset of a fleeing response). A detailed underwater sound modelling assessment was carried out to investigate the potential PTS and TTS to occur, using the latest assessment criteria (Volume 3, Annex 10.2: Underwater Sound Shared Technical Report). A project-specific Version 1 MMMP Volume 4, Annex 2: Marine Mammal Mitigation Protocol (MMMP) (Version 1) will be developed to mitigate the potential for injury (and will therefore also mitigate for mortality and physical injury). Standard industry measures would include: MMObs, PAM and ADD activation prior to clearance. Additional mitigation measures will also be considered if necessary to ensure any risk of injury is reduced as far as practically possible (paragraph 10.11.2.33).

10.11.2.10 It is anticipated that up to 15 UXOs within the Morven South Boundary may require clearance. The maximum UXO size is assumed to be 554kg NEQ and the most realistic maximum size is 132kg NEQ (Table 10.32). In line with the UK Government (2025) joint position statement the Applicant has committed to low order clearance. A clearance donor charge of 0.25kg NEQ is assumed for each low order clearance event. The clearance activities will be tide- and weather-dependent. The aim is to enable clearance of at least one UXO per 24 hours, during daylight hours and good visibility only.

10.11.2.11 Therefore, whilst the Applicant has committed to low order clearance, to adopt a precautionary approach the assessment has also considered high order detonation. High order detonation would only be required as a last resort in the event that low order clearance is unsuccessful following three attempts (JNCC, 2025a). Recent evidence from UXO clearance in the Moray Firth, however, provides high confidence that low order clearance will be successful (Ocean Winds, 2024) and therefore it is anticipated that high order detonation will not be required.

10.11.2.12 Auditory injury ranges for low-order clearance donor charge (0.25kg), and for high order detonation (554kg and 132kg), are presented in Table 10.51 for both the PK (dB re 1 μPa) and SEL (dB re 1 $\mu Pa^2 s$) metrics (NMFS, 2024). Injury ranges based on the PK metric were greatest for harbour porpoise (VHF cetacean), and those based on the SEL metric were greatest for minke whale/humpback whale (LF cetacean).

Table 10.51: Hearing group-specific AUD INJ thresholds for unweighted Peak and hearing weighted Sound Exposure Level and maximum potential effect ranges (R_{max} for PK and $R_{95\%}$ for weighted Sound Exposure Level) for low-order and high-order Unexploded Ordnance clearance/detonation

Hearing group	Metric	Auditory threshold[1]	Maximum horizontal distance (m) to threshold[2]		
			0.25kg	132kg	554kg
LF cetaceans	PK	222	30	2,100	2,960
	SEL	183	150	5,080	8,220
HF cetaceans	PK	230	N/E	690	1,680
	SEL	193	N/E	N/E	30
VHF cetaceans	PK	202	560	9,310	16,300
	SEL	159	20	870	1,640
PCW	PK	223	30	1,930	2,790
	SEL	183	30	1,750	2,810

[1] PK thresholds expressed as dB re 1 μPa, SEL thresholds expressed as dB re 1 $\mu Pa^2 s$.

[2] N/E indicates threshold not exceeded.

10.11.2.13 For low order clearance the assessment found that there would be a risk of injury over a maximum range of 560m for harbour porpoise using the PK metric (Table 10.51) for a 0.25kg NEQ. In case of high order detonation, the range for harbour porpoise may increase to 9,310m for a 132kg (NEQ) UXO, or 16,300m for a 554kg (NEQ) UXO.

10.11.2.14 The maximum number of animals predicted to experience PTS due to low order clearance and high order detonation (in the absence of mitigation) is presented in Table 10.52. These were calculated from the absolute density estimates and injury ranges summarised in Table 10.21 and Table 10.51, respectively.

10.11.2.15 The risk of injury to marine mammals from low order clearance was very low with no more than one animal potentially injured for all species, except bottlenose dolphin and white-beaked dolphin where the injury threshold was not exceeded (Table 10.52). Harbour porpoise was the species at greatest risk during high order detonation only; up to 500 animals (0.1% of the North Sea MU) could be injured (with no mitigation) during clearance of the largest UXO of 554kg (Table 10.52).

10.11.2.16 Note that density estimates are not available for humpback whale (an LF species), so an estimate of the number of animals potentially injured is not possible to quantify. However, given the low incidence of the species humpback whale in this region, it is likely that fewer individuals would be affected than the minke whale estimate and therefore the risk is very small.

Table 10.52: Maximum number of animals potentially injured due to low-order and high-order Unexploded Ordnance clearance/detonation

Species	Density (animals/km²)	Hearing group	Metric[1]	Number of animals[2]			Percentage of full MU population (UK population) for 554kg clearance
				0.25kg	132kg	554kg	
Minke whale	0.042	LF	PK	<1	1	2	0.01 (0.02)
			SEL	<1	4	9	0.04 (0.09)
Bottlenose dolphin	0.005	HF	PK	N/A	<1	1	0.049 (0.05)
			SEL	N/A	N/A	<1	0.049 (0.05)
White-beaked dolphin	0.080	HF	PK	N/A	1	1	0.002 (0.003)
			SEL	N/A	N/A	<1	0.002 (0.003)
Harbour porpoise	0.599	VHF	PK	1	164	500	0.1 (0.3)
			SEL	<1	2	6	0.002 (0.004)
Grey seal	0.252	PW	PK	<1	3	7	0.02
			SEL	<1	3	7	0.02
Harbour seal	1.20×10^{-7}	PW	PK	<1	<1	<1	0.2
			SEL	<1	<1	<1	0.2

[1] PK thresholds expressed as dB re 1 μPa, SEL thresholds expressed as dB re 1 $\mu Pa^2 s$

N/A not applicable since the auditory threshold for injury was not exceeded.

10.11.2.17 The auditory injury ranges for high order detonation do not overlap with any known important areas for any of the key species in this assessment. A summary of the distance from the Morven South Boundary to designated sites is presented in Table 10.53.

Table 10.53: Distance from Morven South Boundary to designated sites and hearing group-specific maximum ranges for onset of Auditory Injury

Hearing group	Designated site	Relevant species	Distance from Morven South(m)	Maximum injury range (m) for 554kg UXO	
				PK	SEL
LF cetaceans	Southern Trench ncMPA	Minke whale	90,800	2,960	8,220
HF cetaceans	Moray Firth SAC	Bottlenose dolphin	215,800	1,680	30
VHF cetaceans	Southern North Sea SAC	Harbour porpoise	135,100	16,300	1,640
PCW	Berwickshire and North Northumberland Coast SAC	Grey seal	97,200	2,790	2,810
	Isle of May SAC		108,600		
	Firth of Tay and Eden Estuary SAC	Harbour seal	109,300		
	Dornoch Firth and Morrich More SAC		253,500		

10.11.2.18 Maximum injury ranges presented for high order detonation in Table 10.51 are larger than the standard 1,000m MZ recommended for UXO clearance(JNCC, 2010b). There may, however, be difficulties in detecting marine mammals over large ranges in excess of 1,000m (McGarry *et al.*, 2017) with a significant decline in visual detection rate with increasing sea state (Embling *et al.*, 2010, Leaper *et al.*, 2015), particularly for smaller species like harbour porpoise.

10.11.2.19 Mitigation set out in the Version 1 MMMP therefore also includes the use of ADD activation (up to 30 minutes) to deter animals from the injury zone if high order detonation is required (Table 10.33). The efficacy of such deterrence will depend upon the device selected and reported ranges of effective deterrence vary. The reported effective deterrence range for harbour porpoise using an ADD varies from 2.5km out to 12km (Brandt *et al.*, 2013, Dähne *et al.*, 2017, Kyhn *et al.*, 2015, Olesiuk *et al.*, 2002, Phillips *et al.*, 2025). A full review of available devices given in Phillips *et al.* (2025), and will provide guidance on the most suitable device for this project.

10.11.2.20 Table 10.54 presents indicative displacement distances per species, based upon conservative swim speeds presented in Table 10.30. With 30 minutes of ADD, all species except for harbour porpoise will be deterred beyond the maximum instantaneous injury zone (PK metric).

Table 10.54: Indicative displacement distances using 30 minutes of Acoustic Deterrent Device activation for marine mammal receptors, assuming conservative swim speeds

Parameter	Potential displacement distance (m)				
	Minke whale	Bottlenose dolphin	White-beaked dolphin	Harbour porpoise	Grey seal
Maximum PK injury zone (554kg NEQ)	2,960	1,680	1,680	16,300	2,790
Swim speed (m/s)	2.3	1.52	1.52	1.5	1.8
30mins ADD	4,140	2,736	2,736	2,700	3,240
Move away beyond the maximum PTS range?	Yes	Yes	Yes	No	Yes

10.11.2.21 Magnitude is assessed considering designed-in measures including the use of low order clearance and standard industry mitigation. Morven South has committed to these measures in the MMMP Volume 4, Annex 2: Marine Mammal Mitigation Protocol (MMMP) (Version 1). For all species the impact is predicted to be of local spatial extent, very short-term duration, intermittent and the effect (injury) is of low reversibility. Implementation of the MMMP will reduce any risk of injury such that the magnitude will be negligible.

10.11.2.22 The quantification of effects presented here for a high order detonation found that for bottlenose dolphin, white-beaked dolphin, minke whale, humpback whale, grey seal and harbour seal the impact can be fully mitigated with industry standard measures applied, including the use of an ADD, and this has also been provided for in the Version 1 MMMP. There may, however, be a residual risk of injury to harbour porpoise from high order detonation since the effect range is beyond the distance that can be fully mitigation with an ADD. Given that details about the UXO clearance technique to be used and charge sizes will not be available until after the consent is granted (following a pre-construction UXO survey), it is not possible to quantify the effects of UXO detonations and therefore, a residual number of animals potentially impacted is not presented within this chapter. Final mitigation required will be agreed post-consent in consultation with MD-LOT and NatureScot and presented in a final MMMP, following more detailed information such as the size, number and quality of UXOs to be cleared (following site investigation surveys).

<u>Sensitivity of the receptor</u>

10.11.2.23 The main characteristic of the acoustic 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 10.2: Underwater Sound Shared Technical Report). In shallow water, interactions between the shock and acoustic waves create a complex pattern (von Benda-Beckmann *et al.*, 2015).

10.11.2.24 Sensitivity of marine mammal receptors to auditory injury from an impulsive underwater sound has been described previously in detail for piling (Section 10.11.1) and, whilst the threshold shifts are related to the frequency characteristics of the sound source, the overall sensitivity (i.e. animals responses to a hearing loss within their auditory range) may be similar regardless of the source.

10.11.2.25 There are limited studies that have assessed level of auditory risk to marine mammals, most focused on harbour porpoise. Von Benda-Beckmann *et al.* (2015) studied the range of effects of explosives on harbour porpoise in the southern North Sea. *In situ* noise measurements were taken at distances up to 2km from the high order detonation of seven UXOs located at approximately 26m to 28m depth on a sandy substrate, with charge weights of up to 263kg. Von Benda-Beckmann *et al.*

(2015) investigated the potential for noise-induced auditory injury to occur based on Lucke *et al.* (2009) threshold criteria of 190dB re. 1 μPa²s ('very likely to occur') and of 179dB re. 1 μPa²s (SEL) ('increasingly likely to occur'). Beyond the 2km range that was monitored during the study noise induced injury was 'very likely to occur' since the SEL recorded at this distance was 191dB re. 1 μPa²s (i.e. just breaching the 190dB re. 1 μPa²s threshold).

10.11.2.26 The same study also modelled possible effect ranges for 210 explosions (of up to 1,000kg charge mass) logged by the Royal Netherlands Navy and the Royal Netherlands Meteorological Institute over a two-year period (2010 and 2011). The authors validated the model using empirical measurements out to 2km and found that the effect distances ranged between hundreds of metres to just over 10km.

10.11.2.27 More recently, sound measurements collected near two detonations of UXO (with charge masses of 325kg and 140kg) indicated an auditory injury effect distance in the range 2.5km to 4km (Salomons *et al.*, 2021), using the weighted SEL values and threshold levels for PTS from Southall *et al.* (2019). When comparing the experimental data and model predictions presented by von Benda-Beckmann *et al.* (2015), Salomons *et al.* (2021) concluded that harbour porpoise may be 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.

10.11.2.28 Post-mortem examination of 24 harbour porpoise found that in ten cases the cause of death was associated with a blast injury. The injured harbour porpoise showed signs of internal bleeding around their lower jaw and head, and damage to the small bones in their ears (Siebert *et al.*, 2022). The charge masses of the explosives in this study were not known, however an overpressure level of 172kPa (equivalent to 190dB re. 1 μPa) may be sufficient to cause shock wave-induced ear trauma (von Benda-Beckmann *et al.*, 2015).

10.11.2.29 Harbour porpoises rely heavily on sound underwater, using echolocation to find food, navigate, and avoid hazards (e.g. fishing nets, vessels). When auditory injury occurs, they can become disoriented. In the study, one porpoise got caught in a fishing net, and another had bruising on one side of its body, possibly because they couldn't detect hazards due to hearing loss. Beyond direct physical trauma, secondary effects of explosions may include displacement, interruption of feeding, chronic stress, and immune suppression. Porpoises may suffer TTS or PTS in orientation and obstacle detection, increasing the risk of bycatch (Siebert *et al.*, 2022). The sensitivity of bottlenose dolphin, white-beaked dolphin and minke whale to UXO clearance is less well studied. During clearance of a 35kg charge at an important feeding area for a resident bottlenose dolphin population in Portugal, no adverse effects were recorded in their behaviour or appearance (dos Santos *et al.*, 2010). Acoustic pressure levels greater than 170dB re 1 μPa were measured, with pressure levels 60dB higher than ambient noise (see paragraph 10.8.3.5). Nonetheless, external injuries consistent with inner ear damage have been found in dolphin near to UXO clearance, with little change in surface animal behaviour. Suggesting, that while surface behaviour might not show any visible change, internal injuries can still occur (Ketten *et al.*, 1993).

10.11.2.30 Therefore, all receptors, are deemed to have limited resilience to PTS, low recoverability and adaptability and are of high international value. The sensitivity of the receptor is therefore considered to be high.

<u>Significance of the effect</u>

10.11.2.31 For all species, the magnitude of the impact from low order clearance is deemed to be negligible and the sensitivity of these receptors is considered to be high. The effect will therefore be of **minor adverse** significance, which is not significant in EIA terms.

10.11.2.32 Whilst the assessment has concluded no significant effect for UXO clearance (due to the implementation of designed-in measures), there remains some uncertainty regarding the nature of the UXO (size and type) to be removed from the Morven South Boundary. Therefore, the following section discusses consideration of secondary mitigation in the unlikely event that a high order detonation may be required.

Secondary mitigation and residual effect

10.11.2.33 Prior to the commencement of UXO clearance works, the Applicant will undertake a UXO risk assessment to fully understand the possible UXOs that require clearance including the size, type and number of UXOs. The measures needed to successfully clear the identified UXOs will be developed in accordance with relevant guidance. Where there is deemed to be a requirement for secondary mitigation measures, the efficacy and application of such measures will be discussed with stakeholders and proposed as a part the final MMMP for UXO clearance works see Volume 4, Annex 2: Marine Mammal Mitigation Protocol (MMMP) (Version 1). It is therefore anticipated that following receipt of more detail regarding size and number of UXO (and tailoring of secondary mitigation measures as described above), the risk of injury to harbour porpoise from the highly unlikely high order detonation will be reduced such that there would be no residual adverse effects.

Construction phase – behavioural disturbance

10.11.2.34 While 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. Suggested thresholds for the onset of behavioural disturbance from explosive detonation do exist (Finneran and Jenkins, 2012), but these are intended for repeated detonations over a 24-hour period. For single detonations, behavioural disturbance is likely to be limited to 'a short-lived startle reaction' (Finneran and Jenkins, 2012) and therefore specific behavioural disturbance thresholds may not be relevant for marine mammals exposed to single explosive events.

10.11.2.35 For single pulses such as UXO detonation the use of TTS onset as an auditory effect has been recommended (Southall *et al.*, 2007). TTS is a reversible hearing impairment in animals, with recovery expected once the noise impact has ceased. While the ecological effects of TTS-induced displacement are not fully understood, these temporary hearing losses may cause short-term disruptions to vital life functions, similar to PTS, but with less likelihood of acute effects. The impact depends on the severity of the hearing shift and the sound characteristics, with recovery speed and completeness varying accordingly. TTS onset triggers a fleeing response, marking the boundary between behavioural disturbance and physical auditory impact. Although TTS may temporarily inhibit some ecological functions, it is reversible and unlikely to cause long-term effects on individuals. Consequently, underwater sound modelling results for TTS onset are described as 'strong behavioural disturbance'.

Magnitude of impact

10.11.2.36 Strong disturbance ranges for low order clearance donor charge (0.25kg), and for high order detonation (554kg and 132kg), are presented in Table 10.55 for both the PK (dB re 1 μPa) and hearing weighted SEL (dB re 1 μPa^{2}s) metrics (NMFS, 2024). As for auditory injury (see Paragraph 10.11.2.11) strong disturbance ranges based on the PK metric were greatest for harbour porpoise (VHF cetacean), and those based on the SEL metric were greatest for minke whale/humpback whale (LF cetacean).

Table 10.55: Hearing group-specific Temporary Threshold Shift thresholds (unweighted Peak and hearing weighted Sound Exposure Levels) and maximum potential ranges ($R_{95\%}$) for strong behavioural disturbance from low-order and high-order Unexploded Ordnance clearance/detonation

Hearing group	Metric	Auditory threshold[1]	Maximum horizontal distance (m) to threshold[2]		
			0.25 kg	132 kg	554 kg
LF cetaceans	PK	216	90	2,830	4,420
	SEL	168	1,330	20,400	30,700
HF cetaceans	PK	224	30	1,590	2,480
	SEL	178	NE	200	290
VHF cetaceans	PK	196	125	14,900	22,300
	SEL	144	200	4,090	5,900
PCW	PK	217	90	265	412
	SEL	168	310	6,740	9,530

[1] PK thresholds expressed as dB re 1 μPa, SEL thresholds expressed as dB re 1 μPa^{2}s.

[2] N/E indicates threshold not exceeded.

10.11.2.37 The largest ranges using the PK metric were predicted for clearance of the 554kg NEQ with potential strong disturbance over a distance of up to 22,300m for harbour porpoise. Using the SEL metric the largest ranges were predicted for clearance of the 554kg NEQ with potential strong disturbance over a distance of up to 30,700m for LF cetaceans (minke whale and humpback whale). It should be noted that impulsive noise thresholds (TTS onset) were used in the underwater sound modelling for strong behavioural disturbance as a result of UXO clearance. However, as previously described in Paragraph 10.11.2.7, the sound is unlikely to be impulsive in character once it has propagated more than a few kilometres (Hastie *et al.*, 2019, NMFS, 2018).

10.11.2.38 The maximum number of animals predicted to experience strong behavioural disturbance due to low order clearance and high order detonation is presented in Table 10.56. These were calculated from the absolute density estimates and strong disturbance ranges summarised in Table 10.21 and Table 10.55, respectively.

Table 10.56: Maximum number of animals potentially experiencing strong behavioural disturbance due to low order and high order Unexploded Ordnance clearance/detonation

Species	Density (animals/km^2)	Hearing group	Metric	Number of animals[1]			Percentage of full MU population (UK population) for 554kg clearance
				0.25kg	132kg	554kg	
Minke whale	0.042	LF	PK	<1	2	3	0.01% (0.03%)
			SEL	<1	55	125	0.62% (1.22%)
Bottlenose dolphin	0.005	HF	PK	<1	<1	<1	0.05% (0.05%)
			SEL	N/A	<1	<1	0.05% (0.05%)
White-beaked dolphin	0.080	HF	PK	<1	1	2	0.005% (0.01%)
			SEL	N/A	<1	<1	0.002% (0.003%)
Harbour porpoise	0.599	VHF	PK	3	418	936	0.27% (0.59%)
			SEL	<1	32	66	0.02% (0.04%)
Grey seal	0.252	PW	PK	<1	6	14	0.04%
			SEL	<1	436	72	0.20%
Harbour seal	1.20×10^{-7}	PW	PK	<1	<1	<1	0.20%
			SEL	<1	<1	<1	0.20%

[1] N/A not applicable since the auditory threshold for injury was not exceeded.

10.11.2.39 The greatest numbers of animals predicted to experience strong behavioural disturbance were harbour porpoise, with up to 418 animals potentially injured by high order detonation of a 132kg UXO, and up to 936 animals potentially injured by high order detonation of a 554kg UXO (both for the PK metric). Up to 125 minke whale and 72 grey seal were predicted to experience strong behavioural disturbance, using the SEL metric (Table 10.56).

10.11.2.40 The TTS ranges do not overlap with any known important areas for any of the key species in this assessment. A summary of the distance from the Morven South Boundary to designated sites is presented in Table 10.57.

Table 10.57: Distance from Morven South Boundary to designated sites and hearing group-specific maximum ranges ($R_{95\%}$) for onset of strong behavioural disturbance

Hearing group	Designated site	Relevant qualifying species	Distance from Morven South (m)	Maximum disturbance range (m) for 554kg UXO	
				PK	SEL
LF	Southern Trench ncMPA	Minke whale	90,800	4,420	30,700
HF	Moray Firth SAC	Bottlenose dolphin	215,800	2,480	290
VHF	Southern North Sea SAC	Harbour porpoise	135,100	22,300	5,900
PW	Berwickshire and North Northumberland Coast SAC	Grey seal	97,200	412	9,530
	Isle of May SAC		108,600		
	Firth of Tay and Eden Estuary SAC	Harbour seal	109,300		
	Dornoch Firth and Morrich More SAC		253,500		

10.11.2.41 Any behavioural effects are reversible, and animals are anticipated to fully recover following cessation of the activity. It is, however, recognised that where designed-in mitigation applies to reduce the risk of auditory injury, the deterrence measures (i.e. ADD) by their nature would contribute to, rather than reduce, the moving away response. Thus, as part of this assessment it has been assumed that disturbance (leading to displacement) would occur during the 30-minute ADD activation period plus the 1 second UXO clearance event. This relates to high order detonation only as no ADD is required in respect of low order clearance.

10.11.2.42 For all species a small proportion of the relevant MUs is predicted to be affected by behavioural disturbance (Table 10.56). However, due to the very temporary nature of the disturbance event, and the small proportions of the respective MUs impacted any effects may be at an individual level, these are not predicted to be at a scale that would lead to any population-level effects.

10.11.2.43 As previously described in paragraph 10.11.2.11, the assessment considered the magnitude of a high order detonation for the MDS of 554kg NEQ. The impact (high order detonation) is predicted to be of regional spatial extent, very short-term duration (~30 minutes), intermittent and both the impact itself (i.e. the elevation in underwater sound during detonation event) and effect of disturbance is reversible (TTS represents a non-trivial disturbance but not permanent injury). The magnitude is therefore considered to be low for all species.

10.11.2.44 Magnitude is assessed considering designed-in measures including the use of low order clearance but no deterrence measures (i.e. ADD) would be required. Morven South has committed to these measures in the Version 1 MMMP Volume 4, Annex 2: Marine Mammal Mitigation Protocol (MMMP) (Version 1). For all species the impact is predicted to be of local spatial extent, very short-term duration, intermittent and the effect (strong behavioural disturbance) is of low reversibility.

Implementation of the MMMP will reduce any strong behavioural disturbance such that the magnitude will be negligible.

Sensitivity of the receptor

10.11.2.45 Scientific understanding of the biological effects of TTS on marine mammals is limited to the results of controlled exposure studies on small numbers of captive animals. Given the difference with the natural environment, and the inability of these small sample sizes to capture intra- and interspecific differences, extrapolating controlled-exposure results to free-living animals should be undertaken with caution.

10.11.2.46 The most likely response to a loud blast would be immediate displacement of animals from the ensonified area and changes in behaviour, for example the interruption of food intake (Siebert *et al.*, 2022). From the limited data available, the evidence points to a rapid recovery following exposure to loud impulsive sounds similar to those expected during high order UXO detonation. For example, recovery rates of harbour porpoise were measured following exposure to a piling playback sound source of 175dB re 1 $\mu Pa^2 s$ (SEL) over 120 minutes. Recovery to the pre-exposure threshold was estimated to occur within 48 minutes following exposure, and the higher the hearing threshold shift, the longer the recovery (SEAMARCO, 2011).

10.11.2.47 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 reviewed in Finneran (2015), which measured TTS occurrence in harbour porpoise (VHF cetacean) at a range of frequencies typical of high-amplitude anthropogenic sounds, the greatest shift in mean TTS occurred at 0.5 kHz with hearing recovery within 60 minutes after the fatiguing sound stopped.

10.11.2.48 Experimental exposure of two captive bottlenose dolphin to sounds simulating distant underwater explosions indicated no TTS greater than 6dB at sound levels up to 221dB re 1 µPa (Finneran *et al.*, 2000). Behavioural changes, such as delaying approach and avoiding certain areas, were observed at lower sound levels (196dB and 209dB re 1 µPa) and persisted at higher levels. However, the use of distant, masked signals and trained animals conditioned to tolerate high noise levels, may suggest that behavioural disruptions could occur at lower levels in untrained free-living animals (Nowacek *et al.*, 2007).

10.11.2.49 In the absence of species-specific recovery rates to TTS for other cetaceans including white-beaked dolphin, minke whale and humpback whale it has been assumed that this would be similar harbour porpoise as the most sensitive species.

10.11.2.50 Regarding pinnipeds, Kastelein *et al.* (2018) measured recovery rates of harbour seal following exposure to a sound source of 193 dB re 1 $\mu Pa^2 s$ (SEL_{cum}) over 360 minutes and found that recovery from TTS to the pre-exposure baseline was estimated to be complete within 72 minutes following exposure. To note, this is a significantly longer exposure than would be expected from a UXO clearance event, which typically involves approximately a 1-second exposure. These are in line with findings reported in SEAMARCO (2011), which showed that for small TTS values, recovery in seal species was very fast (around 30 minutes). Ketten (1995) also reported relatively fast recovery, with full hearing recovery within two hours following exposure.

10.11.2.51 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. Nevertheless, the findings of studies presented in this section indicate that seal species are less vulnerable to TTS than the harbour porpoise for the sound bands tested.

10.11.2.52 In summary, all marine mammal species considered are deemed to have some resilience to strong behavioural disturbance, high recoverability, and high international value. The sensitivity of the receptor to TTS is, therefore, considered to be low.

Significance of the effect

10.11.2.53 Overall, for all species the magnitude of the behavioural disturbance from subsea noise during UXO clearance is deemed to be negligible and the sensitivity of all receptors is considered to be low. The overall significance of the effect is negligible or minor. Due to the very short duration of the impact (~1 second) and high reversibility, the effect was determined to be of **negligible adverse** significance, which is not significant in EIA terms.

Secondary mitigation and residual effect

10.11.2.54 Whilst the assessment has concluded no significant effect for UXO clearance (due to the implementation of designed-in measures), there remains some uncertainty regarding the nature of the UXO (size and type) to be removed from the Morven North Boundary. However, given the very short term and reversible nature of the behavioural effect of underwater sound during UXO clearance (low or high order) there is no further mitigation required with respect to this.

10.11.3 Injury and disturbance to marine mammals from site investigation surveys

10.11.3.1 Geophysical and geotechnical site investigation surveys during the construction phase have the potential to cause disturbance on marine mammal receptors (Table 10.32). A detailed underwater sound modelling assessment has been carried out to investigate the potential for behavioural effects on marine mammals as a result of those activities identified as having the potential to cause an acoustic impact (primarily geophysical surveys), using the latest criteria (Volume 3, Annex 10.2: Underwater Sound Shared Technical Report). The assessment considers several sonar-like sources that may be used for the geophysical surveys, including Multibeam Echo Sounder (MBES), side Scan Sonar (SSS), Sub-Bottom Profiler (SBP (CHIRP 2kHz and 3.5kHz)), Single Beam Echo-Sounder (SBES) and UHRS. The equipment likely to be used, can typically work at a range of signal frequencies depending on the distance to the seabed and the required resolution. For sonar-like sources the signal is highly directional, acts like a beam and is emitted in pulses. Sonar-based sources are considered by the NMFS (2018) as intermittent (non-impulsive) because they generally comprise a single (or multiple discrete) frequency. Unlike the sonar-like survey sources, the UHRS is likely to utilise a sparker, which produces an impulsive, broadband source signal. The survey parameters, such as source sound levels used in the underwater sound modelling are presented in detail in Volume 3, Annex 10.2: Underwater Sound Shared Technical Report.

10.11.3.2 The site investigation surveys, as listed in Table 10.32 will take place during the pre-construction period, involving up to two vessels on site at any one time. A maximum of up to 156 vessel movements (return trips) will take place in total across all geophysical and geotechnical site investigation surveys during the pre-construction phase.

10.11.3.3 The MDS comprises routine geophysical surveys such as MBES and SBES which will also take place during the operation and maintenance phase. There will be no geotechnical surveys undertaken post construction. Routine geophysical surveys will typically be undertaken every three years except for the inter-array cables and interconnectors where surveys will occur annually for the first five years, and every four years thereafter. Up to four survey vessels will be on site at any one time, involving 60 vessel return trips per year.

Pre-construction phase – Auditory Injury

Magnitude of impact

10.11.3.4 For underwater sound modelling of geophysical equipment, the approach was to apply the impulsive source thresholds when evaluating peak sound levels as per (NMFS, 2024). This precautionary approach was advised by Scottish Ministers, in line with the NatureScot representation, during the Scoping Opinion (Table 10.15).

10.11.3.5 The auditory injury range across all geophysical surveys was estimated as 0.09km for grey seal and harbour seal, based on SEL_{24h} (CHIRP 3.5kHz; Table 10.58). For bottlenose dolphin, white-beaked dolphin, minke whale, humpback whale and harbour porpoise the maximum effect range is estimated out to 0.181km, based on SEL_{24h} (MBES; Table 10.58). However, it should be noted that as sonar-like sources have very strong directivity, there is only potential for auditory injury when a marine mammal is directly underneath the noise source. Once the animal moves outside of the main beam, there is no potential for injury.

10.11.3.6 The number of marine mammals potentially experiencing auditory injury within the modelled auditory injury ranges were estimated using species-specific density estimates for the PK metric (Table 10.59) and the SEL_{24h} metric (Table 10.60). Given that the potential effect ranges are small, no more than one animal of each species is deemed to be at risk of experiencing auditory injury across all types of geophysical surveys (Table 10.59; Table 10.60).

10.11.3.7 Note that density estimates are not available for humpback whale (an LF species), so an estimate of the number of animals potentially injured is not possible to quantify. However, given the low incidence of the species humpback whale in this region, it is likely that fewer individuals would be affected than the minke whale estimate and therefore the risk is very small.

10.11.3.8 The auditory injury ranges will not overlap with any known designated areas for any of the species (Table 10.24).

Table 10.58: Maximum horizontal distances in kilometres from the geophysical sources to maximum-over-depth peak (PK) and maximum-over-depth sound exposure level impact thresholds for marine mammals from NMFS (2024a)

Hearing group	Metric	Non-impulsive						Impulsive	
		Auditory threshold	Distance (km)					Auditory threshold	Distance (km)
			MBES	SSS	SBES	CHIRP 2.0kHz	CHIRP 3.5kHz		Sparker
LF cetaceans	PK	222	0.015	0.004	0.007	-	0.007	222	-
	SEL	197	-	-	0.002	0.003	0.071	183	0.016
HF cetaceans	PK	230	0.007	0.002	0.002	-	0.003	230	-
	SEL	201	0.016	0.002	0.003	-	0.039	193	-
VHF cetaceans	PK	202	0.105	0.032	0.007	0.006	0.064	202	0.009
	SEL	181	0.181	0.036	0.007	-	0.114	159	-
PCW	PK	223	0.014	0.004	0.005	-	0.006	223	-
	SEL	195	0.058	-	0.005	0.003	0.091	168	0.004

Table 10.59: Estimated number of animals, percentage of the population (United Kingdom and full Management Unit) with the potential to experience Auditory Injury, based on maximum-over-depth peak (Peak), during geophysical site investigation surveys. NA denotes Not Applicable

Hearing Group	Species	Density (animals/km^2)	Metrics	Number of animals					
				MBES	SSS	SBES	CHIRP 2.0kHz	CHIRP 3.5kHz	Sparker
LF	Minke whale	0.042	Number of animals	<1	<1	<1	-	<1	-
			% of UK portion of the MU	<0.001	<0.001	<0.001	-	<0.001	-
			% of full MU	<0.001	<0.001	<0.001	-	<0.001	-
HF	Bottlenose dolphin	0.005	Number of animals	<1	<1	<1	-	<1	-
			% of UK portion of the MU	<0.001	<0.001	<0.001	-	<0.001	-
			% of full MU	<0.001	<0.001	<0.001	-	<0.001	-
HF	White-beaked dolphin	0.080	Number of animals	<1	<1	<1	-	<1	-
			% of UK portion of the MU	<0.001	<0.001	<0.001	-	<0.001	-
			% of full MU	<0.001	<0.001	<0.001	-	<0.001	-
VHF	Harbour porpoise	0.599	Number of animals	<1	<1	<1	<1	<1	<1
			% of UK portion of the MU	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
			% of full MU	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
PW	Grey seal	0.252	Number of animals	<1	<1	<1	-	<1	-
			% of UK portion	<0.001	<0.001	<0.001	-	<0.001	-

Hearing Group	Species	Density (animals/km²)	Metrics	Number of animals					
				MBES	SSS	SBES	CHIRP 2.0kHz	CHIRP 3.5kHz	Sparker
			of the MU						
			% of full MU	NA	NA	NA	-	NA	-
PW	Harbour seal	1.20 x 10 $^{-7}$	Number of animals	<1	<1	<1	-	<1	-
			% of UK portion of the MU	<0.001	<0.001	<0.001	-	<0.001	-
			% of full MU	NA	NA	NA	-	NA	-

Table 10.60: Estimated number of animals, percentage of the population (United Kingdom and full Management Unit) with the potential to experience Auditory Injury, based on SEL_{24h}, during geophysical site investigation surveys. NA denotes Not Applicable

Hearing Group	Species	Density (animals/ km²)	Metrics	Number of animals					
				MBES	SSS	SBES	CHIRP 2.0kHz	CHIRP 3.5kHz	Sparker
LF	Minke whale	0.042	Number of animals	-	-	<1	<1	<1	<1
			% of UK portion of the MU	-	-	<0.001	<0.001	<0.001	<0.001
			% of full MU	-	-	<0.001	<0.001	<0.001	<0.001
HF	Bottlenose dolphin	0.005	Number of animals	<1	<1	<1	-	<1	-
			% of UK portion of the MU	<0.001	<0.001	<0.001	-	<0.001	-
			% of full MU	<0.001	<0.001	<0.001	-	<0.001	-
HF	White-beaked dolphin	0.080	Number of animals	<1	<1	<1	-	<1	-
			% of UK portion of the MU	<0.001	<0.001	<0.001	-	<0.001	-
			% of full MU	<0.001	<0.001	<0.001	-	<0.001	-

Hearing Group	Species	Density (animals/km^2)	Metrics	Number of animals					
				MBES	SSS	SBES	CHIRP 2.0kHz	CHIRP 3.5kHz	Sparker
VHF	Harbour porpoise	0.599	Number of animals	<1	<1	<1	-	<1	-
			% of UK portion of the MU	<0.001	<0.001	<0.001	-	<0.001	-
			% of full MU	<0.001	<0.001	<0.001	-	<0.001	-
PW	Grey seal	0.316	Number of animals	<1	-	<1	<1	<1	<1
			% of UK portion of the MU	<0.001	-	<0.001	<0.001	<0.001	<0.001
			% of full MU	NA	-	NA	NA	NA	NA
PW	Harbour seal	4.88 x 10-16	Number of animals	<1	<1	<1	<1	<1	<1
			% of UK portion of the MU	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
			% of full MU	NA	NA	NA	NA	NA	NA

10.11.3.9 The impact (elevated underwater sound during site investigation surveys) is predicted to be of local spatial extent, short-term duration, intermittent, and although the impact itself is reversible (i.e. the elevation in underwater sound only occurs during surveys), the effect of auditory injury is permanent. It is predicted that the impact will affect the marine mammal receptor directly. Since the injury is presumed to be fully mitigated via designed -in measures, there is considered to be no residual risk of injury and therefore no population-level effects; the magnitude of impact is therefore considered to be negligible for all marine mammal receptors.

10.11.3.10 As part of the designed-in measures (Table 10.33) standard mitigation Volume 4, Annex 2: Marine Mammal Mitigation Protocol (MMMP) (Version 1) from JNCC (2017) will be adhered to for the geophysical surveys, which will involve the use of MMObs/PAM monitoring (Table 10.34). Where operating mode of the equipment allows, soft starts will be applied for electromagnetic equipment (such as SBP and SSS) as well as seismic sources (UHRS).

Sensitivity of the receptor

10.11.3.11 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 4 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). For context, Tier 1 refers to high-energy airgun surveys with a total volume larger than 1,500 in or arrays with more than 12 airguns, Tier 2 covers the remaining low/intermediate energy airgun and Tier 3 covers most non-airgun seismic sources, which either have characteristics that do not meet the de minimis category (e.g., some sparkers) or could not be fully evaluated in Ruppel *et al.* (2022) (e.g., bubble guns, some boomers). The study also suggested surveys that simultaneously deploy multiple, non-impulsive de minimis sources are unlikely to result in incidental take of marine mammals. All geophysical sources used, in Morven North MBES, SSS, SBES, and both CHIRP systems, are classified as Tier 4, while the sparker may fall into either Tier 3 or Tier 4 depending on its energy output and configuration.

10.11.3.12 Although the likelihood of any marine mammals experiencing auditory injury is minimal, all species considered are deemed to have limited resilience (tolerance) to auditory injury, and limited ability for the receptor to recover (recoverability). The sensitivity of all species is therefore considered to be medium.

Significance of the effect

10.11.3.13 Overall, for all marine mammal receptors, the magnitude of the impact for injurious effects due to elevated sound during pre-construction site investigation surveys is deemed to be negligible and the sensitivity is considered to be medium. The overall significance of the effect is negligible or minor. **Negligible adverse** significance has been concluded, since injury can be fully mitigated with designed-in measures.

Secondary Mitigation and Residual Effect

10.11.3.14 No mitigation measures for marine mammals are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 10.33), is not significant in EIA terms.

Pre-construction phase – behavioural disturbance

Magnitude of impact

10.11.3.15 For intermittent sources (including impulsive and non-impulsive) the underwater sound modelling adopted the National Oceanic and Atmospheric Administration (NOAA) (2019) thresholds with an SPL of 160dB. The underwater sound modelling predicted that the behavioural effects as a result of site investigation surveys can occur within a range of between 0.229km (SSS) and up to 3.80km (CHIRP 3.5kHz) (Table 10.61).

10.11.3.16 For the site investigation surveys, no more than one animal is predicted to be disturbed during MBES, SSS, SBES, CHIRP 2.0kHz and sparker. With the use of the CHIRP 3.5kHz, up to two minke whale, one bottlenose dolphin, four white-beaked dolphin, 27 harbour porpoise, 12 grey seal and up to one harbour seal are at risk of experiencing disturbance and would therefore only affect very small proportions of the relevant MUs (Table 10.61). The underwater sound model assumes the 3.5kHz CHIRP source emits sound equally in all directions due to its wide beam width, simplifying calculations but likely causing an overestimation of how far sound travels. A more accurate model would require detailed beam pattern data, but in its absence, this conservative approach ensures potential impacts are not underestimated.

10.11.3.17 Note that density estimates are not available for humpback whale (an LF species), so an estimate of the number of animals potentially disturbed is not possible to quantify. However, given the low incidence of the species humpback whale in this region, it is likely that fewer individuals would be affected than the minke whale estimate and therefore the risk is very small.

10.11.3.18 However, for those animals disturbed, there is likely to be a proportional response, i.e. not all animals will be disturbed to the same extent. There is no dose-response curve available to apply in the context of site investigation surveys. However, Joy *et al.* (2019) derived a dose-response for killer whale and underwater sound from vessels, indicating that marine mammals display a proportional response to non-impulsive sound. It is important to note that the life history of an individual and the context (ambient sound) will also influence the likelihood of an individual to exhibit an aversive response to sound (Southall *et al.*, 2021). Considering therefore that the underwater sound modelling used a single threshold which assumes all animals are disturbed within this area the numbers of animals presented for site investigation surveys are likely to be an overestimate (Table 10.62).

10.11.3.19 The behavioural disturbance ranges will not overlap with any known designated areas for any of the species (Table 10.24).

Table 10.61: Morven South maximum horizontal distances in kilometres from the geophysical sources to behavioural threshold for marine mammals from intermittent (impulsive and non-impulsive) sources from NMFS (2024a)

Survey type	Potential disturbance range (km) for all species
Geophysical Surveys	
MBES	0.682
SSS	0.229
SBES	0.153
CHIRP 2.0kHz	0.316
CHIRP 3.5kHz	3.798
Sparker	0.501

Table 10.62: Estimated number of animals, percentage of the population (UK and full MU) with the potential to be disturbed during geophysical site investigation surveys. NA denotes Not Applicable

Hearing Group	Species	Density (animals/km^2)	Metrics	Number of animals					
				MBES	SSS	SBES	CHIRP 2.0kHz	CHIRP 3.5kHz	Sparker
LF	Minke whale	0.042	Number of animals	<1	<1	<1	<1	2	<1
			% of UK portion of the MU	0.0006	0.0001	<0.0001	0.0001	0.018	0.0003
			% of full MU	0.0003	0.003	<0.0001	0.0001	0.01	0.002
HF	Bottlenose dolphin	0.005	Number of animals	<1	<1	<1	<1	1	<1
			% of UK portion of the MU	0.0004	<0.0001	<0.0001	0.0001	0.012	0.0002
			% of full MU	0.0004	<0.0001	<0.0001	0.0001	0.011	0.0002
HF	White-beaked dolphin	0.080	Number of animals	<1	<1	<1	<1	4	1
			% of UK portion of the MU	0.0003	<0.0001	<0.0001	0.0001	0.011	0.0002
			% of full MU	0.0003	<0.0001	<0.0001	0.0001	0.008	0.0001
VHF	Harbour porpoise	0.599	Number of animals	1	<1	<1	<1	27	1
			% of UK portion of the MU	0.001	0.0001	0.0003	0.0001	0.017	0.0003
			% of full MU	0.0003	0.00003	0.00001	0.00005	0.0078	0.0001
PW	Grey seal	0.316	Number of animals	1	<1	<1	1	12	1
			% of UK portion of the MU	0.001	0.0001	0.0001	0.0001	0.031	0.0005
			% of full MU	NA	NA	NA	NA	NA	NA

Hearing Group	Species	Density (animals/km^2)	Metrics	Number of animals					
				MBES	**SSS**	**SBES**	**CHIRP 2.0kHz**	**CHIRP 3.5kHz**	**Sparker**
PW	Harbour seal	4.88 x 10^{-16}	Number of animals	<1	<1	<1	<1	<1	<1
			% of UK portion of the MU	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
			% of full MU	NA	NA	NA	NA	NA	NA

10.11.3.20 The impact (elevated underwater sound during site investigation surveys) is predicted to be of local to regional spatial extent, short-term duration, intermittent, and the effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after surveys have ceased). It is predicted that the impact will affect the marine mammal receptor directly. Whilst there may be effects at an individual level, the proportion of the respective MUs affected would be very small/negligible and not at a scale that would lead to any population-level effects. The magnitude of impact was conservatively considered to be low.

Sensitivity of the receptor

10.11.3.21 It is widely recognised that the transmission frequencies of commercial sonar systems (approximately 12kHz to 1,800kHz) overlap with the hearing ranges of multiple marine mammal species (Richardson *et al.*, 1995). Many frequencies associated with sonar systems are very high and have peak frequencies well above marine mammal hearing ranges.

10.11.3.22 Ruppel *et al.* (2022) reported that in response to sonar-like sound sources (e.g. MBES, SBES), marine mammals may show subtle behavioural responses, although species, behavioural context, location, and prey availability are likely to play more of a role than the acoustic signals themselves. In a study undertaken by MacGillivray *et al.* (2014), seven acoustic sources (including air guns, SBP, MBES and SSS) were compared, and the sound level above hearing threshold was documented as a function of horizontal distance. Weighting sounds according to hearing sensitivity allows assessment of relative risks associated with exposure, and whilst this analysis did not directly relate to the potential for behavioural responses, it allowed comparison of modelled acoustic sources. The modelling undertaken in MacGillivray *et al.* (2014) suggested that odontocetes were most likely to hear sounds from mid-frequency sources (such as fisheries, communication, and hydrographic systems), whilst mysticetes, were most likely to hear sounds from LF sources (SBP and airguns), and pinnipeds from both mid and LF sources. For all species included within the study, modelled sensation levels were lowest for the HF sources (e.g. SSS and MBES), which operate at the upper limits of the audible spectrum.

10.11.3.23 A recent study by Kates Varghese *et al.* (2021) on MBES surveys showed that the only marine mammal behaviour that was identified as changing was vocalisation rate, with neither changes in displacement nor foraging being observed. Similarly, Quick *et al.* (2017) reported that tagged short-finned pilot whale (*Globicephala macrorhynchus*) that were exposed to a SBES did not change their foraging behaviour, but variance in directionality of movement was observed, suggesting increased vigilance whilst the SBES was active. It was, however, stated 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. A study by Cholewiak *et al.* (2017) investigated the impact of SBES on toothed whale and reported that fewer beaked whale vocalisations were recorded when the source was actively transmitting. This suggested that animals either move away from the area or reduced foraging activity (although findings were not statistically significant).

10.11.3.24 Many studies to date have focused on the effects of multi-array seismic surveys on marine mammals, and therefore there is less widely available evidence for behavioural responses to seismic sources (e.g. MBES, SSS, SBPs). Multi-array impulsive sound sources are broadband in character (i.e. produce sound across a wide range of frequencies), unlike seismic sources, which typically produce more tonal sound either at a discrete frequency or a range of discrete frequencies. However, findings from studies of multi-array impulsive sources may be useful in supporting predictions of behavioural responses of marine mammals to geophysical survey sources in general, given the overlap of parameters that typically characterise sound sources (i.e. transmission frequency; source level; pulse duration) (see MacGillivray *et al.*, 2014, Ruppel *et al.*, 2022). Whilst evidence on the behavioural responses to MBES is limited, an Independent Scientific Review Panel deemed a 12kHz MBES to be the most plausible trigger for an extreme behavioural response in melon-headed whale (*Peponocephala electra*), 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).

10.11.3.25 Thompson *et al.* (2013) used PAM and DAS to study changes in the occurrence of harbour porpoise across a 2,000km^2 study area during a commercial two-dimensional seismic survey in the North Sea. Although site investigation surveys are considered to be lower in impact magnitude in comparison to seismic, it is useful to consider small seismic sources for context. Thompson *et al.* (2013) found that 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 survey period (ten days) suggesting exposure led to some tolerance of the activity (Thompson *et al.,* 2013). The authors suggested that prolonged seismic survey sound did not lead to broader-scale displacement into sub-optimal or higher risk habitat. Similarly, a ten-month study of overt responses to seismic exploration in humpback whale, sperm whale *Physeter macrocephalus* and Atlantic spotted dolphin (*Stenella frontalis*), demonstrated no evidence of prolonged or large-scale displacement of each species from the region during the survey (Weir , 2008).

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

10.11.3.27 It is expected that, to some extent, all marine mammal receptors will be able to withstand temporary elevated levels of underwater sound during site investigation surveys, and any behavioural responses are highly context specific.

10.11.3.28 All marine mammal receptors are deemed to have the ability to avoid or adapt behaviour, some tolerance (resilience) to behavioural disturbance, and the ability to recover from any impact. The sensitivity of the marine mammal receptor is therefore, considered to be low.

Significance of the effect

10.11.3.29 Overall, for all marine mammal receptors, the magnitude of the impact for behavioural effects due to elevated sound during pre-construction site investigation surveys is deemed to be low and the sensitivity is considered to be low. The overall significance of the effect is negligible or minor. **Negligible adverse** significance has been concluded, on the basis that effects are very localised, intermittent and highly reversible and affect a very small/negligible proportion of the relevant MUs.

Secondary mitigation and residual effect

10.11.3.30 No mitigation measures for marine mammals are considered necessary because the likely effect in respect of injury or disturbance to marine mammals during site investigation surveys in the absence of further mitigation (beyond the designed-in measures outlined in Table 10.33), is not significant in EIA terms.

Operations and maintenance phase – Auditory Injury

Magnitude of impact

10.11.3.31 The potential impacts from auditory injury due to elevated underwater sound during site investigation surveys is expected to be similar as for the pre-construction phase described in Paragraph 10.11.3.4 *et seq.*

10.11.3.32 The impact (elevated underwater sound during site investigation surveys) is predicted to be of local spatial extent, short-term duration, intermittent, and although the impact itself is reversible (i.e. the elevation in underwater sound only occurs during surveys), the effect of auditory injury is permanent. It is predicted that the impact will affect the marine mammal receptor directly. Since the injury is presumed to be fully mitigated via designed -in measures, there is considered to be no residual risk of injury and therefore no population-level effects; the magnitude of impact is therefore considered to be negligible for all marine mammal receptors.

Sensitivity of the receptor

10.11.3.33 The sensitivity of the marine mammal receptors during the operation and maintenance phase is not expected to differ from the sensitivity of the marine mammal receptors during the pre-construction phase. Therefore, the sensitivity of marine mammal receptors to elevated underwater sound during site investigation surveys (auditory injury and behavioural disturbance) is as described previously in paragraph 10.11.3 *et seq*., where it has been assessed as medium for injury.

Significance of the effect

10.11.3.34 Overall, for all marine mammal receptors, the magnitude of the impact for injurious effects due to elevated noise during site investigation surveys in the operation and maintenance phase is deemed to be negligible and the sensitivity is considered to be medium. The overall significance of the effect is negligible or minor. **Negligible adverse** significance has been concluded, as any potential auditory injury is unlikely to impact individuals in a way that would result in population-level effects.

Secondary Mitigation and Residual Effect

10.11.3.35 No mitigation measures for marine mammals are considered necessary because the likely effect in the absence of further mitigation (beyond the designed-in measures outlined in Table 10.33), is not significant in EIA terms.

Operations and maintenance phase – behavioural disturbance

Magnitude of impact

10.11.3.36 The magnitude of potential impacts for behavioural disturbance to marine mammals is described in Paragraph 10.11.3.15 *et seq*. In terms of behavioural disturbance, although the underwater sound from geophysical surveys could result in a negligible alteration to the distribution of marine mammals, these surveys are anticipated to be short-term in nature, targeted to localised areas and occur intermittently over the operation and maintenance phase. Therefore, the impact is likely to be the same or less (due to highly targeted short surveys) than the impact assessed in the pre-construction phase.

10.11.3.37 For the behavioural disturbance, the impact (elevated underwater sound during the geophysical surveys) is predicted to be of local to regional spatial extent within the relevant geographic range of reference, short-term duration, intermittent and 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 marine mammal receptor directly. Whilst there may be effects at an individual level, the proportion of the respective MUs affected would be very small/negligible and not at a scale that would lead to any population-level effects. The magnitude of impact was conservatively considered to be low.

Sensitivity of the receptor

10.11.3.38 The sensitivity of the marine mammal receptors during the operation and maintenance phase is not expected to differ from the sensitivity of the marine mammal receptors during the pre-construction phase. Therefore, the sensitivity of marine mammal receptors to elevated underwater sound during site investigation surveys (auditory injury and behavioural disturbance) is as described previously in paragraph 10.11.3.21 *et seq*., where it has been assessed as low for behavioural disturbance.

Significance of the effect

10.11.3.39 Overall, for all marine mammal receptors, the magnitude of the impact for behavioural effects due to elevated noise during site investigation surveys in the operation and maintenance phase is deemed to be low and the sensitivity is considered to be low. The overall significance of the effect is negligible or minor. **Negligible adverse** significance has been concluded, the basis that effects are very localised, intermittent and highly reversible and affect a very small/negligible proportion of the relevant MUs. The effect is not significant in EIA terms.

Secondary mitigation and residual effect

10.11.3.40 No mitigation measures for marine mammals are considered necessary because the likely effect in respect of injury or disturbance to marine mammals during site investigation surveys in the absence of further mitigation (beyond the designed-in measures outlined in Table 1.15), is not significant in EIA terms.

10.11.4 Injury and disturbance to marine mammals from vessel use and other non-piling sound-producing activities

10.11.4.1 Increased vessel movements and other non-piling sound producing activities associated with Morven South have the potential to result in a range of effects to marine mammals such as injury, avoidance behaviour, displacement, masking of vocalisations or changes in vocalisation rate. Whilst disturbance may result from both the presence of vessels and the sound emissions, at present it is not possible to disentangle the effect from presence versus sound, therefore the assessment has focused on the risk of disturbance due to the sound emissions.

10.11.4.2 Modelling was undertaken based on the MDS as outlined in Table 10.32 with a detailed assessment provided in Volume 3, Annex 10.2: Underwater Sound Shared Technical Report. Numbers have been provided for the construction phase and O&M phase only; vessels involved in decommissioning were assumed to be similar to those used in construction although the impacts will be of a smaller magnitude (i.e. fewer vessels and fewer trips) and therefore decommissioning vessels have not been modelled separately.

10.11.4.3 Numerous vessels (and activities) will occur throughout all phases of Morven South and whilst it is infeasible to reflect all combinations of vessels, four representative (and maximum adverse) scenarios have been modelled to provide an indication of the likely radiated sound fields for the main operations:

- foundation installation;
- wind turbine installation;
- cable laying;
- crew transfer.

10.11.4.4 The four scenarios are calculated for the high-reflectivity seabed, which is the most conservative case. Details of the modelled scenarios, vessels and activities are summarised in Table 10.63, and a full account of the modelling is presented in Volume 3, Annex 10.2: Underwater Sound Shared Technical Report.

10.11.4.5 Impacts from non-vessel sound producing activities (such as rock dumping, dredging) fall within the envelope modelled for the vessels; i.e. where the vessel noise dominates, only vessel noise is modelled. For trenching, the worst-case sound from the activity itself is incorporated in the source and radiated sound levels (see Volume 3, Annex 10.2: Underwater Sound Shared Technical Report for details). Drilling falls within the maximum design envelope for foundation installation where piling would lead to greater impact ranges in Section 10.11.1.

Table 10.63: Summary of modelled vessel scenarios

Scenario	Phase	Vessel	Activity	Description
Foundation installation	Construction	Pile installation vessel	Dynamic positioning	Installation vessels (pile and jacket) are close to the pile location and modelled using dynamic positioning, with tugs moving at low speed (3kts) whilst the guard vessel 1km from site transiting at a higher speed (10kts).
		Jacket installation vessel	Dynamic positioning	
		Tugs	Barge handling	
		Guard vessel	Orbiting	
Wind turbine installation	Construction	Wind turbine installation vessel	Dynamic positioning	Installation vessel and offshore support vessel are close to the pile location and using dynamic positioning whilst the guard vessel is 1km from the site transiting at a higher speed (10kts).
		Offshore support vessel	Dynamic positioning	
		Guard vessel	Orbiting	
Cable laying	Construction	Trenching vessel	Trenching	Precautionary scenario of trenching and cable laying being performed by two separate vessels; trenching vessel and cable laying vessel (with dynamic positioning) with an offshore support vessel (with dynamic positioning) and an orbiting guard vessel 1km from the site (transiting at speed of 10kts).
		Cable lay vessel	Dynamic positioning	
		Support vessel	Dynamic positioning	
		Guard vessel	Orbiting	
Crew transfer	Construction; O&M	Crew transfer vessel	Transit to/from site	Single transiting CTV at a transit speed of 10 kts.

Construction phase – Auditory Injury

10.11.4.6 Injury thresholds (AUD INJ) are based upon hearing group-specific frequency weightings (NMFS, 2024) and a conservative assumption has been made that all individuals will respond aversively to increases in vessel noise (i.e. that there is no intra or interspecific variation or context-dependent differences such as ambient sound level). Sound exposure (SEL_{24h}) has been estimated for each modelled vessel scenario based on 24 hours continuous operation. Modelling considers animals swimming at the depth providing the highest sound levels and does not consider surfacing for breathing.

Magnitude of impact

10.11.4.7 During the construction phase, the increased levels of vessel activity will contribute to background underwater noise levels. The MDS for construction activities (Table 10.32) assumes a total of up to 41 vessels to be present within the Morven South Boundary at any one time. This is likely to be an absolute maximum as there will be up to 3,060 return trips across the five year offshore construction period (average of 595.8 return trips per year = 11.5 trips per week). Vessel types include main installation and support vessels, tug/anchor handlers, cable lay installation & support vessels, guard vessels, survey vessels, seabed preparation vessels for boulder removal, grapnel, pre-sweep/levelling, crew transfer vessels, scour protection installation vessels and cable protection installation vessels.

10.11.4.8 The detailed vessel baseline environment is detailed in Volume 2 Chapter 13: Shipping and Navigation, and Volume 3, Annex 13.1: Shipping and Navigation Shared Navigational Risk Assessment. Two 14-day vessel traffic surveys (comprising AIS, radar and visual observation surveys) were undertaken in summer 2024 (20 June 2024 to 04 July 2024: 14 days) and one in winter

2024 (26 November 2024 to 13 December 2024: 14 days[3]). Table 10.64 summarises the vessel baseline for these survey periods, with Figure 10.22 and Figure 10.23 showing density heat maps of vessel traffic data by type for summer and winter respectively (from Annex 13.1: Shipping and Navigation Shared Navigational Risk Assessment.). A maximum of 13 to 19 unique vessels per day were recorded within the Morven South Shipping and Navigation Study Area across winter and summer survey seasons, respectively. Of these, a maximum of five (winter) to seven (summer) unique vessels per day entered the Morven South Boundary. Survey data shows a seasonal trend with increased vessels during summer months (with increase of recreational and passenger vessels) and decreases in the winter months.

10.11.4.9 Whilst there will be an uplift in vessel activity during phases of Morven South (paragraph 10.11.4.7), the movements will be limited to within the Morven South Boundary and are likely to follow existing shipping routes to and from the ports. For example, Volume 2 Chapter 13: Shipping and Navigation identified 16 main commercial routes within the Morven South Shipping and Navigation Study Area. Density heat maps presented in Figure 10.24 and Figure 10.25 (from Volume 3, Annex 13.1: Shipping and Navigation Shared Navigational Risk Assessment) show areas of higher density in the northwest of the Regional Shipping and Navigation study area during summer and winter surveys.

Table 10.64: Summary of vessel baseline within the Morven South Shipping and Navigation Study Area

Study area	Parameter	Survey period	
		Summer 2024	Winter 2024
Morven South Shipping and Navigation Study Area	Maximum daily unique vessels	19	13
	Minimum daily unique vessels	4	3
	Mean daily unique vessels	11	6 to 7
Morven South boundary	Maximum daily unique vessels	7	5
	Minimum daily unique vessels	1	0
	Mean daily unique vessels	3	1 to 2
	% within Morven South boundary	25	27

[3] Due to adverse weather a number of days were not able to be surveyed for a full 24 hours, with the omitted period of time appended to the end of the survey period to allow for a full 14 days of data to be collected.

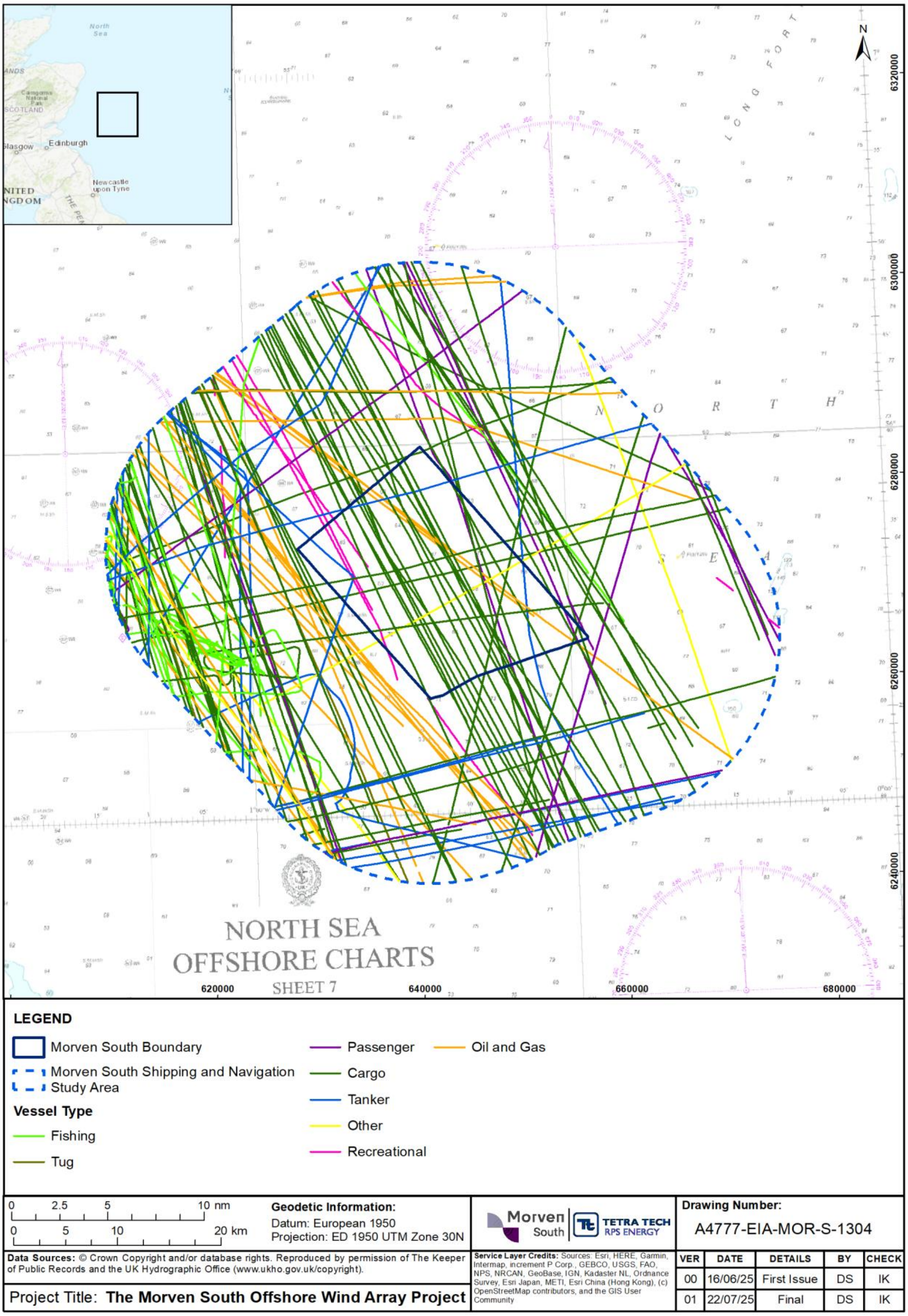

Figure 10.22: 14 days vessel traffic data by vessel type (summer 2024)

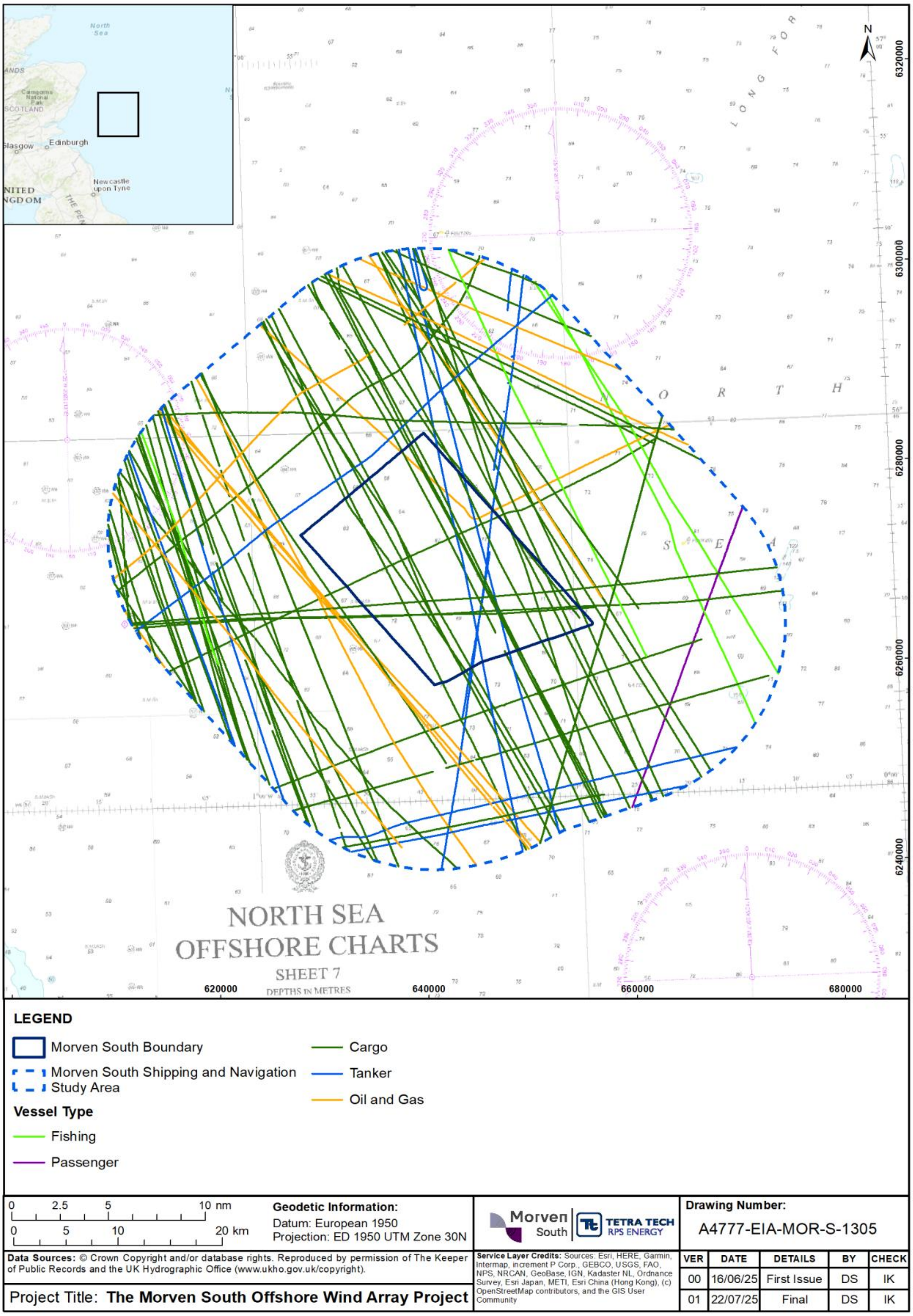

Figure 10.23: 14 days vessel traffic data by vessel type (winter 2024)

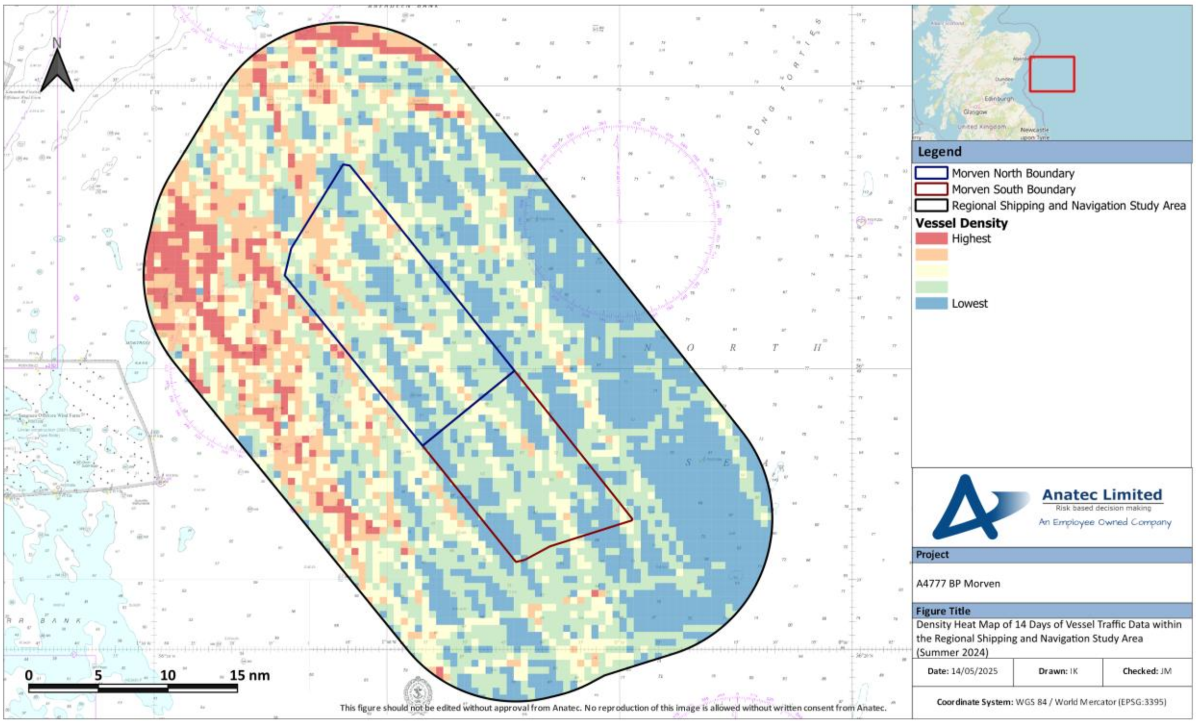

Figure 10.24: Density heat map of 14 days vessel traffic data by vessel type (summer 2024)

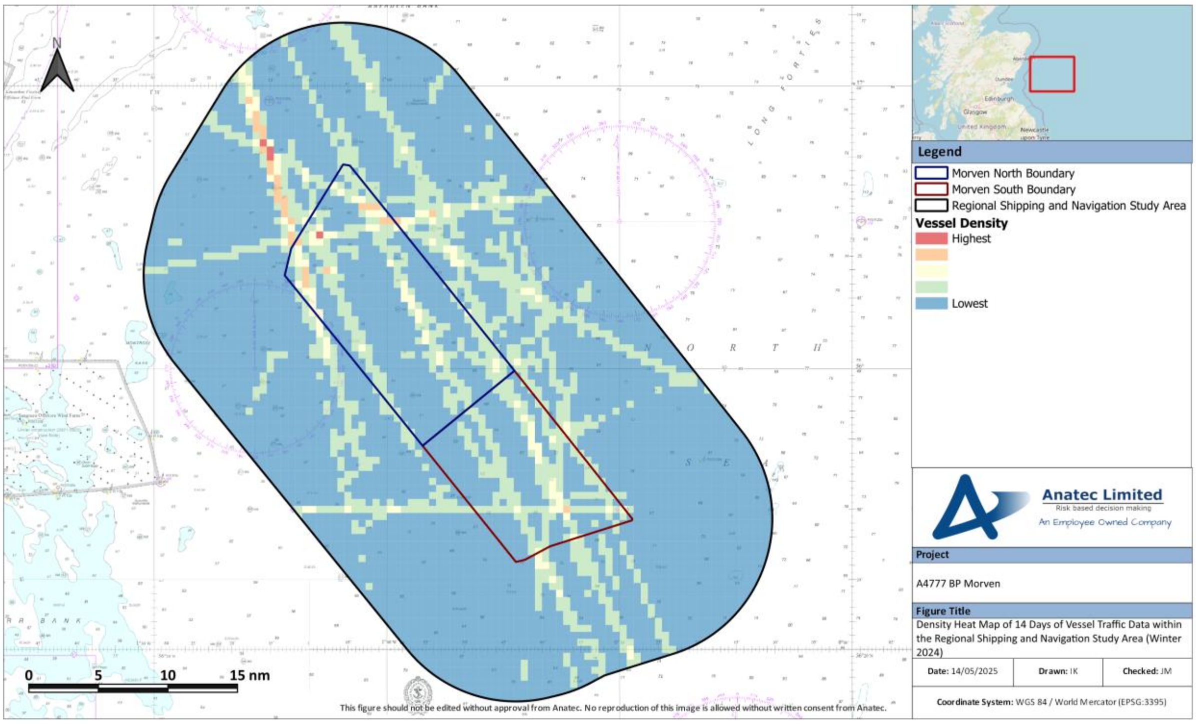

Figure 10.25: Density heat map of 14 days vessel traffic data by vessel type (winter 2024)

10.11.4.10 As discussed in paragraph 10.11.4.3, four indicative scenarios were modelled to represent common scenarios for vessel clustering and the results of underwater sound modelling for each modelled vessel scenario, the distances to hearing group-specific frequency-weighted AUD INJ thresholds, and the number of animals potentially injured are summarised in Table 10.65 to Table 10.68. Calculations of number of animals is based upon the method described in paragraph 10.11.1.31, applying densities summarised in Table 10.21. N/E denotes cases in which the AUD INJ threshold was not exceeded.

10.11.4.11 For the foundation installation, (Table 10.65), crew transfer scenarios (Table 10.68), wind turbine installation (Table 10.66) and cable laying scenario (Table 10.67), the AUD INJ threshold was not exceeded for any species.

Table 10.65: Maximum distances (km) to impact thresholds for auditory injury from the vessel assemblage modelled for foundation installation, based on SEL_{24h} with hearing group-specific frequency weighting applied. N/E denotes cases in which the auditory injury threshold was not exceeded

Hearing group	Species	Threshold (dB re 1 $\mu Pa^2 s$)	Distance to threshold (km)	Number of animals affected
LF	Minke whale Humpback whale	197	N/E	0
HF	Bottlenose dolphin White-beaked dolphin	201	N/E	0
VHF	Harbour porpoise	181	N/E	0
PW	Grey seal Harbour seal	195	N/E	0

Table 10.66: Maximum distances (km) to impact thresholds for auditory injury from the vessel assemblage modelled for wind turbine installation, based on SEL_{24h} with hearing group-specific frequency weighting applied. N/E denotes cases in which the auditory injury threshold was not exceeded

Hearing group	Species	Threshold (dB re 1 $\mu Pa^2 s$)	Distance to threshold (km)	Number of animals affected
LF	Minke whale Humpback whale	197	N/E	0
HF	Bottlenose dolphin White-beaked dolphin	201	N/E	0
VHF	Harbour porpoise	181	N/E	0
PW	Grey seal Harbour seal	195	N/E	0

Table 10.67: Maximum distances (km) to impact thresholds for auditory injury from the vessel assemblage modelled for cable laying, based on SEL_{24h} with hearing group-specific frequency weighting applied. N/E denotes cases in which the auditory injury threshold was not exceeded

Hearing group	Species	Threshold (dB re 1 μPa²s)	Distance to threshold (km)	Number of animals affected
LF	Minke whale Humpback whale	197	N/E	0
HF	Bottlenose dolphin White-beaked dolphin	201	N/E	0
VHF	Harbour porpoise	181	N/E	0
PW	Grey seal Harbour seal	195	N/E	0

Table 10.68: Maximum distances (km) to impact thresholds for auditory injury from the vessel assemblage modelled for crew transfer, based on SEL_{24h} with hearing group-specific frequency weighting applied. N/E denotes cases in which the auditory injury threshold was not exceeded

Hearing group	Species	Threshold (dB re 1 μPa²s)	Distance to threshold (km)	Number of animals affected
LF	Minke whale Humpback whale	197	N/E	0
HF	Bottlenose dolphin White-beaked dolphin	201	N/E	0
VHF	Harbour porpoise	181	N/E	0
PW	Grey seal Harbour seal	195	N/E	0

10.11.4.12 The assessment has adopted a highly precautionary approach assuming that all individual marine mammals will be affected in the same way to 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. Vessels and construction sound will be temporary and transitory, as opposed to permanent and fixed.

10.11.4.13 Designed-in measures adopted as part of Morven South include the development of, and adherence to, a Navigation Safety Plan and Vessel Management Plan (NSPVMP) (Table 10.33). These will include requirements to not deliberately approach marine mammals as a minimum, avoid abrupt changes in course or speed should marine mammals approach the vessel to bow-ride and to remain at safe speeds at all times and reduce speed when a marine mammal is in the vicinity.

10.11.4.14 Whilst the construction phase (including pre-construction surveys) occurs over the medium term (up to 4.5 years), the likelihood of auditory injury is extremely low (see paragraph 10.11.4.11). Furthermore, it is likely that disturbance from underwater sound associated with vessels will deter animals from the injury zone. The impact is predicted to be of highly localised 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 exceeding the AUD INJ threshold is permanent. It is predicted that the impact will affect the receptor directly. The magnitude for all assessed species is, therefore, considered to be **negligible**.

Sensitivity of the receptor

10.11.4.15 The sensitivity of marine mammal receptors to auditory injury has been assessed in detail in paragraph 10.11.1.45 *et seq* and therefore is not reiterated here.

10.11.4.16 Although auditory injury is considered to be a permanent reduction in hearing ability, all marine mammal receptors are considered to be able to avoid or adapt behaviour with some tolerance to the effect. The sensitivity of all receptors is therefore considered to be medium.

Significance of the effects

10.11.4.17 Overall, for all species the magnitude of the impact is deemed to be negligible and the sensitivity of all receptors is considered to be medium. The overall significance of the effect is negligible or minor. **Negligible adverse** significance has been concluded, given the ranges for most scenarios lead to no auditory injury and those ranges that were exceeded led to less than one animal was potentially injured, and the adoption of the Navigation Safety Plan and Vessel Management Plan (NSPVMP). The effect is not significant in EIA terms.

Secondary Mitigation and Residual Effect

10.11.4.18 No mitigation measures for marine mammals are considered necessary because the likely effect in respect of injury to marine mammals due to collision with vessels in the absence of further mitigation (beyond the designed-in measures outlined in Table 10.33), is not significant in EIA terms.

Construction phase – behavioural disturbance

Magnitude of impact

10.11.4.19 As discussed in paragraph 10.11.4.7, the MDS for construction activities (Table 10.32) assumes a maximum of 41 vessels to be present within the Morven South Boundary at any one time, and an average of 541.6 return trips per year (corresponding to a maximum total of 3,060 return trips across offshore construction period).

10.11.4.20 The results of underwater sound modelling for each modelled vessel scenario (see paragraph 10.11.4.3) and the distances to the behavioural disturbance threshold (120db re 1μPa^2) is summarised in Table 10.69.

Table 10.69: Distance to the behavioural disturbance threshold (120db re 1μPa^2) for each modelled vessel assemblage (based upon R_{95}), and corresponding area of disturbance

Disturbance	Foundation installation	Wind turbine installation	Cable laying	Crew transfer
Distance (km)	45.3	36.2	29.5	0.60

10.11.4.21 In the modelled vessel scenarios (see paragraph 10.11.4.3) the threshold for behavioural disturbance was exceeded out to a maximum distance of 45.3km (for foundation installation, Table

10.69). The minimum distance over which behavioural disturbance was predicted was 0.60km for the crew transfer scenario. However, it is important to consider that disturbance from vessel sound is likely to occur only where vessel sound associated with the construction of Morven South exceeds the background ambient sound level. Therefore, consideration of background underwater sound level is valuable when assessing potential effects from elevated underwater sound due to vessel use.

10.11.4.22 A detailed comparison of background sound levels in the North Sea is given in Volume 3, Annex 10.2: Underwater Sound Shared Technical Report, and highlights the North Sea is one of the most intensively used marine areas in the world, and its underwater soundscape reflects this. Farcas *et al.* (2020) produced early large-scale, validated maps of shipping noise in the Northeast Atlantic, including the North Sea, and demonstrated that areas such as the English Channel, Norwegian Trench, and regions near major ports and offshore infrastructure consistently exhibit median SPLs exceeding 120dB re 1μPa, with ship noise often surpassing natural wind-generated sound by more than 20dB. Farcas *et al.* (2020) also highlighted seasonal variability, with ship noise excess peaking in summer months due to increased vessel activity and reduced wind noise. Further studies demonstrated that broadband SPLs in the North Sea typically range from 100 to 130dB re 1μPa, with the highest levels observed in areas like the English Channel, southern North Sea, and major shipping lanes (de Jong *et al*., 2022, Sertlek *et al*., 2024). More recently, Farcas *et al.* (2025) completed the ship noise assessment for the UK Marine Strategy (Descriptor 11) and produced annual median broadband (63 Hz - 4 kHz) sound level data for UK waters for the years 2018 to 2022. Farcas *et al.* (2025) highlighted over half of the UK GNS region exceeded 110dB in all years from 2018 to 2022 (Table 10.70), with almost 20% exceeding 120dB, evidencing marine mammals show some tolerance to moderate ambient noise levels.

Table 10.70: Percentages of the United Kingdom Greater North Sea Region exceeding sound levels (110, 120 and 130 decibels)

Year	Region	Percentage region area exceeding 110 decibels	Percentage region area exceeding 120 decibels	Percentage region area exceeding 130 decibels
2018	UK Greater North Sea	57.4	18.2	3.6
2019	UK Greater North Sea	62.5	19.6	3.8
2020	UK Greater North Sea	61.6	18.7	3.5
2021	UK Greater North Sea	67	19.8	3.6
2022	UK Greater North Sea	69.2	19.5	4.1

10.11.4.23 Frankish *et al.* (2023) highlighted tracked harbour porpoises around Denmark spent over half their time within 10km of a vessel and spent a third of their time experiencing vessel noise above ambient noise, and regularly reacted by moving away during the daytime or diving deeper during the night. Therefore, it is important to bear in mind when viewing these potential disturbance radii (paragraph 10.11.4.20) that the 120 dB re 1 μPa SPL_{rms} criterion is very precautionary and does not consider background sound levels, and that ambient sound levels in the area could well exceed this value (particularly in summer).

10.11.4.24 For impulsive sound sources there is an understanding of the difference between strong and mild disturbance, whereas for non-impulsive (continuous) sound sources such as from vessels, there is only a single available unweighted threshold (120 dB re 1 μPa (rms), the Level B harassment threshold) (NMFS, 2005) which is proposed as the basis for the onset of a behavioural reaction in all marine mammal species. There is no differentiation between mild and strong disturbance for continuous underwater sound (just one single fixed threshold for Level B harassment) and this assumes 100% of animals above this threshold are disturbed (single step-function criterion used in the NMFS thresholds assume a "all-or-none" threshold). JNCC *et al.* (2010) state that "it is most unlikely that a passing vessel would cause more than trivial disturbance. It is the repeated or chronic exposure to vessel noise that could cause disturbance".

10.11.4.25 In reality, as with piling sound, there is likely to be a proportional response for animals disturbed (i.e. not all animals will be disturbed to the same extent). At present there is no agreed dose-response curve available to apply in the context of non-impulsive sound sources for marine mammal species in the North Sea and few dose response relationships have been established for addressing impacts of vessel sound on cetaceans (Frankish *et al.*, 2023). However, there is substantial empirical evidence of a proportional response to vessel sound in marine mammals in scientific literature.

10.11.4.26 Williams *et al.* (2014) measured swim speed, dive time, and surfacing behaviours of northern resident killer whales (a HF cetacean) when tugs, cargo vessels and cruise ships transited past the whales. Behavioural responses of killer whales to ship transits were modelled (as a dose–response function of estimated received noise levels in both broadband and audiogram-weighted terms). The authors concluded 'subtle' or 'minor' responses (i.e. those ≤ 2 on the Southall *et al.* (2007) severity scale e.g. minor change in respiration) occurred around broadband received levels of 130 dB re 1 µPa (rms). More 'severe' or 'moderate' responses, i.e. those ≤ 3 on the Southall *et al.* (2007) severity scale, (i.e. minor change in locomotion speed, direction, and/or deviation, moderate change in respiration) were, hypothesised to occur at received levels beyond 150 dB re 1 µPa (but authors caveated data was lacking at these received levels).

10.11.4.27 More recently, Joy *et al.* (2019) developed two dose-response functions for southern resident killer whales relating to 'low' and 'moderate' disturbance scored based on the Southall *et al.* (2007) severity scale, using data from three empirical studies (which included Williams *et al.* (2014)). Measured dive depths, whale movement, and respiration rates using Digital Acoustic Recording Tags (DTAGs) alongside Geographic Positioning System (GPS) field measurements were utilised (Wright *et al.*, 2017) alongside data from PAM at Lime Kiln listening station with scored amplitude changes of killer whale calls in response to passing commercial ship traffic. Joy *et al.* (2019) set the threshold for low response (corresponding to Southall *et al.* (2007) severity scale of 2-3) at received levels of 129.5 dB re 1 µPa and for moderate response (corresponding to Southall *et al.* (2007) severity scale of 4-6) at 137.2dB re 1 µPa. This dose response was used in the noise exposure model to conclude how behavioural response to received levels translates into 'potential lost foraging time' (see paragraph 10.11.4.44 *et seq.*). Notably, a low severity response was assumed to last 5 minutes whilst moderate severity responses were assumed to last of 25 minutes (therefore although moderate severity responses had a lower chance of occurring, their net effect on 'potential lost foraging time' is greater than low severity responses). Joy *et al.* (2019) concluded slower ships reduced underwater noise, despite longer transit times, benefiting whale habitat near shipping lanes.

10.11.4.28 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. Harbour porpoise responses were measured using arrays of echolocation click detectors (CPODs) which were deployed in 25km by 25km impact and reference blocks throughout the construction period (2017 to 2019). Calibrated noise recorders were deployed at three locations to characterise variation in underwater sound levels. The magnitude of harbour porpoise responses was then quantified in relation to changes in the acoustic environment and vessel activity. Harbour porpoise responses decreased as the mean vessel distance increased (−24% at 3km) until no apparent response was observed at 4km (+ 7.2%) (and could be interpreted as a form of dose response).

10.11.4.29 Volume 3, Annex 10.2: Underwater Sound Shared Technical Report presents the maximum distance to the identified threshold level from the closest sound source for each vessel scenario (see paragraph 10.11.4.3), summarised in Table 10.71. Following the thresholds derived by Joy *et* *al.* (2019) and (Joy *et al.*, 2019), Williams *et al.* (2014) Table 10.71 demonstrates that at 130 dB re 1 µPa SPL_{rms} (subtle/low behavioural responses) impact distances are smaller (e.g. ranging from 13km to 0.13km) and more localised compared to distances out to 120 dB re 1 µPa SPL_{rms}. Similarly, at 150 dB re 1 µPa SPL_{rms} (severe behavioural responses; (Williams *et al.*, 2014)) the distances range from 0.90km to <0.01km, and more conservatively at 140 dB re 1 µPa SPL_{rms} (moderate behavioural response; (Joy *et al.*, 2019)) the distances range from 3.99km to 0.03km, therefore indicating a highly localised impact area for stronger disturbance responses. This suggests that higher sound levels affect marine mammals only very close to the source causing moderate disturbance in a smaller, localised area. Lower noise levels (out to 120 dB re 1 µPa SPL_{rms}) impact a much larger area, but the disturbance is less intense and therefore careful interpretation of impact ranges out to this distance (45.3km) is required.

Table 10.71: Maximum horizontal distances in kilometres to maximum-over-depth sound pressure level (SPL dB re 1µPa) (based on R_{95}). Distances at 130 and 150 dB re 1µPa highlighted to show 'subtle' versus 'severe' responses in high frequency cetaceans according to Williams *et al.* (2014). The 130 dB re 1µPa is closest to the threshold for a low response whilst 140 dB re 1µPa is closest to the threshold for a moderate response derived by (Joy *et al.*, 2019)

SPL (dB re 1µPa)	Maximum horizontal distance to threshold level (km)			
	1) Foundation installation	2) Turbine installation	3) Cable Laying	4) Crew transfer
120	45.3	36.2	29.5	0.60
125	24.7	20.5	16.0	0.27
130	**13.0**	**10.7**	**8.67**	**0.13**
135	7.12	6.27	5.07	0.04
140	**3.99**	**3.18**	**2.53**	**0.03**
145	1.96	1.59	1.25	<0.01
150	**0.90**	**0.72**	**0.57**	**<0.01**
155	0.42	0.34	0.26	<0.01
160	0.19	0.16	0.08	<0.01
165	0.06	0.04	0.04	-
170	0.03	0.03	<0.01	-
175	<0.01	<0.01	<0.01	-
180	<0.01	<0.01	<0.01	-
185	<0.01	<0.01	<0.01	-
190	<0.01	<0.01	<0.01	-

10.11.4.30 In addition to evidence for proportional (dose) responses of marine mammals to vessels, empirical data has been gathered from field studies on wild harbour porpoise to determine realistic impact ranges (summarised in Table 10.72, noting studies are for a VHF species and does not account for different hearing groups, but is likely to be precautionary).

10.11.4.31 Wisniewska *et al.* (2018a) used animal-borne acoustic tags on seven harbour porpoises in coastal waters with high levels of vessel traffic and suggested a maximum reaction distance of 7km (based on a single vessel pass, for a single animal) for harbour porpoise. AIS data and the rapid increase and decrease in sound levels suggested this reaction in one harbour porpoise was in response to a fast ferry moving between the island of Zealand and the Jutland Peninsula, with a recorded speed of 33 knots (much higher than the modelled speeded for typical vessels used in construction on Morven South) and closest approach to the harbour porpoise of 140m. Graham *et al.* (2017) used echolocation detectors and noise recorders to assess harbour porpoise responses during construction of a North Sea wind farm over a 10-month period. Whilst the focus of the study was on response to piling, AIS detections within 1 km/500m of each C-POD allowed a control for disturbance by vessel activity. The study indicated higher vessel activity within 1km was significantly associated with an increased probability of response in harbour porpoise. Frankish *et al.* (2023) demonstrated harbour porpoise responded to broadband received sound pressure levels (Lp, VHF) and proximity to ships. Highest deterrence probabilities occurred at short distances from ships (<300m), but porpoises were still predicted to respond 5–9 % of the time to ships >2km away depending on received values of Lp,vhf. Porpoises were mostly deterred by ships in shallow waters (15–30m depth), while changes in dive behaviour was predominately found in deeper waters (50–100m depth.

Table 10.72: Disturbance ranges cited in literature and derived using behavioural response thresholds from the literature. Maximum disturbance ranges are presented rounded to the nearest kilometre

Study	Description	Maximum disturbance range
Williams *et al.* (2014)	Severe response at max modelled range of 0.86km based on 150 dB re 1 µPa SPL_{rms} (killer whale) for study in the western end of the Johnstone Strait, British Columbia, Canada	1km
Graham *et al.* (2019)	Increased probability of response 1km for harbour porpoise	1km
Frankish *et al.* (2023)	Highest deterrence probabilities occurred at short distances from ships (<300 m), porpoises were still predicted to respond 5–9 % of the time to ships >2kmfor harbour porpoise	2km
Joy *et al.* (2019)	Moderate response at max modelled range based on 140 dB re 1 µPa SPL_{rms} (killer whale) for a study in the Salish Sea	4km
Benhemma-Le Gall *et al.* (2021)	24% response rate at 3km, no response at 4km for harbour porpoise	4km
Verboom (2014)	Does not approach the study dredging ship in full operation at less than 5kmfor harbour porpoise	5km
Wisniewska *et al.* (2018a)	Maximum reaction distance 7km for harbour porpoise	7km

10.11.4.32 Therefore, to give a quantitative indication of impact, a range of distances from empirical studies (1 to 7km) (see Table 10.72) have been used as an effective impact range (and conservatively assumes all animals within this radius are disturbed, rather than a dose response) and the numbers of animals predicted to be disturbed is presented in Table 10.73, applying densities summarised in Table 10.21. It is important to highlight that multiplying these animals by the numbers of vessels would lead to unrealistic estimates as it does not allow for any overlap between vessels (and therefore would double count), nor does it account for periods when vessels are stationary.

10.11.4.33 Note that density estimates are not available for humpback whale (an LF species), so an estimate of the number of animals potentially disturbed is not possible to quantify. However, given the low incidence of the species humpback whale in this region, it is likely that fewer individuals would be affected than the minke whale estimate and therefore the risk is very small.

Table 10.73: Potential number of animals predicted to be disturbed per vessel for a range between 1km (minimum) and 7km (maximum) with percentage of the full MU and UK portion of the MU disturbed

Species	1km			4km			7km		
	Number of animals	% MU	% UK Portion of MU	Number of animals	% MU	UK Portion of MU	Number of animals	% MU	UK Portion of MU
Harbour porpoise	31	0.009	0.019	2	0.001	0.001	93	0.027	0.058
Bottlenose dolphin	<1	0.049	0.053	<1	0.049	0.053	<1	0.049	0.053
White-beaked dolphin	5	0.011	0.015	<1	0.002	0.003	13	0.030	0.038
Minke whale	3	0.015	0.029	<1	0.005	0.010	7	0.035	0.068
Grey seal	13	0.035		<1	0.003		39	0.106	
Harbour seal	<1	0.205		<1	0.205		<1	0.20	

10.11.4.34 Temporally, disturbance would be expected to occur intermittently as a vessel passes and there is evidence to suggested that duration of disturbance is very short-lived with animals recovering quickly after the event (paragraph 10.11.4.27). This is described in more detail in the sensitivity section below (see paragraphs 10.11.4.43 *et seq.*) but the temporal nature of the effect is factored into the conclusion of magnitude.

10.11.4.35 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, for all assessed species, is therefore considered to be low.

<u>Sensitivity of the receptor</u>

10.11.4.36 Disturbance levels for marine mammal receptors will be dependent on individual hearing ranges, background noise and the marine mammal activity at the time of disturbance (IWC, 2006, Senior *et al.*, 2008) with the level of response dependent on upon vessel type and behaviour (e.g., heading, speed) (Oakley *et al.*, 2017, Hermannsen *et al.*, 2019). It is difficult to quantifiably assess the direct responses of animals to vessel noise, as effects are only measurable when there are step changes in the noise level above the gradually increasing baseline levels (Tournadre, 2014), such as those directly owing to changes in vessel speed or routing. Wisniewska *et al.* (2018a) highlighted a lack of baseline 'sound-free' periods with which to compare and suggested that demonstrating behavioural responses to noise under natural conditions convincingly is notoriously difficult, particularly because the history of an animal's exposure to vessel noise is rarely known. Evidence suggests that characteristics of individual ship encounters besides noise and proximity, such as route predictability (steady vs. erratic paths) or speed may be relevant to the degree of disturbance (Oakley *et al.*, 2017, Baş *et al.*, 2015). Marine mammal receptors may, therefore, be accustomed to regular and predictable vessel traffic such as that found in the Morven South Shipping and Navigation Study Area (see paragraph 10.11.4.9), resulting in minimal additional disturbance (see paragraph 10.11.4.41 *et seq.*).

10.11.4.37 Cetaceans can both be attracted to and disturbed by vessels. Aversive behaviours to vessel presence may include increased swimming speed, greater time travelling, less time resting or socialising, avoidance, increased group cohesion and longer dive (Marley *et al.*, 2017, Miller *et al.*, 2008, Toro *et al.*, 2021). Behaviour also depends on the animals' activity at the time, for example resting dolphins are likely to avoid vessels, foraging dolphins will ignore them, and socialising dolphins may approach vessels (Richardson *et al.*, 1995). Harbour porpoise is particularly sensitive to HF sound and likely to avoid vessels at close ranges (Heinänen and Skov (2015); Benhemma-Le Gall *et al.* (2021). Wisniewska *et al.* (2018b) studied the temporary change in foraging rates of harbour porpoise in response to vessel sound in coastal waters with high traffic rates and showed that occasional high sound levels coincided with vigorous fluking, bottom diving, interrupted foraging and even cessation of echolocation.

10.11.4.38 Vessel presence in foraging grounds could result in reduced foraging success. For example, whale-watching boats within an important feeding ground for minke whale led to a reduction in foraging activity (Christiansen and Lusseau, 2015), potentially leading to reduced reproductive success since female body condition associated with foetal growth in capital breeders (Christiansen *et al.*, 2014) (noting baseline sound levels are low in Faxafloi Bay in Iceland compared to the North Sea (McGarry *et al.*, 2017). A subsequent study in the same area found no significant long term effects of disturbance from whale-watching on vital rates, as whales moved into disturbed areas when sandeel numbers were lower across their wider foraging area (Christiansen and Lusseau, 2015). A vessel slowdown trial in critical habitat of at-risk southern resident killer whale showed a 22% reduction in 'potential lost foraging time' for killer whale with slower vessels (with 40% reduction when 100% of vessels were under the 11 knot speed limit) (Joy *et al.*, 2019) (see paragraph 10.11.4.41 *et seq*). Foraging context is important when interpreting avoidance behaviour, for examples in grey seals avoidance rates were dependent on the perceived risk (e.g. silence, pile driving sound, operational sound from tidal turbines) versus the quality of the prey patch (Hastie *et al.*, 2021).

10.11.4.39 Disturbance may lead to changes in vocalisation in marine mammals. Bottlenose dolphins exposed to increases in ship sounds in the North Atlantic (both within and below the dolphin call bandwidth) resulted in simplified vocal calls, higher dolphin whistle frequencies and a reduction in whistle contour complexity (Fouda *et al.* (2018), potentially decreasing effective communication. Bottlenose dolphin has been found to both increase and decrease whistle frequencies in noisy environments, avoiding acoustic masking and improving signal transmission (Heiler *et al.*, 2016, La Manna *et al.*, 2013, May-Collado and Wartzok, 2008, Peters, 2018, Rako Gospić and Picciulin, 2016). Therefore, if the benefits of staying in an area exceed the cost of disturbance, animals may tolerate disturbance rather than avoid it (Antichi *et al.*, 2022) (see paragraphs 10.11.4.43 *et seq).* Marine mammals therefore could continue to regularly visit the areas where they may be affected by the vessel presence (Rako Gospić and Picciulin, 2016, Antichi *et al.*, 2022). Given the existing vessel activity in the Morven South area, marine mammals are likely to continue using the area without long-term impacts on reproduction or survival.

10.11.4.40 Reactions of pinnipeds to approaching vessels includes increased alertness (Henry and Hammill, 2001), head raising (Niemi, 2013) and flushing off haul-out sites into the sea (Andersen *et al.*, 2012, Blundell and Pendleton, 2015, Jansen *et al.*, 2015, Johnson and Acevedo-Gutiérrez, 2007) (noting studies focused on the presence of the vessel rather than vessel sound). Mikkelsen *et al.* (2019) found when studying responses of seals to ship sound, a tagged grey seal changed its diving behaviour, switching rapidly from a dive ascent to descent. Pérez Tadeo *et al.* (2021) found that ecotourism vessels approaching within 500 m of White Strand Beach in south-west Ireland showed strong influence on the proportion of grey seal entering the water and increase in vigilance and decrease in resting behaviour. This is similar to a previous study on harbour seal which showed avoidance behaviour or alert reactions in harbour seal when vessels approach within 100 m of a haul-out (Paterson *et al.*, 2015). Such disturbance to seal haul-outs could have adverse consequences during the pupping season, due to trade-offs between feeding and nursing. Harbour seal has been shown to be alerted and move away when a boat approaches (Andersen *et al.*, 2012, Blundell and Pendleton, 2015) but this response varies by season. During the breeding season, they show weaker and shorter lasting responses appearing more reluctant to flee and return to the haul-out site after being disturbed (Andersen *et al.*, 2012) (likely due to trade-off with nursing). In a study of harbour seal in Alaska, haul-out probability was adversely affected by vessels, with cruise ships having the strongest effect (Blundell and Pendleton, 2015). High co-occurrence between grey seal/harbour seal and shipping traffic within 50kmof 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).

10.11.4.41 Evidence suggests that nuanced characteristics of individual ship encounters besides noise and proximity, such as route predictability (steady vs. erratic paths) or speed may be relevant to the degree of disturbance (Oakley *et al.*, 2017, Baş *et al.*, 2015). Marine mammal receptors may, therefore, be accustomed to regular and predictable vessel traffic such as that found in the Morven South Shipping and Navigation Study Area (see paragraph 10.11.4.9), resulting in minimal additional disturbance.

10.11.4.42 Reactions of marine mammals to vessel sound are often linked to changes in the engine and propeller speed with faster or erratic movements triggering avoidance (Richardson *et al.*, 1995, Watkins, 1986). Dolphins and porpoises are more sensitive to HF sound from small, fast moving vessels, whilst mysticetes (e.g. 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 but suggested vessel presence, not just vessel sound, resulted in disturbance. Hao *et al.* (2024) found harbour porpoise responses were linked to the speed of the approaching boat (and therefore the rate of change in sound level), rather than to sound intensity (as the received sound level did not vary with boat speed). Harbour porpoise were more likely to move further away from the boat path when approached at slower speeds (10 knots) than at faster speeds (20 knots), but swam faster when approached at faster speeds (20 knots) and slowed down again once the boat has passed.

10.11.4.43 Joy *et al.* (2019)demonstrated slower vessels have smaller footprints (despite longer passage times) and lower risk of eliciting behavioural responses in southern resident killer whale. Speed reductions resulted in significant reductions in broadband noise exposure from all commercial vessel types (as well as noise reductions across most frequency bands) and therefore important reductions to noise exposure risk. Most vessels involved in the construction phase are likely to be travelling considerably slower than 11 knots (see modelled scenarios in paragraph 10.11.4.3) (with all vessels travelling at safe speeds at all times and reduce speed if appropriate when a marine mammal is in the vicinity, detailed in the Navigation Safety Plan and Vessel Management Plan (NSPVMP) (Table 10.33).

10.11.4.44 There is indication of tolerance to vessel traffic in the scientific literature (and anthropogenic sounds and activities in general) and so a slight increase from the existing levels of traffic in the vicinity of Morven South may not necessarily result in high levels of disturbance (Vella *et al.*, 2001). Whilst it cannot be assumed that tolerance to a stressor is evidence of absence of detrimental consequences for targeted animals (e.g. physiological responses are not easily detectable in free-ranging wild animals), there is evidence of animals (from multiple species) remaining in areas of high vessel traffic.

10.11.4.45 For example, Wisniewska *et al.* (2018a) found tagged porpoises did not appear to avoid highly trafficked areas, potentially because these overlapped with important foraging habitats (deep waters which may aggregate important prey items). Harbour porpoise dove away from the surface but resumed foraging eight minutes later. Similarly, Frankish *et al.* (2023)found that tagged harbour porpoises dove deep in response to ships (monitoring by AIS) particularly at short distances from ships (2km).

10.11.4.46 Oakley *et al.* (2017) studied reactions of harbour porpoise to vessel traffic in the coastal waters of South West Wales, UK, observing 2,153 vessels (large commercial cargo ships, kayaks, recreational/commercial fishing vessels, rib, jet-ski, speedboat, cruiser and yachts) from seven land-based sites noting interactions with harbour porpoise. The study found 74% of interactions were neutral, with harbour porpoise showing no change in directional movement prior to, and after the arrival of the vessel. The mean distance for a neutral reaction to a vessel approach was approximately 250m (ranging between 10m to 1km). At Port Talbot docks, there were five cases of continuing presence of harbour porpoise near large cargo ships, often alongside the ship or within 800m of it, indicating habituation to the stationary ships, vessel traffic at the site and associated sound. Oakley *et al.* (2017) recorded ten instances (26%) of negative behaviour in individuals of harbour porpoise, with the mean distance from a vessel for a negative reaction circa 25m.

10.11.4.47 Potlock *et al.* (2023) used cetacean porpoise detector (C-POD) detections of sonar activity as a proxy for vessel disturbance during wind turbine construction off Blyth, Northumberland. Sonar activity significantly reduced harbour porpoise and dolphin presence – by 50% for eight minutes sonar per hour for harbour porpoise / 13 minutes per hour for dolphin. Despite this, dolphin occurrence during and after construction were not significantly different to the occurrence before the construction phase. Similarly, the increase in harbour porpoise occurrence across this study suggests that construction and after construction vessel activity did not result in any overall decline in area usage (Potlock *et al.*, 2023). Owen *et al.* (2024) studied the long-term presence of harbour porpoise during the rerouting of the major shipping lane through the Kattegat into the Baltic Sea and found no significant changes in monthly presence or foraging behaviour; nor was there any increase in presence in areas where the vessel traffic/sound levels had decreased. The study suggested harbour porpoise have preferred habitat that they continued to use, even when faced with sudden changes in vessel traffic and noise levels

10.11.4.48 Hao *et al.* (2024) used drone video footage to study harbour porpoise reactions to boats approaching at different speeds (10 or 20 knots) and found that porpoises generally reacted within close proximity (<200m), and quickly (<50s) resumed their behaviour once the boat had passed. Similar late responses and quick recovery times have also been observed in other species such as bottlenose dolphin (Lemon *et al.*, 2006, Ribeiro *et al.*, 2005) and is potentially a strategy to reduce unnecessary energy expenditure.

10.11.4.49 A study by Veneruso *et al.* (2011) on bottlenose dolphin to vessel interactions in New Quay bay, West Wales recorded 13% negative response behaviour, 6% positive and 82% neutral responses. Thompson *et al.* (2011) (Scottish Natural Heritage (SNH)(now NatureScot) commissioned report) undertook a modelling study which predicted that increased vessel movements associated with offshore wind development in the Moray Firth would not have an adverse effect on the local population of bottlenose dolphin (although, similar to Benhemma-Le Gall *et al.* (2021), it did note that foraging may be disrupted by disturbance from vessels).

10.11.4.50 Therefore, there is substantial evidence from scientific peer-reviewed literature indicating that marine mammals can return quickly to the area. Thus, whilst there might be an initial immediate avoidance behaviour to vessels, animals would be likely to return to the area and vessel presence is therefore unlikely to elicit an effect of ongoing displacement. Therefore, marine mammals are deemed to have some resilience (tolerance) to behavioural disturbance, high recoverability and high international value. The sensitivity of the receptor is therefore considered to be low.

<u>Significance of the effect</u>

10.11.4.51 Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The overall significance of the effect is negligible or minor. **Minor adverse** significance has been concluded, although there are unlikely to be any population-level effects, short-term (but localised) disturbance events could occur intermittently throughout construction

<u>Secondary Mitigation and Residual Effect</u>

10.11.4.52 Designed-in measures adopted as part of Morven South include the development of, and adherence to, a Navigation Safety Plan and Vessel Management Plan (NSPVMP) (Table 10.33).

These will include requirements to not deliberately approach marine mammals as a minimum, avoid abrupt changes in course or speed should marine mammals approach the vessel to bow-ride and to remain at safe speeds at all times and reduce speed when a marine mammal is in the vicinity.

Operations and maintenance phase

10.11.4.53 The MDS for the O&M phase (Table 10.32) assumes a total of up to 19 vessels to be present within the Morven South boundary at any one time (8 crew transfer vessels/workboats, two jack-up vessels, 2 cable repair vessels, 4 survey vessels (unmanned surface vehicles), and three other vessels). The following activities will require vessel use (Table 10.32):

- for foundations (wind turbine); up to 702 annual return trips;
- for wind turbines; up to 1,165 annual return trips;
- for foundations (OSP): up to 35 annual return trips;
- for offshore substation: up to a total of 101 annual return trips;
- for inter-array cables: up to a total of 351 annual return trips;
- for interconnectors: up to a total of 33 annual return trips.

10.11.4.54 Whilst there will be an uplift in vessel activity during the construction phase of Morven South (paragraph 10.11.4.7), the movements will be limited to within the Morven South Boundary and are likely to follow existing shipping routes to and from the ports. The designed-in measures to reduce the behavioural disturbance to marine mammals, the Navigation Safety Plan and Vessel Management Plan (NSPVMP) will be issued to all project vessel operators as described in Table 10.33.

10.11.4.55 Whilst sound modelling was not carried out for specific O&M vessels, it is considered that the trenching scenario is a suitable proxy for excavator or back-hoe dredging (representing a conservative assessment of radiated sound at least as the Dynamic Positioning (DP) vessels would swamp the soundscape, and if DP is not required then levels would be noticeably lower). It is considered the CTV would be a suitable proxy for a cable repair vessel (falling under general transit noise). It is considered therefore that underwater sound results will be similar to that presented in the construction phase. The volume of vessel movements and return trips during the operation and maintenance phase is significantly lower than during the construction phase.

Operations and maintenance phase – Auditory Injury

Magnitude of impact

10.11.4.56 An overview of potential impacts from elevated underwater sound due to vessel use and other non-piling noise producing activities as well as associated effects (auditory injury) are discussed in paragraph 10.11.4.6 *et seq*. for the construction phase and have not been reiterated here for the operation and maintenance phase of Morven South.

10.11.4.57 The impact is predicted to be of highly localised 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 auditory injury is permanent. It is predicted that the impact will affect the receptor directly. The magnitude for all assessed species is, therefore, considered to be negligible**.**

Sensitivity of the receptor

10.11.4.58 The sensitivity of marine mammal receptors to auditory injury has been assessed in detail in paragraph 10.11.1.45 *et seq* and therefore is not reiterated here.

10.11.4.59 Although auditory injury is considered to be a permanent reduction in hearing ability, all marine mammal receptors are considered to be able to avoid or adapt behaviour with some tolerance to the effect. The sensitivity of all receptors is therefore considered to be medium.

Significance of the effect

10.11.4.60 Overall, for all species the magnitude of the impact is deemed to be negligible and the sensitivity of all receptors is considered to be medium. The overall significance of the effect is negligible or minor. As there was predicted to be no auditory injury for most scenarios, or risks of injury were limited to very localised ranges that can be mitigated via the adoption of the NSPVMP, the effect will be of **negligible adverse** significance, which is not significant in EIA terms.

Secondary Mitigation and Residual Effect

10.11.4.61 No mitigation measures for marine mammals are considered necessary because the likely effect in respect of injury to marine mammals due to collision with vessels in the absence of further mitigation (beyond the designed-in measures outlined in Table 10.33), is not significant in EIA terms.

Operations and maintenance phase - behavioural disturbance

Magnitude of impact

10.11.4.62 A summary of the modelled scenarios for the impact of elevated underwater sound due to vessel use and other non-piling noise producing activities have been presented in Table 10.63. Vessels primarily used during operation and maintenance will crew transfer vessels, jack-up vessels, cable repair vessels and excavators or backhoe dredgers. The representative scenarios presented for construction phase capture the maximum design scenario for operation and maintenance with the exception of the foundation installation scenario which is redundant for the operation and maintenance phase.

10.11.4.63 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, for all assessed species, is therefore considered to be low.

Sensitivity of the receptor

10.11.4.64 The sensitivity of the marine mammal receptors during the operation and maintenance phase is not expected to differ from that during the construction phase, which is discussed previously in paragraph 10.11.4.36 *et seq*. and is deemed to be low.

Significance of the effect

10.11.4.65 Overall the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The overall significance of the effect is negligible or minor. **Minor adverse** significance has been concluded, although there are unlikely to be any population-level effects, short-term (but localised) disturbance events could occur intermittently throughout the operation and maintenance.

Secondary Mitigation and Residual Effect

10.11.4.66 No mitigation measures for marine mammals are considered necessary because the likely effect in respect of injury to marine mammals due to collision with vessels in the absence of further mitigation (beyond the designed-in measures outlined in Table 10.33), is not significant in EIA terms.

Decommissioning phase

10.11.4.67 During the decommissioning phase of Morven South, the increased levels of vessel activity will contribute to background subsea noise levels. A Decommissioning Programme will be submitted to MD-LOT for consultation and approval and will be updated during Morven South's lifespan to take account of changing best practice and new technologies. It is anticipated there will be a range of vessels used for decommissioning activities such as removal of infrastructure (Table 10.32). There is no information regarding the number of vessel transits for the decommissioning phase and therefore a quantitative assessment is not possible for this phase. However, it is anticipated that the number of vessels, number of transits and duration of the decommissioning phase will be considerably less compared to the construction phase

10.11.4.68 The MDS for decommissioning activities associated with Morven South (Table 10.32) assumes that noise from vessels is likely to be the same, or lower than the vessel activity described for the construction phase.

Decommissioning phase - Auditory Injury

Magnitude of impact

10.11.4.69 An overview of potential impacts from elevated underwater sound due to vessel use and other non-piling noise producing activities as well as associated effects (auditory injury) are discussed in paragraph 10.11.4.6 *et seq.* for the construction phase and have not been reiterated here for the decommissioning phase of Morven South.

10.11.4.70 The impact is predicted to be of highly localised 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 auditory injury is permanent. It is predicted that the impact will affect the receptor directly. The magnitude for all assessed species is, therefore, considered to be negligible.

Sensitivity of the receptor

10.11.4.71 The sensitivity of marine mammal receptors to auditory injury has been assessed in detail in paragraph 10.11.1.45and therefore is not reiterated here.

10.11.4.72 Although auditory injury is considered to be a permanent reduction in hearing ability, all marine mammal receptors are considered to be able to avoid or adapt behaviour with some tolerance to the effect. The sensitivity of all receptors is therefore considered to be medium.

Significance of the effect

10.11.4.73 Overall, for all species the magnitude of the impact is deemed to be negligible and the sensitivity of all receptors is considered to be medium. The overall significance of the effect is negligible or minor. **Negligible adverse** significance has been concluded, given the ranges for most scenarios lead to no auditory injury and those ranges that were exceeded led to less than one animal was potentially injured, and the adoption of the NSPVMP. The effect is not significant in EIA terms.

Secondary Mitigation and Residual Effect

10.11.4.74 No mitigation measures for marine mammals are considered necessary because the likely effect in respect of injury to marine mammals due to collision with vessels in the absence of further mitigation (beyond the designed-in measures outlined in Table 10.33), is not significant in EIA terms.

Decommissioning phase - behavioural disturbance

Magnitude of impact

10.11.4.75 An overview of potential impacts from elevated underwater sound due to vessel use and other non-piling noise producing activities, as well as associated effects (behavioural disturbance), is discussed in paragraph 10.11.4.19 *et seq.* for the construction phase and have not been reiterated here for the decommissioning phase of Morven South.

10.11.4.76 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, for all assessed species, is therefore considered to be low.

Sensitivity of the receptor

10.11.4.77 The sensitivity of the marine mammal receptor during decommissioning phase is not expected to differ from that during the construction phase, which is discussed previously in paragraph 10.11.4.36 *et seq*. and is deemed to be low.

Significance of the effect

10.11.4.78 Overall the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The overall significance of the effect is negligible or minor. **Minor adverse** significance has been concluded, although there are unlikely to be any population-level effects, short-term (but localised) disturbance events could occur intermittently throughout decommissioning.

Secondary Mitigation and Residual Effect

10.11.4.79 No mitigation measures for marine mammals are considered necessary because the likely effect in respect of injury to marine mammals due to collision with vessels in the absence of further mitigation (beyond the designed-in measures outlined in Table 10.33), is not significant in EIA terms.

10.11.5 Injury to marine mammals due to collision with vessels

Construction phase

10.11.5.1 Vessel traffic associated with the transport and installation of offshore infrastructure for Morven South will increase the number of vessel movements above baseline levels during the construction phase. This increase could lead to increased interactions between marine mammals and vessels during construction. Whilst a broad range of vessel types may be involved in collisions with marine mammals (Laist *et al.*, 2001) vessels travelling at higher speeds pose a greater risk and severity of injury because of the potential for a stronger impact (Schoeman *et al.*, 2020), particularly at speeds above 14kn (Laist *et al.*, 2001).

10.11.5.2 Collisions between vessels and marine mammals have the potential to result in both fatal and non-fatal injuries (Laist *et al.*, 2001, Cates and Acevedo-Gutiérrez, 2017, Vanderlaan and Taggart, 2007). Evidence for fatal collisions has been gathered from carcasses floating, washing up on beaches, and those caught on vessel bows (Laist *et al.*, 2001, Peltier *et al.*, 2019). 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 (Douglas *et al.*, 2008, Jensen *et al.*, 2003). However, fatalities from ship strikes often go unreported (Authier *et al.*, 2014). Evidence of animals which have survived ship strikes with no discernible injury (i.e. non-fatal injuries) have also been documented (Luksenburg and Parsons, 2014, Wells *et al.*, 2008).

10.11.5.3 Guidance provided by NOAA defines serious injury to marine mammals 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 (Helker *et al.,* 2017, NMFS , 2023). In contrast, non-serious injury is likely to result in short-term impacts which may have long-term effects on health and lifespan.

Magnitude of impact

10.11.5.4 As discussed in Paragraph 10.11.4.7, vessel traffic will increase up to 3,060 return trips by construction vessels throughout the construction phase (Table 10.32). This increase, described in more detail in Section 10.11.3.1, could lead to an increase in interactions between marine mammals and vessels.

10.11.5.5 All vessels will be required to adhere to the NSPVMP. This includes provisions:

- to not deliberately approach marine mammals;
- to avoid abrupt changes in course or speed should marine mammals approach the vessel to bow-ride;
- to remain at safe speeds at all times and to reduce speed when a marine mammal is in the vicinity.

10.11.5.6 These measures are appropriate to reduce the risk of collisions with marine mammals as far as practicable, which would subsequently only be present for transiting (as opposed to stationary) vessels. In addition, sound emissions from construction vessels are likely to deter animals from the potential zone of impact.

10.11.5.7 A proportion of construction vessels will be relatively small in size (e.g. tugs, support vessels, crew transfer vessels, dive boats, barges) with good manoeuvrability and would be able to avoid marine mammals where detected (Schoeman *et al.,* 2020). Larger vessels such as cargo-barges and installation vessels with lower manoeuvrability may need larger distances to avoid an animal. However, they would also be expected to travel at slower speeds, providing more time to react if a marine mammal is detected.

10.11.5.8 The impact is predicted to be of local spatial extent in the context of the geographic frame of reference, medium term duration, intermittent and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive marine mammal 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.

<u>Sensitivity of the receptor</u>

10.11.5.9 Marine mammals are largely able to detect and avoid vessels due to their hearing sensitivity, particularly when those vessels are conducting activities such as seismic surveys (Koski *et al.,* 2009). However, it remains unclear why some individuals do not always move out of the path of an approaching vessel (Schoeman *et al.,* 2020) and analyses indicate that the interaction of factors like ambient or background noise can interfere with the ability of marine mammals to detect approaching ships (Gerstein *et al.,* 2005). It has also been suggested that behaviours like resting, foraging, nursing, and socialising may distract animals from detecting approaching vessels regardless of detection abilities (Dukas , 2002, Gerstein *et al.,* 2005). As such there can be consequences to this lack of response to disturbance for all marine mammals; behavioural habituation can result in decreased wariness of vessel traffic, and therefore an increased collision risk (Cates and Acevedo-Gutiérrez, 2017).

10.11.5.10 Vessel strikes are known to be a cause of mortality in marine mammals (Carrillo and Ritter, 2010), and it is possible that mortality from vessel strikes is under-recorded (Van Waerebeek *et al.*, 2007), particularly for smaller marine mammals (Schoeman *et al.*, 2020). Collisions between vessels and large whales can often lead to death or serious injury (Kraus , 1990), while collisions between cetaceans and vessels are not necessarily lethal on all occasions (Van Waerebeek *et al.*, 2007). Necropsies and observations of whales surviving vessel strikes have established a relationship between the severity of injury and vessel speed (Combs , 2018, Conn and Silber, 2013, Rommel *et al.,* 2007, Vanderlaan and Taggart, 2007, Wiley *et al.,* 2016), and although all types of vessels may hit whales, most lethal and serious injuries are caused by large ships (e.g. 80m or longer) and vessels travelling at speeds faster than 14kn (Laist *et al.,* 2001).

10.11.5.11 Given that harbour porpoise is small and highly mobile, and considering its potential avoidance response to vessel noise (see Paragraph 10.11.4.37), it can be assumed that this species will largely avoid vessel collisions. This is supported by data from the UK Cetaceans Stranding Investigation Programme (CSIP) (CSIP, 2015) which 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 may have resulted from vessel strikes (CSIP, 2015).

10.11.5.12 For bottlenose dolphin evidence from long term photo-identification data shows that only one out of a group of 277 bottlenose dolphin present within the study region exhibited marks indicative of vessel interactions (Olson *et al.,* 2022). Similarly, moderate impacts from collisions may be sustainable at species level because many strikes are non-lethal (Van Waerebeek *et al.,* 2007).

10.11.5.13 Collision risk for seals is less understood than for cetaceans. 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). During one study in the Moray Firth seals travelling between haul-outs and foraging sites used the same areas as vessels but tended to remain beyond 20m from vessels (Onoufriou *et al.,* 2016). Across 2,241 observation days only three observations were recorded of seals occurring closer than 20m to a vessel.

10.11.5.14 Thus, on the basis that not all collisions are lethal, there is considered to be a medium potential for recovery. Furthermore, factors such as interspecific differences in bone strength may result in different risks of incurring blunt force trauma (Clifton *et al.,* 2008) and provide further complex variability in lethality of collisions.

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

Significance of the Effect

10.11.5.16 Overall, the magnitude of the impact is deemed to be low (particularly with the adoption of the NSPVMP, (Volume 4, Annex 5: Navigation Safety Plan and Vessel Management Plan (NSPVMP) (Version 1)) and the sensitivity of the receptors is considered to be medium. The effect will therefore be of **minor adverse** significance, which is not significant in EIA terms.

Secondary Mitigation and Residual Effect

10.11.5.17 No mitigation measures for marine mammals are considered necessary because the likely effect in respect of injury to marine mammals due to collision with vessels in the absence of further mitigation (beyond the designed-in measures outlined in Table 10.33), is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

10.11.5.18 Vessels will be required during the decommissioning phase for activities such as removal of foundation, cables and cable protection (Table 10.17). Collision risk from vessels is assumed to be as described for the construction phase, and an overview of the potential impacts is described in paragraphs Paragraph 10.11.5.4 *et seq.*, so has not been reiterated here for the decommissioning phase. There is no information regarding the number of vessel transits for the decommissioning phase and therefore a quantitative assessment is not possible for this phase. However, it is anticipated that the number of vessels, number of transits and duration of the decommissioning phase will be considerably less compared to the construction phase.

10.11.5.19 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 the receptor

10.11.5.20 The sensitivity of the receptors during the decommissioning phase is not expected to differ from that during the construction phase. Therefore, the sensitivity of marine mammal receptors to collision risk is as described previously in Paragraph 10.11.5.9 *et seq.*, where it has been assessed as medium.

Significance of the effect

10.11.5.21 Overall, the magnitude of the impact is deemed to be low (particularly with the adoption of the NSPVMP (Table 10.33) 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.

Secondary mitigation and residual effect

10.11.5.22 No mitigation measures for marine mammals are considered necessary because the likely effect in respect of injury to marine mammals due to collision with vessels in the absence of further mitigation (beyond the designed-in measures outlined in Table 10.33), is not significant in EIA terms.

10.11.6 Effects on marine mammals due to changes in prey availability

10.11.6.1 Potential effects on fish and shellfish during the construction, operation and maintenance and decommissioning phases of Morven South, are identified in Volume 2, Chapter 9: Fish and Shellfish Ecology. There is the potential for changes in the availability or distribution of prey species as a result, which could affect the foraging ability of marine mammal species.

10.11.6.2 Key prey species for marine mammals (see Volume 3, Annex 10.1: Marine Mammals Shared Baseline Technical Report for detail on marine mammal feeding ecology) that may occur within the Morven South Boundary include, *inter alia*:

- mackerel (Scomber scombrus;)
- sandeels (Ammodytes marinus);
- gadoids (including cod (Gadus morhua), haddock (Melanogrammus aeglefinus), whiting (Merlangius merlangus), Norway pout (Trisopterus esmarkii);
- clupeids (including herring (*Clupea harengus)* and sprat (*Sprattus sprattus*);
- flatfish (including plaice Pleuronectes platessa and sole (*Solea solea)*, (*Microstomus kitt*).

10.11.6.3 These prey species have been identified as being of regional or national importance within the Morven South Fish and Shellfish Ecology Study Area (Volume 2, Chapter 9: Fish and Shellfish Ecology).

Construction phase

Magnitude of impact

10.11.6.4 Potential impacts on marine mammal prey species during the construction phase have been assessed in Volume 2, Chapter 9: Fish and Shellfish Ecology using the appropriate MDS for these receptors. Construction impacts on prey species include temporary habitat loss/disturbance, long-term habitat loss, increased SSCs and associated deposition, colonisation of hard structures and associated fish aggregation, and injury/disturbance to fish and shellfish receptors from underwater sound from piling and UXO clearance.

Habitat loss

10.11.6.5 The installation of infrastructure for Morven South will lead to temporary habitat loss/disturbance from activities including boulder and sand wave clearance, installation of interconnector cables and offshore export cables, and use of jack-up vessels for installation of wind turbine and OSP foundations. Long term habitat loss will occur under wind turbine and OSP foundations, inter-array and interconnector cable protection and cable crossing protection, inter-array junction boxes and associated scour protection. The extent of habitat disturbance/loss during the construction phase is summarised in Table 10.74.

Table 10.74: Maximum Design Scenario for temporary habitat loss/disturbance and long-term habitat loss during the construction phase

Impact	Area of habitat (m^2)	Percentage of Morven South Fish and Shellfish Ecology Study Area
Temporary habitat loss/disturbance	62,596,300	0.120%

Impact	Area of habitat (m²)	Percentage of Morven South Fish and Shellfish Ecology Study Area
Long-term habitat loss	1,820,664 installed in the construction phase and persisting into the O&M phase	0.004%

10.11.6.6 Temporary habitat loss and disturbance has the potential to affect spawning, nursery or feeding grounds of fish and shellfish receptors, and may therefore impact prey availability for marine mammals. Given the highly localised nature of effects (i.e. within the Morven South Boundary) and the limited spatial extent of habitats affected (as a proportion of the northern North Sea), as well as the medium-term duration of effects and recovery beginning immediately following cessation of construction activities, temporary habitat loss/disturbance during the construction phase was assessed in Volume 2, Chapter 9: Fish and Shellfish Ecology, as being of low magnitude.

10.11.6.7 Long term habitat loss within the Morven South Fish and Shellfish Ecology Study Area will occur during construction (i.e. through placement of infrastructure), although effects will extend throughout the operation and maintenance phase. Long term habitat loss will occur under wind turbine and OSP foundations, inter-array and interconnector cable protection and cable crossing protection, inter-array junction boxes and associated scour protection.

10.11.6.8 The extent of long-term habitat loss during the construction phase is summarised in Table 10.74. Many species of fish and shellfish (notably herring and sandeel) are reliant upon the presence of suitable sediment/habitat for their survival, and therefore, seabed habitats removed by the infrastructure installation will reduce the area available for foraging, spawning, and nursing.

10.11.6.9 The Morven South Fish and Shellfish Ecology Study Area is located over low intensity spawning and low intensity nursery grounds for sandeel, and a mix of preferred, marginal and unsuitable habitat type, with the preferred habitat types in the north-west of the Morven South Boundary (see Volume 3, Annex 9.1: Fish and Shellfish Ecology Shared Technical Report). Herring spawning habitat is largely unsuitable within the Morven South Fish and Shellfish Ecology Study Area, with core spawning grounds existing outside the Morven South Boundary. Therefore, the area of herring spawning grounds affected by this impact is expected to be very limited, in the context of available favourable sediments habitat outside the Morven South Fish and Shellfish Ecology Study Area. Long term habitat loss during the construction phase was assessed in Volume 2, Chapter 9: Fish and Shellfish Ecology as being of low magnitude. All fish and shellfish IEFs were assessed as being of low sensitivity, with the exception of sandeel which was of medium sensitivity; the significance of the effect of habitat loss on all fish and shellfish species was determined to be minor adverse.

Underwater sound

10.11.6.10 There is the potential for underwater sound during construction (from piling and UXO clearance) to result in injury and/or disturbance to fish and shellfish communities (see Volume 2, Chapter 9: Fish and Shellfish Ecology). For the PK metric and the MDS assessed in Volume 2, Chapter 9: Fish and Shellfish Ecology, the maximum recoverable injury range is estimated at 0.27km^2 to 1.94km^2 from the modelled monopile piling location. The potential for mortality or mortal injury to fish eggs would also occur within an area of up to 1.94km^2. However, this is highly conservative due to the implementation of soft starts during piling, which will allow fish to move away before received sound reaches injurious levels. As such, the maximum injury ranges predicted for soft start initiation (i.e. those in the order of tens of metres) are likely to be more realistic.

10.11.6.11 Using the SEL_{24h} metric, underwater sound modelling showed that injury may occur out to 14km (e.g. mortality may occur out to 7.38km). TTS, from which animals will recover, was predicted to occur out to a maximum distance of 37.1km (based on static fish). Given that there is limited evidence of behavioural disturbance from underwater sound, TTS is often used as a proxy for behavioural disturbance in fish. Qualitative assessment of behavioural effects in fish to underwater sound suggested, however, that responses will differ depending on the sensitivity of the species and the presence/absence of a swim bladder (Popper *et al.*, 2014). For the least sensitive species (e.g. flatfish), the risk of behavioural effects is moderate to high in the nearfield (tens of metres) and intermediate field (i.e. hundreds of metres). For more sensitive species (e.g. herring, gadoids, sprat etc.) behavioural effects may occur further away from the source (i.e. over several kilometres or more from the source). The magnitude of underwater sound effects was considered to be low and the sensitivity of the fish and shellfish receptors was assessed as low to medium. Therefore, as detailed in Volume 2, Chapter 9: Fish and Shellfish Ecology, the effect of underwater sound from piling and UXO on fish and shellfish receptors was minor adverse significance.

Suspended Sediment Concentrations and associated deposition

10.11.6.12 Morven South preparation activities and installation of infrastructure associated with Morven South may lead to increased SSCs and associated deposition. During the construction phase, these activities will include sandwave clearance and installation of wind turbines and OSPs, and sandwave clearance and installation of inter-array and interconnector cable. Overall, the impact is predicted to be of local spatial extent, short term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low. All fish and shellfish IEFs were assessed as being of low sensitivity, with the exception of sandeel and herring which were of medium sensitivity; the significance of the effect of increase in SSCs on all fish and shellfish species was determined to be minor adverse.

Colonisation of hard structures

10.11.6.13 During all phases phase, Morven South will maintain up to 3,074,239m^2 of artificial hard structures on the seabed, including wind turbine and OSP foundations, scour protection, cable protection, and cable crossing protection. These structures will persist throughout the 35-year operational lifespan, introducing a hard substrate into the water column. Whilst these structures are dispersed across Morven South and not concentrated in one area, they represent a long-term, continuous alteration of the seabed environment. For fish and shellfish species, the impact is predicted to be of local spatial extent, long term duration, continuous, and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is considered to be low due to the wide availability of similar habitats within the Morven South Boundary and Regional Fish and shellfish Ecology Study Area. All fish and shellfish IEFs were assessed as being of low sensitivity and the significance of the effect of colonisation of hard structures on all fish and shellfish species was determined to be minor adverse.

Summary of magnitude of indirect effects on marine mammals

10.11.6.14 Marine mammals forage over extensive distances and exploit a wide range of different prey items, with the ability to switch prey sources depending on season and availability. The impacts resulting from the construction of Morven South on fish and shellfish receptors will be highly localised and largely restricted to the boundaries of Morven South. In context of the wider available foraging habitat within the northern North Sea, the area of impact is very small. Marine mammals within the Morven Regional Marine Mammal Study Area may also have the potential to be directly affected as a result of effects such as injury and disturbance from elevated underwater sound impacts during piling/UXO clearance and it is likely that the effects to prey resources (e.g. behavioural displacement) are likely to occur over a similar, or lesser, extent and duration as those for marine mammals. It is therefore considered that there would be no additional displacement of marine mammals as a result of any changes in prey resources during the construction phase, as marine mammals would already be potentially disturbed as a result of underwater sound during piling and UXO clearance.

10.11.6.15 On the basis of the assessments presented in Volume 2, Chapter 9: Fish and Shellfish Ecology, negligible or minor adverse effects have been predicted to occur to fish and shellfish species (marine mammal prey) as a result of the construction of Morven South, which are not significant in EIA terms.

10.11.6.16 Therefore, the impact on marine mammals is predicted to be of local spatial extent in the extent of the relevant geographic frame of reference (i.e. MU), medium term duration, intermittent and the effect on marine mammals is of high reversibility. The magnitude is therefore, considered to be low.

Sensitivity of the Receptor

10.11.6.17 The fish and shellfish communities found within the Morven South Fish and Shellfish Ecology Study Area (see Volume 2, Chapter 9: Fish and Shellfish Ecology) are characteristic of the fish and shellfish assemblages in the wider northern North Sea. It is highly likely that, considering the highly mobile nature of marine mammals, similar prey resources exist in the wider norther North Sea region. Foraging over greater distances could, however, result in an energetic cost, which would be particularly pertinent for harbour porpoise, which have a high metabolic rate and limited energy storage capacity, limiting their ability to buffer against diminished food. Despite this, if animals do have to travel further to alternative foraging grounds, the impacts are expected to be short term in nature and reversible (i.e. elevated underwater sound affecting prey distribution would occur during piling only).

10.11.6.18 Minke whale may be particularly vulnerable to potential effects on sandeels, particularly in the event that abundance becomes reduced. Minke whale stomach content analysis found that in the North Sea sandeel is their key food resource, followed by clupeids and to a lesser extent mackerel (Robinson and Tetley, 2005, Tetley *et al.*, 2008); see Volume 3, Annex 10.01: Marine Mammals Shared Baseline Technical Report for more details. However, modelling by Langton *et al.* (2021) shows that the Morven South Marine Mammal Study Area has extremely low probability of sandeel presence, with areas where predicted density is high closer to the coasts or towards the Firth of Forth. For sandeels, the assessment presented within Volume 2, Chapter 9: Fish and Shellfish Ecology, concluded that all impacts would be of minor adverse significance, which is not significant in EIA terms, therefore minke whale are not considered to be affected indirectly through impacts to sandeel.

10.11.6.19 All receptors are deemed to be of high resilience and adaptability, high recoverability and high international value. The sensitivity of all marine mammals is therefore considered to be low.

Significance of the effect

10.11.6.20 Overall, the magnitude of the impact is deemed to be low and the sensitivity of all species is considered to be low. The overall significance of the effect is negligible or minor. The effect will be of **minor adverse** significance, as some effects are expected at the individual level, with the ZoI likely extending beyond the Morven Marine Mammal Study Area. This is not significant in EIA terms.

Secondary Mitigation and residual effect

10.11.6.21 No mitigation measures for marine mammals are considered necessary because the likely effect due to changes in prey availability in the absence of further mitigation (beyond the designed-in measures outlined in Table 10.33), is not significant in EIA terms.

Operations and maintenance phase

Magnitude of impact

10.11.6.22 Potential impacts on marine mammal prey species during the operation and maintenance phase have been assessed in Volume 2, Chapter 9: Fish and Shellfish Ecology, using the appropriate MDS for fish and shellfish receptors. The assessment considers temporary habitat loss/disturbance and long-term habitat loss, colonisation of hard structures, increased SSCs and associated deposition, and EMF from subsea cables.

Habitat loss

10.11.6.23 The MDS is for up to 7,967,400m^2 of temporary habitat loss/disturbance during the operation and maintenance phase. This equates to 0.51% of the Morven South the Fish and Shellfish Ecology Study Area. The MDS for long-term subtidal habitat loss is assessed in paragraphs 10.11.6.5 *et seq.*

for the construction phase, and is therefore not reiterated here. Given that these impacts will be similar to those identified for temporary habitat loss/disturbance during the construction phase and will be highly restricted to the immediate vicinity of these operations, the magnitude was assessed as low. All fish and shellfish IEFs were assessed as being of low sensitivity, with the exception of herring which was of medium sensitivity; the significance of the effect of long-term habitat loss on all fish and shellfish species was determined to be minor adverse.

SSCs and Associated Deposition

10.11.6.24 Increased SSCs may occur during repair or remedial burial activities to interconnector and offshore export cables during the operation and maintenance phase, as summarised in Table 10.75.

Table 10.75: Maximum design scenario for repair and reburial of interconnector and offshore export cables during the operations and maintenance phase

Activity	Cable length (km)	
	Interconnector cables	Inter-array cables
Repair of cables	2	10
Reburial of cables	11	17

10.11.6.25 Inter-array cables will be repaired in two events and reburied in one event every five years. Interconnector cables will be repaired in up to ten events over 25 years, with reburial occurring in one event every five years. This will occur over the 35-year operation and maintenance phase, using similar methods to those for cable installation during the construction phase.

10.11.6.26 The assessment in Volume 2, Chapter 9: Fish and Shellfish Ecology considered that for the herring and sandeel IEFs, the magnitude of the impact is deemed to be negligible and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of negligible to minor adverse significance, which is not significant in EIA terms. For all other fish and shellfish IEFs, the magnitude of the impact is deemed to be negligible and the sensitivity of the receptor is considered to be low, with the exception of herring and sandeel which was of medium sensitivity. The significance of the effect was determined as minor adverse.

EMF

10.11.6.27 EMFs generated by up to 684km of subsea cables associated with Morven South may have potential effects on fish and shellfish species. These EMFs, emitted from both buried and dynamic cables, are strongest close to the source but decrease rapidly with distance, returning to background levels within a few to tens of metres. Most cables will be buried or have cable protection, which significantly reduces EMF exposure at the seabed. Due to the rapid attenuation of EMFs and the limited spatial extent of exposure, fish and shellfish are unlikely to experience significant behavioural changes or barrier effects. The impact on these species is therefore expected to be of local spatial extent, long term duration, continuous and high reversibility (at the end of the operation and maintenance phase). It is predicted that the impact will affect the receptor directly. The magnitude was therefore considered to be low. All fish and shellfish IEFs were assessed as being of low sensitivity and the significance of the effect of EMF was determined to be minor adverse.

Colonisation of hard structures

10.11.6.28 The MDS for colonisation of hard structures is assessed in paragraphs 10.11.6.13 *et seq.* for the construction phase, and is therefore not reiterated here. Given that these impacts will be similar to those identified for colonisation of hard structures during the construction phase and will be highly restricted to the immediate vicinity of these operations, the magnitude was assessed as low.

Summary of magnitude of impact on marine mammals

10.11.6.29 The impact on marine mammals is predicted to be of local spatial extent in the context of the geographic frame of reference, long term duration, continuous and the effect on marine mammals is of high reversibility. The magnitude is therefore, considered to be low. All fish and shellfish IEFs were assessed as being of low sensitivity and the significance of the effect of colonisation of hard structures was determined to be minor adverse.

Sensitivity of the receptor

10.11.6.30 Marine mammals are highly mobile and wide-ranging, it therefore expected that individuals could forage in alternative areas if required. However, infrastructure (e.g. turbines) provides a hard substrate for the potential colonisation (Delefosse *et al.*, 2018) by various marine life. Faecal deposits from animals colonising structures, likely alter the surrounding seafloor communities by increasing food availability in Morven South (Degraer *et al.*, 2021). This increased food availability is likely to attract fish and marine mammals, who can exploit the increased foraging opportunities in Morven South.

10.11.6.31 Species such as harbour porpoise, minke whale, white-beaked dolphin, harbour seal and grey seal have been frequently recorded around offshore oil and gas structures (Lindeboom *et al.*, 2011, Delefosse *et al.*, 2018, Todd *et al.*, 2015). Fernandez-Betelu *et al.* (2022)deployed an array of C-PODs within the vicinity of four offshore structures. The probability of porpoise occurrence and foraging activity was found to decrease with distance from offshore structures. These findings demonstrated that marine mammals are attracted to man-made structures (Fernandez-Betelu *et al.*, 2022). Acoustic results from a T-POD measurement within a Dutch wind farm found that relatively more harbour porpoise were found in the wind farm area compared to the two reference areas (Lindeboom *et al.*, 2011, Scheidat, 2021). This study concluded that the presence within the wind farm area was due to increased food availability as well as the exclusion of fisheries and reduced vessel traffic in the wind farm. Further evidence suggesting that wind farms are used for foraging includes a study by (Russell and McConnell, 2014) where the movements of tagged harbour seals commonly exhibited grid-like movement patterns within two active wind farms in the North Sea. Brandt *et al.* (2009) suggested, however, that a small increase in detections during the night at hydrophones deployed in close proximity to single wind turbines may indicate increased foraging behaviour near the monopiles. Whilst there is some mounting evidence of potential benefits of man-made structures in marine environment (Coolen *et al.*, 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 (Elliott and Birchenough, 2022, Inger *et al.*, 2009, McLean *et al.*, 2022, Rouse *et al.*, 2020).

10.11.6.32 Therefore, given the expected adaptability of marine mammals foraging ability, the sensitivity of the marine mammal receptors is considered to be low.

Significance of the effect

10.11.6.33 Overall, the magnitude of the impact is deemed to be low and the sensitivity of the marine mammal receptors is considered to be low. The overall significance of the effect is negligible or minor. The effect will be of minor adverse significance (though could be minor beneficial for some species dependent on the reef effect), which is not significant in EIA terms.

Secondary mitigation and residual effect

10.11.6.34 No mitigation measures for marine mammals are considered necessary because the likely effect due to changes in prey availability in the absence of further mitigation (beyond the designed-in measures outlined in Table 10.33), is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

10.11.6.35 Potential impacts on marine mammal prey species during the decommissioning phase have been assessed in Volume 2, Chapter 9: Fish and Shellfish Ecology.

10.11.6.36 The magnitude of impacts is anticipated to be the same or less than for the construction phase. Therefore, the impact on marine mammals is predicted to be of a local spatial extent in the extent of the geographic frame of reference, medium term duration, intermittent and the effect on marine mammals is of high reversibility. The magnitude is therefore, considered to be low.

Sensitivity of the receptor

10.11.6.37 The sensitivity of marine mammal receptors during the decommissioning phase is not expected to differ from the sensitivity of the receptors during the construction phase. The sensitivity of the receptors is therefore, considered to be low.

Significance of the effect

10.11.6.38 Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The overall significance of the effect is negligible or minor. The effect will be of **minor adverse** significance (though could be minor beneficial for some species dependent on the reef effect, if infrastructure is kept *in situ*), which is not significant in EIA terms.

Secondary mitigation and residual effect

10.11.6.39 No mitigation measures for marine mammals are considered necessary because the likely effect due to changes in prey availability in the absence of further mitigation (beyond the designed-in measures outlined in Table 10.33), is not significant in EIA terms.

10.11.7 Proposed monitoring

10.11.7.1 Site specific monitoring is not proposed because the assessment concluded that Morven North would not give rise to significant effects for marine mammals, either alone or when considered cumulatively with other plans, projects or activities. The Applicant will, however, continue to liaise with MD-LOT, and key stakeholders to help identify opportunities for proportionate, evidence led regional or strategic monitoring that can improve understanding of the environmental implications of offshore wind, particularly where recognised evidence gaps exist. This may include contributing to, or participating in, relevant ongoing initiatives under the ScotMER programme (Scottish Government, 2026).

10.12 Whole project assessment and Cumulative Effects Assessment methodology

10.12.1 Methodology

10.12.1.1 The Morven Programme comprises four distinct projects: Morven North, Morven South, Morven Hawthorn Pit Grid Connection Project (MHPGC Project), and Morven Branxton Area Grid Connection Project (MBAGC Project).

10.12.1.2 The following assessment scenarios have been considered to identify the LSE[1] of Morven South in-combination with other projects on the same receptor, as follows (and summarised in Table 10.76):

- Whole project assessment: to identify the potential impacts associated with Morven South together with each grid connection option in turn, (Scenario 1: MHPGC and Scenario 2: MBAGC Project), each of which would comprise a “Whole Project”;
- Morven Programme assessment: to identify potential impacts associated with all four components of the Morven Programme (Scenario 3);

- CEA: to identify the potential impacts associated with Morven South together with other relevant projects, plans and activities including other components of the Morven Programme, using a tiered approach (Scenario 4).

10.12.1.3 The whole project assessment and CEA have been undertaken in accordance with the methodology described in Volume 1, Chapter 6: EIA methodology. Agreement on the cumulative projects and impacts taken forward to the cumulative assessment were discussed and agreed with stakeholders (see Table 10.15), specifically:

- MD-LOT: Targeted Consultation on Morven North and Morven South and approach to CEA on the 3rd of March 2025;
- MD-LOT and NatureScot workshop on the 23rd of October 2025.

Table 10.76: Scenarios to be considered in the Morven South whole project assessment and Cumulative Effects Assessment for marine mammals

Whole project assessment		Morven Programme assessment (Offshore Ornithology and Shipping and Navigation Only)	Cumulative Effects Assessment
Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
Morven South + MHPGC Project	Morven South + MBAGC Project	Morven South + Morven North + MHPGC Project + MBAGC Project	Morven South + Tier 1, Tier 2, and Tier 3 Plans/Projects screened in

10.12.1.4 For the purposes of this marine mammal chapter, Scenarios 1, 2, and four have been taken forward for assessment; Scenario 3 has not been included as it is not applicable to this chapter. As discussed in Volume 1, Chapter 6: EIA Methodology, the Morven Programme assessment (Scenario 3) is only required for specific chapters to provide further context to, and to support, the conclusions of the CEA scenario (Scenario 4), in agreement with the relevant stakeholders for these topics (see Table 10.15). As Scenario 3 does not form the basis of the CEA conclusions, it is considered a supplementary assessment to the CEA scenario (Scenario 4) for these specific topics. The approach to cumulative effects assessment presented in this marine mammal chapter complies with the requirements under the EIA Regulations to assess the LSE on the environment arising from a project cumulatively with other relevant plans, projects and activities, and no supplementary assessment of the Morven Programme (Scenario 3) is required or has been requested by relevant stakeholders with regard to marine mammals.

10.12.1.5 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 6.1: Cumulative Effects Screening). Each project or plan 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.

10.12.1.6 In undertaking the CEA for Morven South, it should be noted that other projects and plans under consideration will have differing potential for proceeding to an operational stage and hence a differing potential to ultimately contribute to a cumulative impact alongside Morven South. Therefore, a tiered approach has been adopted, whereby all third-party projects and plans considered have been allocated into 'tiers' reflecting their current stage within the planning and development process. This provides a framework for placing relative weight upon the potential for each project/plan included in the CEA to ultimately be realised, based upon the project/plan's current stage of maturity and certainty in the project/plan's parameters. The tiered approach utilised within the Morven South CEA employs the following tiers:

- Tier 1 assessment – Existing developments either built (operational) or under construction[4]; approved developments awaiting implementation; and permitted/submitted application(s), but not yet determined, plus Morven South has also been included.
- Tier 2 assessment – All plans/projects assessed under Tier 1, plus MHPGC Project and plans/projects where a scoping report has been submitted and is in the public domain.
- Tier 3 assessment – All plans/projects assessed under Tier 1 and 2, plus MBAGC Project and plans/projects that are reasonably foreseeable (e.g. projects identified in development plans, projects in other plans and programmes, offshore renewable energy projects that have a Crown Estate Scotland Lease Option Agreement).

10.12.1.7 The specific projects and plans screened into the CEA for marine mammals are outlined in Table 10.78. The following approach has been applied in order to screen projects in and out of the CEA:

- Long list:
  - Projects that fell within the Morven Regional Marine Mammal Study Area) were screened in as agreed with Statutory Nature Conservation Bodies (SNCBs).
  - From this subset, projects with no temporal overlap with any phase of Morven South were screened out.
  - From this subset, projects where there is no effect-receptor pathway were screened out.
  - The short list of projects was then taken forward for further screening.
- Short list:
  - Projects where any of the construction, O&M and/or decommissioning activities were already occurring in 2025 were screened out as these were considered to be part of the baseline;
  - Projects that are expected to remain in construction up to one year after the commencement of construction for Morven North or Morven South have been included within the cumulative assessment.

10.12.1.8 Remaining projects were considered at a species-specific level to determine if further screening could occur if a project was within the Regional Marine Mammal Study Area but not within a specific species' MU (which may be smaller, such as those for grey seal and harbour seal);

10.12.1.9 For potential impacts within the construction phase, temporal overlap was considered to occur for projects constructing up to one year on either side of the construction phase of Morven South (2033 to 2042) based on NatureScot advice for other Scottish projects ((Caledonia OWF Ltd, 2024a, Cenos Offshore Windfarm Limited, 2024a, Muir Mhòr Offshore Wind Farm, 2024). Therefore, projects with construction occurring within 2032 to 2043 were considered to have the potential for temporal overlap for a relevant impact;

10.12.1.10 Impact-specific effects were further screened based on the outcome of the project alone assessment and taking a proportionate approach (further to information submitted by recent ScotWind projects) to focus only on those impacts where there is potential for a cumulative effect. This is discussed further in paragraph 10.12.2.2 where the cumulative MDSs for each impact screened into the assessment is defined.

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[4] Note that existing developments are included in Tier 1 CEA long list but are generally screened out of the CEA assessments, aside from the following exceptions:

1) Existing developments which were not present at the time of baseline characterisation, where a potential cumulative impact-receptor pathway has been identified.

2) Existing developments are screened into tier 1 assessments for specific topics where there is a large conceptual, temporal and spatial overlap between project impacts. In these instances, the potential for ongoing effects through cumulative impact-receptor pathways throughout project lifetime, across the development phases, means that they are considered within quantitative assessment for these topic CEAs (e.g., offshore ornithology assessments consider the cumulative effects of operational offshore wind farms).

10.12.1.11 The potential impacts that have been considered in the CEA (listed in Table 10.79) is a subset of those considered for the Morven South alone assessment. This is because some of the potential impacts identified and assessed for the Morven South alone assessment are localised and temporary in nature or have been assessed to have negligible significance. It is considered therefore, that these potential impacts have limited or no potential to interact with similar changes associated with other plans or projects. These have therefore been scoped out of the whole project assessment and CEA. These impacts and the justification for scoping them out of the whole project assessment and CEA are presented in Table 10.77.

10.12.1.12 Similarly, some of the potential impacts considered within the Morven South alone assessment are specific to a particular phase of development (e.g. construction, operation and maintenance or decommissioning). Where cumulative effects with other plans or projects only have potential to occur where there is spatial or temporal overlap with Morven South during certain phases of development, impacts associated with a certain phase may be omitted from further consideration where no plans or projects have been identified that have the potential for cumulative effects during this period.

Table 10.77: Impacts screened in and out of the whole project assessment and Cumulative Effects Assessment for marine mammals. Note ✓ and × indicates to which phase the impact relates

Impact	Phase			Screened in or out of whole project assessment and CEA	Justification
	C	O	D		
Injury from underwater sound generated during piling	✓	×	×	Out	Suitable mitigation must be in place following statutory guidelines for all projects to reduce the risk of injury from piling for the projects alone to negligible (EPS legislation). Therefore, there is no potential for residual risks that could lead to a cumulative effect, and this impact is screened out.
Disturbance from underwater sound generated during piling	✓	×	×	In	Underwater sound from piling could lead to population-level disturbance to marine mammals where multiple projects are piling either sequentially or within a similar time frame due to the potential large effect area that extends beyond the boundaries of OWF sites. This impact is screened in for construction.
Injury and disturbance from underwater sound generated during UXO clearance	✓	×	×	Out	Morven South has committed to using low order clearance techniques such that injury can be mitigated via standard industry measures. Furthermore, all projects considered as part of the cumulative assessment are expected to include low order deflagration as the method of clearance in line with the Joint Position statement (UK Government, 2025) and it has been reported that this technique has successfully cleared all types of UXO with none resulting in high order detonation (Ocean Winds, 2024). Therefore, there is no risk of injury to marine mammals as a result of underwater sound generated during UXO clearance. Disturbance could occur as a very short term (1 second) event that leads to a startle response and therefore no prolonged effect and no potential for cumulative effects.
Injury to marine mammals from site investigation surveys	✓	✓	×	Out	**Pre-construction phase** Injury during pre-construction site investigation surveys (i.e. not during construction phase) predicted small effect ranges (0.9km) that would be localised within the Morven South Boundary. This range is for the SBP Chirp which is a directional system expected to radiate noise primarily vertically with limited horizontal spread. For all other survey equipment, the disturbance ranges were between 2m to 262m. Typically, each type of survey would involve no more than two survey vessels on site at any one time and assuming an (unlikely) worst case where each survey type is conducted from a different vessel, a total of 156 vessels movements would be involved over the pre-construction phase. Injury could occur intermittently within relatively short timeframes (six to eight months) for up to one or two years, depending on survey type. The number

Impact	Phase			Screened in or out of whole project assessment and CEA	Justification
	C	O	D		
					of vessels is captured in the assessment on vessel sound and this impact therefore focuses only on the survey noise. Due to the very small effect ranges for different surveys there is not anticipated to be any potential for cumulative effects and this impact is screened out. **O&M phase** Injury during site investigation surveys predicted small effect ranges that would be localised within the Morven South Boundary. Typically, each type of survey would involve no more than two survey vessels and there would be no more than four vessels conducting geophysical or remotely operated vehicle (ROV) surveys of the wind turbine/OSP foundations or inter-array cables and all associated infrastructure. Effect ranges for injury are highly localised and therefore, a negligible risk of injury to marine mammal receptors is predicted from the project alone. Disturbance could occur intermittently within relatively short timeframes (six to eight months) annually for the first five years and thereafter every four years. Thus, there is limited potential for a cumulative effect with other plans or projects, and this impact has been screened out.
Disturbance to marine mammals from site investigation surveys	✓	✓	×	Out	**Pre-construction phase** Disturbance during pre-construction site investigation surveys (i.e. not during construction phase) predicted small effect ranges (3.7km) that would be localised within the Morven South Boundary. This range is for the SBP Chirp which is a directional system expected to radiate noise primarily vertically with limited horizontal spread. For all other survey equipment, the disturbance ranges were between 150m to 680m. Typically, each type of survey would involve no more than two survey vessels on site at any one time and assuming an (unlikely) worst case where each survey type is conducted from a different vessel, a total of 156 vessels movements would be involved over the pre-construction phase. Disturbance could occur intermittently within relatively short timeframes (six to eight months) for up to one or two years, depending on survey type. The number of vessels is captured in the assessment on vessel sound and this impact therefore focuses only on the survey noise. Due to the very small effect ranges for different surveys there is not anticipated to be any potential for cumulative effects and this impact is screened out. **O&M phase** Disturbance during site investigation surveys predicted small effect ranges (<3.7km) that would be localised within the Morven South Boundary. This range is for the SBP

Impact	Phase			Screened in or out of whole project assessment and CEA	Justification
	C	O	D		
					Chirp which is a directional system expected radiate noise primarily vertically with limited horizontal spread. For all other survey equipment, the disturbance ranges were between 150m to 680m.Typically, each type of survey would involve no more than two survey vessels and there would be no more than four vessels conducting geophysical or ROV surveys of the wind turbine/OSP foundations or inter-array cables and all associated infrastructure. Effect ranges for disturbance are highly localised and therefore a negligible risk of injury to marine mammal receptors is predicted from the project alone. Disturbance could occur intermittently within relatively short timeframes (six to eight months) annually for the first five years and thereafter every four years. Thus, there is limited potential for a cumulative effect with other plans or projects, and this impact has been screened out.
Injury to marine mammals from vessel use and other non-piling sound-producing activities	✓	✓	✓	Out	During all phases, effect ranges for injury are highly localised and therefore negligible risk of injury to marine mammal receptors is predicted from project alone. Thus, there is limited potential for a cumulative effect with other plans or projects, and this impact has been screened out.
Disturbance to marine mammals from vessel use and other non-piling sound-producing activities	✓	✓	✓	In (for the construction and O&M phases) Out (for the decommissioning phase)	**Construction and O&M** Large numbers of vessel potentially involved in OWFs potentially leading to a chronic disturbance during the construction phase (Morven South with up to 41 present on site at any one time and an average of 595.8 trips per year). There is potential for cumulative effects of vessel noise with construction of other CEA projects. **Decommissioning** Limited information is available to assess this quantitatively for the project alone and cumulatively and it is anticipated that only small numbers of vessels would be involved during this phase. This impact is therefore screened out of the decommissioning phase.
Injury to marine mammals due to collision with vessels	✓	✓	✓	Out	Vessel movements will be managed via the implementation of a NSPVMP (Volume 4, Annex 5: Navigation Safety Plan and Vessel Management Plan (NSPVMP) (Version 1)), which includes adherence to codes of conduct such as limited speeds, not approaching animals and following designated transit routes. It is anticipated that there will be a very low risk of collision, and as a result, this impact has been screened out.

Impact	Phase			Screened in or out of whole project assessment and CEA	Justification
	C	O	D		
Effects on marine mammals due to changes in prey availability	✓	✓	✓	Out	Changes in prey availability are anticipated to be highly localised across all phases and there were no significant effects predicted for fish and shellfish receptors from the project alone or cumulatively during any phase(Volume 2, Chapter 9: Fish and Shellfish Ecology). Marine mammals are highly mobile and can exploit a range of prey resources. Most habitat loss and disturbance of fish and shellfish tends to be temporary and reversible with only a very small amount of long-term habitat alteration due to presence of foundations, which can infer some positive effects due to colonisation of hard structures and creation of additional foraging opportunities. Therefore, there is no potential for cumulative effects and this impact is screened out for all phases.

Table 10.78: List of other projects and plans considered within the cumulative effects assessment for marine mammals (dates are estimates)

Project/plan	Status	Distance from Morven South (km)	Description of project/plan	Dates of construction (If applicable)	Dates of operation (If applicable)	Overlap with Morven South
Morven South	Application submitted/ awaiting decision	-	Proposed Development	2033 – 2042[5]	2038 – 2073 or 2043 to 2078[6]	-
Tier 1						
Morven North	Application submitted/ awaiting decision	0	Included as part of Scenario 4	2033 – 2042[5]	2038 – 2073 or 2043 to 2078[6]	Part of scenario 4
Berwick Bank OWF	Consented	34	Berwick Bank OWF is proposed for up to 307 turbines with a capacity of up to 4,100MW.	2025 - 2033	2034 - 2069	The construction and O&M phases of Berwick Bank OWF overlap with the construction and O&M phases of Morven South.
Caledonia	Application submitted / Pre-construction	146	Caledonia OWF is proposed for up to 150 turbines at a capacity of 2,000MW.	2028 – 2032	2033 - 2068	Construction completed in year prior to Morven South; O&M phases overlap.

[5] At this stage, Morven North and Morven South could be constructed anywhere between 2033 to 2042, with both projects possibly being constructed concurrently or one after another. As a precaution, the widest possible construction phase of ten years has been used in the CEA.

[6] While Morven North and Morven South could be constructed anywhere between 2033 to 2042, the O&M phase has been assumed as commencing in 2038 as a precaution in the instance that one project is constructed first and operational while the other is still in its construction phase. The operational lifecycle of Morven North and Morven South is 35 years and could end in either 2073 (if operational in 2038) or in 2078 (if operational in 2043).

Project/plan	Status	Distance from Morven South (km)	Description of project/plan	Dates of construction (If applicable)	Dates of operation (If applicable)	Overlap with Morven South
Cenos OWF	Application submitted / Pre-construction	124	Cenos OWF is proposed for up to 1,400 MW.	2030 – 2036	2037 -2071	The construction and O&M phases of Cenos OWF overlap with the construction and O&M phases of Morven South.
Muir Mhòr OWF	Application submitted/ awaiting decision	77	Muir Mhòr OWF is proposed for a capacity of 798MW.	2029 – 2033	2034 - 2069	The construction phase of Muir Mhòr OWF overlaps with that of Morven South for one year in 2033.
Ossian OWF	Application submitted/ awaiting decision	5	The Ossian OWF is proposed for up to 3,610MW capacity.	2031 – 2038	2039 - 2074	The construction and O&M phases of the Ossian OWF overlap with those of Morven South.
Ayre OWF[7]	Application submitted/ awaiting decision	246	Ayre OWF is proposed for up to 67 turbines (either floating and/or fixed foundations) at a capacity of 1,000MW.	2029 – 2034	2035 - 2064	The construction and O&M phases of Ayre OWF overlap with those of Morven South.
Tier 2						
Bellrock OWF	Consenting/pre-construction	35	Bellrock Floating OWF is proposed for up to 132 turbines at a capacity of 1,800MW.	2027 – 2030	2031 onwards	The O&M phase of Bellrock OWF overlaps with the O&M phase of Morven South.

[7] The cumulative iPCoD modelling was based upon the information available at the time of undertaking the modelling; however, it is noted that since completing the cumulative iPCoD modelling, Ayre has moved from a Tier 2 to a Tier 1 project.

Project/plan	Status	Distance from Morven South (km)	Description of project/plan	Dates of construction (If applicable)	Dates of operation (If applicable)	Overlap with Morven South
Bowdun OWF	Consenting/Pre-Construction	44	Bowdun OWF is proposed for up to 67 turbines (either floating and/or fixed foundations) at a capacity of 1,008MW.	2029 – 2033	2034 onwards	The construction and O&M phases of the Bowdun OWF overlap with those of Morven South.
Tier 3						
There were no Tier 3 projects identified.						

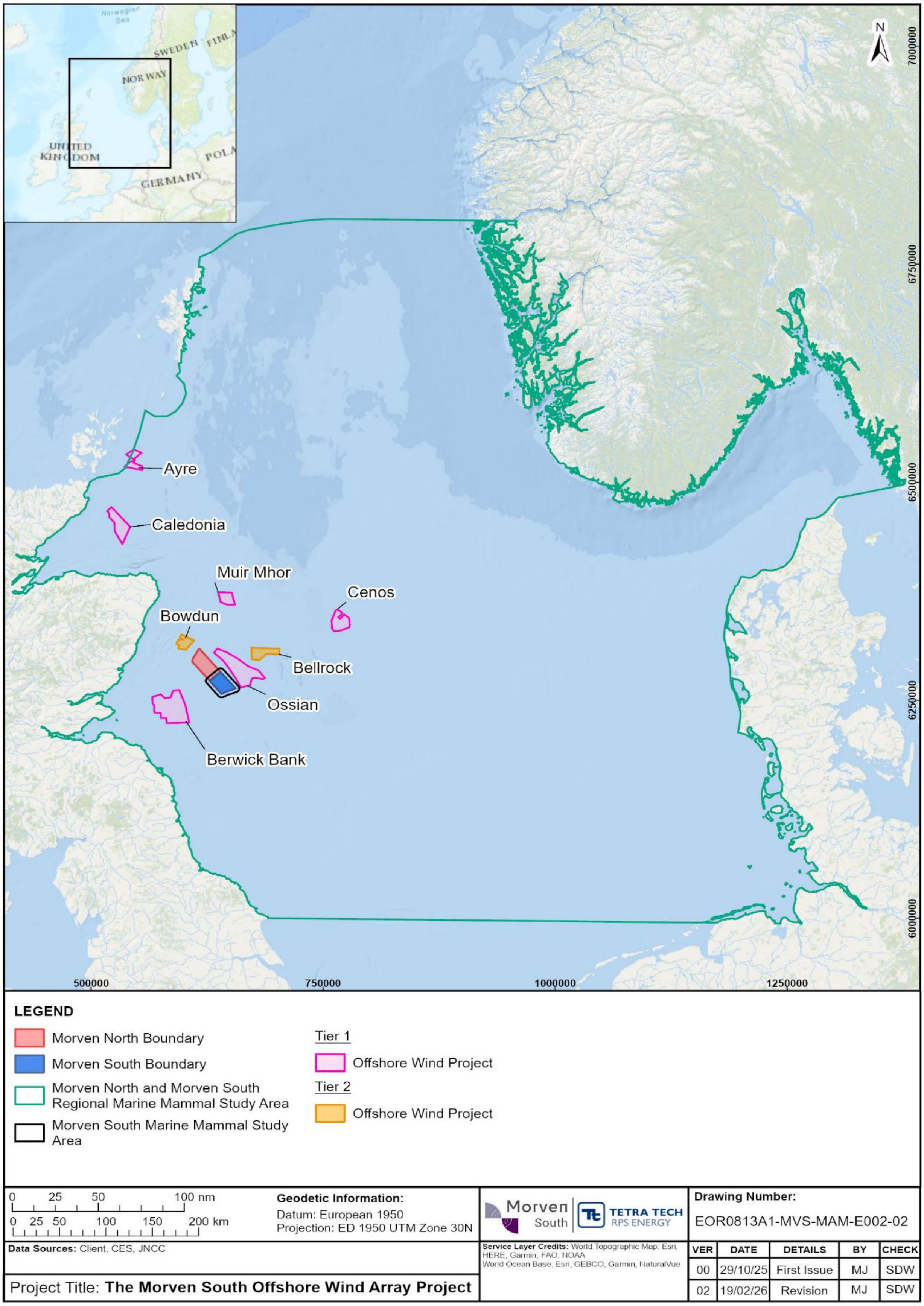

Figure 10.26: Projects Screened into the Cumulative Effects Assessment for marine mammals

10.12.2 Maximum Design Scenario

10.12.2.1 The cumulative MDSs identified in Table 10.79 have been selected as those having the potential to result in the greatest potential cumulative effect on an identified receptor or receptor group. The cumulative MDSs have been based on the Morven South alone assessment MDS (Table 10.32), as well as publicly available information on other third party projects and plans that have been screened into the CEA (Table 10.78). Where applicable, the Morven South alone assessment MDS, the Project Description contained within the MHPGC Project Scoping Report and project information available for MBAGC Project have also informed the cumulative MDSs outlined in Table 10.79.

10.12.2.2 During the CEA screening exercise for marine mammals, projects were identified within the Morven Regional Marine Mammal Study Area (see paragraph 10.12.1.7 for the screening approach to identify these projects). The identified projects were then further refined depending on the scale of each potential impact. For the purposes of the MDS for the CEA, projects have been screened in and out on the following basis per impact:

- **Disturbance from underwater sound generated from piling (Construction phase)** – the ZoI for piling can extend beyond the boundaries of proposed OWFs and therefore, adopting a precautionary approach, the assessment has screened in projects within the Morven Regional Marine Mammal Study Area whose construction phases overlap with the construction phase of Morven South (2033 to 2042). Further, projects wherein construction occurs within one year either side of this phase (i.e. within 2032 to 2043) were also included, as the sequential piling at respective projects could lead to a longer duration of effects and allows for potential delays in offshore construction programmes.
- **Disturbance to marine mammals from vessel use and other non-piling sound-producing activities** (Construction and O&M phases) – 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 and O&M phases. However, the potential to experience disturbance by marine mammal receptors would be expected to be localised to within the close vicinity (i.e. within kilometres) of the respective projects and as such the CEA has focused only on projects within a 86km buffer of Morven South as a precautionary approach.

10.12.2.3 The CEA presented in this marine mammal chapter has been undertaken on the basis of information presented in the EIA Reports for the other projects, which is based upon their respective MDS. The level of potential cumulative impact on marine mammals would likely be reduced significantly from those presented here.

Table 10.79: Maximum Design Scenario considered for the assessment of potential whole project and cumulative effects on marine mammals

C= Construction, O= Operations and maintenance, D= Decommissioning phases

"✓" is used to denote the phase the potential impact can occur, "✗" outlines there is no impact within this project phase

Potential Cumulative Effect	Phase			Maximum Design Scenario	Justification
	C	O	D		
Disturbance from underwater sound generated from piling	✓	O	O	Scenario 4 MDS as described for Morven South (Table 10.32), assessed cumulatively with the following other projects and plans: Tier 1 • Morven North; • Berwick Bank OWF; • Caledonia OWF; • Cenos OWF; • Muir Mhòr OWF; • Ayre OWF; • Ossian OWF. Tier 2 • Bowdun OWF. Tier 3 • No Tier 3 projects identified for this impact.	The Morven Regional Marine Mammal Study Area was used to screen projects into the CEA for this impact. As detailed in paragraphs 10.12.1.7 and 10.12.1.7, projects with a construction phase between 2032 to 2043 were screened in. The MHPGC Project and MBAGC Project were not included for this impact as no piling is likely to occur and therefore there is no conceptual impact receptor pathway. Therefore, this impact focusses on Scenario 4 only.
Disturbance to marine mammals from vessel use and other (non-piling) sound producing activities	✓	✗	✗	Scenario 1 MDS as described for Morven South (Table 10.32), assessed cumulatively with MHPGC Project. Scenario 2 MDS as described for Morven South (Table 10.32), assessed cumulatively with MBAGC Project. Scenario 4	A precautionary buffer of 86km from the Morven South Boundary was used to screen projects into the CEA for this impact. The MHPGC Project and MBAGC Project were included for this impact as an increase in vessels is likely to occur for this impact.

Potential Cumulative Effect	Phase			Maximum Design Scenario	Justification
	C	O	D		
				MDS as described for Morven South (Table 10.32), assessed cumulatively with the following other projects and plans: Tier 1 • Morven North; • Berwick Bank OWF; • Muir Mhòr OWF; • Ossian OWF. Tier 2 • MHPGC Project; • Bowdun OWF; Tier 3 • MBAGC Project.	
	×	✓	×	Scenario 1 MDS as described for Morven South (Table 10.32), assessed cumulatively with MHPGC Project. Scenario 2 MDS as described for Morven South (Table 10.32), assessed cumulatively with MBAGC Project. Scenario 4 MDS as described for Morven South (Table 10.32), assessed cumulatively with the following other projects and plans: Tier 1 • Morven North; • Berwick Bank OWF; • Ossian OWF.	

Potential Cumulative Effect	Phase			Maximum Design Scenario	Justification
	C	O	D		
				Tier 2 • MHPGC Project; • Bellrock OWF; • Bowdun OWF; Tier 3 • MBAGC Project.	

10.12.3 Impact Assessment

10.12.3.1 A description of the significance of whole project and cumulative effects upon marine mammal receptors arising from each identified impact is given below. The whole project assessment and CEA for Morven South is presented in Table 10.88, Table 10.90, Table 10.91 and Figure 10.26.

Disturbance from underwater sound generated from piling (construction phase only)

10.12.3.2 Given that the MHPGC Project and MBAGC Project will not include piling, a whole project assessment of Scenario 1 and Scenario 2 has therefore not been undertaken for this impact. A summary of the CEA (Scenario 4 only) is presented in Table 10.80.

10.12.3.3 As detailed in Table 10.77, there is no potential for cumulative effects of auditory injury from underwater sound from pilling and therefore, the cumulative assessment focuses on disturbance only.

10.12.3.4 As detailed in Table 10.79, Morven South and five other Tier 1 projects and two Tier 2 projects were identified with the potential for cumulative impacts associated with underwater sound from pilling

- Tier 1:
  - Morven North;
  - Berwick Bank OWF;
  - Caledonia OWF;
  - Cenos OWF;
  - Muir Mhòr OWF;
  - Ayre OWF;
  - Ossian OWF.
- Tier 2:
  - Bowdun OWF.

10.12.3.5 The wind turbine and OSP piling parameters (where relevant) for these projects are presented in Table 10.80. These tables also include the piling phases of each Tier 1 project; however, it should be noted that piling at each of these projects will occur as a discrete stage within the overall construction phase (listed in Table 10.78), and therefore, the periods of piling may not coincide. These timelines are, therefore, indicative and may be subject to change.

Table 10.80: Wind turbine and Offshore Substation Platform piling parameters incorporated into the Maximum Design Scenarios of the cumulative projects

Project	Scenario	Capacity (MW)	Max number of wind turbines/OSPs	Max number of piles	Max pile diameter (m)	Max hammer energy (kJ)	Max number of piling days	Piling phase	Reference
Morven South	Wind turbine	1,500	95	380	3.7	4,000	192	2035 - 2036	N/A
	OSP (HVAC collector)		4	96	5.3	4,500	48		
	OSP (HVDC converter)		1	48	5.3	4,500	24		
Tier 1									
Morven North	Wind turbine	1,500	96	384	3.7	4,000	192	2034 - 2035	Morven Offshore Wind Ltd, 2026
	OSP (HVAC collector)		4	96	5.3	4,500	48		
	OSP (HVDC converter)		1	48	5.3	4,500	24		
Berwick Bank OWF	Wind turbine	4,100	307	1,432	5.5	4,000	95	Apr – Dec 2026, Apr – Dec 2027, Apr – Dec 2031	SSE Renewables (2022)
	OSP		8	192	3	4,000	17	Jan - Mar 2026, Jan - Mar 2027, Jan - Mar 2031	

Project	Scenario	Capacity (MW)	Max number of wind turbines/OSPs	Max number of piles	Max pile diameter (m)	Max hammer energy (kJ)	Max number of piling days	Piling phase	Reference
Caledonia OWF	Jacket	2,000	101	404	4	4,400	105	Between October 2028 and February 2030	Caledonia OWF Ltd (2024b)
	Anchor pile		39	702	4.8	2,000	410	March 2030 to February 2032	
Cenos OWF	Wind turbine	1350	95	855	4.5	2,500	285	Between April to August in 2031 to 2033	Cenos Offshore Windfarm Limited (2024b)
	OSP		2	12	3.50	4,400	8	March 2031	
Muir Mhòr OWF	Wind turbine	798	67	603	4	2,400	151	Between March to October in 2029 to 2031	Muir Mhòr Offshore Wind Farm (2024)
	OSP		2	12	5	3,200	24		
Ossian OWF	Wind turbine	3,600	265	1,590	4.5	3,000	530	Between Q2 to Q4 each year from 2031 to 2038	Ossian OWFL (2024)
	OSP		15	216	4.5	4,400	72		
Ayre OWF	Wind turbine	1,005	40	360	5	4,500	360	Between 2031 and 2034	Ayre OWF Limited (2025)
	OSP		2	36	4.5	4,500	36		
Tier 2									
Bowdun OWF	Wind turbine	1,008	134	Based on 67 Wind Turbine foundations, with four legs and with one pin pile per leg, giving a total of 268 piles. If an average of two piles were installed per day (as per the Morven North MDS), up to 134 piling days were calculated.				May commence in 2029, with an estimated construction phase of five years	Bowdun OWF Limited (2024)

Project	Scenario	Capacity (MW)	Max number of wind turbines/OSPs	Max number of piles	Max pile diameter (m)	Max hammer energy (kJ)	Max number of piling days	Piling phase	Reference
	OSP		60	Based on Five OSPs, with six legs and four pin piles per leg, giving a total of 120 piles. If an average of two piles were installed per day (as per the Morven North MDS), up to 60 piling days were calculated.					

* Captures the 4.5m pin pile (HVAC collector OSP) and the 5m pin pile (HVDC converter OSP), see Table 10.36.

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10.12.3.6 Methods used to assess behavioural disturbance differed across the Tier 1 projects, with criteria and noise thresholds used in the modelling differing between projects. Therefore, it is necessary to exercise considerable caution when comparing the sound modelling results of each Tier 1 project, which are presented in Table 10.80. There were also differences between projects in the way results were presented, and in which species were assessed.

10.12.3.7 For the assessment of Morven South alone, humpback whale was assessed qualitatively. Similarly, this species were either not assessed for the Tier 1 projects or also assessed qualitatively.

10.12.3.8 Some projects presented the disturbance range within which animals could experience behavioural disturbance, and the potential numbers of animals disturbed, whilst others only presented the number of animals disturbed. In addition, the densities used varied across the Tier 1 projects to estimate the number of animals potentially disturbed. As these values were derived from different sources per project, density details may reflect various densities of respective species throughout the year (i.e. seasonal versus average across the year). The Tier 1 projects also used different reference populations and MUs. Therefore, assessment of the potential behavioural effects on marine mammals predicted by the Tier 1 projects is not necessarily directly comparable to those presented for Morven South alone due to different approaches taken by other offshore developers, with different noise criteria and thresholds used, and differing levels of detail presented in associated EIA Reports.

10.12.3.9 Given uncertainty in the degree of temporal and spatial overlap of these activities summing these figures would give an overestimate of the total number of animals impacted. There is also the possibility that the same individuals might be affected on multiple occasions across projects sequentially. Given uncertainties surrounding animal turnover and movements at this temporal and spatial scale it is very challenging to predict a realistic overall level of disturbance. Sinclair (2025) provides a detailed discussion on the challenges for offshore wind cumulative assessment for marine mammals. Key challenges are a lack of standardisation of the screening range, the timeframe for consideration, and the approach to the quantitative assessment. It is highlighted in this paper that CEAs assume compounding worst-case scenarios.

10.12.3.10 The combination of uncertainties in project timelines and the need to apply precautionary assumptions leads to numerous levels of precaution within this CEA which results in highly precautionary estimates of effects. Specifically, the main areas of precaution in the assessment include:

- The number of developments undertaking construction activities at the same time: for example, the assessment precautionarily assumes that up to nine offshore windfarm developments could all be constructing on the same day within Scottish waters. This is considered to be unlikely;
- The inclusion of lower tier developments (Tier 2) which do not have quantitative information or detail on indicative piling timelines. The most reliable information regarding construction timelines is available for Tier 1 projects, as these have publicly accessible quantitative assessments and the highest probability of being completed;
- The assumption that piling can take place at any time during the construction period is applied to developments lacking publicly available detailed piling schedules. Consequently, most projects show piling activities spanning multiple consecutive years, leading to disturbance levels that are significantly higher than what would occur;
- Use of EDR approach (see paragraph 10.12.3.11) for Tier 2 projects in the absence of quantitative information on number of animals disturbed. This is not based on project-specific modelling and is therefore likely to differ to the final EIA.

10.12.3.11 In the absence of a guidance for a standardised approach, this assessment has followed the common industry approach taken for marine mammal CEA outlined in paragraph 10.12.1.7. For Tier 2 projects no quantitative information is available in the public domain (information restricted to scoping reports only) and therefore for Tier 2 projects, published EDRs will be used to derive indicative numbers of animals disturbed, on the assumption that there is sufficient information to develop a piling scenario (i.e. number and type of foundations and offshore construction (or piling) phase provided) in the scoping reports (as discussed with MD-LOT and NatureScot workshop on the 23rd of October 2025, see Table 10.15). For piling, an EDR of 20km was used for monopiles/pin piles without noise abatement, based on the latest EDR guidance (JNCC, 2025d). SCANS IV densities are used for calculating numbers of cetaceans disturbed for Tier 2 projects (with SCANS III used for bottlenose dolphin only, where SCANS IV densities were not available). For pinnipeds, the densities used for Morven are used in the absence of project-specific densities (see Table 10.21).

10.12.3.12 The disturbance impacts predicted for Morven South together with the Tier 1 and Tier 2 projects identified have been taken through for population modelling using iPCoD in order to inform the CEA. The maximum temporal situation for Morven South was used as a maximum design scenario as this is suggested the larger changes in population compared to the maximum spatial design.

10.12.3.13 Since this chapter was drafted, a refinement to the project information available within the three-month CEA longlist review has resulted in Ayre moving from a Tier 2 to a Tier 1 project. As the three-month CEA longlist review constitutes a qualitative update, no reruns of the existing iPCoD models have been undertaken. Instead, the EDR-based approach mentioned in paragraph 10.12.3.11 still applies to Ayre. The cumulative effects assessment tables for piling and the number of animals disturbed have been updated to align with the values published in the Ayre EIA; however, no changes have been made to the iPCoD modelling outputs, as this remains a qualitative update and the underlying modelling approach is unchanged.

10.12.3.14 Even though the cumulative assessment tables have been updated and Ayre has moved from a Tier 2 to a Tier 1 project, the text discussing the iPCoD results will continue to refer to Ayre as a Tier 2 project, as it was included in the cumulative modelling on the basis of its former Tier 2 status.

10.12.3.15 The outcome of the cumulative assessment is also not expected to change, despite the iPCoD models not being rerun. The Ayre project-alone assessment classified behavioural disturbance as low magnitude for harbour porpoise, bottlenose dolphin and minke whale. For grey seal and harbour seal, Ayre was assessed against different MUs and would therefore be excluded if iPCoD were rerun; however, the current iPCoD results already show no population-level impacts, and this conclusion would not be expected to change.

Harbour porpoise

10.12.3.16 Table 10.81 presents compiled information on the predicted effects from Tier 1 and Tier 2 projects included in the iPCoD cumulative assessment for harbour porpoise (see Volume 3, Annex 10.5: Marine Mammal iPCoD Modelling Report). As discussed in paragraph 10.12.3.11, for Tier 2 projects, an indicative number of animals disturbed is based on the 20km EDR approach, using information gathered from the scoping reports for Ayre OWF and Bowdun OWF (no magnitude is available at the Scoping stage for Tier 2 projects).

10.12.3.17 Piling windows (Table 10.80) show significant overlap mainly from 2029 to 2033, with Muir Mhòr, Caledonia, Cenos, Ossian, and Berwick Bank (and Tier 2 projects Ayre and Bowdun OWFs) all piling during this period. Morven South and Morven North piling occurs later, from 2034 to 2036. Extended piling occurs at Caledonia from 2028 to 2032 and at Ossian from 2031 to 2038. This overlap indicates a high potential for cumulative piling disturbance between 2029 and 2033, prior to piling at Morven South.

10.12.3.18 Across all Tier 1 projects, the maximum number of harbour porpoise potentially disturbed ranges from 808 individuals (0.23% of the whole MU population; 0.51% of the UK portion) during piling at Morven North, to 14,630 individuals (4.22% of the whole MU population; 9.15% of the UK portion) during piling at Muir Mhòr OWF. Although some of the estimates appear high, these corresponded to low or negligible magnitude levels as presented in the respective Environmental Impact Assessments. For Tier 2 projects, Ayre and Bowdun, up to 753 animals were estimated to be disturbed using the EDR approach, (0.217% of the whole MU population; 0.472% of the UK portion).

10.12.3.19 Results of the cumulative iPCoD modelling for harbour porpoise showed that the median ratio of impacted to unimpacted population size at a time point of six years after commencement of piling of Morven South was 0.9847, and after 25 years this was 0.9829 (see Volume 3, Annex 10.5: Marine Mammals iPCoD Modelling Report). Changes in the impacted population size over time are larger than those predicted for an unimpacted population, as can be seen in Figure 10.27. The impacted population was predicted to be up to 9,547 individuals smaller than the unimpacted population after the end of cumulative piling at all projects (i.e. in 2038), this corresponded to 2.75% of the NS MU reference population. The difference between mean impacted and un-impacted population sizes reduced to 9,035 individuals (approximately 2.61% of the reference population) after 25 years.

10.12.3.20 There is considered potential for a population-level effects from the cumulative iPCoD modelling upon harbour porpoise within the NS MU in the medium term (i.e. during the period when multiple projects are piling). The population was shown to stabilise in the long-term, after piling has ceased, although the lack of density dependence in the model means that recovery was not illustrated graphically. This modelling study concluded that Morven South is likely to have only a small relative contribution to this cumulative effect, since much of the population effects were seen in the years preceding piling at Morven South when there was a high level of piling activity expected from multiple projects (see Volume 3, Annex 10.5: Marine Mammals iPCoD Modelling Report for further details).

10.12.3.21 Overall, it was considered that there is low potential for long-term cumulative effects on this species as a result of cumulative piling at Morven South and Tier 1 and Tier 2 projects.

Table 10.81: Number of harbour porpoise potentially disturbed, based on the temporal scenario, for the cumulative effects assessment as a result of underwater sound generated from piling (North Sea Management Unit population was used for all projects). *For Tier 2 projects, an indicative number of animals disturbed based on the EDR approach is presented

Project	Foundation type	Max number of animals potentially disturbed	Percentage of whole MU population (percentage of UK portion of MU in brackets)	Magnitude as presented in EIA
Morven South	Wind turbine	846	0.24% (0.53%)	Low (Section 10.11.1)
	OSP (AC collector)	866	0.25% (0.54%)	
	OSP (DC converter)	866	0.25% (0.54%)	
Tier 1				
Morven North	Wind turbine	808	0.23% (0.51%)	Low (Volume 2, Chapter 10: Marine Mammals)
	OSP (AC collector)	834	0.24% (0.52%)	
	OSP (DC converter)	834	0.24% (0.52%)	
Berwick Bank OWF	Piling	2,815	0.81% (1.76%)	Low
	OSP	1,828	0.53% (1.15%)	
Caledonia OWF	Piling (jacket)	8,201	2.37% (5.14%)	Low
	Piling (anchor)	6,648	1.92% (4.16%)	
Cenos OWF	Piling	8,863	2.56% (5.55%)	Low

Project	Foundation type	Max number of animals potentially disturbed	Percentage of whole MU population (percentage of UK portion of MU in brackets)	Magnitude as presented in EIA
	OSP	9,529	2.75% (5.97%)	
Muir Mhòr OWF	Piling	14,630	4.22% (9.15%)	Low
	OSP	15,245	4.40% (9.55%)	
Ossian OWF	Piling	3,857	1.11% (2.42%)	Negligible
	OSP	7,310	2.11% (4.58%)	
Ayre OWF	Wind turbine	1,633	0.47% (1.01%)	Low
	OSP	1,633	0.47% (1.01%)	
Tier 2*				
Bowdun	Wind turbine	753	0.217 (0.472%)	N/A
	OSP	753	0.217 (0.472%)	

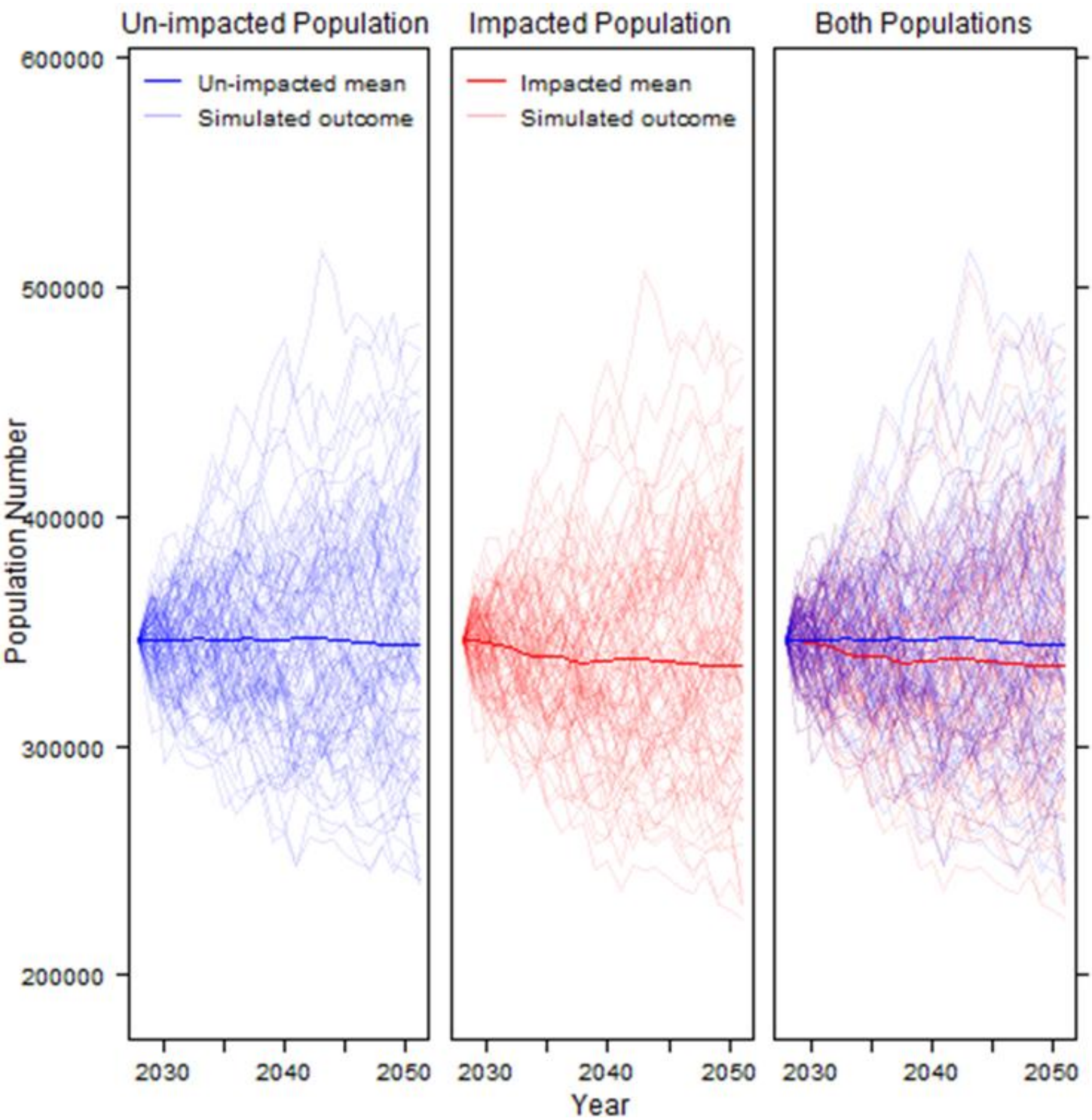

Figure 10.27: Simulated harbour porpoise population trajectories in an unimpacted versus impacted population for the cumulative modelling

Bottlenose dolphin

10.12.3.22 Table 10.82 presents compiled information on the predicted effects from Tier 1[8] and Tier 2 projects included in the iPCoD cumulative assessment for bottlenose dolphin (see Volume 3, Annex 10.5: Marine Mammal iPCoD Modelling Report). As discussed in paragraph 10.12.3.11, for Tier 2 projects, an indicative number of animals disturbed is based on the 20km EDR approach, using information gathered from the scoping reports for Ayre OWF and Bowdun OWF (no magnitude is available at the Scoping stage for Tier 2 projects).

10.12.3.23 Across all Tier 1 projects, for the GNS MU, the maximum number of bottlenose dolphin potentially disturbed ranges from seven individuals (0.37% of the UK portion of the GNS MU population/ 0.35% of the whole GNS MU)during piling at Morven North, to 75 individuals (3.98% of the UK portion of the GNS MU/3.71% of the whole GNS MU population) during piling at Muir Mhòr OWF (Table 10.82). These disturbance estimates correspond to low magnitude levels as presented in the respective Environmental Impact Assessments. For Tier 2 projects, Ayre and Bowdun, up to 38 animals were estimated to be disturbed using the EDR approach (1.8% of the CES + GNS (UK only portion) MU). For the CES MU, the maximum number of bottlenose dolphin potentially disturbed ranges from two individuals (0.89% of the CES MU population) during piling at Ossian Array, to 51 individuals (23.21% of the CES MU population) during piling at Muir Mhòr OWF (Table 10.82). Note, however, that the Morven South project did not affect the CES MU population, and therefore zero bottlenose dolphin are disturbed from this population (Table 10.82).

10.12.3.24 Due to the complexity of different projects assessing against different MUs for bottlenose dolphin, there were three different cumulative models run:

- BND-03: GNS MU population only, and the model only included projects which had included this population within their iPCoD modelling (i.e. only Caledonia and Muir Mhòr, alongside Morven South and the Tier 2 projects were included as a precaution). The vital rates used were those for all other bottlenose dolphin MUs;
- BND-04: Combined GNS MU and CES MU and modelled using the vital rates for the CES MU. Only Cenos was not included in the modelling as this project did not assess bottlenose dolphin from either MU in its iPCoD modelling report;
- BND-05: Combined GNS MU and CES MU and modelled using the vital rates for all other MUs. Only Cenos was not included in the modelling as this project did not assess bottlenose dolphin from either MU in its iPCoD modelling report.

10.12.3.25 The modelling scenario which resulted in the largest difference between the mean impacted and un-impacted population sizes was BND-04, the results of which have been discussed here. Full details of the cumulative iPCoD modelling for this species is provided in Volume 3, Annex 10.5: Marine Mammal iPCoD Modelling Report. Results of the cumulative iPCoD modelling scenario BND-04 showed that the median ratio of impacted to unimpacted population size at a time point of six years after commencement of piling was 0.9971, and 25 years after commencement of piling at cumulative projects this was 0.9975. Changes in the impacted population size over time are larger than those predicted for an unimpacted population, as can be seen in Figure 10.28, although both increased over time. The impacted population was predicted to be up to 158 individuals smaller than the unimpacted population in 2039 the year after all cumulative piling had finished (corresponding to approximately 7.48% of the combined MUs reference population) with the difference increasing to 271 individuals (approximately 12.84% of the combined MUs reference population) after 25 years.

10.12.3.26 There is considered potential for population-level effects from the cumulative iPCoD modelling upon bottlenose dolphin within the GNS and CES MUs in the medium term (i.e. during the period

[8] The cumulative iPCoD modelling was based upon the information available at the time of undertaking the modelling; however, it is noted that since completing the cumulative iPCoD modelling there have been updates to the bottlenose dolphin assessments for Muir Mhor and Caledonia, which have now been published

when multiple projects are piling). The population was shown to stabilise in 2039, after piling has ceased, although the lack of density dependence in the model means that recovery was not illustrated graphically. This was observed in all three bottlenose dolphin cumulative iPCoD modelling scenarios that were run. This modelling study concluded that Morven South is likely to have only a small relative contribution to this cumulative effect, since much of the population effects were seen in the years preceding piling at Morven South when there was a high level of piling activity expected from multiple projects (see Volume 3, Annex 10.5: Marine Mammals iPCoD Modelling Report for further details).

10.12.3.27 Therefore, it was considered that there is low potential for long-term cumulative effects on this species as a result of cumulative piling at Morven South and Tier 1[9] and Tier 2 projects.

Table 10.82: Number of bottlenose dolphin potentially disturbed, based on the temporal scenario, for the cumulative effects assessment as a result of underwater sound generated from piling. * For Tier 2 projects, an indicative number of animals disturbed based on the EDR approach is presented

Project	Foundation type	Max number of animals potentially disturbed		Percentage of whole MU population (percentage of UK portion of MU in brackets, where relevant)		Magnitude as presented in EIA
		CES MU	GNS MU	CES MU (only in UK)	GNS MU	
Morven South	Wind turbine	0	8	0%	0.42%	Low (Section 10.11.1)
	OSP (AC collector)	0	8	0%	0.42%	
	OSP (DC converter)	0	8	0%	0.42%	
Tier 1						
Morven North	Wind turbine	0	7	0%	0.37%	Low (Volume 2, Chapter 10: Marine Mammals)
	OSP (AC collector)	0	8	0%	0.42%	
	OSP (DC converter)	0	8	0%	0.42%	
Berwick Bank OWF	Piling	5	GNS MU not assessed	2.23%	N/a	Low
	OSP	4		1.79%		
Caledonia OWF	Piling (jacket)	52	35	23.21%	1.73% (1.86%)	CES MU: Medium GNS MU: Low
	Piling (anchor)	46	27	20.54%	1.34% (1.43%)	

[9] It is highlighted that, whilst updates to the Caledonia and Muir Mhor bottlenose dolphin assessment have subsequently been published, the piling phases of these two projects did not directly overlap with the piling phase of Morven North. Furthermore, as stated above, Morven North (and South) contributed only a very small (and not significant) change to the bottlenose dolphin population and therefore the conclusions of the cumulative assessment are considered unlikely to change in light of any updated assessment to these two projects

Project	Foundation type	Max number of animals potentially disturbed		Percentage of whole MU population (percentage of UK portion of MU in brackets, where relevant)		Magnitude as presented in EIA
		CES MU	GNS MU	CES MU (only in UK)	GNS MU	
Cenos OWF	Piling	Species not included in the Cenos OWF modelling				
	OSP					
Muir Mhòr OWF	Piling	8	74	3.27%	3.66% (3.93%)	Low
	OSP	7	75	2.86%	3.71% (3.98%)	
Ossian OWF	Piling	2	GNS MU not assessed	0.89%	N/a	Low
	OSP	4		1.79%		
Ayre OWF	Wind turbine	13		0.56%(0.60%)		Low
	OSP	13		0.56%(0.60%)		
Tier 2*						
Bowdun	Wind turbine	38		1.8% (of CES + GNS (UK only) MU)		N/A
	OSP	38		1.8% (of CES + GNS (UK only) MU)		

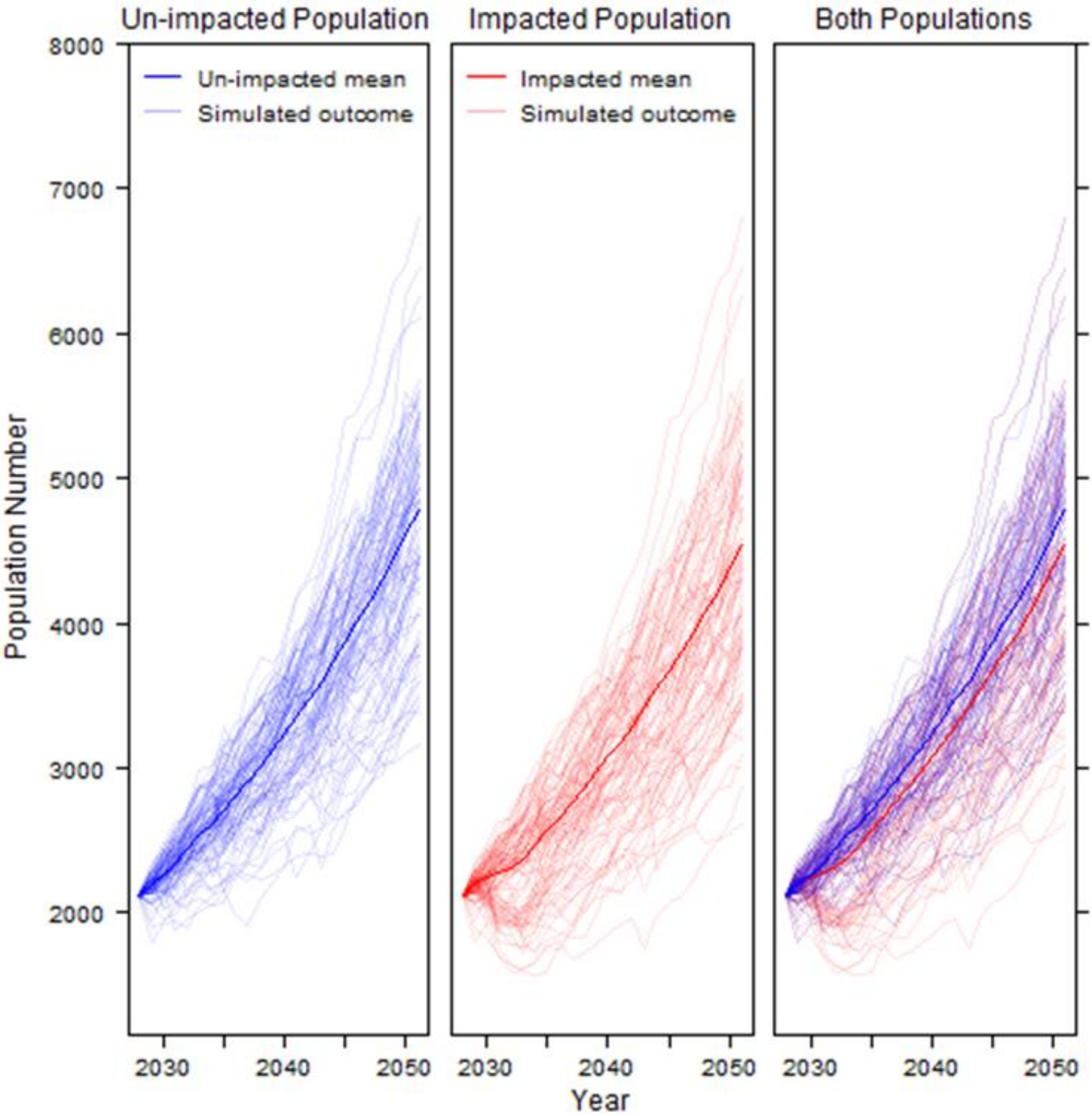

Figure 10.28: Simulated bottlenose dolphin population trajectories for the combined Greater North Sea and Coastal East Scotland management units in an unimpacted versus impacted population for the cumulative scenario BND-04

White-beaked dolphin

10.12.3.1 Table 10.83 presents compile information on the predicted effects from Tier 1 and 2 projects included in the cumulative assessment for white-beaked dolphin.

Table 10.83: Number of white-beaked dolphin potentially disturbed, based on worst-case spatial scenario, for the Cumulative Effects Assessment as a result of underwater sound generated from piling (Celtic and GNS Management Unit population was used for all projects).* For Tier 2 projects, an indicative number of animals disturbed based on the EDR approach is presented

Project	Foundation type	Max number of animals potentially disturbed	Percentage of whole MU population (percentage of UK portion of MU in brackets)	Magnitude as presented in EIA
Morven South	Wind turbine	108	0.25% (0.32%)	Negligible (Section 10.11.1)
	OSP (AC collector)	112	0.26% (0.33%)	
	OSP (DC converter)	112	0.26% (0.33%)	
Tier 1				
Morven North	Wind turbine	113	0.26% (0.33%)	Negligible (Volume 2, Chapter 10: Marine Mammals)
	OSP (AC collector)	116	0.26% (0.34%)	
	OSP (DC converter)	116	0.26% (0.34%)	
Berwick Bank OWF	Piling	830	1.89% (N/A)	Low
	OSP	516	1.17% (N/A)	
Caledonia OWF	Piling (jacket)	2,873	6.54% (8.31%)	Medium
	Piling (anchor)	2,363	5.38% (6.88%)	
Cenos OWF	Piling	896	2.63% (N/A)	Medium
	OSP	964	2.38% (N/A)	
Muir Mhòr OWF	Piling	6,750	15.36% (19.84%)	Medium
Ossian OWF	Piling	710	1.62% (N/A)	Negligible
	OSP	1,347	3.07% (N/A)	
Ayre OWF	Wind turbine	1,402	4.38%(15/6%)	Medium
	OSP	1,402	4.38%(15/6%)	
Tier 2*				
Bowdun OWF	Wind turbine	101	0.23% (0.30%)	N/A
	OSP	101	0.23% (0.30%)	

10.12.3.1 The current version of iPCoD does not allow modelling for this species and therefore population modelling has not been carried out for this species.

10.12.3.2 Whilst it is inappropriate to combine the total number of white-beaked dolphin predicted to be at risk of disturbance, the numbers are an indication that potentially a notable proportion of the management unit reference population could be cumulatively at risk of disturbance.

10.12.3.3 The cumulative impact (due to elevated subsea noise arising during piling) is predicted to be of regional spatial extent, medium term duration, intermittent and high reversibility (with animals returning to baseline levels within hours/days after piling have ceased). Impacts could result in temporary changes to behavioural and/or distribution of individuals, but not at a scale that could result in adverse effects to the long-term population trajectory. The magnitude is therefore considered to be medium.

Minke whale

10.12.3.4 Table 10.84 presents compiled information on the predicted effects from Tier 1 and Tier 2 projects included in the iPCoD cumulative assessment for minke whale (see Volume 3, Annex 10.5: Marine Mammal iPCoD Modelling Report). As discussed in paragraph 10.12.3.11, for Tier 2 projects, an indicative number of animals disturbed is based on the 20km EDR approach, using information gathered from the scoping reports for Ayre OWF and Bowdun OWF (no magnitude is available at the Scoping stage for Tier 2 projects).

10.12.3.5 Across all Tier 1 projects, the maximum number of minke whale potentially disturbed ranges from 102 individuals (0.51% of the whole MU population; 0.99% of the UK portion) during piling at Morven South, to 735 individuals (3.65% of the whole MU population; 7.14% of the UK portion) during piling at Muir Mhòr OWF (Table 10.84).These disturbance estimates correspond to low or negligible magnitude levels as presented in the respective Environmental Impact Assessments. For Tier 2 projects, Ayre and Bowdun, up to 53 animals (0.263% of the whole MU population; 0.515% of the UK portion) were estimated to be disturbed during piling.

10.12.3.6 Results of the cumulative iPCoD modelling for minke whale showed that the median ratio of impacted to unimpacted population size at a time point of six years after commencement of piling was 1.0000, and 25 years after commencement of piling at cumulative projects this was 0.9965 (see Volume 3, Annex 10.5: Marine Mammal iPCoD Modelling Report). Changes in the impacted population size over time are larger than those predicted for an unimpacted population, as can be seen in Figure 10.29. The impacted population was predicted to be up to 48 individuals smaller than the unimpacted population after all cumulative piling had finished (corresponding to approximately 0.24% of the CGNS MU reference population) with the difference increasing to 94 individuals (approximately 0.47% of the CGNS MU reference population) after 25 years. However, as illustrated in Figure 10.29, the impacted population appeared to stabilise.

10.12.3.7 Therefore, it was considered that there is low potential for long-term cumulative effects on this species as a result of cumulative piling at Morven South and Tier 1 and Tier 2 projects.

Table 10.84: Number of minke whale potentially disturbed, based on worst-case spatial scenario, for the Cumulative Effects Assessment as a result of underwater sound generated from piling (Celtic and Greater North Sea Management Unit population was used for all projects).* For Tier 2 projects, an indicative number of animals disturbed based on the EDR approach is presented

Project	Foundation type	Max number of animals potentially disturbed	Percentage of whole MU population (percentage of UK portion of MU in brackets)	Magnitude as presented in EIA
Morven South	Wind turbine	122	0.61% (1.19%)	Low (Section 10.11.1)
	OSP (AC collector)	122	0.61% (1.19%)	
	OSP (DC converter)	102	0.51% (0.99%)	
Tier 1				
Morven North	Wind turbine	119	0.59% (1.16%)	Low (Volume 2, Chapter 10: Marine Mammals)
	OSP (AC collector)	119	0.59% (1.16%)	
	OSP (DC converter)	107	0.53% (1.04%)	
Berwick Bank OWF	Piling	132	0.66% (1.28%)	Low
	OSP	86	0.43% (0.84%)	
Caledonia OWF	Piling (jacket)	502	2.50% (4.88%)	Low
	Piling (anchor)	415	2.06% (4.03%)	
Cenos OWF	Piling	358	1.78% (3.48%)	Negligible
	OSP	384	1.91% (3.73%)	
Muir Mhòr OWF	Piling	735	3.65% (7.14%)	Low
	OSP	777	3.86% (7.55%)	
Ossian OWF	Piling	169	0.84% (1.64%)	Low
	OSP	319	1.59% (3.10%)	
Ayre OWF	Wind turbine	51	0.25% (0.49%)	Low
	OSP	51	0.25% (0.49%)	
Tier 2*				
Bowdun OWF	Wind turbine	53	0.263% (0.515%)	N/A
	OSP	53	0.263% (0.515%)	

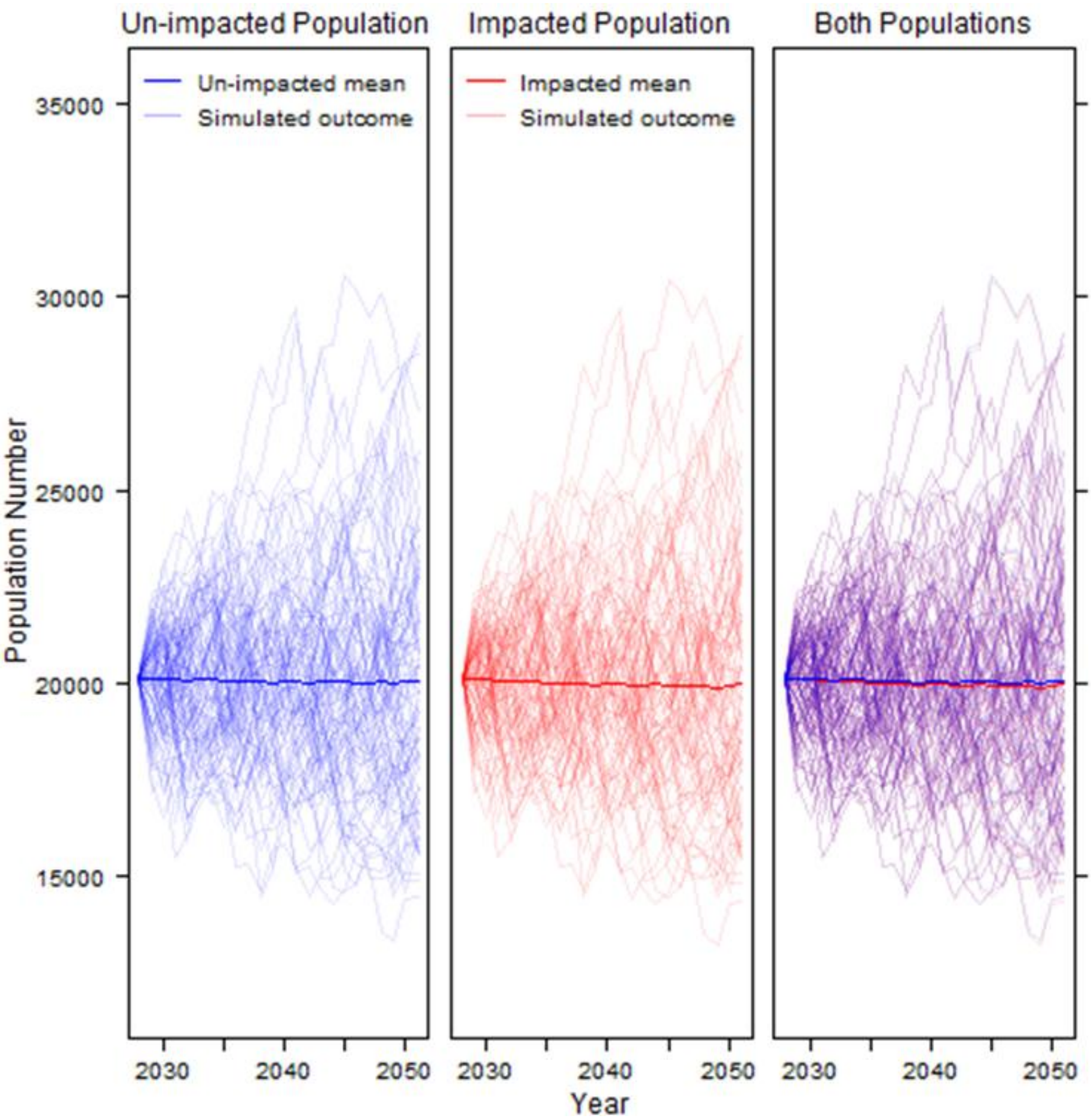

Figure 10.29: Simulated minke whale population trajectories in an unimpacted versus impacted population for the cumulative modelling

Humpback whale

10.12.3.8 Table 10.85 presents compiled information on the predicted effects from Tier 1 projects included in the cumulative assessment for the humpback whale.

10.12.3.9 As no density estimates are available for humpback whale, this species has been assessed qualitatively. Consequently, humpback whale could only be considered cumulatively for Tier 1 projects, and only the magnitude of impact has been defined. Of the Tier 1 projects included within the cumulative assessment, all except Berwick Bank included humpback whale within their assessments; however, where it was assessed, this was also undertaken qualitatively due to the absence of robust density data. Based on the available information, the magnitude of cumulative impact from elevated subsea noise during piling is considered low, reflecting the low potential for long-term cumulative effects on this species arising from the combined piling activities at Morven South together with other Tier 1 projects.

Table 10.85: Magnitude for humpback whale based on worst-case spatial scenario, for the Cumulative Effects Assessment as a result of underwater sound generated from piling

Project	Magnitude as presented in EIA
Morven South	Low (Section 10.11.1)
Tier 1	
Morven North	Low (Volume 2, Chapter 10: Marine Mammals)
Caledonia OWF	Low
Cenos OWF	Negligible
Muir Mhòr OWF	Low
Ossian OWF	Low

Grey seal

10.12.3.10 Table 10.86 presents compiled information on the predicted effects from Tier 1 and Tier 2 projects included in the iPCoD cumulative assessment for grey seal (see Volume 3, Annex 10.5: Marine Mammal Mammals Interim Population Consequences of Disturbance (iPCoD) Modelling Report). As discussed in paragraph 10.12.3.11, for Tier 2 projects, an indicative number of animals disturbed is based on the 20km EDR approach, using information gathered from the scoping reports for Ayre OWF and Bowdun OWF (no magnitude is available at the Scoping stage for Tier 2 projects).

10.12.3.11 Across all Tier 1 projects, the maximum number of grey seals potentially disturbed ranges from 131 individuals (0.36% of the MUs) during piling at Ossian OWF, to 4,426 individuals (12.06% of the MUs) during piling at Caledonia OWF (Table 10.86). These disturbance estimates correspond to low or negligible magnitude levels as presented in the respective Environmental Impact Assessments. For Tier 2 projects, Ayre and Bowdun, up to 398 animals were estimated to be disturbed using the EDR approach (1.085% of the combined seal MUs reference population)

10.12.3.12 Results of the cumulative iPCoD modelling for grey seal showed that the median ratio of impacted to unimpacted population size at a time point of six years after commencement of piling was 1.0000 and 25 years after commencement of piling at cumulative projects this was still at 1.0000 (see Volume 3, Annex 10.5: Marine Mammal Marine Mammal Mammals Interim Population Consequences of Disturbance (iPCoD) Modelling Report). Changes in the impacted population size over time are larger than those predicted for an unimpacted population, as can be seen in Figure 10.30. The impacted population was predicted to be up to 220 individuals smaller than the unimpacted population after the end of the cumulative piling (corresponding to approximately 0.60% of the combined seal MUs reference population) with the difference increasing to 234 individuals (approximately 0.64% of the reference population) after 25 years. However, as illustrated in Figure 10.30, the impacted population appeared to stabilise.

10.12.3.13 Therefore, it was considered that there is low potential for long-term cumulative effects on this species as a result of cumulative piling at Morven South and Tier 1 and Tier 2 projects.

Table 10.86: Number of grey seal potentially disturbed, based on the temporal scenario, for the cumulative effects assessment as a result of underwater sound generated from piling. * For Tier 2 projects, an indicative number of animals disturbed based on the EDR approach is presented

Project	Foundation type	MU assessed	Max number of animals potentially disturbed	Percentage of UK portion of MU	Magnitude as presented in EIA
Morven South	Wind turbine	East Scotland and Northeast England (therefore UK only)	153	0.42%	Low (Section 10.11.1)
	OSP (AC collector)		161	0.44%	
	OSP (DC converter)		161	0.44%	
Tier 1					
Morven North	Wind turbine	East Scotland and Northeast England (therefore UK only)	176	0.48%	Low (Volume 2, Chapter 10: Marine Mammals)
	OSP (AC collector)		199	0.54%	
	OSP (DC converter)		199	0.54%	
Berwick Bank OWF	Piling	East Scotland and Northeast England (therefore UK only)	1,450	3.40%	Low
	OSP		720	1.69%	
Caledonia OWF	Piling (jacket)	Moray Firth, North Coast and Orkney, and East Scotland (therefore UK only)	4,426	12.06%	Low
	Piling (anchor)		2,960	8.07%	
Cenos OWF	Piling	East Scotland (therefore UK only population)	127	4.66%	Negligible
	OSP		137	5.02%	
Muir Mhòr OWF	Piling	Moray Firth, North Coast and Orkney, and East Scotland (therefore UK only)	1,156	2.21%	Low
	OSP		1,176	2.25%	
Ossian OWF	Piling	East Scotland and Northeast England (therefore UK only)	131	0.36%	Negligible
	OSP		344	0.94%	
Ayre OWF	Wind turbine	MU not assessed			
	OSP				

Project	Foundation type	MU assessed	Max number of animals potentially disturbed	Percentage of UK portion of MU	Magnitude as presented in EIA
Tier 2					
Bowdun OWF	Wind turbine	East Scotland and Northeast England (therefore UK only) (as per Morven MUs)	398	1.085%	N/A
	OSP		398	1.085%	

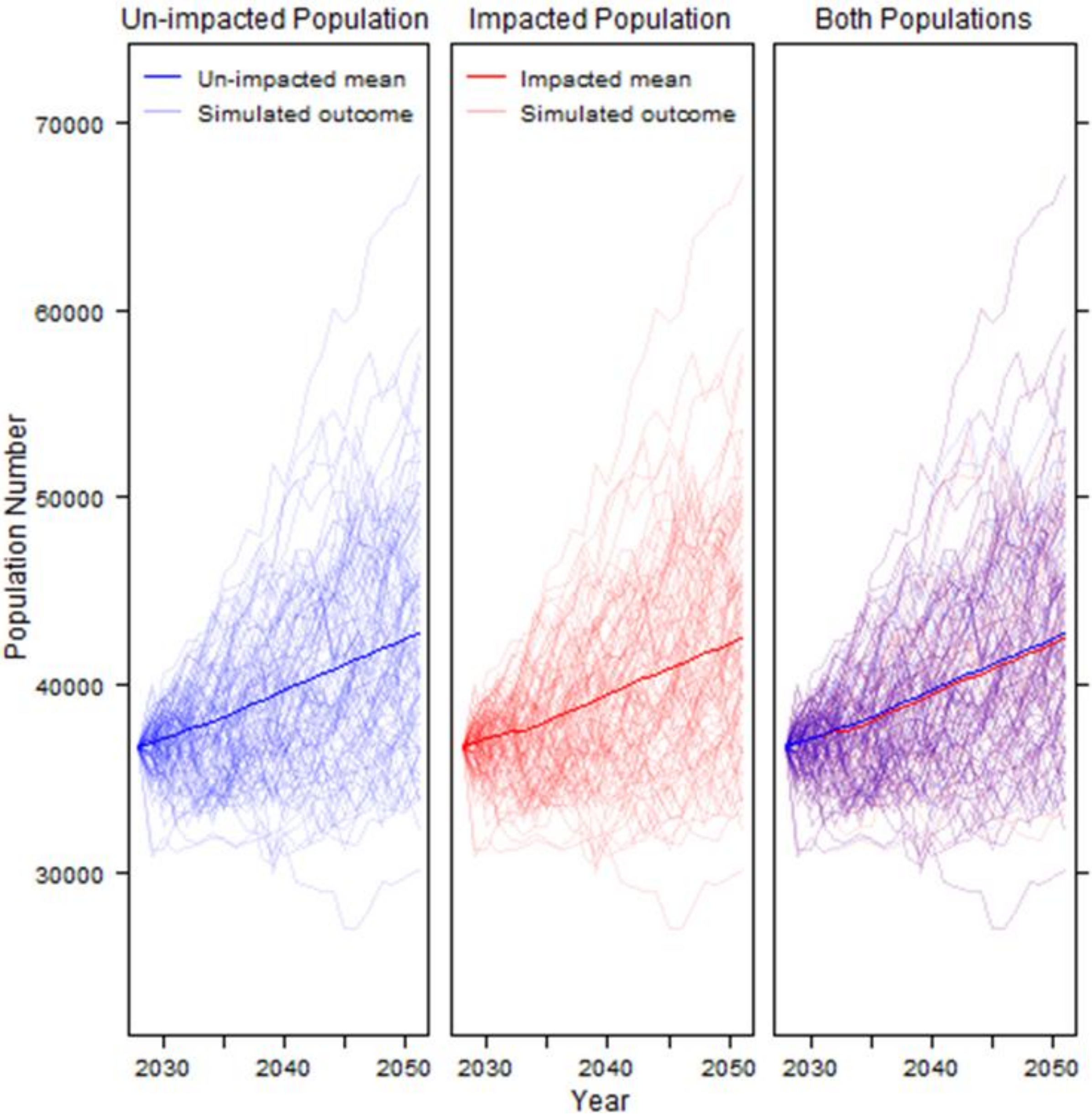

Figure 10.30: Simulated grey seal population trajectories in an unimpacted versus impacted population for the cumulative modelling

Harbour seal

10.12.3.14 Table 10.87 presents compiled information on the predicted effects from Tier 1 and Tier 2 projects included in the iPCoD cumulative assessment for harbour seal (see Volume 3, Annex 10.5: Marine Mammal iPCoD Modelling Report). As discussed in paragraph 10.12.3.11, for Tier 2 projects, an indicative number of animals disturbed is based on the 20km EDR approach, using information gathered from the scoping reports for Ayre OWF and Bowdun OWF (no magnitude is available at the Scoping stage for Tier 2 projects).

10.12.3.15 Across all Tier 1 projects, the maximum number of harbour seals potentially disturbed is very low, ranging from up to one animals (0.2% of the MUs) during piling at Morven North and Morven South, to three animals (0.51% of the MUs) during piling at Berwick Bank OWF (Table 10.87). These disturbance estimates correspond to low or negligible magnitude levels as presented in the respective Environmental Impact Assessments. For Tier 2 projects, Ayre and Bowdun, up to one animal was estimated to be disturbed using the EDR approach (0.205% of the harbour seal MUs).

10.12.3.16 Results of the cumulative iPCoD modelling for harbour seal indicated no difference in the simulated trajectories of harbour seal between the unimpacted population and impacted population across all time points. The median and mean counterfactual of population size for the cumulative modelling remained at one throughout (see Volume 3, Annex 10.5: Marine Mammal Mammals Interim Population Consequences of Disturbance (iPCoD) Modelling Report and Figure 10.31).

10.12.3.17 Therefore, it was considered that there is low potential for long-term cumulative effects on this species as a result of cumulative piling at Morven South and Tier 1 and Tier 2 projects.

Table 10.87: Number of harbour seal potentially disturbed, based on the temporal scenario, for the cumulative effects assessment as a result of underwater sound generated from piling.).* For Tier 2 projects, an indicative number of animals disturbed based on the EDR approach is presented

Project	Foundation type	MU assessed	Max number of animals potentially disturbed	Percentage of whole MU population (percentage of UK portion of MU in brackets)	Magnitude as presented in EIA
Morven South	Wind turbine	East Scotland and Northeast England (therefore UK only)	1	0.2%	Low (Section 10.11.1)
	OSP (AC collector)		1	0.2%	
	OSP (DC converter)		1	0.2%	
Tier 1					
Morven North	Wind turbine	East Scotland and Northeast England (therefore UK only)	1	0.2%	Low (Volume 2, Chapter 10: Marine Mammals)
	OSP (AC collector)		1	0.2%	
	OSP (DC converter)		1	0.2%	
Berwick Bank OWF	Piling	East Scotland and Northeast England (therefore UK only)	3	0.51%	Low
	OSP		1	0.17%	
Caledonia OWF	Piling (jacket)	Species/MU not assessed			
	Piling (anchor)				
Cenos OWF	Piling				
	OSP				
Muir Mhòr OWF	Piling	East Scotland (therefore UK only)	1	0.28%	Negligible
	OSP		1	0.28%	
Ossian OWF	Piling	Species/MU not assessed			
	OSP				
Ayre OWF	Wind turbine	MU not assessed			
	OSP				

Project	Foundation type	MU assessed	Max number of animals potentially disturbed	Percentage of whole MU population (percentage of UK portion of MU in brackets)	Magnitude as presented in EIA
Tier 2					
Bowdun OWF	Wind turbine	East Scotland and Northeast England (therefore UK only)	1	0.205%	N/A
	OSP		1	0.205%	

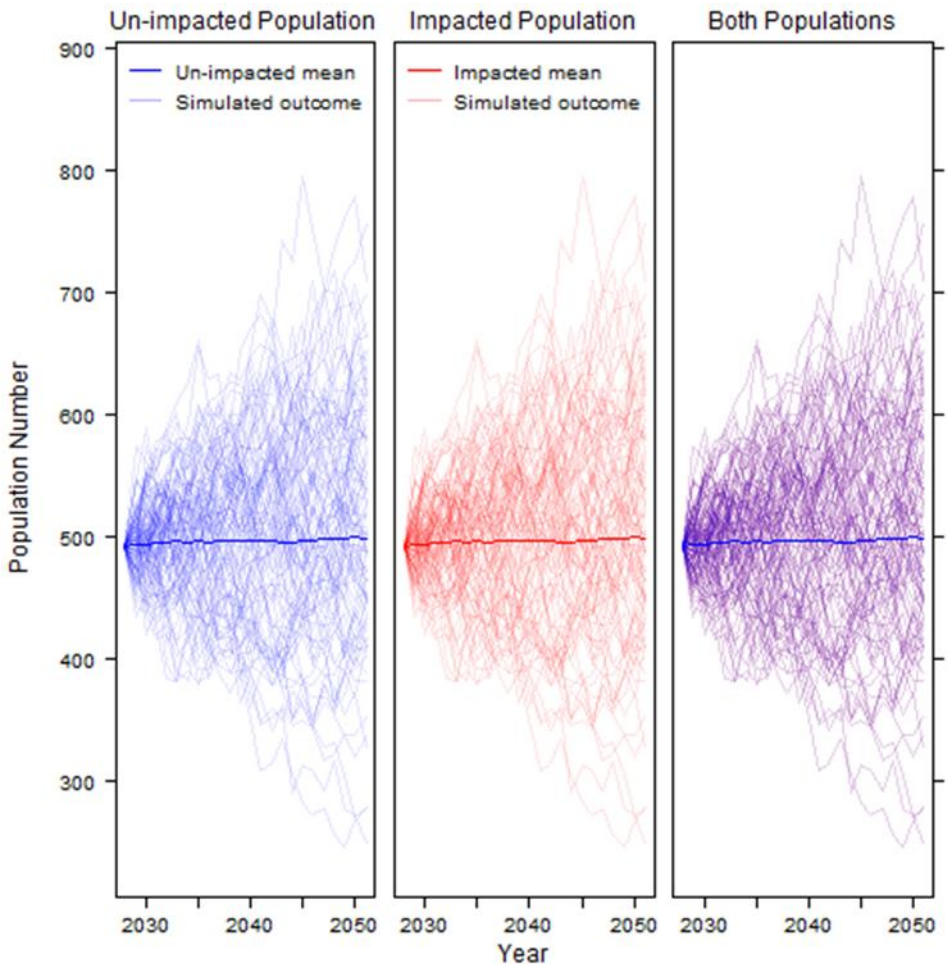

Figure 10.31: Simulated harbour seal population trajectories in an unimpacted versus impacted population for the cumulative modelling

Table 10.88: Morven South Cumulative Effects Assessment for disturbance from underwater sound generated during piling

	Cumulative Effects Assessment
	Scenario 4: Morven South and Tier 1, Tier 2 and Tier 3 Projects
Construction phase	
Magnitude of impact	The Cumulative Effects Assessment for Scenario 4 considers Morven South together with the Tier 1 and Tier 2 (no Tier 3 projects screened into this impact) below. Tier 1 Tier 1 includes: • Morven North • Berwick Bank OWF • Caledonia OWF • Cenos OWF • Ayre OWF • Muir Mhòr OWF and • Ossian OWF. Table 10.80 summarises the MDSs of the respective cumulative projects, and maximum number of animals potentially disturbed, and the associated percentage of the total MU population are presented in Table 10.81. Given uncertainty in the degree of temporal and spatial overlap of these activities, summing these figures would give an overestimate of the total number of animals impacted and therefore is not carried out. For harbour porpoise, across all Tier 1 projects, the maximum number of harbour porpoise potentially disturbed ranges from 808 animals (0.23% of the whole MU population; 0.51% of the UK portion) during piling at Morven North, to 14,630 animals (4.22% of the whole MU population; 9.15% of the UK portion) during piling at Muir Mhòr OWF (which lies ~77km from Morven South). Cumulative population modelling (which included Tier 2) showed that there is considered potential for a population-level effect upon harbour porpoise within the North Sea MU in the medium term (i.e. during the period when multiple projects are piling). However, the population was shown to stabilise in the long-term, after cumulative piling ceased. This modelling study concluded that Morven South is likely to have only a small relative contribution to this cumulative effect, since much of the population effects were seen in the years preceding piling at Morven North when there was a high level of piling activity expected from multiple projects (see Volume 3, Annex 10.5: Marine Mammals iPCoD Modelling Report for further details).

	Cumulative Effects Assessment
	Scenario 4: Morven South and Tier 1, Tier 2 and Tier 3 Projects
	For bottlenose dolphin, across all Tier 1 projects, for the GNS MU, the maximum number of bottlenose dolphin potentially disturbed ranges from seven individuals (0.37% of the GNS MU population) during piling at Morven North, to 75 individuals (3.71% of the GNS population) during piling at Muir Mhòr OWF (Table 10.82). For the CES MU, the maximum number of bottlenose dolphin potentially disturbed ranges from two individuals (0.89% of the CES MU population) during piling at Ossian OWF, to 51 individuals (23.21% of the CES MU population) during piling at Muir Mhòr OWF (Table 10.82). Cumulative population modelling (which included Tier 2) showed that there is considered potential for a population-level effects upon bottlenose dolphin within the reference MUs in the medium term (i.e. during the period when multiple projects are piling). However, the population was shown to stabilise in the long-term, after cumulative piling ceased. This modelling study concluded that Morven South is likely to have only a small relative contribution to this cumulative effect, since much of the population effects were seen in the years preceding piling at Morven South when there was a high level of piling activity expected from multiple projects (see Volume 3, Annex 10.5: Marine Mammals iPCoD Modelling Report for further details). For white-beaked dolphin, across all Tier 1 projects, the maximum number of white-beaked dolphin potentially disturbed ranges from 108 individuals (0.25% of the whole MU population; 0.32% of the UK portion) during piling at Morven North, to 6,750 individuals (15.36% of the whole MU population; 19.84% of the UK portion) during piling at Muir Mhòr OWF (Table 10.83). The current version of iPCoD does not allow modelling for this species and therefore population modelling has not been carried out for this species. For minke whale, across all Tier 1 projects, the maximum number of minke whale potentially disturbed ranges from 102 individuals (0.51% of the whole MU population; 0.99% of the UK portion) during piling at Morven South, to 735 individuals (3.65% of the whole MU population; 7.14% of the UK portion) during piling at Muir Mhòr OWF (Table 10.84). Cumulative population modelling (which included Tier 2) showed that changes in the impacted population size over time were larger than those predicted for an unimpacted population, although the impacted population appeared to stabilise towards the end of the model, after cumulative piling had ceased. Across all Tier 1 projects, humpback whale was assessed qualitatively, and the resulting magnitude of impact was consistently considered negligible or low. As no density estimates are available for this species, quantitative disturbance calculations could not be undertaken, and therefore only a qualitative assessment was possible. For grey seal, across all Tier 1 projects, the maximum number of grey seals potentially disturbed ranges from 131 individuals (0.36% of the MUs) during piling at Ossian OWF, to 4,426 individuals (12.06% of the MUs) during piling at Caledonia OWF (Table 10.86) (which lies 146km from Morven South). Cumulative population modelling (which included Tier 2) showed that changes in the impacted population size over time were larger than those predicted for an unimpacted population, although the impacted population appeared to stabilise towards the end of the model, after cumulative piling had ceased. For harbour seal, the maximum number of harbour seals potentially disturbed is very low, ranging from up to one animals (0.2% of the MUs) during piling at Morven North and Morven South, to three animals (0.51% of the MUs) during piling at

	Cumulative Effects Assessment
	Scenario 4: Morven South and Tier 1, Tier 2 and Tier 3 Projects
	Berwick Bank OWF (which lies 34km from Morven South) (Table 10.87). Cumulative population modelling (which included Tier 2) showed there was no difference in the trajectories of the impacted and un-impacted populations. The cumulative effect is predicted to be of regional spatial extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low. <u>Tier 2</u> Tier 2 includes Tier 1 projects, plus Ayre OWF and Bowdun OWF (floating and/or fixed foundations). For harbour porpoise, the maximum number of animals potentially disturbed is 753 animals (0.217% of the whole MU population; 0.472% of the UK portion) during piling at Ayre OWF and Bowdun OWF (using EDR approach) (Table 10.81). Population modelling included Tier 2. For bottlenose dolphin, the maximum number of animals potentially disturbed is 38 animals (1.8% of the CES + GNS (UK only portion) MU) during piling at Ayre OWF and Bowdun OWF (using EDR approach) (Table 10.82). For white-beaked dolphin, the maximum number of animals potentially disturbed is 101 animals (0.23% of the whole MU population; 0.30% of the UK portion) during piling at Ayre OWF and Bowdun OWF (using EDR approach) (Table 10.83). For minke whale, the maximum number of animals potentially disturbed is 53 animals (0.263% of the whole MU population; 0.515% of the UK portion) during piling at Ayre OWF and Bowdun OWF (using EDR approach) (Table 10.82). For grey seal, the maximum number of animals potentially disturbed is 398 grey seals (1.085% MUs) during piling at Ayre OWF and Bowdun OWF (using EDR approach) (Table 10.82). For harbour seal, the maximum number of animals potentially disturbed is one harbour seal (0.205% of the harbour seal MUs) during piling at Ayre OWF and Bowdun OWF (using EDR approach) (Table 10.82). The cumulative effect is predicted to be of regional spatial extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low. Except for white-beaked dolphin, for which the magnitude is considered to be medium.
Sensitivity of receptor	The sensitivity of the receptor is as detailed in Section10.11.1 for the alone assessment and not repeated here. For harbour porpoise, the sensitivity is considered to be medium. For all other receptors, the sensitivity is considered to be low.
Significance of effect	<u>Tier 1</u> For harbour porpoise, overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be medium. The cumulative effect will be of **minor adverse** significance, which is not significant in EIA terms.

	Cumulative Effects Assessment
	Scenario 4: Morven South and Tier 1, Tier 2 and Tier 3 Projects
	For white-beaked dolphin, overall, the magnitude of the cumulative impact is deemed to be medium and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms. For all other receptors, overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The overall significance of the effect is negligible or minor. As a precaution, **minor adverse** significance has been concluded for behavioural disturbance, which is not significant in EIA terms. This is because any disturbance is expected to be temporary, with species showing tolerance and recoverability, and therefore the effect is unlikely to result in population-level consequences. <u>Tier 2</u> For harbour porpoise, overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms. For white-beaked dolphin, overall, the magnitude of the cumulative impact is deemed to be medium and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms. For all other receptors, overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The overall significance of the effect is negligible or minor. The cumulative effect was concluded to be of **minor adverse** significance (rather than negligible) as there will be some changes at the individual level during piling of cumulative projects within the relevant geographic frames of reference (i.e. species MUs) although this is unlikely to result in effects at a population-level for any species. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Disturbance to marine mammals from vessel use (construction phase and operations and maintenance phases)

10.12.3.18 The summary of the whole project assessment for disturbance to marine mammals from vessel use is presented in Table 10.90 (Scenario 1 and 2) and the CEA is presented in Table 10.91 (Scenario 4).

10.12.3.19 As detailed in Table 10.77, it is considered there is no potential for cumulative effects of auditory injury from underwater sound from vessel use and therefore, the cumulative assessment focuses on disturbance only.

10.12.3.20 As detailed in Table 10.79, Morven South and three other Tier 1 projects and the MHPGC Project and two other Tier 2 projects were identified with the potential for cumulative impacts associated with underwater sound from vessel use. The MBAGC Project was the only Tier 3 project identified:

- Tier 1:
  - Morven North (in the construction and O&M phases);
  - Berwick Bank OWF (in the construction and O&M phases);
  - Muir Mhòr OWF (in the construction phase, O&M phase impact not included in original EIA);
  - Ossian OWF (in the construction and O&M phases).
- Tier 2:
  - MHPGC Project (in the construction and O&M phases);
  - Bellrock OWF (in the O&M phase only);
  - Bowdun OWF (in the construction and O&M phases).
- Tier 3:
  - MBAGC Project (in the construction and O&M phases).

10.12.3.21 The numbers of animals disturbed by vessel noise (where available, i.e. Tier 1 Projects) for these projects are presented in Table 10.89 for their construction phases. This impact has also been scoped in for the O&M phase, however numbers of animals potentially disturbed in this phase were considered to be lesser than or equal to those calculated for the construction phase of respective projects, and are therefore not included in Table 10.89.

10.12.3.22 Berwick Bank OWF is located approximately 34km from Morven South. For the construction phase, the MDS for Berwick Bank OWF (SSE Renewables, 2022) detailed up to 316 return trips of up to nine boulder clearance vessels and 104 return trips of up to three sandwave clearance vessels, construction activities associated with site preparation and inter-array and offshore export cables. Additionally, vessel movements associated with other activities such as foundation and OSPs/Offshore convertor station platform installation, will contribute to a maximum scenario of up to 11,484 vessel round trips over the construction phase. Vessel types will include main installation vessels, cargo barges, support vessels, tug/anchor handlers, guard vessels and others. The EIA described that whilst this will lead to an uplift in vessel activity, the movements will be limited to within the Proposed Development array area and Proposed Development export cable corridor and will follow existing shipping routes to/from the ports. For Berwick Bank OWF, a maximum disturbance range of 4,320m was modelled for installation vessels, construction vessels, and rock placement vessels (SSE Renewables, 2022) (although disturbance ranges were much lower for excavator, backhoe dredger, pipe laying, geophysical survey vessel and jack-up vessel as well as jack-up rig (300m)). This led to up to 48 harbour porpoise, two bottlenose dolphin, 14 white-beaked dolphin, two minke whale, 70 grey seal and up to one harbour seal disturbed (Table 10.89). For other non-piling activities, a maximum disturbance range of 4,389 m was modelled for cable laying activities.

10.12.3.23 For the O&M phase, the MDS for Berwick Bank OWF (SSE Renewables, 2022) detailed vessels for inspections, repairs, and surveys including up to 4 CTVs (832 annual return trips), 1 jack-up vessel (2 trips/year), 2 support vessels (26 trips/year), 1 cable repair vessel (5 trips/lifetime), 2 service operation vessels (4 daily movements), 1 cable survey vessel (1 trip/year), and one excavator/backhoe dredger (5 trips/lifetime). The uplift in vessel activity during the operation and maintenance is considered to be relatively small in the context of the baseline levels of vessel traffic (SSE Renewables, 2022), and vessel movements will be within the Berwick Bank array area and the Berwick Bank export cable corridor and will follow existing shipping routes to/from the ports. The size and noise outputs from vessels during the operation and maintenance phase will be similar to those used in the construction phase (numbers of animals was not presented in the Berwick Bank OWF EIA), however, the number of vessel round trips and their frequency is much lower for the operation and maintenance phase compared to the construction phase.

10.12.3.24 Ossian OWF is located approximately 5km from Morven South. For the construction phase, the MDS for Ossian OWF for construction activities associated with the Array assumes up to a total of 97 vessels to be present within the site boundary at any one time making up to 7,902 return trips over the duration of site preparation and construction phases (72 months) including site preparation, floating wind turbine installation, OSPs installation (topside and foundations), and inter-array cables and interconnectors. Vessel movements will be confined to the Ossian Array and Proposed offshore export cable corridor(s) and will follow existing shipping routes to/from port (Ossian OWFL, 2024). For the Ossian OWF, a maximum disturbance range of 3,259m was modelled for a range of vessel types, including survey vessels, support vessels, and UXO clearance vessels (Ossian OWFL, 2024). This led to up to 22 harbour porpoise, up to one bottlenose dolphin, four white-beaked dolphin, up to one minke whale and six grey seal disturbed (Table 10.89). Other non-piling activities included drilling, with a maximum disturbance range of 309m.

10.12.3.25 Muir Mhòr is located approximately 77km from MorvenSouth. For the construction phase, the MDS for Muir Mhòr assumes up to 49 vessels may be involved across all activities, resulting in a maximum of 1,543 return trips. This includes up to six vessels for anchor and mooring pre-lay (201 return trips), seven vessels for floater tow-out and hook-up (201 return trips), six vessels for WTG installation (445 return trips), six vessels for OEP installation (36 return trips), seven vessels for export cable installation (60 return trips), nine vessels for inter-array cable installation (100 return trips), six vessels providing construction support (444 return trips), and two miscellaneous vessels (56 return trips). Further, under a worst-case scenario, whereby the total maximum number of construction vessels expected to be offshore at any one time (49 vessels an unrealistic assumption) are present in addition to the maximum average number of vessels recorded during the baseline (62 within the offshore ECC during summer, 18 within the Array Area during summer), the expected number of vessels present within every 5km² is four for the offshore ECC (assuming an area of 144.05km²) and two for the Array Area (assuming an area of 198.93km²)(Muir Mhòr Offshore Wind Farm, 2024).

10.12.3.26 As no density estimates are available for humpback whale, this species has been assessed qualitatively. Consequently, humpback whale could only be considered cumulatively for Tier 1 projects, and only the magnitude of impact has been defined. Of the Tier 1 projects included within the cumulative assessment, all except Berwick Bank included humpback whale within their assessments; however, where it was assessed, this was also undertaken qualitatively due to the absence of robust density data.

10.12.3.27 No MDS is available for Bellrock OWF, at scoping stage (Bellrock Offshore Wind Farm, 2024) and therefore numbers of vessels or type of vessels are unknown, but the Scoping Report includes use of vessels as a key potential underwater sound impact for both construction and operation and maintenance phases (though Bellrock is only screened into the CEA for the operation and maintenance phase as there will be no temporal overlap with the construction phase (plus one year buffer) of Morven South). The Bellrock Site Scoping Report commits to Vessel Best Practice Measures which includes The Scottish Marine Wildlife Watching Code.

10.12.3.28 No MDS is available for Bowdun OWF, at scoping stage (Bowdun OWF Limited, 2024), and therefore numbers of vessels or type of vessels are unknown, but the Bowdun Site Scoping Report includes injury and disturbance from underwater sound generated by vessel use and other sound producing activities as an impact. Designed-in measures include a NSPVMP.

Table 10.89: Number of animals potentially disturbed from underwater sound from vessels, with percentage of management unit disturbed (UK portion in brackets), for the construction phase* Indicates UK only population. N/A = Not Presented in EIA

Species	Project	MU assessed	Max number of animals potentially disturbed	Percentage of whole MU population (percentage of UK portion of MU in brackets)	Magnitude as presented in EIA (Construction Phase)
Harbour porpoise	Morven North	North Sea	93	0.027 (0.058)	Low
	Morven South		93	0.027 (0.058)	Low
	Berwick Bank OWF		48	0.014% (0.030%)	Low
	Ossian OWF		22	0.006% (0.014%)	Low
	Muir Mhòr		N/A		Low
Bottlenose dolphin	Morven North	GNS	<1	0.049% (0.053%)	Low
	Morven South	GNS	<1	0.049% (0.053%)	Low
	Berwick Bank OWF	CES*	2	0.893%	Low
	Ossian OWF		1	0.446%	Low
	Muir Mhòr	Coastal East Scotland* and GNS	N/A		Low
White-beaked dolphin	Morven North	CGNS	13	0.03% (0.038%)	Low
	Morven South		13	0.03% (0.038%)	Low
	Berwick Bank OWF		14	0.032% (0.041%)	Low
	Ossian OWF		4	0.009% (0.012%)	Low
	Muir Mhòr		N/A		Low
Minke whale	Morven North	CGNS	7	0.035% (0.068%)	Low
	Morven South		7	0.035% (0.068%)	Low
	Berwick Bank OWF		2	0.010% (0.019%)	Low
	Ossian OWF		1	0.005% (0.010%)	Low

Species	Project	MU assessed	Max number of animals potentially disturbed	Percentage of whole MU population (percentage of UK portion of MU in brackets)	Magnitude as presented in EIA (Construction Phase)
	Muir Mhòr		N/A		Low
Humpback whale	Morven North	N/A			Low
	Morven South				Low
	Ossian OWF				Low
	Muir Mhòr				Low
Grey seal	Morven North	East Scotland seal MU + Northeast England seal MU*	49	0.134%	Low
	Morven South	East Scotland seal MU + Northeast England seal MU*	39	0.106%	Low
	Berwick Bank OWF	East Scotland and Northeast England*	70	0.164%	Low
	Ossian OWF		6	0.016%	Low
	Muir Mhòr	East Scotland	N/A		Low
Harbour seal	Morven North	East Scotland seal MU + Northeast England seal MU	1	0.205%	Low
	Morven South	East Scotland seal MU + Northeast England seal MU	1	0.205%	Low
	Berwick Bank OWF	East Scotland and Northeast England*	1	0.171%	Low
	Muir Mhòr	East Scotland	N/A		Low
	Ossian OWF	Species not included in EIA for Ossian OWF.			

Table 10.90: Morven South whole project assessment for disturbance to marine mammals from vessel use

	Whole project assessment	
	Scenario 1: Morven South+ MHPGC Project	**Scenario 2: Morven South + MBAGC Project**
Construction phase		
Magnitude of impact	The whole project assessment for Scenario 1 considers Morven South together with the MHPGC Project. Disturbance to marine mammals from vessel used and other sound-producing activities is scoped in for the MHPGC Project (EnBW, 2024) however at this stage, the numbers of vessels is unknown for the MHPGC Project. It is likely to be fewer vessels for cable construction than for Morven South over a period of up to 2.5 years, and activities are likely to include pre-construction site investigation surveys; seabed preparation activities; offshore export cables installation; post installation surveys and additional cable protection (EnBW, 2024). Cumulatively across the sites there may be a minor uplift in vessel activity from the baseline (although noting that the assessments are based on the MDS and 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 (Morven South) and/or offshore cable corridor routes (MHPGC Project) and are likely to follow existing shipping routes to and from port. Introduction of vessels during construction phase 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 tolerance to sound from vessels (see discussion in paragraph 10.11.4.43). The duration of vessel activity is medium term (e.g. throughout the construction phase) and localised for each project, although it should be noted that vessel movements will occur intermittently over this period. The whole project impact is predicted to be of local spatial extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.	The whole project assessment for Scenario 2 considers Morven South together with the MBAGC Project. Given the similarities with Scenario 1 and the lack of publicly available parameters for the MBAGC Project in order to further quantify the whole project assessment, the magnitude of impact for Scenario 2 is as provided in the column for Scenario 1. The whole project impact is predicted to be of local spatial extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

	Whole project assessment	
	Scenario 1: Morven South+ MHPGC Project	**Scenario 2: Morven South + MBAGC Project**
Sensitivity of receptor	The sensitivity of the marine mammal receptors is low, as detailed in Section 10.11.1 for the alone assessment. It is considered that not all species make aversive movements to vessels, effect ranges are small (based on empirical evidence of receptors in the field) and effects are very short lived (10.11.4.36 *et seq.*).	
Significance of effect	Overall, the magnitude of the whole project impact is deemed to be low and the sensitivity of the receptor is considered to be low. The overall significance of the effect is negligible or minor. Disturbance is expected to be temporary, with species showing tolerance and recoverability, and although there will be effects at the individual level this is not predicted to lead to population-level effects. **Minor adverse** significance has been concluded for behavioural disturbance, which is not significant in EIA terms. Because any disturbance is expected to be temporary, with species showing tolerance and recoverability, and therefore the effect is unlikely to result in population-level consequences.	
Operations and maintenance phase		
Magnitude of impact	The whole project assessment for Scenario 1 considers Morven South together with MHPGC Project. Disturbance to marine mammals from vessel used and other sound-producing activities is scoped in for the MHPGC Project (EnBW, 2024) however at this stage, the numbers of vessels is unknown for the MHPGC Project. It is likely to be fewer vessels than for Morven South over a period of up to 35 years, and routine O&M activities may be carried out from Crew Transfer Vessels or Service Operation Vessels, with major maintenance activities (such as component exchanges) potentially requiring jack-up vessels, or specialist vessels such as cable repair and cable laying vessels (EnBW, 2024). Cumulatively across the sites there may be a minor uplift in vessel activity from the baseline (although noting that the assessments are based on the MDS and 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 (Morven South) and/or offshore cable corridor routes (MHPGC Project) and are likely to follow existing shipping routes to and from port. Introduction of vessels during the O&M 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 tolerance to sound from	The whole project assessment for Scenario 2 considers Morven South together with MBAGC Project. Given the similarities with Scenario 1 and the lack of publicly available parameters for the MBAGC Project in order to further quantify the whole project assessment, the magnitude of impact for Scenario 2 is as provided in the column for Scenario 1. The whole project impact is predicted to be of local spatial extent, long term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

	Whole project assessment	
	Scenario 1: Morven South+ MHPGC Project	**Scenario 2: Morven South + MBAGC Project**
	vessels (see discussion in paragraph 10.11.4.43). Although the duration of vessel activity is considered to be long term (e.g. throughout the O&M phase) and localised for each project, it should be noted that vessel movements will occur intermittently over this period. The whole project impact is predicted to be of local spatial extent, long term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.	
Sensitivity of receptor	The sensitivity of the receptor is low, as detailed in Section 10.11.1 for the alone assessment. It is considered that not all species make aversive movements to vessels, effect ranges are small (based on empirical evidence of receptors in the field) and effects are very short lived (10.11.4.36 *et seq.*).	
Significance of effect	Overall, the magnitude of the whole project impact is deemed to be low and the sensitivity of the receptor is considered to be low. The overall significance of the effect is negligible or minor. **Minor adverse** significance has been concluded for behavioural disturbance, which is not significant in EIA terms. Because any disturbance is expected to be temporary, with species showing tolerance and recoverability, and therefore the effect is unlikely to result in population-level consequences.	

Table 10.91: Morven South Cumulative Effects Assessment for disturbance to marine mammals from vessel use

	Cumulative Effects Assessment Scenario 4: Morven South and Tier 1, Tier 2 and Tier 3 Projects
Construction phase	
Magnitude of impact	The Cumulative Effects Assessment for Scenario 4 considers Morven South together with the Tier 1, Tier 2 and Tier 3 projects below. <u>Tier 1</u> The Tier 1 assessment includes Morven South, Morven North, Berwick Bank OWF, Muir Mhòr OWF and Ossian OWF. Numbers of animals potentially disturbed from underwater sound from vessels at each Tier 1 project (with percentage of MU disturbed, and UK portion of the MU, where available) are presented in Table 10.89. The construction phase of Morven South has the potential to overlap with Morven North, Berwick Bank, Muir Mhòr and Ossian OWF (projects within 86km of Morven South) (see Table 10.78). It would not be realistic to present simply the sum of all vessels anticipated within each offshore wind farm as per respective MDSs as it is highly unlikely that all non-piling construction activities and all vessels would be on site at any one time at each project, and even less likely across cumulative projects due to constraints on vessels and equipment. Furthermore, the introduction of vessels during construction phase 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 tolerance to sound from vessels (see paragraphs 10.11.4.43 *et seq.*). Disturbance impact ranges are localised around each project (e.g. 4.3km for Berwick Bank, 3.25km for Ossian OWF (Muir Mhòr did not present disturbance ranges)) and disturbance ranges are unlikely to significantly overlap additively given the distances between projects, but it is acknowledged that the cumulative impact of repeated but individually small disturbances over multiple projects may lead to greater disturbance to marine mammals within the 86km screening buffer for this impact. Berwick Bank, Muir Mhòr and Ossian OWF committed in their EIAs that vessel movements will be confined to the respective array and offshore export cable corridor(s) and will follow existing shipping routes to/from port (SSE Renewables, 2022, Ossian OWFL, 2024), with animals familiar to baseline existing shipping routes. Although the duration of vessel activity is considered to be medium term (e.g. throughout the respective construction phases) and localised for each project, it should be noted that vessel movements will occur intermittently over this period. Standard industry measures will be in place (such as the VMP) for each project. As no density estimates are available for humpback whale, this species has been assessed qualitatively. Consequently, humpback whale could only be considered cumulatively for Tier 1 projects, and only the magnitude of impact has been defined. Of the Tier 1 projects included within the cumulative assessment, all except Berwick Bank included humpback whale within their assessments; however, where it was assessed, this was also undertaken qualitatively due to the absence of robust density data. Overall, the cumulative effect is predicted to be of regional extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

	Cumulative Effects Assessment
	Scenario 4: Morven South and Tier 1, Tier 2 and Tier 3 Projects
	Tier 2 The Tier 2 assessment includes Morven South, the Tier 1 projects and Tier 2 Projects: MHPGC Project, and Bowdun OWF. For Bowdun OWF exact numbers or type of vessels are not in the public domain (Bowdun OWF Limited, 2024), but it is considered disturbance impacts are likely to be at a similar scale to that of Morven South alone (see Section 10.11.4). Given than Bowdun is ~44km from Morven South, it is unlikely that significant disturbance effects will overlap with those from Morven South. Designed-in measures include a NSPVMP at Bowdun, and it is likely vessel movements will be confined to the respective array and offshore export cable corridor(s) and will follow existing shipping routes to/from port. It is possible that the construction phase of the MHPGC Project may overlap with that of Morven South, however there are no details on their construction programmes currently available in the public domain. However, any additional cumulative effects over and above Tier 1 projects would extend over a similar timeframe and would similarly lead to short-term reversible effects from intermittent vessel disturbance events The cumulative effect is predicted to be of regional extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low. Tier 3 The Tier 3 assessment includes Morven South, the Tier 1 projects, the Tier 2 Projects, and the MBAGC Project. It is possible that the construction phases of the MBAGC Project may overlap with that of Morven South, however there are no details on the construction programme currently available in the public domain. The contribution of the MBAGC project is considered to be small in relation to Tier 1 and Tier 2 projects and would not elevate the assessment of magnitude. The cumulative effect is predicted to be of regional extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.
Sensitivity of receptor	The sensitivity of the receptor is low, as detailed in Section 10.11.1 the alone assessment. It is considered that not all species make aversive movements to vessels, effect ranges are small (based on empirical evidence of receptors in the field) and effects are very short lived (10.11.4.36 *et seq.*).
Significance of effect	Tier 1 Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The overall significance of the effect is negligible or minor. As a precaution, **minor adverse** significance has been concluded for behavioural disturbance, which is not significant in EIA terms. Because any disturbance is expected to be temporary, with species showing tolerance and recoverability, and therefore the effect is unlikely to result in population-level consequences.

	Cumulative Effects Assessment Scenario 4: Morven South and Tier 1, Tier 2 and Tier 3 Projects
	<u>Tier 2</u> Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The overall significance of the effect is negligible or minor. The cumulative effect will, therefore, be of negligible or minor adverse significance. As a precaution, **minor adverse** significance has been concluded for behavioural disturbance, which is not significant in EIA terms. Because any disturbance is expected to be temporary, with species showing tolerance and recoverability, and therefore the effect is unlikely to result in population-level consequences. <u>Tier 3</u> Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The overall significance of the effect is negligible or minor. The cumulative effect will, therefore, be of negligible or minor adverse significance. As a precaution, **minor adverse** significance has been concluded for behavioural disturbance, which is not significant in EIA terms. Because any disturbance is expected to be temporary, with species showing tolerance and recoverability, and therefore the effect is unlikely to result in population-level consequences.
Further mitigation and residual significance	No mitigation measures for marine mammals are considered necessary because the likely cumulative effect the absence of further mitigation (beyond the designed-in measures outlined in Table 10.33)is not significant in EIA terms.
Operations and maintenance phase	
Magnitude of impact	The cumulative effects assessment for Scenario 4 considers Morven South together with the Tier 1, Tier 2 and Tier 3 projects below. <u>Tier 1</u> The Tier 1 assessment includes Morven South, Morven North, Berwick Bank OWF and Ossian OWF. The number of animals potentially disturbed from underwater sound from vessels at each Tier 1 project (with percentage of MU disturbed, and UK portion of the MU) are presented in Table 10.89 for the construction phase and it is considered the size/noise outputs from vessels will be similar to those in the construction phase, but the number of vessel round trips and their frequency is much lower for the operation and maintenance phase. The O&M phase of Morven South has the potential to overlap with Morven North, Berwick Bank, and Ossian OWF (projects within 86km of Morven South) (see Table 10.78). It would not be realistic to present simply the sum of all vessels anticipated within each offshore wind farm as per respective MDSs as it is highly unlikely that all non-piling construction activities and all vessels would be on site at any one time at each project, and even less likely across cumulative projects due to constraints on vessels and equipment. Furthermore, the introduction of vessels during O&M phase of the projects will not be a novel impact for marine mammals present in

	Cumulative Effects Assessment
	Scenario 4: Morven South and Tier 1, Tier 2 and Tier 3 Projects
	the area and therefore marine mammals are anticipated to demonstrate some degree of tolerance to sound from vessels (see paragraphs 10.11.4.43 *et seq.*). Disturbance impact ranges (presented for the construction phase for each project) are localised around each project and disturbance ranges are unlikely to significantly overlap additively given the distances between projects, but it is acknowledged that the cumulative impact of repeated but individually small disturbances over multiple projects may lead to greater disturbance to marine mammals. Berwick Bank and Ossian OWF committed in their EIAs that vessel movements will be confined to the respective Array and offshore export cable corridor(s) and will follow existing shipping routes to/from port (SSE Renewables, 2022, Ossian OWFL, 2024), with animals familiar to baseline existing shipping routes. Although the duration of vessel activity is considered to be long term (e.g. throughout the respective O&M phases) and localised for each project, it should be noted that vessel movements will occur intermittently over this period. Standard industry measures will be in place (such as the VMP) for each project. As no density estimates are available for humpback whale, this species has been assessed qualitatively. Consequently, humpback whale could only be considered cumulatively for Tier 1 projects, and only the magnitude of impact has been defined. Of the Tier 1 projects included within the cumulative assessment, all except Berwick Bank included humpback whale within their assessments; however, where it was assessed, this was also undertaken qualitatively due to the absence of robust density data. Overall, the cumulative effect is predicted to be of regional extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low. <u>Tier 2</u> The Tier 2 assessment includes Morven South, the Tier 1 projects and Tier 2 Projects: MHPGC Project, Bellrock and Bowdun OWF. For Bowdun OWF the exact numbers or type of vessels are not in the public domain (Bowdun OWF Limited, 2024), but it is considered disturbance impacts are likely to be at a similar scale to that of Morven South alone (see Section 10.11.4). Given than Bowdun is ~44km from Morven South, it is unlikely that significant disturbance effects will overlap with those from Morven South. Designed-in mitigation includes a NSPVMP at Bowdun, and it is likely vessel movements will be confined to the respective Array and offshore export cable corridor(s) and will follow existing shipping routes to/from port. Similarly for Bellrock OWF (Bellrock Offshore Wind Farm, 2024) use of vessels is included under underwater sound impacts in the Scoping Report. For Bellrock OWF the exact numbers or type of vessels are not in the public domain (Bowdun OWF Limited, 2024), but it is considered disturbance impacts are likely to be at a similar scale to that of Morven South alone (see Section 10.11.4). Given that Bellrock OWF is ~35km from Morven South, it is highly unlikely that significant disturbance effects will overlap with those from Morven South, but it is acknowledged that the cumulative impact of repeated but individually small disturbances over multiple projects may lead to greater disturbance to marine mammals. Designed-in measures includes Vessel best practice measures (Bellrock Offshore Wind Farm, 2024). It is possible that the construction phase of the MHPGC Project may overlap with that of Morven South, however there are no details on MHPGC construction programmes currently available in the public domain. However, any additional cumulative effects over and

	Cumulative Effects Assessment Scenario 4: Morven South and Tier 1, Tier 2 and Tier 3 Projects
	above Tier 1 projects would extend over a similar timeframe and would similarly lead to short-term reversible effects from intermittent vessel disturbance events The cumulative effect is predicted to be of regional extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low. <u>Tier 3</u> The Tier 3 assessment includes Morven South, the Tier 1 projects, the Tier 2 Projects, and the MBAGC Project. It is possible that the construction phases of the MBAGC Project may overlap with that of Morven South, however there are no details on the MBAGC Project construction programmes currently available in the public domain. The contribution of the MBAGC Project is considered to be small in relation to Tier 1 and Tier 2 projects and would not elevate the assessment of magnitude The cumulative effect is predicted to be of regional extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.
Sensitivity of receptor	The sensitivity of the receptor is low, as detailed in Section 10.11.1 for the alone assessment. It is considered that not all species make aversive movements to vessels, effect ranges are small (based on empirical evidence of receptors in the field) and effects are very short lived (10.11.4.36 *et seq.*).
Significance of effect	<u>Tier 1</u> Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The overall significance of the effect is negligible or minor. As a precaution, **minor adverse** significance has been concluded for behavioural disturbance, which is not significant in EIA terms. Because any disturbance is expected to be temporary, with species showing tolerance and recoverability, and therefore the effect is unlikely to result in population-level consequences. <u>Tier 2</u> Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The overall significance of the effect is negligible or minor. As a precaution, **minor adverse** significance has been concluded for behavioural disturbance, which is not significant in EIA terms. Because any disturbance is expected to be temporary, with species showing tolerance and recoverability, and therefore the effect is unlikely to result in population-level consequences. <u>Tier 3</u>

	Cumulative Effects Assessment Scenario 4: Morven South and Tier 1, Tier 2 and Tier 3 Projects
	Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The overall significance of the effect is negligible or minor. As a precaution, **minor adverse** significance has been concluded for behavioural disturbance, which is not significant in EIA terms. Because any disturbance is expected to be temporary, with species showing tolerance and recoverability, and therefore the effect is unlikely to result in population-level consequences.
Further mitigation and residual significance	No mitigation measures for marine mammals are considered necessary because the likely cumulative effect the absence of further mitigation (beyond the designed-in measures outlined in Table 10.33), is not significant in EIA terms.

10.13 Proposed monitoring

10.13.1.1 Site specific monitoring is not proposed because the assessment concluded that Morven North would not give rise to significant effects for marine mammals, either alone or when considered cumulatively with other plans, projects or activities. The Applicant will, however, continue to liaise with MD-LOT, and key stakeholders to help identify opportunities for proportionate, evidence led regional or strategic monitoring that can improve understanding of the environmental implications of offshore wind, particularly where recognised evidence gaps exist. This may include contributing to, or participating in, relevant ongoing initiatives under the ScotMER programme (Scottish Government, 2026).

10.14 Transboundary effects

10.14.1.1 A screening of transboundary impacts has been carried out (see Volume 3, Annex 6.2: Transboundary Effects Screening). The potential for significant transboundary effects with regard to marine mammals to result from Morven South upon the interests of other European Economic Area (EEA) States has been assessed as part of the EIA. The potential transboundary impacts are summarised below:

- injury and disturbance from underwater sound generated from piling;
- injury and disturbance from underwater sound generation from UXO clearance;
- injury and disturbance from vessel use and other (non-piling) sound producing activities.

10.14.1.2 Potential transboundary effects could occur where elevations in underwater sound, particularly during construction piling, could ensonify large areas causing wide-ranging disturbance of marine mammals. The underwater sound disturbance contours predicted for piling extended across the northern North Sea and therefore animals transiting between these waters could be behaviourally disturbed across different states. The assessment of Morven South alone considered the effects on marine mammal populations within relevant MUs which covered, at a minimum, the population within the northern North 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 Morven South 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 of **minor adverse** significance which is not significant in terms of EIA Regulations.

10.14.1.3 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 (PK) was predicted up to 9,310m for a 132kg (NEQ) UXO and 16,300m for a 554kg (NEQ) UXO (for harbour porpoise) whilst a moving away response, using the TTS metric, was predicted up to 30,700m SEL_{24h} (for minke whale). Ranges of this extent could therefore affect individuals transiting between transboundary nations. These predictions are, however, highly precautionary since the low order clearance techniques will be used in line with the Joint Position Statement (UK Government, 2025), which would considerably reduce the potential injury and/or disturbance ranges. For injury, tertiary mitigation measures will be applied to reduce the risk of permanent auditory injury (Table 10.33) which includes the use of low order clearance, and with these in place the assessment concluded the magnitude for the project alone for all species would be negligible. For behavioural disturbance, the magnitude is considered to be low for all species for the project alone. The sensitivity of all marine mammals to PTS is high and to disturbance (TTS) is low. Therefore, the significance of auditory injury for low order clearance at a transboundary level is **minor adverse**, which is not significant in EIA terms. For behavioural disturbance the effect will be of negligible or minor adverse significance. Disturbance is expected to be temporary, with species showing tolerance and recoverability, and although there will be effects at the individual level this is not predicted to lead to population-level effects. Transboundary effects are therefore concluded to be of **minor adverse** significance, which is not significant in EIA terms.

10.14.1.4 For vessel use and other (non-piling) sound producing activities the range of disturbance modelled could extend out to 45.3km. 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 only a single available threshold (120 dB re 1 µPa (rms)), (the Level B harassment threshold) (NMFS, 2005), (no distinction between mild and strong disturbance), it can be assumed that not all animals found within those ranges would be disturbed at the same level. Moreover, for those animals disturbed, there is likely to be a proportional response (i.e. not all animals will be disturbed to the same extent). Furthermore, there is an indication of tolerance to vessel traffic in the scientific literature for marine mammals, particularly in the North Sea which has high baseline levels of vessel traffic. Empirical evidence suggest strong disturbance is more likely to occur over ranges not exceeding 7km (see paragraph 10.11.4.32). The assessment concluded the magnitude for the project alone, with respect to the relevant MUs, would be low, the sensitivity is low and the significance of the effect to be of minor adverse significance. Therefore, the significance of disturbance from vessel use and other (non-piling) sound producing activities at a transboundary level is considered to be of **minor adverse** significance which is not significant in terms of EIA Regulations.

10.14.1.5 For other potential impacts, including elevated underwater sound from geophysical and geotechnical surveys, increased likelihood of injury due to collision with vessels, changes in prey availability and operation related sound emissions, the effects on marine mammals were predicted to be very localised and are therefore considered unlikely to result in significant transboundary effects on marine mammal IEFs.

10.15 Inter-related effects

10.15.1.1 For marine mammals, the following potential impacts have been considered within the inter-related assessment:

- injury and disturbance from underwater sound generated from piling;
- injury and disturbance from underwater sound generation from UXO clearance;
- disturbance to marine mammals from pre-construction site investigation surveys;
- injury and disturbance to marine mammals from vessel use and other non-piling sound-producing activities;
- injury to marine mammals due to collision with vessels;
- effects on marine mammals due to changes in prey availability.

10.15.1.2 Table 10.92 lists the inter-related effects (project lifetime effects) that are predicted to arise during the construction, O&M and decommissioning of Morven South and the inter-related effects (receptor-led effects) that are predicted to arise for marine mammals receptors.

10.15.1.3 As noted above, effects on marine mammals also have the potential to have secondary effects on other receptors and these effects are fully considered in the topic-specific chapters. These receptors and effects are:

- changes in the marine mammal community could have indirect effects on fish and shellfish populations.

Table 10.92: Summary of likely significant inter-related effects on the environment from individual effects occurring across the construction, operation and maintenance, and decommissioning phases of Morven South and from multiple effects interacting across all phases (receptor-led effects)

C= Construction, O= O&M, D= Decommissioning phases

Description of impact	Phase			Likely significant inter-related effect	Significance
	C	O	D		
Morven South lifetime effects					
Injury and disturbance from underwater sound generated from piling	✓	×	×	Whilst underwater sound could occur during all phases of Morven South, underwater sound generated during piling is limited to the construction phase only and therefore, no likely significant inter-related effects across multiple phases of Morven South from piling (Morven South lifetime effects) are predicted. Increased underwater sound during piling activities associated with construction of Morven South has the potential to interact with other sources of underwater sound associated with the construction phase of Morven South (such as UXO clearance). However, the underwater sound produced as a result of piling during construction of Morven South is likely to reach over a larger area (e.g. injury range of 4,450m from SEL_{24} during the concurrent piling of two foundations, Table 10.46) compared to other underwater sound producing activities associated with Morven South. Therefore during this phase, it is considered unlikely that piling would act additively with other sound producing activities occurring at the same time, as the sound produced during piling is likely to mask other sound sources. Although piling itself occurs during the construction phase only, it would contribute to the overall temporal duration of underwater sound impacts (not just piling) across all phases of Morven South and is discussed below in receptor-led effects.	Injury and disturbance from underwater sound generated from piling are anticipated to interact in such a way as to result in combined effects of minor adverse significance in the construction phase (i.e. not of greater significance than the assessments presented for each individual phase).
Injury and disturbance from underwater sound	✓	×	×	Whilst underwater sound could occur during all phases of Morven South, increased underwater sound generated during from UXO clearance is limited to the construction	Injury and disturbance from underwater sound generation from UXO clearance are anticipated to interact in such a way as to result in combined

Description of impact	Phase			Likely significant inter-related effect	Significance
	C	O	D		
generation from UXO clearance				phase only and therefore, no likely significant inter-related effects across multiple phases of Morven South from UXO clearance (Morven South lifetime effects) are therefore predicted. Increased underwater sound during UXO clearance during pre-construction activities could interact with other sources of underwater sound in the construction phase. This has the potential to contribute to an increase in the underwater sound which in turn could affect marine mammals. Low order clearance methods are the default, which has the potential to result in auditory injury ranges of up to 560m (PK) (Table 10.52) and localised disturbance (TTS as a proxy) out to 1,330m (SEL) (Table 10.56). However, the MDS also includes consideration of a high order detonation, with potential for auditory injury out to 16,300m (PK) for the maximum assumed UXO size (554kg NEQ) and out to 9,310m (PK) for the most realistic maximum UXO size (132 kg NEQ) (Table 10.52). Disturbance (TTS as a proxy) may occur out to 30,700m (SEL) for the maximum assumed UXO size (554kg NEQ) and out to 20,400m (SEL) for the most realistic maximum UXO size (132 kg NEQ). Additional disturbance is possible due to use of ADDs and soft start charges. It should be noted however, that for each UXO clearance, the duration of the impact, including mitigation, will be very short, and there will be breaks between UXO clearance events to allow periods of recovery. It has however been concluded on a precautionary basis that temporally UXO clearance could add to the overall duration of elevated underwater sound from other activities (e.g. site investigation surveys), during the construction phase and will contribute to the overall duration of underwater sound impacts across all phases	effects of minor adverse significance in the construction phase (i.e. not of greater significance than the assessments presented for each individual phase).

Description of impact	Phase			Likely significant inter-related effect	Significance
	C	O	D		
				of Morven South and is discussed below in receptor-led effects.	
Disturbance to marine mammals from pre-construction site investigation surveys	✓	✓	×	Elevated underwater sound during pre-construction site investigation surveys could be additive over the construction and operation and maintenance phases of Morven South with sequential sound from site investigation surveys leading to extended effect on marine mammals. However, this impact will occur as short-term events with cessation of sound in between events allowing periods of recovery, and the impact is localised (maximum auditory injury range of 0.9km (Table 10.58)) with disturbance of 3.80km (Table 10.61). Additive effects are possible (though unlikely given intermittency of surveys) and the duration of elevated underwater sound from all activities could be extended.	Disturbance to marine mammals from pre-construction site investigation surveys are anticipated to interact in such a way as to result in combined effects of effects of minor adverse significance in the construction phase (i.e. not of greater significance than the assessments presented for each individual phase).
Injury and disturbance to marine mammals from vessel use and other non-piling sound-producing activities	✓	✓	✓	Elevated underwater sound during vessel use and other non-piling sound-producing activities could occur across all three phases of Morven South. Vessels will be used throughout all stages of Morven South and could cause additional disturbance to marine mammals. Auditory injury was not exceeded for all species, and disturbance effects are likely to be localised for non-piling activities and during vessel movements (e.g. out to maximum of 45.3km (Table 10.69)) with breaks in activity within phases, however, temporally these effects could occur over all phases of Morven South and lead to additive effects.	Injury and disturbance to marine mammals from vessel use and other non-piling sound-producing activities are anticipated to interact in such a way as to result in combined effects of minor adverse significance in all phases (i.e. not of greater significance than the assessments presented for each individual phase).
Injury to marine mammals due to collision with vessels	✓	×	✓	Over the lifetime of Morven South there will be an ongoing risk of collision associated with vessels throughout the construction and decommissioning phases. If injury to marine mammals from collisions did occur this could lead to losses of individuals, but it is unlikely to lead to population-level effects. The risk of mortality is likely to be	Injury to marine mammals due to collision with vessels are anticipated to interact in such a way as to result in combined effects of minor adverse significance in all phases (i.e. not of greater significance than the assessments presented for each individual phase).

Description of impact	Phase			Likely significant inter-related effect	Significance
	C	O	D		
				low due to vessels moving at low speed, particularly by adopting good practice code of conduct for vessel operators (Volume 4, Annex 5: Navigation Safety Plan and Vessel Management Plan (NSPVMP) (Version 1); see Table 10.33) and therefore the risks will be reduced. It is important to consider that, to some extent, the underwater sound from the vessels themselves would act antagonistically with this impact by deterring animals away from vessels and thereby further reducing the risk of injury due to collision.	
Effects on marine mammals due to changes in prey availability	✓	✓	✓	Fish and shellfish communities may be affected through all phases of Morven South and therefore could present a long-term effect on marine mammals through changes/reductions to prey availability. Inter-related effects on fish and shellfish receptors are described in more detail in Volume 2, Chapter 9: Fish and Shellfish Ecology. Volume 2, Chapter 9: Fish and Shellfish Ecology concluded that for all potential impacts and at all phases of Morven South the effects were unlikely to lead to significant effects on fish and shellfish communities, and therefore unlikely to lead to significant effects on marine mammals. Even in the context of longer-term impacts there is unlikely to be an additive effect as marine mammals can exploit a suite of prey species and only a small area will be affected when compared to available foraging habitat in the northern North Sea.	Effects on marine mammals due to changes in prey availability are anticipated to interact in such a way as to result in combined effects of minor adverse significance in all phases (i.e. not of greater significance than the assessments presented for each individual phase).
Receptor-led effects					
Stressor 1: injury or disturbance from elevated underwater sound (from piling, UXO clearance, site investigation surveys, vessels, operational noise from turbines)					
During the pre-construction phase, activities resulting in elevated underwater sound includes UXO clearance, site investigation surveys, vessel use and other sound producing activities. These activities are likely to result in disturbance to marine mammals which may be additive in nature if activities are synchronised,					

Description of impact	Phase			Likely significant inter-related effect	Significance
	C	O	D		
as it could lead to a larger area disturbed at any one time. Disturbance is likely to occur as short-term, localised events for each activity within the pre-construction phase. Prior to piling, for example, UXO clearance could result in no more than 15 single clearance events (Table 10.32), with disturbance occurring mainly during the implementation of mitigation (ADDs and soft start) rather than the UXO clearance event itself which would be no more than seconds for each. There is also a small potential that animals could experience injury during UXO clearance (if high order detonation is used). Site investigation surveys will occur intermittently during the pre-construction phase, whilst disturbance during vessel activity will occur intermittently with timings linked to the pre-construction activities (UXO and site investigation surveys). During the construction phase, activities resulting in elevated underwater sound include piling, other construction activities and vessel movements could occur. Since injury to marine mammals will be reduced through the MMMP (Volume 4, Annex 2: Marine Mammal Mitigation Protocol (MMMP) (Version 1)) (Table 10.33), the key focus is on disturbance effects. Disturbance due to impact piling could occur intermittently on a total of 264 days over the construction phase of five years. Other construction activities (e.g. drilling) and vessel movements would occur intermittently within the five year construction phase. When piling occurs the disturbance effects are likely to be greater than for any of the other activities contributing to elevated underwater sound so there is less likely to be an additive or synergistic effect during piling. Benhemma-Le Gall *et al.* (2021) found that piling was the main cause of displacement during construction with observed responses at distances of up to 10 to 15km at Beatrice and Moray East OWFs; without piling there was still a disturbance response due to vessel activity and other construction, but that the effect ranges (up to 4km) were less compared to piling. This demonstrates that the main driver for disturbance will be piling and that there would be less potential for additive or synergistic, inter-related effects from other activities during this time. Indeed, the effect of piling may be antagonistic with effects from other sound-producing activities as it dominates the soundscape and therefore may 'cancel out' any other effects that could occur. There may, however, be an additive effect spatially where two or more sound producing activities occur in different parts of Morven South (though this is highly unlikely), or temporally due to ongoing disturbance from activities throughout the construction phase (e.g. if they occur consecutively). During the operation and maintenance phase, activities resulting in elevated underwater sound include vessel activity and geophysical surveys. These activities have the potential to result in disturbance to marine mammals which may be additive if activities are synchronised, as it could lead to a larger area disturbed at any one time. Disturbance is likely to occur as short-term, localised events for vessel activity (and it is likely other non-service vessels will be excluded from the OWF) and geophysical surveys and the disturbance from operational noise is expected to be highly localised and minimal. There may be a slight additive effect spatially where two or more noise producing activities occur in different parts within the Morven South Boundary, or temporally due to ongoing disturbance from activities throughout the operation and maintenance phase (e.g. if they occur consecutively). During decommissioning, vessel movements associated with decommissioning activities will result in elevated underwater sound which could lead to disturbance to marine mammals. Disturbance is likely to occur as short-term, localised events and there may be an additive effect spatially where vessels are operating in different parts within the Morven South Boundary, or temporally due to ongoing disturbance throughout the decommissioning phase. Therefore, marine mammal receptors have the potential to experience ongoing disturbance due to elevations in underwater sound from different sources at all phases of Morven South. The sensitivity of key species will be linked to their ability to tolerate the stressor such that their ability to function normally (e.g. forage, reproduce, communicate, avoid predators) is not impeded. The assessment, which adopts a highly precautionary approach has demonstrated that for all impacts, considered in isolation, the residual effects will not be significant, as either the spatial scale is very localised or where larger scale effects do occur (i.e. during piling or UXO) these will be highly reversible with animals returning to baseline levels rapidly.					

Description of impact	Phase			Likely significant inter-related effect	Significance
	C	O	D		
There are, however, uncertainties as to how all activities interact to contribute to an additive effect from underwater sound as a stressor. It is highlighted that the impact assessment adopted a conservative approach assuming the maximum extent of effects throughout each phase with no allowance for any acclimatisation to, or compensation for elevated levels of sound. Whilst it is acknowledged that this approach is appropriate due to inherent uncertainties in undertaking such assessments, it may lead to overestimates of the effects. To some extent it is anticipated that animals will acclimatise to or compensate for such increases in underwater sound. Graham *et al.* (2019), for example, demonstrated acclimatisation in harbour porpoise, showing that the proportional response of harbour porpoise to piling noise decreased over the piling phase, with the proportion of animals disturbed at a received level of 160dB re 1 µPa decreased from 91.5% to 49.2% from the first pile to the last pile. Kastelein *et al.* (2019) suggest that harbour porpoise (a species with high daily energy requirements) may be able to compensate for period of disturbance as they can dramatically increase their food intake in a period following fasting without any detriment to their health. In the Moray Firth, buzzing activity of harbour porpoise (representing foraging) was higher compared to baseline levels during the construction of Moray East OWF, possibly in relation to increased prey availability as a result of introduction of hard substrates (e.g. jacket foundations and scour protection) (although there may be an additional energetic cost from the fleeing and distance travelled to compensate for) (Benhemma-Le Gall *et al.*, 2021). Russell *et al.* (2014) demonstrated pinnipeds trace anthropogenic structures at sea, with three animals concentrating their foraging effort within the windfarm's array. Similarly, Rose *et al.* (2025) found for harbour porpoise, significantly higher detection rates within OWFs than in their vicinity (surrounding 2.5km), and suggested OWFs in operation may attract rather than deter harbour porpoise (due to reef and/or refugium effects). Therefore, significance is considered to be minor adverse and, therefore, not significant in EIA terms.					
Stressor 2: injury due to collisions with vessels					
Injury due to collisions with vessels is associated with increased vessel movement, the impact of which was assessed from different types of vessels and at different phases of Morven South. Over the lifetime of Morven South there will be an increased temporal risk to marine mammal receptors however, with the designed-in measures and mitigation such as the NSPVMP (Volume 4, Annex 5: Navigation Safety Plan and Vessel Management Plan (NSPVMP) (Version 1)) (Table 10.33) the potential risk of injury due to collision is likely to be reduced and therefore it is not anticipated that an additive effect will occur. Additionally, to some extent the sound from the vessels themselves (Stressor 1.) would act antagonistically with this impact by deterring animals away from vessels and thereby further reducing the risk of injury due to collision. Furthermore, marine mammals in this area are already accustomed to a high level of vessel activity. For example, Buckstaff (2004) demonstrated that bottlenose dolphin increased their rate of whistle production at the onset of a vessel approach and then decreased production during and after it had passed. This increased whistle production may be a tactic to reduce signal degradation to ensure that information is being communicated in an elevated noisy environment, but it also demonstrates that animals are aware of approaching vessel from a distance. This corroborates previous research of Nowacek *et al.* (2001), which found that bottlenose dolphin swim in tighter aggregated groups during vessel approaches, therefore if a vessel is loud enough to be detected by an animal for which it adjusts its behaviour, the likelihood of collision decreases. Furthermore, not all collisions that do occur are lethal (e.g. dependent depth of laceration, anatomical site of injury, health of animal (Vanderlaan and Taggart, 2007, Combs, 2018, Conn and Silber, 2013, Rommel *et al.*, 2007, Wiley *et al.*, 2016)) and is highly species dependent, and therefore the assessment precautionarily considered recovery potential to be medium from vessel collisions. Therefore, significance is considered to be minor adverse and, therefore, not significant in EIA terms.					

Description of impact	Phase			Likely significant inter-related effect	Significance
	C	O	D		
Stressor 3: changes in prey communities					
The EIA considered overall effects on fish and shellfish communities from multiple stressors (see in Volume 2, Chapter 9: Fish and Shellfish Ecology) and therefore, in this respect, has taken an ecosystem-based approach. For some impacts stressors will be over the same timescales as marine mammals (such as underwater sound effects on fish and shellfish) whilst for others, such as temporary habitat loss, timescales may be different to those assessed for marine mammals (e.g. low mobility or sessile species may recover much more slowly). The assessment of effects (section 10.11.6) demonstrated that due to the high mobility of marine mammals, generalist feeding strategy and ability to exploit different prey species, combined with the small scale of potential changes in context of wider available foraging habitat for marine mammals, the changes to fish and shellfish communities are unlikely to have an effect even from multiple stressors. A recent study by (Watson *et al.*, 2024) reviewed the global impact of OWFs on ecosystem services and showed operational phase impacts were variable and detailed investigations into fish and shellfish recorded a net positive effect of wind farm operations on these species groups. Studies have found that the foundations of OWFs act as artificial reefs and fish aggregation devices (Degraer *et al.*, 2020, Langhamer, 2012) by providing space for the settlement, shelter and foraging (including pelagic and demersal fish and marine mammals). Equally, OWFs can act as a de-facto MPAs by limiting activities that can negatively affect the environment, which can potentially enhance both biodiversity and fisheries in surrounding areas (Buyse *et al.*, 2022, Ashley *et al.*, 2014). Therefore, significance is considered to be minor adverse and, therefore, not significant in EIA terms.					
Multiple stressors: inter-related effect of all stressors					
The inter-related effect of all stressors in-combination is discussed in detail in Section 10.15.2 below. The significance is considered to be minor adverse and, therefore, not significant in EIA terms.					

10.15.2 Multiple stressors: inter-related effect of all stressors

10.15.2.1 It is possible that multiple stressors interact across the lifetime of Morven South. Arrigo *et al.* (2020) suggests that large organisms at higher trophic levels, such as marine mammals, may be generally negatively impacted by increasing interaction strength between stressors from different activities, but the variability in the response to such interactions is small and therefore unlikely to lead to population-level effects.

10.15.2.2 For elevated underwater sound (Stressor 1) there is the potential for marine mammals to forage in different habitats and to compensate for reduced foraging time. As such the ability of displaced animals will depend on the availability of prey resources in the habitat to which the animals are displaced. Studies have shown that for small, localised marine mammal populations with high site fidelity, there may be biological risks posed by displacement (Forney *et al.*, 2017). For example, due to the importance of the areas for survival (i.e. areas of high resource availability), animals may be highly motivated to remain in an area despite adverse impacts which may increase stress (Rolland *et al.*, 2012). Thus, the inter-related effects of underwater sound (Stressor 1) and changes in fish and shellfish prey resources (Stressor 3) needs to be considered. Impacts on fish and shellfish prey resources were predicted to be localised and short-term and therefore unlikely to contribute to an inter-related effect where animals are displaced beyond the boundaries of Morven South. Within the Morven South Boundary however, there may be short-term inter-related effects of noise disturbance and reduced fish and shellfish prey resources. For marine mammals remaining in proximity to Morven South, a substantial disruption in foraging may not be as easy to compensate for where there are shifts in the species composition or localised reductions of fish and shellfish communities. Gordon *et al.* (2003) suggested it may be possible that damaged or disoriented prey could attract marine mammals to an area of impact due to providing short-term feeding opportunities (but increasing levels of exposure), however, there is currently little evidence available to investigate such indirect effects on marine mammals.

10.15.2.3 Therefore, whilst the assessment has largely described potential adverse effects, there is also potential for some beneficial effects on marine mammal receptors. Construction of OWFs can lead to the introduction of hard substrates which can lead to the establishment of new species and new fauna communities, and this may in turn attract marine mammals (Lindeboom *et al.*, 2011, Raoux *et al.*, 2017, Fowler *et al.*, 2018). Thus, even where there is potential for an inter-related effect between ongoing vessel noise during the operation and maintenance phase this may be compensated for, to some extent, by an increase in available prey resources. Russell *et al.* (2014) and Russell and McConnell (2014) demonstrated that harbour seals and grey seals moved between hard structures at two operational wind farms and used space-state models to predict where animals were remaining at these locations to actively forage and where they were travelling to the next foundation structure.

10.15.2.4 Similarly, Rose *et al.* (2025) utilised 13 years of data from C-POD monitoring between 2010 and 2023, to carry out a comparison of harbour porpoise detection rates measured within OWFs in operation (positioned in the German Bight) to those in the vicinity of the same wind farm (2.5km buffer). Results showed significantly higher detection rates within OWFs than in their vicinity, with an increase of 10.6% in the factor model. Rose *et al.* (2025) suggested operational OWFs may attract rather than deter harbour porpoise due to reef effects (offshore foundations and piles serve as a hard substrate and attract fish and other hard substrate-related fauna), as well as refugium effects (within the areas of German OWFs fishing is prohibited). Even though service vessels still operate within OWFs, and intrinsic ambient noise is present around the wind turbines, these impacts apparently did not deter harbour porpoise. Lindeboom *et al.* (2011) studied the ecological effects of the Egmond aan Zee OWF and found that even though the fish community was highly dynamic in time and space, with only minor effects upon fish assemblages observed during the operation and maintenance phase, some fish species (e.g. cod) benefited from the ‘shelter’ within the wind farm. This is likely due to reduced fishing activity and the new hard substratum with associated fauna which attracts predator species. Lindeboom *et al.* (2011) suggested the observed increase in echolocation activity of harbour porpoise within the wind farm may be correlated with presence of additional increased food sources compared to reference areas.

10.15.2.5 The potential interrelationship between underwater sound and collision risk has been addressed in earlier discussions (Table 10.92) and it is considered likely that marine mammals will move away from moving vessels in response to engine noise, therefore reducing the risk of collision (classed as an antagonistic interaction). Alternatively, marine mammals may tolerate and persist in a highly stressed state (as a result of injury caused by underwater sound) whilst the vessels are approaching (Muto *et al.*, 2018). Animals could also become habituated to vessel noise and not move away from the vessel (McWhinnie *et al.*, 2018) which would result in a synergistic interaction (Wright and Weilgart, 2011). Therefore, the outcome will depend on the degree of habituation and prior experience and a number of acoustical properties that allow an approaching vessel to be detected by a marine mammal species (Gerstein *et al.*, 2005). However, as described in the impact assessment, with the designed-in measures and mitigation in place (Table 10.33) it is likely that any risk of injury from collision with vessels will be negligible.

10.15.2.6 Evidence for the potential long-term effects of OWF on marine mammals (related to all potential stressors) comes from monitoring programmes which baseline levels of abundance to construction and post-construction phases. Limited monitoring studies regarding impacts on marine mammals from OWF have been carried out to date.

10.15.2.7 Aerial survey haul-out counts were conducted before, during and after the construction phases at Scroby Sands OWF, off the coast of Norfolk, to monitor harbour and grey seal counts at haul-out site, located less than two kilometres away from the OWF array (Skeate *et al.*, 2012). A decline in harbour seal numbers was reported during construction, with numbers remaining lower over several subsequent years. However, the numbers of grey seals increased dramatically year after year throughout the construction and early operational periods. It has been suggested that it is possible that changes in harbour seal numbers may be linked to rapid colonisation of competing grey seal (Skeate *et al.*, 2012). It was noted regional changes in patterns of haul-outs of harbour seal in the Wash coincided with the construction of the Scroby Sands OWF, but such changes in harbour seal number could have been part of wider regional dynamics (Verfuss *et al.*, 2016). It should be noted that Scroby Sands Wind Farm is located 2.5km off the coast of Great Yarmouth whereas Morven South is located further (105.3km from Firth of Tay and Eden Estuary SAC, designated for harbour seal) offshore and therefore a greater distance from haul-out sites. As a part of marine mammal monitoring at Robin Rigg OWF, boat-based surveys for cetaceans were conducted before, during, and after construction (Canning *et al.*, 2013). The monitoring data suggested that harbour porpoise were displaced from the wind farm site during the construction phase and operation period when compared to the pre-construction numbers. However, because there was only one year of pre-construction survey, natural variation cannot be ruled out as the reason for the observed change, especially since control survey locations outside of the wind farm also appeared to experience declines in harbour porpoise density.

10.15.2.8 With the rapid expansion of OWFs, post-construction monitoring programmes are being implemented at various developments in Europe. Tougaard *et al.* (2003) studied short-term effects of the construction of wind turbines on harbour porpoise at Horns Rev OWF and showed a decrease in porpoise acoustic activity within the wind farm at the onset of piling operations, but subsequent recovery to higher levels a few hours after each piling operation was completed. Tougaard *et al.* (2003) also showed that over the entire construction phase at Horns Reef there was no significant change in the abundance of harbour porpoise in the wind farm area compared to reference areas. Teilmann *et al.* (2008) also reported that during the operation and maintenance phase porpoise activity was higher in both the wind farm and reference area compared to baseline levels. As a result of monitoring at Nysted OWF, it was demonstrated initially during construction and the first two years of operation that there were lower acoustic detections of harbour porpoise in the wind farm area, with recovery starting to occur within two years after the end of construction (Teilmann *et al.*, 2006). Teilmann *et al.* (2006) suggested that animals were gradually habituating and returning to the wind farm area.

10.15.2.9 Nabe-Nielsen *et al.* (2011) suggested, using simulations of the response of harbour porpoise to wind farm construction, that wind farms already existing off Danish coast do not impact on harbour porpoise population dynamics and that the that construction of new wind farms is not expected to cause any changes in the long-term dynamics of the population. Likewise, Edrén *et al.* (2010) and

McConnell *et al.* (2012) investigated possible interactions between seals and Danish OWFs (Nysted Wind Farm and Rødsand II) and found that although there was a temporary reduction in the number of seals hauled out during construction operations (i.e. piling), there was no long-term effect on haul-out behaviour trends.

10.15.2.10 Therefore, the examples of monitoring studies suggest marine mammal receptors can quickly recover and return to the impacted area, despite the potential effects from multiple stressors associated with OWFs. As such, the significance of multiple inter-related stressors is considered to be minor adverse and therefore not significant in EIA terms.

10.16 Summary of impacts, Mitigation, Likely Significant Effects and Monitoring

10.16.1.1 Information on marine mammals within the Morven Regional Marine Mammal Study Area was collected through a detailed desktop review of existing studies and datasets. These are summarised in Table 10.18.

10.16.1.2 Table 10.93 (project alone assessment) presents a summary of the potential impacts, mitigation measures and the conclusion of LSE[1] in respect to marine mammals. The impacts assessed include:

- injury and disturbance from underwater sound generated from piling;
- injury and disturbance from underwater sound generation from UXO clearance;
- injury and disturbance to marine mammals from pre-construction site investigation surveys;
- injury and disturbance to marine mammals from vessel use and other non-piling sound-producing activities;
- injury to marine mammals due to collision with vessels;
- effects on marine mammals due to changes in prey availability.

10.16.1.3 Overall, it is concluded that there will be no LSE[1] arising from Morven South during the construction, O&M or decommissioning phases. Table 10.94 presents a summary of the potential cumulative impacts, mitigation measures and the conclusion LSE[1] on marine mammals in EIA terms. The cumulative effects assessed include:

- injury and disturbance from underwater sound generated from piling;
- injury and disturbance to marine mammals from vessel use and other non-piling sound-producing activities.

10.16.1.4 Overall, it is concluded that there will be no likely significant cumulative effects from Morven South alongside other projects/plans.

10.16.1.5 No likely significant transboundary effects have been identified in regard to effects of Morven South.

Table 10.93: Summary of Likely Significant Effects, mitigation and monitoring

C= Construction, O= O&M, D= Decommissioning phases

Description of impact	Phase			Designed-in measures	Magnitude of impact	Sensitivity of receptor	Significance of effect	Additional mitigation measures	Significance of residual effect	Proposed monitoring
	C	O	D							
Injury and disturbance from underwater sound generated from piling	✓	×	×	MMMP Soft start	Injury Minke whale: Low All other species: Negligible	Injury All species: Medium	Injury Minke whale: Minor adverse significance All other species: Negligible adverse significance	None	Negligible adverse significance	None
					Disturbance All species: Low	Disturbance Harbour porpoise: medium All other species: low	Disturbance All species: Minor adverse significance	None	Minor adverse significance	None
Injury and disturbance from underwater sound generation from UXO clearance	✓	×	×	Low order clearance	Injury All species: Negligible	All species: High	All species: Minor adverse significance	UXO Risk assessment	Minor adverse significance	None
					Disturbance All species: Negligible	All species: Low	All species: Negligible adverse significance	None	Negligible adverse significance	None
Injury and disturbance to marine mammals	✓	✓	×		All species: Negligible	All species: Medium	All species: Negligible adverse significance	None	Negligible adverse significance	None

Description of impact	Phase			Designed-in measures	Magnitude of impact	Sensitivity of receptor	Significance of effect	Additional mitigation measures	Significance of residual effect	Proposed monitoring
	C	O	D							
from pre-construction site investigation surveys					All species: Low	All species: Low	All species: Negligible adverse significance	None	Negligible adverse significance	None
Injury and disturbance to marine mammals from vessel use and other non-piling sound-producing activities	✓	✓	✓	NSPVMP	Injury All species: Negligible	Injury All species: Medium	All species: Negligible adverse significance	None	Minor adverse significance	None
					Disturbance All species: Low	Disturbance All species: Low	All species: Minor adverse significance	None	Minor adverse significance	None
Injury to marine mammals due to collision with vessels	✓	✓	✓	NSPVMP	All species: Low	All species: Medium	All species: Minor adverse significance	None	Minor adverse significance	None
Effects on marine mammals due to changes in prey availability	✓	✓	✓	NSPVMP	All species: Low	All species: Low	All species: Minor adverse significance	None	Minor adverse significance	None

Table 10.94: Summary of likely significant cumulative environment effects, mitigation and monitoring

C= Construction, O= O&M, D= Decommissioning phases

Description of impact	Phase			Designed-in measures	Magnitude of impact	Sensitivity of receptor	Significance of effect	Additional mitigation measures	Significance of residual effect	Proposed monitoring
	C	O	D							
Disturbance from underwater sound generated from piling	✓	×	×	MMMP Soft start	White-beaked dolphin: Medium All other species: Low	Harbour porpoise: Medium All other species: Low	All species: Minor adverse significance	None	Minor adverse significance	None
Disturbance to marine mammals from vessel use and other non-piling sound-producing activities	✓	✓	✓	NSPVMP	All species: Low	All species: Low	All species: Minor adverse significance	None	Minor adverse significance	None

10.17 References

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