BERWICK BANK WIND FARM
ENVIRONMENTAL IMPACT ASSESSMENT REPORT

Volume 2, Chapter 10: Marine Mammals

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Final

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10.1. INTRODUCTION

1. This chapter of the Offshore Environmental Impact Assessment (EIA) Report presents the assessment of the likely significant effects (as per the "EIA Regulations") on the environment of the Berwick Bank Wind Farm offshore infrastructure which is the subject of this application (hereafter referred to as "the Proposed Development") on marine mammals. Specifically, this chapter considers the potential impacts of the Proposed Development seaward of Mean High Water Springs (MHWS) during the construction, operation and maintenance, and decommissioning phases.

2. "Likely Significant Effect (LSE)" is a term used in both the EIA Regulations and the Habitat Regulations. Reference to LSE in this Offshore EIA report refers to "LSE" as used by the EIA Regulations. This Offshore EIA report is accompanied by a Report to Inform Appropriate Assessment (RIAA) (SSER, 2022d) which uses the term as defined by the Habitats Regulations.

3. The assessment presented is informed by the following technical chapters:

- volume 2, chapter 7: Physical Processes;
- volume 2, chapter 9: Fish and Shellfish Ecology; and
- volume 2, chapter 13: Shipping and Navigation.

4. This chapter summarises information contained within volume 3, appendix 10.2. The technical report provides a detailed characterisation of the marine mammal species ecology within the vicinity of the Proposed Development and the wider northern North Sea, based on existing literature and site-specific surveys, and provides information on marine mammal species of ecological importance and conservation value. This chapter is also informed by a technical report developed to understand underwater noise emissions associated with the Proposed Development, which is included as volume 3, appendix 10.1.

10.2. PURPOSE OF THIS CHAPTER

5. The primary purpose of the Offshore EIA Report is outlined in volume 1, chapter 1. It is intended that the Offshore EIA Report will provide the Scottish Ministers, statutory and non-statutory stakeholders with sufficient information to determine the likely significant effects of the Proposed Development on the receiving environment.

6. In particular, this marine mammals EIA Report chapter:

- presents the existing environmental baseline established from desk studies, site-specific surveys and consultation with stakeholders;
- identifies any assumptions and limitations encountered in compiling the environmental information;
- presents the likely significant environmental effects on marine mammals arising from the Proposed Development and reaches a conclusion on the likely significant effects on marine mammals, based on the information gathered and the analysis and assessments undertaken; and
- highlights any necessary monitoring and/or mitigation measures which are recommended to prevent, minimise, reduce or offset the likely significant adverse environmental effects of the Proposed Development on marine mammals.

10.3. STUDY AREA

7. For the purposes of the marine mammals characterisation, two appropriate marine mammals study areas were defined (Figure 10.1):

- The Proposed Development marine mammal study area: this area encompasses the Proposed Development array area and Proposed Development export cable corridor plus a ~16 km buffer (hereafter referred to as 'Proposed Development aerial survey area').
- The regional marine mammal study area: marine mammals are highly mobile and may range over large distances and therefore, to provide a wider context, the desktop review considers the marine mammal ecology, distribution and density/abundance within the wider northern North Sea. The regional marine mammal study area also informs the assessment where the Zone of Influence (ZoI) for a given impact (e.g. underwater noise) may extend beyond the Proposed Development marine mammal study area.

8. Regional marine mammal study area boundaries were discussed with NatureScot and Marine Scotland Science (MSS) during Road Map Meeting 1 and Road Map Meeting 2 (volume 3, appendix 10.3). In accordance with advice received during consultation, population level effects were informed by species Management Units (MUs). However, where MUs for a given species extended over a very large scale (e.g. minke whale *Balaenoptera acutorostrata* and white-beaked dolphin *Lagenorhynchus albirostris*), the assessment will also consider effects over a smaller scale; within Small Cetacean Abundance in the North Sea (SCANS) III Block R.

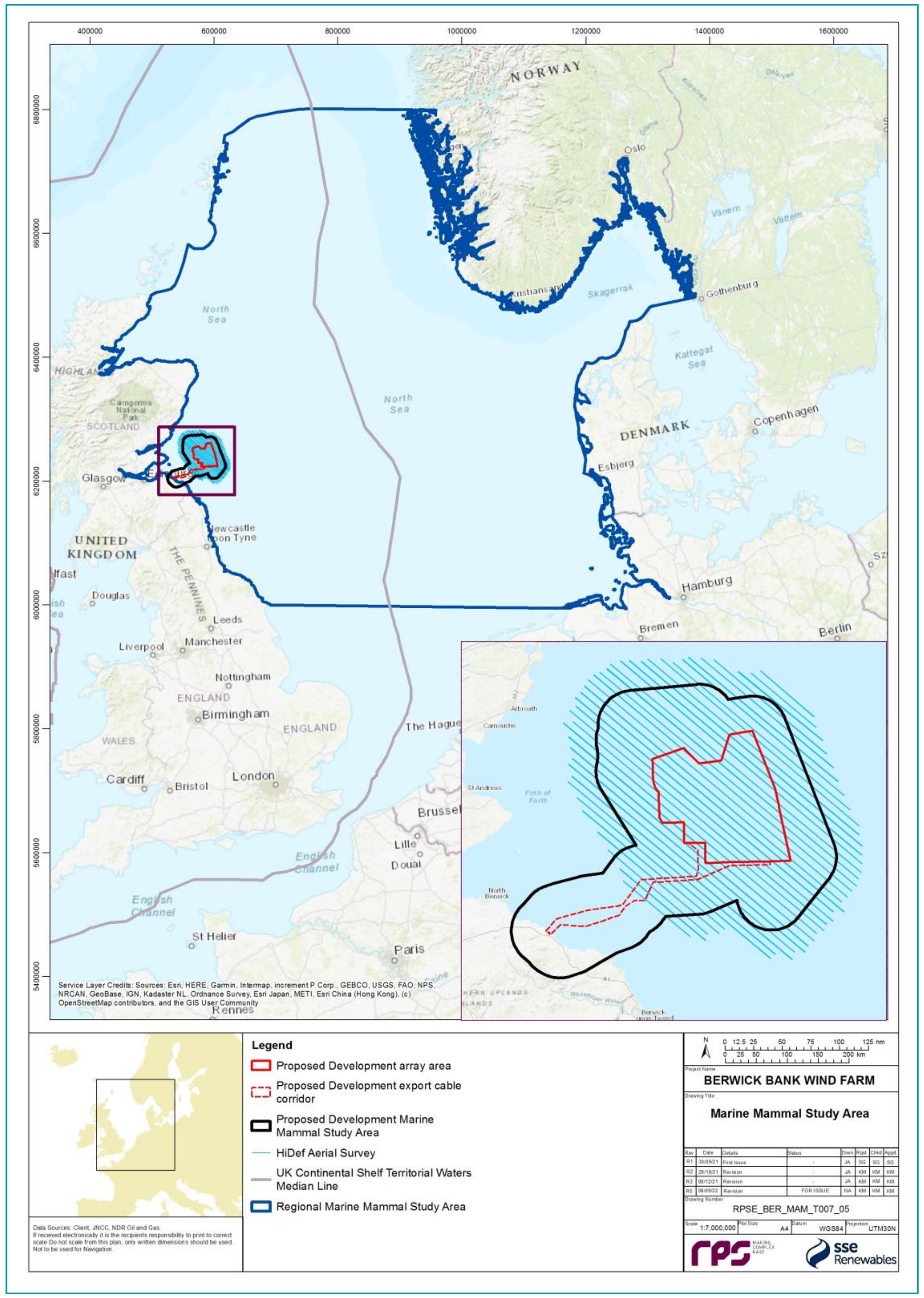

Figure 10.1: Marine Mammals Study Areas

10.4. POLICY AND LEGISLATIVE CONTEXT

9. Policy and legislation on renewable energy infrastructure is presented in volume 1, chapter 2 of the Offshore EIA Report. Policy and legislation specifically in relation to marine mammals, is contained in the Marine (Scotland) Act 2010, the Habitats Regulations (this is a collective term which include three sets of regulations, see section 2.4.1 of volume 1, chapter 2 for more details), Scotland's National Marine Plan 2015, The Sectoral Marine Plan for Offshore Wind Energy 2020, Nature Conservation (Scotland) Act 2004 and the United Kingdom (UK) Marine Policy Statement. A summary of the legislative provisions and policy frameworks relevant to marine mammals is provided in Table 10.1 to Table 10.8.

Table 10.1: Summary of Marine (Scotland) Act 2010 Relevant to Marine Mammals

Summary of Relevant Legislation	How and Where Considered in the Offshore 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 impact of the Proposed Development on the marine mammals are considered in section 10.11 to best inform ministers of the sustainability of the development.
Legislation pertaining to Protection of Seals	
The Act provides improved protection for seals. Certain haul-out sites have been designated where seals are protected from intentional or reckless harassment.	All relevant designated haul-out sites are listed in section 10.7.1, and further described in volume 3, appendix 10.2 and effects on these are considered in section 10.11.
The Act seeks to balance seal conservation with other pressures and requirements (such as species conservation). Part 6 prohibits the killing or taking of seals except under specific licence.	No licence is required as there will be no killing or taking of seals in relation to the Proposed Development.
Marine Protected Areas (MPAs)	
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 MPAs.	As agreed with stakeholders (see Table 10.9), there are no marine mammal Nature Conservation Marine Protected Areas (ncMPAs) in the vicinity of the Proposed Development that should be included in this chapter.

Table 10.2: Summary of the Habitats Regulations Relevant to Marine Mammals

Summary of Relevant Legislation	How and Where Considered in the Offshore EIA Report
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, the relevant competent authority must undertake an appropriate assessment of the implications for the site in view of that site's conservation objectives. If the potential for adverse effects on European site integrity cannot be discounted, the Project could only proceed if imperative reasons of over-riding public interest are found to exist and if compensatory measures can be secured.	All relevant European sites are listed in section10.6.2, along with their proximity to the Proposed Development and effects on these are considered in section 10.11. Section 10.12 also considers impacts on European sites from other plans and projects in-combination with the Proposed Development. European sites are further assessed in accordance with the Habitats Regulations Assessment is presented in the Report to Inform Appropriate Assessment in the RIAA (SSER, 2022d).

Summary of Relevant Legislation	How and Where Considered in the Offshore EIA Report
Species Protection	
A person is guilty of an offence if they deliberately capture, injure, or kill any wild animal or a European Protected Species (EPS). In Scottish inshore waters (within 12 nm of the coast), offences relating to the protection of marine EPS are provided for under the Habitats Regulations[1].	All the relevant protected species have been identified in section 10.7, and the environmental assessments in section 10.11 consider the conservation status of marine mammal receptors in coming to a conclusion regarding the significance of effect and proposed mitigation. An EPS licence will be applied for in relation to any activity which has potential to result in such an offence and this application would be informed by the assessments presented in section 10.11.

Table 10.3: Summary of Scotland's National Marine Plan Relevant to Marine Mammals

Summary of Relevant Policy Framework	How and Where Considered in the Offshore EIA Report
General Policies	
GEN9 section of the Plan refers to Natural Heritage and provides that "*Development and use of the marine environment must:* *comply with legal requirements for protected areas and protected species;* *not result in significant impacts on the national status of Priority Marine Features (PMFs); and* *protect and, where appropriate, enhance the health of the marine area."*	Protected species and PMFs are identified in section 10.7. Section 10.11 presents an assessment of the significance of the effects of the Proposed Development on marine mammal receptors along with mitigation measures adopted to prevent, minimise, reduce or offset potential impacts.
Paragraph 4.47 *et seq.* of the Plan refers to MPAs and provides that "The Marine Acts place a duty on all regulators to ensure that there is no significant risk of hindering the achievement of the conservation objectives of an MPA before giving consent to an activity. Where an ongoing activity presents a significant risk of hindering the achievement of the conservation objectives of an MPA there will be a management intervention. *This intervention will be practical and proportionate, utilising the most appropriate statutory mechanism to reduce the risk."*	Section 10.11 presents assessments of the significance of the effects of the Proposed Development on marine mammal receptors, however, as agreed with stakeholders (see Table 10.9), no marine mammal MPAs are considered. An MPA Assessment in relation to relevant ecological features (SSE Renewables Development, 2022b) has been undertaken for the Proposed Development which considers the potential for effects to designated features of MPAs.
Paragraph 4.51 *et seq.* of the Plan refers to protected species and provides that "*The presence (or potential presence) of a legally protected species is an important consideration. If there is evidence to suggest that a protected species is present or may be affected by a proposed development, steps must be taken to establish their presence. The level of protection afforded by legislation must be factored into the planning and design of the development and any impacts must be fully considered prior to the determination of the application. (…) For certain species deliberate or reckless disturbance or harassment is prohibited and can only be carried out in accordance with the terms of a licence.*"	Protected species and PMFs are identified in section 10.7. Section 10.11 presents an assessment of the significance of the effects of the Proposed Development on marine mammal receptors. A EPS licence will be applied for in relation to any activity which has potential to result in such an offence and this application would be informed by assessment presented in section 10.11.
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 the Project in the context of climate change (volume 3, appendix 21).
Offshore Wind and Marine Renewable Energy Policies	
Renewables 6 section of the Plan refers to Planning Policies and provides that: *"New and future planned grid connections should align with relevant sectoral and other marine spatial planning processes, where appropriate, to ensure a co-ordinated and strategic approach to grid planning. Cable and network owners and marine users should also take a joined-up approach to development and activity to minimise impacts on the marine historic and natural environment and other users."*	The maximum design scenario for the Proposed Development, including cables, is shown in section 10.8.1. The cumulative effect of impacts based on the maximum design scenario for the proposed Development along with the maximum design scenario from other projects in the area is assessed in section 10.12. Further information on the route selection process for the Proposed Development export cable corridor is presented in volume 1, chapter 4.

Table 10.4: Summary of Scottish PMFs Relevant to Marine Mammals

Summary of Relevant Policy Framework	How and Where Considered in the Offshore 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.	Relevant PMFs are identified in section 10.7.3. Section 10.11 assesses the significance of the effect of the Proposed Development on all marine mammal receptors, including PMFs.

Table 10.5: Summary of The Sectoral Marine Plan for Offshore Wind Energy 2020 Relevant to Marine Mammals

Summary of Relevant Policy Framework	How and Where Considered in the Offshore 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.	The potential for adverse effects on the identified environmental (i.e. marine mammal) receptors is considered fully in section 10.11. The cumulative effects of the Proposed Development alongside other projects identified in the regional marine mammal study area are assessed in section 10.12.

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

Summary of Relevant Policy Framework	How and Where Considered in the Offshore EIA Report
Offshore Wind and Marine Renewable Energy Policies	
Regional cumulative effects include the potential for adverse 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.	The cumulative effects of the Proposed Development and other projects identified in the regional marine mammal study area are assessed in section 10.12, along with appropriate mitigation measures, where required.

Table 10.6: Summary of the UK Marine Policy Statement Relevant to Marine Mammals

Summary of Relevant Policy Framework	How and Where Considered in the Offshore EIA Report
General Policies	
Ensure a sustainable marine environment which promotes healthy, functioning marine ecosystems and protects marine habitats, species and our heritage assets.	The magnitude of impacts and the sensitivity of marine mammal receptors are analysed in section 10.11 to determine if the relevant impacts represent a significant effect on the marine mammal receptors.
The marine environment plays an important role in mitigating climate change.	The impact of climate change on the baseline environment and how this will influence the predictions made in the effects assessment is considered as part of the future baseline in section 10.7.4.
Biodiversity is protected, conserved and where appropriate recovered and loss has been halted.	Section 10.11 presents an assessment of the significance of the effects of the Proposed Development on marine mammal receptors along with mitigation measures adopted to prevent, minimise, reduce or offset potential impacts.
Offshore Wind and Marine Renewable Energy Policies	
Marine businesses are acting in a way which respects environmental limits and is socially responsible.	Section 10.11 presents an assessment of the significance of the effects of the Proposed Development on marine mammal receptors along with mitigation measures adopted to prevent, minimise, reduce or offset potential impacts.

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 Offshore EIA Report
General Policies	
Places duties on public bodies in relation to the conservation of biodiversity and strengthens wildlife enforcement legislation. Wild animal protection is extended 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.	Section 10.11 presents an assessment of the significance of the effects of the Proposed Development on marine mammal receptors along with mitigation measures adopted to prevent, minimise, reduce or offset potential impacts. An EPS licence will be applied for in relation to any activity which has potential to result in such an offence and this application would be informed by assessment presented in section 10.11.

Table 10.8: Summary of The Scottish Biodiversity Strategy (Scotland's Biodiversity, 2004) Relevant to Marine Mammals

Summary of Relevant Policy Framework	How and Where Considered in the Offshore EIA Report
General Principles	
Sets out a vision for 2030 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.	Section 10.11 presents an assessment of the significance of the effects of the Proposed Development on marine mammal receptors along with mitigation measures adopted to prevent, minimise, reduce or offset potential impacts.

10.5. CONSULTATION

10. The Marine Mammals Road Map was a 'live' document which has been used as a tool to facilitate early engagement with stakeholders and subsequent engagement throughout the pre-application phase of the Proposed Development (volume 3, appendix 10.3). This has included reaching points of agreement on potential impacts to be scoped out of the assessment, and/or agreeing the level of assessment which will be presented for potential impacts scoped into the assessment, so that the focus in the Offshore EIA Report submission documents is on likely significant environmental effects as defined by the EIA Regulations. Marine mammal Important Ecological Features (IEFs) are those marine mammal receptors that have the potential to be affected by the Proposed Development. Additionally, these pre-Application consultation meetings have provided an opportunity for stakeholders to comment on the aerial survey data interim data analyses report (volume 3, appendix 10.2, annex A) and discuss data and methods used in the assessment of significance of effects on marine mammal IEFs (see paragraph 21 for the description of IEFs and section 10.11 for the assessment of likely significant effects).

11. The Marine Mammals Road Map (up to date at the point of Application) is presented in volume 3 appendix 10.3 and documents meetings and records discussion points. At the request of Marine Scotland - Licensing Operations Team (MS-LOT) the Berwick Bank Wind Farm Audit Document for Post-Scoping Discussions (SSER, 2022d) (hereafter 'the Audit Document) has been produced and submitted alongside the application to document discussions on key issues, post-receipt of the Berwick Bank Wind Farm Scoping Opinion (MS-LOT, 2021).

12. A summary of the key issues raised during consultation activities undertaken to date of submission of the Offshore EIA report, specific to marine mammals is presented in Table 10.9, together with how these issues have been considered in the production of this marine mammals Offshore EIA Report chapter. Where consultation responses provided with respect to 2020 Berwick Bank remain relevant and applicable to the current proposal, or where the SNCBs have directed reference to them, these have been incorporated into this chapter. Further detail is presented within volume 1, chapter 5 as well as volume 3, appendix 10.3.

Table 10.9: Summary of Key Consultation of Relevance to Marine Mammals

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
Relevant Consultation Undertaken for 2020 Berwick Bank			
18 December 2019	Initial consultation meeting: MS-LOT, MSS and NatureScot	Stakeholders discussed and advised to use following datasets for baseline characterisation: previous boat surveys for the area, SCANS III surveys, Joint Cetacean Protocol (JCP) Phase III, Sea Mammal Research Unit (SMRU) harbour seal *Phoca vitulina* and grey seal *Halichoerus grypus* at-sea usage maps, telemetry and haul out counts plus additional sources (such as citizen science projects).	All suggested datasets were used to inform the baseline characterisation and are listed in section 10.6.1, and further described in volume 3, appendix 10.2.
		NatureScot advise to consider different densities within Proposed Development export cable corridor for coastal species such as seals and bottlenose dolphins *Tursiops truncatus*.	Various densities were considered for bottlenose dolphin and seal species and are summarised in section 10.7 and further described in volume 3, appendix 10.2. Densities used in the assessment were agreed with stakeholders as a part of the Road Map process for all species (volume 3, appendix 10.3).
		Initial agreement of impacts likely to be scoped in, including Permanent Threshold Shift (PTS) and disturbance from piling, disturbance from non-piling construction activities, vessel disturbance, vessel collision risk, changes in water clarity, changes in prey abundance and distribution. Impacts to be scoped out: Temporary Threshold Shift (TTS), Electromagnetic fields (EMF), operational noise, toxic contamination.	Final agreement on impacts to be scoped in/out was achieved during marine mammals Road Map Meeting 1 (volume 3, appendix 10.3) and via the Berwick Bank Wind Farm Scoping Opinion (MS-LOT, 2022)). It has been agreed with stakeholders that changes in water clarity (i.e. increased suspended sediment concentrations (SSC) and associated sediment deposition) will be scoped out as direct impact on marine mammal receptors, however, it is considered as indirect impact under prey abundance and distribution assessment. Section 10.8 provides a summary of impacts scoped in/out along with appropriate justification.
		Agreement on approach to EIA: quantitative PTS assessment using Southall *et al.* (2019); data to be acquired from other developments to inform realistic setting PTS limits, pile/pin driving and unexploded ordnance (UXO) to be included as a noise impact, underwater noise modelling for behavioural disturbance/displacement using best practice methods (harbour porpoise *Phocoena phocoena* and harbour seal dose response curves); potential need to provide a more ecosystem type approach to impact assessment (including fish attraction to structures and predator aggregation devices).	Subsea noise assessment adopts current Southall *et al*. (2019) guidance. Noise modelling has been provided for potential injury (PTS) and disturbance as a result of all potential noise sources (i.e. pile driving, UXO clearance (TTS provided instead of disturbance ranges), vessel noise and site investigation surveys). A summary of noise modelling is presented in section 10.11 for each activity and further described in volume 3, appendix 10.1. The assessment of behavioural disturbance/displacement as a result of underwater noise during piling has been assessed using harbour porpoise (for all cetaceans; Graham *et al*., 2019) and seals dose response curves (Russel and Hastie, 2017) and described in section 10.11, paragraph 75 *et seq*. The assessment of impact as a result of changes in fish and shellfish communities is in line with ecosystem approach and considers predator-prey relationships in the vicinity of hard substrate. The assessment of significance of this impact is presented in section 10.11, paragraph 429 *et seq*. Additionally, a holistic, ecosystem based approach with relation to interrelated effects is provided in volume 2, chapter 20, where potential for interaction of multiple effects on receptor group is considered.
		NatureScot suggested potential need for post consent monitoring of offshore species by extending the East Coast Marine Mammal Acoustic Study (ECOMMAS) array.	Any requirement for additional monitoring using acoustic recorders will be agreed as part of post-consent monitoring plan.
		MS-LOT advise to use absolute densities if providing a quantitative impact assessment.	Densities used in the assessment were agreed with stakeholders as a part of the Road Map process (volume 3, appendix 10.3) and are presented in section 10.7 and further described in volume 3, appendix 10.2.
30 June 2020	MS-LOT, MSS and NatureScot	NatureScot query about moving away from baseline fish ecology surveys that could help with the assessment of the predator prey interactions.	MSS have done a lot of research in the vicinity of the proposed Development in the past. Therefore, there is a lot of existing data and the Applicant is confident that it is adequate to support a robust baseline characterisation in order to inform the assessment of impacts on fish and shellfish receptors (see volume 2, chapter 9). This assessment is subsequently used to inform the assessment of indirect impacts from changes in prey availability on marine mammals (presented in section 10.11, paragraph 429 *et seq*).
		NatureScot query about possibility to use ECOMMAS data in the Marine Mammal assessment.	ECOMMAS data is considered in the bottlenose dolphin baseline characterisation in volume 3, appendix 10.2.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
		NatureScot query about the use of the Marine Mammal Management Units (MMMU) for the marine mammals regional study area.	Population estimates from the MMMU are used in terms of assessment of potential impacts on population. A summary of relevant MU used in the assessment is provided in section 10.7 and further described in volume 3, appendix 10.2.
07 October 2020	NatureScot	Key species to be addressed are harbour porpoise, bottlenose dolphin, white-beaked dolphin, minke whale, harbour seal and grey seal.	Listed species are considered in the assessment and summarised in section 10.7.1 (see volume 3, appendix 10.2 for more details).
		Consultee raised concerns over the potential disturbance of marine mammals from underwater noise emitted during pile-driving and UXO clearance.	The assessment of effects takes a precautionary approach to assessing the potential effects of pile driving and UXO clearance based on published and accepted noise criteria (volume 3, appendix 10.1) and on the basis of the maximum design scenario (section 10.8.1). Section 10.11 provides the assessment of potential disturbance of marine mammals from piling (paragraph 116 *et seq*) and UXO (paragraph 295 *et seq*) clearance activities. The assessment provided is in line with UXO joint interim position statement (UK Government, 2022).
		Request to agree approach to cumulative/in-combination impact assessments for marine mammal interests for HRA, EIA and EPS licensing requirements.	Identification of cumulative effects was undertaken on a receptor specific basis using a cumulative screening matrix approach as presented in section 10.12. The approach to cumulative assessment was agreed with stakeholders during Road Map Meeting 3 meeting (volume 3, appendix 10.3).
		Updated Inter-Agency Marine Mammal Working Group (IAMMWG) (2021) should be used with reference to abundance estimates for cetaceans MUs in Scottish waters.	As agreed through the Road Map process (volume 3, appendix 10.3), IAMMWG (2021) are used as reference population for harbour porpoise, white-beaked dolphin and minke whale. Reference populations are presented in section 10.7.1, and further described in volume 3, appendix 10.2.
		Concern raised about North Sea (NS) MU and Celtic and Greater North Sea (CGNS) MU being too large to be used as baseline reference population for harbour porpoise, advice to use SCANS III block R as reference population for harbour porpoise, white-beaked dolphin and minke whale. Use Cheney *et al*. (2013) for the most up-to-date bottlenose dolphin population estimate.	To provide context within the regional marine mammal study area, SCANS III Block R population estimates are presented along abundance estimates for relevant MUs harbour porpoise, white-beaked dolphin and minke whale. Most up to date bottlenose dolphin population estimate was agreed during Road Map process (volume 3, appendix 10.3) as 224 individuals based on five-year average from Arso Civil *et al*. (2021). Reference populations are presented in section 10.7.1, and further described in volume 3, appendix 10.2.
		Connectivity of seal species and designated areas to be taken into consideration: • harbour seal – Firth of Tay and Eden Estuary Special Area of Conservation (SAC); and • grey seal – Isle of May SAC, Berwickshire and North Northumberland Coast SAC.	The connectivity of seal species with Firth of Tay and Eden Estuary SAC (harbour seal) and Isle of May SAC, Berwickshire and North Northumberland Coast SAC (grey seal) is presented in section 10.7.1 and section 10.11, and further described in volume 3, appendix 10.2, annex B. Connectivity data is based on Sinclair (2022), a seal telemetry study conducted by SMRU for both grey and harbour seal, commissioned to look at connectivity with SACs/haul outs and the Proposed Development. Full consideration of potential adverse effects on the integrity on European Sites (AEoI) is also given in RIAA (SSER, 2022d).
		Consultees advise to take into account for all activities that differing sets of Habitats Regulations apply within 12 nm and beyond 12 nm (with regard to EPS).	An EPS assessment has been undertaken in accordance with the stipulations of the Conservation of Habitats and Species Regulations 1994/2017 (within 12nm) and Offshore Marine Regulations 2017 (outside of 12nm). This assessment is based on the information provided in section 10.11 of this chapter and therefore same activities, MUs and reference populations have been addressed. The assessment provided is in line with the latest guidance on the protection of Marine EPS from injury and disturbance published by Marine Scotland (Marine Scotland, 2020).
		The Offshore EIA Report should include the following impacts: noise emitting pre-construction activities such as UXO clearance, various foundation installation methods (including impact piling driving and drilling), impacts associated with floating structures, vessel noise and vessel presence, changes in prey availability by considering changes in key trophic levels across all development phases. Decommissioning impacts should be assessed with regard to full removal.	Final agreement on impacts to be scoped in/out was achieved during marine mammals Road Map Meeting 1 (volume 3, appendix 10.3) and via Scoping Opinion (Marine Scotland, 2022). Section 10.8 provides a summary of impacts scoped in/out along with appropriate justification. Note: Floating structures are no longer included in the Proposed Development design, therefore the assessment for these is not included.
		Use marine mammals densities based on SCANS III for cetaceans and Special Committee on Seals (SCOS) reports for seals. For bottlenose dolphins use Quick *et al*. (2014) and Arso Civil *et al*. (2019). Use ECOMMAS for context in relation to dolphin species and harbour porpoise.	Densities used in the assessment were agreed with stakeholders as a part of the Road Map process (volume 3, appendix 10.3). ECOMMAS east coast data was used to inform the baseline characterisation, however, as agreed during Road Map Meeting 2, coastal densities are based on additional assessment using recent literature (Arso Civil *et al*. 2019, Arso Civil *et al*. 2021) and offshore densities are based on SCANS III (Hammond *et al*. 2021). Densities taken forward to the assessment for all species are presented in section 10.7.1 and described in detail in volume 3, appendix 10.2.
		Subsea noise approach: instantaneous PTS should be provided as unweighted zero-to-peak sound pressure level (SPL) while accumulated PTS should be provided as weighted cumulative sound exposure level (SEL); information provided should include detail of all parameters/choices used in the noise modelling environment, including assumptions made on fleeing responses and any use of Acoustic Deterrent Device (ADD) mitigation.	Subsea noise report provides instantaneous PTS as unweighted zero-to-peak SPL and accumulated PTS as weighted cumulative SEL. Further details of the approach (e.g. fleeing speeds and use of ADD) were agreed with stakeholders as part of the Road Map process (volume 3, appendix 10.3). The approach is described in detail in volume 3, appendix 10.1.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
		Concerns related to use 1% conversion factor methodology. Consultees also advised to apply the interim population consequences of disturbance model (iPCoD) approach.	The noise modelling approach and conversions factors were reviewed with respect to any relevant empirical evidence information collected at other offshore wind farms and discussed as part of the Road Map process (volume 3, appendix 10.3). In view of the position of the SNCBs and data paucity in this area, a comprehensive literature review and evaluation was undertaken to determine the most robust – and conservative – conversion factor to take forward for assessment, see volume 3, appendix 10.1, annex A). This review, undertaken by Seiche and peer reviewed by Richard (Dick) Wood, recommended that a conversion factor of 4% reducing to 0.5% represented a realistic and precautionary value for the assessment. Further, a sensitivity analysis (volume 3, appendix 10.1, annex B) was undertaken to compare the results with respect to injury ranges based on different conversion factors suggested by the SNCBs. The requirement and approach to population modelling was agreed as part of the Road Map process (volume 3, appendix 10.3). The results of iPCoD modelling are presented in (volume 3, appendix 10.4).
		Where impact pathways have been identified, the full range of mitigation techniques and published guidance should be considered and discussed in the Offshore EIA Report.	Where potential significant effects are identified, secondary mitigation is presented in section 10.11 and summarised in section 10.15.
		No satisfactory explanation of reasoning behind conclusion that no impacts are expected with relation to transboundary effects.	Direct effects on transboundary states are unlikely to occur due to the distance between these states and the Proposed Development boundary and the potential scale over which direct effects could occur (i.e. elevations in underwater noise would not reach this far. Further justification is provided in section 10.13.
		Marine mammals assessment should be informed by physical processes modelling.	Noted, indirect impacts on marine mammals due to potential effects on fish and shellfish prey communities as a result of changes in physical processes has been considered and was informed by the physical processes modelling (see volume 2, chapter 7). Direct effects on marine mammals due to changes in physical processes has been scoped out of the assessment (Table 10.17).
		Effects on seals hauled out on land (and designated haul-out sites) can be screened out from the assessment.	The effects on intertidal ecology (seals hauled out on land) has been screened out from marine mammal assessment.
19 November 2020	MS-LOT	Consultees raised the following concerns with respect to marine mammals (which should be considered form the Proposed Development alone and cumulatively with other projects): • underwater noise generated during construction (turbine foundation installation, UXO clearance) and the potential for this to cause behavioural disturbance and/or auditory injury; • disturbance from shipping (construction and maintenance vessels) along with preparation of a Vessel Monitoring Plan (VMP); and • potential risks from floating turbine structures. Recommendation to prepare a pre-construction Piling Strategy (PS) to discuss embedded mitigation measures such as piling soft start and ramp-up measures.	Final agreement on impacts to be scoped in/out was achieved during marine mammals Road Map Meeting 1 (volume 3, appendix 10.3) and via the Berwick Bank Wind Farm Scoping Opinion (MS-LOT, 2022). Section 10.8 provides a summary of impacts scoped in/out along with appropriate justification. Note: Floating structures are no longer included in the Proposed Development design, therefore the assessment for these is not included. The production and content of pre-construction PS will be discussed with SNCBs at a later stage when more details about the construction and piling programme are available.
		Underwater noise abatement methods such as bubble curtains for noisy activities should be considered in the Offshore EIA report.	Consideration is given to a range of secondary mitigation measures for all noise producing activities, including piling and UXO clearance, paragraphs 243 *et seq* and 337 *et seq,* respectively
		Plans and projects to be included in the cumulative impact assessment should be selected per species.	Identification of cumulative effects was undertaken on a receptor specific basis using a cumulative screening matrix approach as presented in section 10.12. The approach to cumulative assessment was agreed with stakeholders during Road Map Meeting 3 (volume 3, appendix 10.3).
		Additional data sources to be considered: Hague *et al*. (2020), revised analysis of Heinänen and Skov (2015) to be used instead of original paper and Carter *et al*. (2020) to aid information from Russel *et al*. (2017).	Additional data sources are used to characterise the baseline for marine mammals are presented in section 10.6.1, and further described in volume 3, appendix 10.2. Note: as per August 2022 revised version of the Heinänen and Skov (2015) has not been published.

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		MU population sized based on SCANS III should be used for minke whale, white-beaked dolphin and harbour porpoise to assess impacts against the whole MU population and at a regional scale. Density estimates for these species should be sources from Hague *et al*. (2020), for bottlenose dolphin from Cheney *et al*. (2013). Assessment for harbour seals might need further discussion, for grey seal SCOS seal MUs should be used to inform the assessments.	To provide context within the regional marine mammal study area, SCANS III Block R population estimates are presented along abundance estimates for relevant MUs harbour porpoise, white-beaked dolphin and minke whale. Most up to date bottlenose dolphin population estimate was agreed during Road Map process as 224 individuals based on five-year average from Arso Civil *et al*. (2021). Reference populations are presented in section 10.7.1, and further described in volume 3, appendix 10.2. Densities used in the assessment were agreed with stakeholders as a part of the Road Map process (volume 3, appendix 10.3). As agreed during Road Map Meeting 2, coastal densities are based on additional assessment using recent literature (Arso Civil *et al*. 2019, Arso Civil *et al*. 2021) and offshore densities are based on SCANS III (Hammond *et al*. 2021). Densities taken forward to the assessment for all species are presented in section 10.7.1 and described in detail in volume 3, appendix 10.2.
		Concerns over 1% energy conversion factor based on the recent evidence from piling noise monitoring in the Moray Firth, justification required if this approach is to be used.	The noise modelling approach and conversions factors were reviewed with respect to any relevant empirical evidence information and discussed as part of the Road Map process (volume 3, appendix 10.3). As requested, in addition to 1% constant energy conversion factor, a range of conversion factors is now presented in the volume 3, appendix 10.5. For a full description of additional analysis undertaken by the Applicant to ensure compliance with MS-LOT advice, summary of the results and justification for the most appropriate conversion factor to be taken forward to the assessment please refer to paragraph 102 *et seq*. as well as volume 3, appendix 10.5. The full account of discussion between the Applicant and the SNCBs is provided in the Audit Document (SSER, 2022d).
		Recommendation to use iPCoD model to assess impacts of Proposed Development alone and cumulatively with other plans and projects in the region.	The requirement and approach to population modelling was agreed as part of the Road Map process (volume 3, appendix 10.3). The results of iPCoD modelling are presented in volume 3, appendix 10.4 and summarised in section 10.11.2.
09 March 2021	MS-LOT	Species specific MUs must be used as the baseline reference for cetacean population.	Relevant MUs as a baseline reference for cetacean population were agreed during Road Map Meeting 1 (volume 3, appendix 10.3). Most up to date bottlenose dolphin population estimate was agreed during Road Map Meeting 2 and is based on five-year average from Arso Civil *et al*. (2019). Reference populations are presented in section 10.7.1, and further described in volume 3, appendix 10.2.
		The density values for all the key species require further discussion.	Densities used in the assessment were agreed with stakeholders as a part of the Road Map process (volume 3, appendix 10.3). Densities taken forward to the assessment for all species are presented in section 10.7.1 and described in detail in volume 3, appendix 10.2.
		Pathways associated with pre-construction noise impacts, foundation installation methods, floating foundations (such as EMF from mid-water cables, changes in prey density and distribution and displacement or barrier effects), disturbance from vessel use and other activities, change in prey species availability and decommissioning impacts, must be fully considered and assessed in the Offshore EIA Report. The Offshore EIA Report must assess all phases of the Proposed Development from pre-construction to decommissioning (as close to full removal as possible).	Final agreement on impacts to be scoped in/out was achieved during marine mammals Road Map Meeting 1 (volume 3, appendix 10.3) and via Scoping Opinion (Marine Scotland, 2022). Section 10.8 provides a summary of impacts scoped in/out along with appropriate justification. Note: Floating structures are no longer included in the Proposed Development design, therefore the assessment for these is not included.
		Noise modelling and population modelling will be necessary for any pile driving activity and UXO clearance.	Noise modelling approach was discussed as part of the Road Map process (volume 3, appendix 10.3) and is presented in volume 3, appendix 10.1. The requirement and approach to population modelling was agreed as part of the Road Map process (volume 3, appendix 10.3). The results of iPCoD modelling are presented in volume 3, appendix 10.4.
		The approach to noise mitigation should be informed by best available evidence, including any outputs from work undertaken during construction of the wind farms in the Moray Firth and Forth and Tay area and also English waters, including consideration of additional underwater noise abatement methods and technologies.	Any empirical evidence gathered from constructed wind farms is used to inform the noise mitigation, measures to reduce potential impacts are presented along with the assessment of significance in Marine Monitoring Management Protocol (MMMP) and summarised in section 10.11, for piling mitigation see paragraph 243 *et seq*.
		Recommendation to include VMP and a PS as key components of the Proposed Development.	An outline Navigational Safety Plan combined with Vessel Management Plan (NSPVMP) (a combined vessel management plan and a navigational safety plan (NSP)) will be provided with the application (see volume 4, appendix 25). The production and content of PS will be discussed pre-construction with SNCBs when more details about the construction and piling programme are available.

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		Recommendation to consider the cross-border effects on the Berwickshire and North Northumberland Coast SAC in relation to grey seals.	The Berwickshire and North Northumberland Coast SAC, designated for grey seal, has been considered in section 10.7.2 and is further assessed in accordance with the Habitats Regulations in the RIAA (SSER, 2022d).
07 December 2021	NatureScot EIA Scoping Advice	NatureScot recommend using the most recent IAMMWG (2021) MU population estimates.	IAMMWG (2021) are used as reference population for harbour porpoise, white-beaked dolphin and minke whale. Reference populations are presented in section 10.7.1, and further described in volume 3, appendix 10.2.
		For grey seal, we advise that there is potential connectivity with the cable route and both the Isle of May SAC as well as Berwickshire and North Northumberland Coast SAC.	The connectivity of seal species with Firth of Tay and Eden Estuary SAC (harbour seal) and Isle of May SAC, Berwickshire and North Northumberland Coast SAC (grey seal) is presented in sections 10.7.1 and 10.11, and further described in volume 3, appendix 10.2, annex B.
		NatureScot are content with the use of the North Sea pup production area given that grey seal SACs were designated on the basis of the numbers of pups born during the breeding season and therefore the reference population should be the wider pup production areas.	Pup production is discussed mainly in relation to the east of Scotland and the north-east of England with general reference to the wider North Sea for context. Full details are provided in volume 3, appendix 10.2.
		The North Sea region is a large area, therefore NatureScot recommend the use of the Firth of Forth area for the Isle of May, and the Firth of Forth plus the Farne Islands for Berwickshire and North Northumberland Coast (see SCOS, 2020). This latter site crosses the border between Scotland and England and needs to be considered in the assessment.	As per clarification received from NatureScot on 17 March 2022, the assessment of impacts for grey seal is based on at-sea maps (Carter *et al*., 2020) for non-breeding populations and Joint Nature Conservation Committee (JNCC) standard data forms for breeding populations. Through the provision of the Berwick Bank Wind Farm HRA Screening Report (SSER, 2021b) in October 2021, Natural England has been consulted on the appropriate SACs and potential impacts to be taken forward for consideration of LSE in the RIAA (SSER, 2022d).
		Carter *et al*. (2020) habitat preference maps should be used for the prediction of the at sea seal abundance and distribution.	Published at-sea density maps (Carter *et al*., 2020; corrected for absolute densities) are presented in the baseline for grey seal in section 10.7, further described in volume 3, appendix 10.2 and used for the assessment of significance in section 10.11.
		Request to separate the effects from vessel noise and presence (given the differing sizes, types and number of vessels needed for the differing stages of development) and other activities, and how the influence of such may change depending on the marine mammal species being considered.	Presence and noise associated with vessels is separated, however, although vessel noise and noise associated with other construction activities is presented under the same impact header, the ranges of potential injury/disturbance are discussed and presented separately based on noise modelling for each in section 10.11, paragraph 352 *et seq*.
		Cumulatively it will be important to understand the likely level and effect of such disturbance and whether it could result in population level effects on marine mammals.	The assessment considers inter-related effects of different aspects of the Proposed Development on the same receptor along with other projects in section 10.12.
		Changes in prey availability as a result of habitat loss or disturbance needs to be provided in adequate detail.	The assessment of impacts provided in section 10.11, paragraph 428 *et seq*, refers to volume 2, chapter 9 to determine the potential changes in prey resources focussing on key prey items for the marine mammal IEFs identified.
		More consideration is required in the Offshore EIA Report to ensure that impacts to key prey species (such as sandeel *Ammodytidae*, herring *Clupea harengus*, mackerel *Trachurus trachurus* and sprat *Sprattus sprattus*) and their habitats are considered across all development phases for Berwick Bank alone and in-combination with other wind farms in the Forth/Tay area, particularly given the importance of this area for a number of prey species.	The assessment of key prey species is provided in volume 2, chapter 9 and is brought forward into assessment for marine mammals in section 10.11, paragraph 428 *et seq*, to ensure an ecosystem approach is taken. Additionally, a description of the likely inter-related effects arising from the Proposed Development on marine mammals is provided in volume 3, appendix 18.1.
		Consideration across key trophic levels is suggested to enable better understanding of the consequences (positive or negative) of any potential changes in prey distribution and abundance on marine mammal (and other top predator) interests and how this may influence population level impacts. Advice within the benthic interests and fish/shellfish assessment will be helpful in this regard.	The assessment of key prey species is provided in volume 2, chapter 9 and is brought forward into assessment for marine mammals in section 10.11, paragraph 428 *et seq*, to ensure an ecosystem approach is taken. Additionally, a description of the likely inter-related effects arising from the Proposed Development on marine mammals is provided in volume 3, appendix 18.1.
		Requirement for the risk assessment to consider a high order detonation in terms of impact and mitigation as the maximum adverse scenario, unless the preferred low order/deflagration method has robust supporting evidence that can be presented.	Application of low order techniques is the preferred option for UXO clearance. However, there is a small risk of unintended consequences should low order clearance accidentally result in high order detonation of UXO (as per paragraph 297, approximately 10% of the total number of UXOs could result in high order detonation). Therefore the assessment of potential impacts due to the underwater noise during UXO clearance and subsequent secondary mitigation is based on the maximum design scenario of high order detonation and is presented in section 10.11, paragraph 294 *et seq*.
		The literature to support the 0.5% conversion factor is limited and typically based on measurements taken from much shallower water than Scottish Offshore Wind Farm locations and using a much lower hammer energy. Noise measurements in the Moray Firth estimated an initial conversion factor of > 10%, during the soft start impact piling of the pin piles, measured when the pin piles were above the water surface (Thompson *et al*. 2020). A range of conversion factors is suggested to be adopted: 1%, 4% and 10%.	The noise modelling approach and conversions factors were reviewed with respect to any relevant empirical evidence information and discussed as part of the Road Map process (volume 3, appendix 10.3). As requested, a range of conversion factors is now presented in the volume 3, appendix 10.5. The 0.5% constant conversion factor has not been taken forward to the assessment. For a full description of additional analysis undertaken by the Applicant to ensure compliance with NatureScot advice, summary of the results and justification for the most appropriate conversion factor to be taken forward to the

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			assessment please refer to paragraph 102 *et seq*. as well as volume 3, appendix 10.5.
		The significance of underwater noise disturbance to marine mammals and the consequences of this on relevant populations should be assessed using the iPCoD approach (interim population consequences of disturbance model), depending on underwater noise modelling outputs.	As agreed during Road Map process (volume 3, appendix 10.3), iPCoD modelling has been undertaken for harbour porpoise, bottlenose dolphin, minke whale, harbour seal and grey seal. The results of iPCoD modelling are presented in volume 3, appendix 10.4.
		NatureScot will need to agree the approach to cumulative impact assessment for marine mammal interests for HRA, EIA and EPS licensing requirements.	Identification of cumulative effects was undertaken on a receptor specific basis using a cumulative screening matrix approach as presented in section 10.12. The approach to cumulative assessment was agreed with stakeholders during Road Map Meeting 3 (volume 3, appendix 10.3). An EPS licence will be applied for in relation to any activity which has potential to result in such an offence and this application would be informed by the assessments presented in section 10.12.
07 December 2021	MSS EIA Scoping Advice	MSS, in agreement with NatureScot, recommends that minke whale and white-beaked dolphin should be assessed against the whole MU population and at a regional scale, based on SCANS III Block R.	To provide context within the regional marine mammal study area, SCANS III Block R population estimates are presented along abundance estimates for relevant MUs harbour porpoise, white-beaked dolphin and minke whale. Reference populations are presented in section 10.7.1, and further described in volume 3, appendix 10.2. The assessment of significance of impacts is presented in section 10.11.
		MSS recommend that the abundance estimates provided in the updated Hammond *et al*. (2021) report are used.	As agreed through the Road Map process (volume 3, appendix 10.3), IAMMWG (2021) are used as reference population for harbour porpoise, white-beaked dolphin and minke whale. Reference populations are presented in section 10.7.1, and further described in volume 3, appendix 10.2.
		MSS advise that the best estimate of the Moray Firth SAC bottlenose dolphin population size is 224 (95% = 214 – 234). This is based on a five-year weighted mean population size using data from 2015 – 2019, which are presented in Arso Civil *et al*. (2021).	As requested by MSS, bottlenose dolphin population estimate taken to the assessment is 224 individuals based on five-year average from Arso Civil *et al*. (2021). Reference population is presented in section 10.7.1, and further described in volume 3, appendix 10.2.
		For the distribution of bottlenose dolphins, MSS recommended that the assessment use two different distributions of density to account for the range expansion and habitat preferences of the east coast bottlenose dolphin population. One approach evenly distributes the east coast proportion of the population within the 20 m depth contour across the population range between Peterhead and the Farne Islands. The other distributes this same proportion of the population according to the habitat preference model in Arso Civil *et al*. (2019), focussing more on the key areas (both in terms of the extent of bottlenose dolphin use of the area and in terms of the potential areas of impact) around the Tay. The first approach will represent an 'average' density scenario and the second will represent a 'maximum' density scenario. MSS are content with the two density estimates generated using these approaches (densities of 0.197 animals/km^2 and 0.294 animals/km^2, respectively).	As agreed with MSS, to reflect the patchiness in bottlenose dolphin distribution, a dual approach has been applied. For all areas, except the outer Firth of Tay, the east coast proportion of the population was assumed to be evenly distributed across the area between the 2 to 20 m bathymetric contours, between Peterhead and the Farne Islands (0.197 animals/km^2). To calculate the density within the outer Firth of Tay, we used habitat preference of bottlenose dolphins around eastern Scotland modelled by Arso Civil *et al*. (2019) (0.294 animals/km^2). Further methodology is described in volume 3, appendix 10.2.
		MSS acknowledge NatureScot' rationale and preference for the Carter *et al*. (2020) habitat preference maps and using the current scalars to calculate absolute abundance. MSS consider that the scalars can be used, but with caution, noting that they may require updating.	Published at sea density maps (Carter *et al*., 2020; corrected for absolute densities based on currently available scalars) are presented in the baseline for grey seal in section 10.7, further described in volume 3, appendix 10.2 and used for the assessment of significance in section 10.11.
		MSS note the applicants plan to develop some key management plans for the wind farm construction relating to marine mammals, such as a PS, VMP and MMMP. While we welcome the commitment to these to aid mitigation planning, we advise that such plans do not rule out the potential for additional mitigation measures, depending upon the results of the impact assessment to be presented in the Offshore EIA Report and HRA. We also recommend that key mitigation actions are detailed in the Offshore EIA Report, where they are required to aid decision making.	An outline NSPVMP (a combined vessel management plan and a navigational safety plan (NSP)) will be provided with the application (see volume 4, appendix 25). The production and content of PS will be discussed pre-construction with SNCBs when more details about the construction and piling programme are available. The Offshore EIA Report provides an overview of the mitigation protocol including secondary mitigation, where required. Designed-in measures are presented in section 10.10 and if secondaryl mitigation is required, it is presented along the assessment in section 10.11.
		MSS welcome the commitment to use deflagration to dispose of unexploded ordnance. However, we note that the deflagration technique is currently only offered by one company and that other low order UXO clearance technologies are available. To avoid difficulty with later licensing processes, it may be sensible to refer to "low order techniques" for unexploded ordnance disposal, rather than strictly to the specific method of deflagration.	Low order clearance is now referred to as "low order techniques" throughout the chapter. More details about the UXO clearance techniques is presented along with assessment of significance in section 10.11, paragraph 294 *et seq*.
		MSS recommend that a MMMP will also be required for any UXO disposal, due to the potential risk of underwater noise.	The MMMP will also include secondary mitigation to reduce the risk of injury from UXO clearance.
		MSS note that any data collection and analysis undertaken (i.e. aerial surveys) to characterise the baseline environment for the other sources of underwater noise (e.g. piling), will also be relevant for the UXO assessment, and this data may prove useful in the EPS licensing process.	All data collected and analysed during the Proposed Development's Digital Aerial Surveys (DAS) is used in the assessment of potential impacts of underwater noise due to piling and UXO clearance in section 10.11, paragraph 294 *et seq*. The EPS assessment will be based on the information provided in section 10.11.
		MSS agree that disturbance from pre-construction surveys should be scoped in for the construction phase, however in addition to disturbance there is the potential for injury to marine mammals. We also recommend that quantitative (rather than qualitative) assessment using appropriate underwater noise modelling should be undertaken for pre-construction surveys (e.g. geophysical),	Impacts of potential injury and disturbance form site investigation surveys is scoped in based on subsea noise modelling, presented in more detail in volume 3, appendix 10.1. The assessment of significance of impacts is presented in section 10.11, paragraph 250 *et seq*.

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		due to the risk of injury and disturbance to marine mammals from certain survey techniques.	
		MSS agree that disturbance from vessels, injury from vessel collision and effects from changes in prey availability should be scoped in for all phases. However, MSS note that in both their previous and current advice, NatureScot advised separation of vessel presence and noise from noise generated by other construction related activities. We support this approach, noting this previous advice has not been reflected in the current scoping report.	Injury and disturbance to marine mammals from elevated underwater noise due to vessel use and other activities, injury of marine mammals due to collision with vessels as well as changes in fish and shellfish communities affecting prey availability have been all considered for all phases of the Proposed Development. Final agreement on impacts to be scoped in/out was achieved during marine mammals Road Map Meeting 1 (volume 3, appendix 10.3) and via Scoping Opinion (Marine Scotland, 2022). Section 10.8 provides a summary of impacts scoped in/out along with appropriate justification. Presence and noise associated with vessels is separated, however, although vessel noise and noise associated with other construction activities is presented under the same impact header, the ranges of potential injury/disturbance are discussed and presented separately based on noise modelling for each. in section 10.11, paragraph 352 *et seq*.
		MSS recommend that in addition to underwater noise produced during pile-driving, geophysical surveys and vessel noise, the underwater noise generated from UXO clearance should also be assessed quantitatively.	The quantitative assessment of significance of impacts associated with UXO clearance is presented in section 10.11, paragraph 294 *et seq*.
		Throughout the scoping report there are no mentions of additional underwater noise abatement methods and technologies other than deflagration (e.g. bubble curtains). MSS advise that noise abatement methods for noisy activities, such as impact piling, should be considered where practicable and discussed in the Offshore EIA Report.	The project design envelope does not consider noise abatement methods as part of the design and therefore the assessment does not include this. However, the Offshore EIA Report provided an overview of the mitigation protocol including secondary mitigation, where required. Designed-in measures are presented in section 10.10 and if secondary mitigation is required, it is presented along the assessment in section 10.11.
Road Map Meetings			
24 August 2021	Road Map Meeting 1: NatureScot, MS-LOT and MSS (for more details volume 3, appendix 10.3)	Concerns raised over the regional marine mammal study area being too large.	Agreement on the regional marine mammal study area was reached during Road Map Meeting 2. Regional marine mammal study area is defined in section 10.3.
		Recommendation to discuss with SMRU moving the date of potential updates to Carter *et al*. (2020) forward so it can be used for this assessment.	Carter *et al*. (2020) at sea usage estimates (corrected for absolute densities) are used in this assessment. Both, seal at sea usage maps and densities estimates from Proposed Development aerial digital survey data are presented in the baseline for grey seal in section 10.7 and further described in volume 3, appendix 10.2.
		Use of correction factors to account for availability bias during aerial digital surveys. Tagging data is likely to be the best option for understanding dive profiles.	Availability bias accounted for and relative densities estimated using the aerial digital survey data were corrected to provide an approximation of absolute densities. Further description is provided in volume 3, appendix 10.2, annex A. Perception bias not an issue for DAS as the cameras can be angled to reduce glare.
		MSS recommend using ECOMMAS data to predict densities of bottlenose dolphin in coastal (inshore) areas.	ECOMMAS data was used in the assessment, however, as agreed during Road Map Meeting 2, coastal densities are based on additional assessment using recent literature (Arso Civil *et al*. 2019, Arso Civil *et al*. 2021) and offshore densities are based on SCANS III (Hammond *et al*. 2021).
		MSS recommend to scope in deflagration impacts.	Impacts of low order techniques are scoped in and assessment of the effects is provided in section 10.11, paragraph 294 *et seq*.
		NatureScot suggest that export cable corridor is missing from the construction phase.	The maximum design scenario for the Proposed Development, including cables, is shown in section 10.8.1. The significance of impacts based on maximum design scenario for the proposed Development is assessed in section 10.11.
20 October 2021	Road Map Meeting 2: NatureScot, MS-LOT and MSS (for more details volume 3, appendix 10.3)	Regional marine mammal study area boundaries were discussed with specific reference to cumulative assessment with no issues raised.	Regional marine mammal study area is defined in section 10.3.
		Agreements on methodology for the bottlenose dolphin coastal densities.	To reflect the patchiness in bottlenose dolphin distribution, a dual approach has been applied. For all areas, except the outer Firth of Tay, the east coast proportion of the population was assumed to be evenly distributed across the area between the 2 m to 20 m bathymetric contours, between Peterhead and the Farne Islands. To calculate the density within the outer Firth of Tay, the Applicant has used habitat preference of bottlenose dolphins around eastern Scotland modelled by Arso Civil *et al*. (2019). Further methodology is described in volume 3, appendix 10.2.
		IAMMWG (2021) is being reviewed and new abundance/density data will be available for minke whale and white-beaked dolphin.	It was confirmed by the consultees following the Road Map 2 meeting, that abundance and density values for both species have not changed upon the review and are provided as per IAMMWG (2021). Reference populations are presented in section 10.7.1, and further described in volume 3, appendix 10.2.
		The approach to combining grey seal and 'seal species' sightings from aerial digital data to derive density estimates for grey seal needs justification. Stakeholders are in favour of using published at-sea density maps (Carter *et al*. 2020) vs recent site-specific data for the assessment.	Justification for using grey seal plus 'seal species' sightings in data analysis is provided in volume 3, annex 10.2. Published at-sea density maps (Carter *et al*., 2020; corrected for absolute densities) are presented in the baseline for grey seal in section 10.7, further described in volume 3, appendix 10.2 and used for the assessment of significance in section 10.11.
		MSS suggest using following conversion factors: 1%, 4% and 10% instead of 0.5%.	The noise modelling approach and conversions factors were reviewed with respect to any relevant empirical

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			evidence information and discussed as part of the Road Map process (volume 3, appendix 10.3). As requested, a range of conversion factors is now presented in the volume 3, appendix 10.5. The 0.5% constant conversion factor has not adopted. For a full description of additional analysis undertaken by the Applicant to ensure compliance with SNCBs advice, summary of the results and justification for the most appropriate conversion factor to be taken forward to the assessment please refer to paragraph 102 *et seq*. as well as volume 3, appendix 10.5.
		NatureScot query on whether the Weston Energy Flux Model (proposed noise modelling method) is a version of the Centre for Environment Fisheries and Aquaculture Science (Cefas) Energy Flux Model.	The Weston Energy Flux Model is different to the Cefas Energy Flux Model. However, t both models are an implementation of the mathematical formula within the Weston papers (Weston, 1976; 1980a; 1980b) and therefore both models should provide the same outputs if the same input data are used. Numerous Offshore Wind Farm projects within the last 5 to 10 years have used the Weston Energy Flux (i.e. Greater Gabbard, Hornsea Project One, Teesside). Detailed approach to noise modelling is provided in volume 3, appendix 10.1 and volume 3, appendix 10.1, annex A.
		MS-LOT confirm whether high order detonation is ruled out for UXO.	Application of low order techniques is preferred option for UXO clearance. However, there is a small risk of potential for unintended consequence of low order clearance to result in high order detonation of UXO (as per paragraph 297, approximately 10% of the total number of UXOs could result in high order detonation). Therefore the assessment of potential impacts due to the underwater noise during UXO clearance and secondary mitigation was based on the maximum design scenario of high order detonation and is presented in section 10.11, paragraph 294 *et seq*.
		MSS recommend that the SCANS III block is presented alongside the MU in the assessment as an element of regional context.	To provide context within the regional marine mammal study area, SCANS III Block R population estimates are presented along abundance estimates for relevant MUs harbour porpoise, bottlenose dolphin, white-beaked dolphin and minke whale. Reference populations are presented in section 10.7.1, and further described in volume 3, appendix 10.2.
18 January 2022	Road Map Meeting #3: NatureScot, MS-LOT and MSS (for more details volume 3, appendix 10.3),	NatureScot and MSS do not agree there is a scientific consensus on the use of the 0.5% conversion factor and remain of the view that this literature is not a strong enough proxy for us to be able to accept a 0.5% conversion factor.	Further to recommendations from SNCBs a 0.5% constant conversion factor has not been adopted in the subsea noise assessment (see above for previous responses in this consultation table on the approach adopted for the subsea noise assessment).
		NatureScot and MSS suggest that conversion factor% can be modelled on a reducing scale in line with pin pile penetration depth. This would be consistent with the pattern of noise measurements made in the Moray Firth (Beatrice Offshore Windfarm Limited (Ltd) (BOWL) and Moray East). This pattern is also corroborated in Offshore Renewables Joint Industry Programme (ORJIP) ReCon project draft results which used pin pile measurements out with Scottish waters.	Decreasing conversion factors have been modelled as the piling progresses for pin piles with 10% reducing to 1% and 4% reducing to 0.5%. Further details are presented in volume 3, appendix 10.1, annex A.
		NatureScot and MSS suggest a benchmarking exercise to provide supporting evidence for the choice of conversion factor% taken forward for assessment. This could use measured received levels (RLs) from other Offshore Wind Farm projects to back calculate the conversion factor% using the full acoustic model of choice. Consultees recognise that there will be inherent uncertainties, however they consider this exercise would aid confidence and transparency in the conversion factor% relied on for the assessment.	Based on recommendations by SNCBs a benchmarking exercise was undertaken to determine the most representative and precautionary conversion factor with evidence and justification presented in a fully referenced and peer-reviewed report (volume 3, appendix 10.1, annex A and Annex B).
		NatureScot and MSS advise that predictions on instantaneous PTS impact ranges should be made using the highest conversion factor% and the highest hammer energy.	The assessment of injury (PTS) as a result of underwater noise during piling presented in section 10.11, paragraph 10.11.2.116 *et seq*, is based on the conversion factor resulting in the largest injury ranges for the different marine mammal hearing groups and the highest hammer energy of 4,000 kJ.
		NatureScot and MSS advise that accumulated PTS (SELcum) over the entire piling sequence should be made using the decreasing conversion factor%.	Accumulated PTS (SELcum) over the entire piling sequence has been assessed using the decreasing conversion factor%. as the piling progresses. Further details are presented in volume 3, appendix 10.1.
		NatureScot and MSS agree that the use of the impulsive PTS threshold over extended distance is likely to be over precautionary given the likely change in impulse characteristics with propagation. It has been suggested to consider the higher frequency content as Southall *et al*. (2021) suggested as an interim measure.	Use of the higher frequency content (as per Southall *et al*. (2021)) as an interim measure has been considered and discussed volume 3, appendix 10.1.
		NatureScot and MSS advise that any evidence provided to support the choice of conversion factor% and approach taken to assessment, needs to be similar in content to a scientific journal submission.	A scientific approach is adopted to support the choice of conversion factor% and is presented in volume 3, appendix 10.1, Annex A and Annex B.
		NatureScot and MSS are content with the approach to the cumulative assessment.	Methodology and projects screened in to the cumulative assessment are presented in section 10.12.
		NatureScot support using Carter *et al*. (2020) density maps rather than site-specific data to inform grey seal densities in the assessment.	Published at-sea density maps (Carter *et al*., 2020; corrected for absolute densities) are presented in the baseline for grey seal in section 10.7, further described in volume 3, appendix 10.2 and used for the assessment of significance in section 10.11.
		NatureScot suggest using 224 individuals as estimated population of bottlenose dolphins.	Most-up to date bottlenose dolphin population estimate taken to the assessment is 224 individuals based on five years average from Arso Civil *et al*. (2021). Reference population is presented in section 10.7.1, and

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
			further described in volume 3, appendix 10.2.
		NatureScot and MSS provided clarifications following Road Map Meeting #3 (via email sent on 25 February 2022): iPCoD modelling should be undertaken for harbour seal to better understand potential population-level impacts. The East Scotland (ES) MU population should be used as the reference population, and demographic parameters should be taken from Sinclair *et al*. (2020).	iPCoD modelling has been undertaken for harbour seal with the East Scotland ES MU population taken as the reference population and demographic parameters taken from Sinclair et al. (2020). The results of iPCoD modelling are presented in volume 3, appendix 10.4.
		NatureScot and MSS provided clarifications following Road Map Meeting #3 (via email sent on 25 February 2022): For iPCoD modelling for harbour porpoise and minke whale, two approaches are recommended: • 100% of the MU population, and • a sub-population based on the SCANS III estimate of abundance for harbour porpoise and minke whale. This can be used to derive a % of the MU population. Using both of these numbers will provide a range of outputs, which can be used to assess the population level impacts.	iPCoD modelling has been carried out to predict the population level effect on minke whale and harbour porpoise against their respective MUs and also considering the SCANS block R population as a vulnerable subpopulation which assumes animals within this block are potentially vulnerable to repeated exposure (volume 3, appendix 10.4)
		NatureScot and MSS provided clarifications following Road Map Meeting #3 (via email sent on 25 February 2022) where they indicated that using the range of conversion factors is needed to set context (i.e. 1%, 4% and 10%) and it is required to provide evidenced argument for the choice of conversion factor taken forward to assessment.	An evidence-based approach was undertaken to determine the most representative and precautionary conversion factor to adopt and results presented in the form of a peer-reviewed scientific report (volume 3, appendix 10.1, annex A). Three different conversion factors were explored (1% constant, 4% reducing to 0.5%, 10% reducing to 1%, 4% constant and 10% constant) with results presented in a sensitivity assessment volume 3, appendix 10.1, annex B.
		NatureScot provided clarifications following Road Map Meeting #3 (via email sent 20 May 2022): Nature Scot is content that the reducing conversion factor scenario taken through to the assessment will be 4% reducing to 0.5% and queries that the source level, that relates to the conversion factor, should be presented.	As requested previously by SNCBs, a range of conversion factors is now presented in the volume 3, appendix 10.5. The 1 % constant conversion factor and 4% reducing to 0.5% has been taken forward to the assessment. For a full description of additional analysis undertaken by the Applicant to ensure compliance with SNCBs advice, summary of the results and justification for the most appropriate conversion factor to be taken forward to the assessment please refer to paragraph 102 *et seq*. as well as volume 3, appendix 10.1. For source levels, please refer to volume 3, appendix 10.1.
Berwick Bank Wind Farm Offshore Scoping Report (SSER, 2022a)			
04 February 2022	MS-LOT Scoping Opinion	MS-LOT advise that for species with MUs extending over a very large scale, these species must be assessed against the whole MU population and in addition, must be assessed at a regional scale based on SCANS III Block R.	To provide context within the regional marine mammal study area, SCANS III Block R population estimates are presented along abundance estimates for relevant MUs harbour porpoise, white-beaked dolphin and minke whale. Reference populations are presented in section 10.7.1, and further described in volume 3, appendix 10.2. The assessment of significance of impacts is presented in section 10.11.
		Additionally, MS-LOT advise that additional sources of information identified in the NatureScot December representation and the MSS December advice must be fully considered by the Developer.	All datasets suggested by NatureScot and MSS were used to inform the baseline characterisation and are listed in section 10.6.1, and further described in volume 3, appendix 10.2.
		MS-LOT highlights the NatureScot's December representation and the MSS December advice with regard to the use of IAMMWG (2021) and advise that further discussion is required if agreement has not already been reached via the Developer's Road Map process.	As agreed through the Road Map process (volume 3, appendix 10.3), IAMMWG (2021) are used as reference population for harbour porpoise, white-beaked dolphin and minke whale. Reference populations are presented in section 10.7.1, and further described in volume 3, appendix 10.2.
		MS-LOT directs the Developer to the NatureScot December representation and the MSS December advice on the most appropriate abundance estimate to use for the assessment. In relation to the distribution of bottlenose dolphins, the Scottish Ministers refer to the MSS December advice to use two different distributions of density to account for the range expansion and habitat preferences of the east coast dolphin population.	As agreed through the Road Map process (volume 3, appendix 10.3), IAMMWG (2021) are used as reference population for harbour porpoise, white-beaked dolphin and minke whale. Reference populations are presented in section 10.7.1, and further described in volume 3, appendix 10.2. As agreed with MSS, to reflect the patchiness in bottlenose dolphin distribution, a dual approach has been applied. For all areas, except the outer Firth of Tay, the east coast proportion of the population was assumed to be evenly distributed across the area between the 2 m to 20 m bathymetric contours, between Peterhead and the Farne Islands and separate density has been calculated in the outer Firth of Tay, using habitat preference of bottlenose dolphins around eastern Scotland modelled by Arso Civil *et al*. (2019). Further methodology is described in volume 3, appendix 10.2.
		MS-LOT advise the potential connectivity with the export cable corridor route and both the Isle of May SAC and Berwickshire and North Northumberland Coast SAC. In addition, the Scottish Ministers highlight NatureScot's December representation recommending using of the Firth of Forth area for the Isle of May SAC and the Firth of Forth plus the Farne Islands for Berwickshire and North Northumberland Coast SAC.	An email received from NatureScot on 17 March 2022 provided clarification on their scoping representation of December 2021 and confirmed that the assessment of impacts for grey seal should be based on at-sea maps (Carter *et al*., 2020) for non-breeding populations and JNCC standard data forms for breeding populations and this has been incorporated into the assessment. For more information about the reference populations see volume 3, appendix 10.2 and section 10.11 for the assessment of significance.

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		With regard NatureScot's recommendation to use the Carter *et al*. (2020) habitat preference maps for the prediction of the at sea seal abundance and distribution, the Scottish Ministers highlight the concerns raised in the MSS December advice in relation to using the current scalars. MSS have requested advice on the use of these scalars and in the meantime have advised the scalars should be used with caution, noting they may require to be updated. This was discussed further during the Developer's Road Map process and the assessment should reflect this further discussion.	Published at-sea density maps (Carter *et al*., 2020; corrected for absolute densities based on currently available scalars) are presented in the baseline for grey seal in section 10.7, further described in volume 3, appendix 10.2 and used for the assessment of significance in section 10.11.
		MS-LOT agrees with the potential impacts scoped-in, however, they advise that the NatureScot December representation and MSS December advice regarding UXO clearance, pre-construction surveys, disturbance from vessel use and other construction activities, change in prey species availability must also be fully considered and assessed in the Offshore EIA Report.	Injury/disturbance to marine mammals from elevated underwater noise due to vessel use and other activities, pre-construction site investigation surveys, UXO clearance as well as changes in fish and shellfish communities affecting prey availability have been all considered for all phases of the Proposed Development in section 10.11. Final agreement on impacts to be scoped in/out was achieved during marine mammals Road Map Meeting 1 (volume 3, appendix 10.3) and via Scoping Opinion (Marine Scotland, 2022). Section 10.8 provides a summary of impacts scoped in/out along with appropriate justification.
		MS-LOT highlight the MSS December advice regarding the potential for low order UXO clearance methods to still generate noise and therefore the risk of injury and disturbance must be considered and assessed in the Offshore EIA Report. In addition, the Scottish Ministers advise that that the Offshore EIA Report must include a maximum design scenario of high order detonation in terms of impact and mitigation, unless there is robust supporting evidence that can be presented to show the consistent performance of the preferred low order or deflagration method.	Application of low order techniques is preferred option for UXO clearance. There is a small risk that low order clearance of UXO could result in a high order detonation (as per paragraph 297, approximately 10% of the total number of UXOs could result in high order detonation). Therefore the assessment of potential impacts due to the underwater noise during UXO clearance and secondary mitigation is based on the maximum design scenario of high order detonation and is presented in section 10.11, paragraph 294 *et seq*.
		MS-LOT advise that the effects of disturbance from vessel use and other construction activities must be considered and assessed separately. The Scottish Ministers highlight NatureScot's December representation and notes their previous advice on this matter.	Presence and noise associated with vessels is separated, however, although vessel noise and noise associated with other construction activities is presented under the same impact header, the ranges of potential injury/disturbance are discussed and presented separately based on noise modelling for each in section 10.11, paragraph 352 *et seq*.
		MS-LOT advise more consideration is required to ensure impacts to key species and their habitats are considered across all of the phases of the Proposed Development and in combination with the neighbouring consented wind farms in the Forth and Tay area. The Scottish Ministers highlight the NatureScot December representation and MSS December advice on benthic interests and fish and shellfish as well in this regard.	The assessment of impacts provided in section 10.11, paragraph 428 *et seq*, refers to volume 2, chapter 9 to determine the potential changes in prey resources focussing on key prey items for the marine mammal IEFs identified.
		MS-LOT advise that a quantitative assessment using appropriate underwater noise modelling should be undertaken for pre-construction surveys. Additionally, MS-LOT highlight the MSS December advice with regard to the potential for injury.	The quantitative assessment of significance of impacts associated with site investigation surveys, based on subsea modelling, is presented in section 10.11, paragraph 250 *et seq*. Further details related to subsea modelling are presented in volume 3, appendix 10.1.
		MS-LOT advise that the NatureScot December representation and MSS December advice must be fully considered, including noise abatement methods and technologies, as well as the recommendation to assess underwater noise generated from UXO quantitatively.	NatureScot and MSS December advice has been fully considered. The Offshore EIA Report provides an overview of the mitigation protocol including secondary mitigation required. Designed-in measures are presented in section 10.10 and if secondary mitigation is required, it is presented along the assessment in section 10.11. The quantitative assessment of significance of impacts associated with UXO clearance is presented in section 10.11, paragraph 294 *et seq*.
		MS-LOT highlight the NatureScot December representation regarding conversion factors and also the discussions which have taken place during the Developer's Road Map Process with both MSS and NatureScot. MS-LOT advise that a range of conversion factors of 1%, 4% and 10% must be adopted by the Developer as part of the assessment in the Offshore EIA Report. The Developer should provide justification for which of the results are being relied on within the assessment to inform appropriate mitigation.	As described earlier in this consultation table, an evidence-based approach was undertaken to determine the most representative and precautionary conversion factor to adopt and results presented in the form of a peer-reviewed scientific report (volume 3, appendix 10.1, annex A). Based on recommendations from SNCBs through the Road Map process, three different conversion factors were explored (1% constant, 4% reducing to 0.5%, 10% reducing to 1%, 4% constant and 10% constant) with results presented in a sensitivity assessment volume 3, appendix 10.1, annex B.
		MS-LOT advise that the interim Population Consequences of Disturbance model must be used to assess the population level effects for bottlenose dolphin, harbour porpoise, minke whale and grey seal. Confirmation should be sought on its use for harbour seal through the Developer's Road Map process.	As agreed during Road Map process (volume 3, appendix 10.3), iPCoD modelling has been undertaken for harbour porpoise, bottlenose dolphin, minke whale, harbour seal and grey seal. The results of iPCoD modelling are presented in volume 3, appendix 10.4.
		MS-LOT agree with the cumulative effects identified in the Scoping Report but advise that further discussion and agreement as part of the Developer's Road Map process is required. Noting that an agreed approach to cumulative impact assessment for marine mammals for HRA, EIA and EPS licensing is also still required.	Identification of cumulative effects was undertaken on a receptor specific basis using a cumulative screening matrix approach as presented in section 10.12. The approach to cumulative assessment was agreed with stakeholders during Road Map Meeting 3 (volume 3, appendix 10.3). The application will also include RIAA for consideration of potential impacts on marine mammal SACs (SSER, 2022d). An EPS licence will also be applied for with respect to injury/disturbance from any activities associated with the Proposed Development.
		MS-LOT advise that a VMP, PS and MMMP will be key components of the Proposed Development. The Scottish Ministers direct the Developer further to the MSS December advice	An outline NSPVMP (a combined vessel management plan and NSP) will be provided with the application (see volume 4, appendix 25). The production and content of PS will be discussed pre-construction with

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		and NatureScot December representation in this regard. In addition, the Scottish Ministers also highlight the advice from MSS with regard to 'low order techniques' and also the indication that a MMMP will likely be required for any UXO clearance.	SNCBs when more details about the construction and piling programme are available. MMMP will be discussed as a part of the Road Map process. Low order clearance is now referred to as "low order techniques" throughout the chapter. More details about the UXO clearance techniques is presented along with assessment of significance in section 10.11, paragraph 294 *et seq*. The MMMP will also include mitigation to reduce the risk of injury from UXO clearance.
		MS-LOT highlight NatureScot's December representation with regard to the revision of the conservation objectives for the seal SACs. In addition, the Scottish Ministers highlight NatureScot's December representation and the MSS December advice with regard to updating the baseline information provided in the HRA Screening Report. MS-LOT advise that this must include consideration of the discussions as part of the Developer's Road Map process and the extended correspondence amongst the Developer, NatureScot and MSS on bottlenose dolphins.	The RIAA references the most up-to-date conservation objectives as well as updated baseline information (for more details see section 7.4 of the RIAA (SSE Renewables Development, 2022b). In line with MSS advice received on 09 Dec 2021, to reflect the patchiness in bottlenose dolphin distribution, a dual approach has been applied. For all areas, except the outer Firth of Tay, the east coast proportion of the population was assumed to be evenly distributed across the area between the 2 m to 20 m bathymetric contours, between Peterhead and the Farne Islands and separate density has been calculated in the outer Firth of Tay, using habitat preference of bottlenose dolphins around eastern Scotland modelled by Arso Civil *et al*. (2019). Further methodology is described in volume 3, appendix 10.2.
		MS-LOT advise that the risk assessment for underwater noise from UXO clearance, must consider the maximum design scenario as detailed previously.	Application of low order techniques is preferred option for UXO clearance. However, there is a small risk of potential for unintended consequence of low order clearance to result in high order detonation of UXO (as per paragraph 297, approximately 10% of the total number of UXOs could result in high order detonation). Therefore the assessment of potential impacts due to the underwater noise during UXO clearance and secondary mitigation is based on the maximum design scenario of high order detonation and is presented in section 10.11, paragraph 294 *et seq*.
		In addition, the Scottish Ministers agree with NatureScot's December representation regarding underwater noise from vessels and the requirement for further consideration of changes in prey availability including direct impact of habitat loss or prey disturbance, impact of the colonisation of hard structures, effects on fish populations from habitat disturbance and EMF effects on changes in prey availability. The Scottish Ministers advise that the points raised by NatureScot must be fully addressed.	Presence and noise associated with vessels is separated, however, although vessel noise and noise associated with other construction activities is presented under the same impact header, the ranges of potential injury/disturbance are discussed and presented separately based on noise modelling for each in section 10.11, paragraph 352 *et seq*. The assessment of key prey species is provided in volume 2, chapter 9 (including habitat loss or prey disturbance, impact of the colonisation of hard structures, effects on fish populations from habitat disturbance and EMF effects on changes in prey availability) and is brought forward into assessment for marine mammals in section 10.11, paragraph 428 *et seq*, to ensure an ecosystem approach is taken.
		MS-LOT stated that they are content with the preliminary screening of the Southern Trench ncMPA and confirm the site can now be screened out. The Scottish Ministers are content that no further marine mammal ncMPAs are to be included.	Southern Trench ncMPA has been screened out (see section 10.9.3 for more details about designated sites).
06 August 2022	Road Map Meeting 4: NatureScot, MS-LOT and MSS (for more details volume 3, appendix 10.3)	MSS suggest that injury ranges should account for the risk of instantaneous injury and use SPL_{pk} as a precaution (rather than SEL_{cum}) and that the mitigation zone is usually based on the worst outcome, which is SPL_{pk} at max hammer. MSS would recommend to not use a 1% conversion factor and provided feedback previously on the Seiche paper as to why 1% conversion factor is not appropriate. The recommendation is to use max hammer energy and maximum conversion factor.	The ranges for SPLpk were based on the maximum over the entire piling sequence (i.e. from initiation to full hammer energy) and are therefore conservative. As presented during previous Road Map Meetings (see volume 3, appendix 10.3), the assessment is very precautionary as it looks at both SPLpk and SELcum and takes whichever is the largest of these two (dual metric approach as recommended by Southall et al. (2019)). Supplementary details about impact ranges based on maximum hammer energy and maximum conversion factor are presented in volume 3, appendix 10.1, Annex B as well as volume 3, appendix 10.5 and referred to in paragraph 127.
		MSS suggest that the constant 4% conversion factor should be modelled.	Injury ranges based on a maximum hammer energy of 4,000kJ, SPLpk metric and two constant conversion factors – 4% and 10% - are presented in sensitivity analysis (volume 3, appendix 10.1, annex B), conversion factor appendix (volume 3, appendix 10.5) and in the assessment presented in section 10.11.
		NS suggest that in line with the agreement signed by Scottish Government (this is public knowledge), low order techniques should be used during UXO clearance.	Application of low order techniques is preferred option for UXO clearance and will be applied where possible. However, there is a small risk of potential for unintended consequence of low order clearance to result in high order detonation of UXO (as per paragraph 297, approximately 10% of the total number of UXOs could result in high order detonation). Therefore, the assessment of potential impacts due to the underwater noise during UXO clearance and secondary mitigation was based on the maximum design scenario of high order detonation and is presented in section 10.11, paragraph 294 et seq.
		UXO clearance technique and associated mitigation - MSS support use of ADD as mitigation technique, however there is scientific paper that questions the efficacy of scare charges. This paper has not been published yet. MS-LOT also welcomes details on low order efficacy and confirms there will be monitoring requirements in this regard.	Prior to the commencement of UXO clearance works, a more detailed assessment will be produced as a part of the EPS licence supporting information. Additionally, choice of appropriate secondary mitigation measures will be informed by available studies and will be agreed as a part of a UXO specific MMMP.

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		MS-LOT recognise that there is not much information in the public domain for Scotwind projects, however, an acknowledgement of the projects should be given within the EIA.	ScotWind projects were considered in screening, but not taken forward due to lack of information (see volume 3, appendix 6.4).
		NatureScot suggest that reference should be to cumulative projects along east Scotland, rather than north-east Scotland in order to consider the Scotwind projects.	This is correct, all projects within the east of Scotland has been considered (see section 10.11).
		MSS advise that monitoring is going to be required, however the type of monitoring is unknown at this time. If there are particular areas where it is being noticed that there is a lack of evidence, then the monitoring is likely to focus here.	The Applicant has proposed underwater noise monitoring for UXO clearance activities (section 10.11.3). The possibility of monitoring being required and any requirement for monitoring will be discussed post submission of the Application and will agreed with MS and key stakeholders post-consent.
09 August 2022, 08 September 2022	Further clarifications following Road Map Meeting 4 (via email)	NatureScot support modelling SELcum over the entire piling sequence using the decreasing conversion factor % (i.e. 4% reducing to 0.5%) to estimate the level of risk. NatureScot also advised that it is their experience to date that instantaneous PTS is used to establish injury ranges to inform mitigation requirements. As a summary, stakeholders would like the assessment to include: • Instantaneous PTS impact ranges using the highest hammer energy for 1%, 4% and 10% constant conversion factor. • Accumulated PTS using a decreasing conversion factor %, including 4% decreasing to 0.5% and 10% reducing to 1%.	In line with industry guidance on taking a dual metric approach to determining potential injury ranges (Southall, 2019), both SPL_{pk} and SEL_{cum} have been modelled for PTS, and both are presented in the assessment that has been undertaken for each of the marine mammal hearing groups (see section 10.11). These were modelled and presented for 1% conversion factor, 4% reducing to 0.5% and 10% reducing to 1% in volume 3, appendix 10.5. To satisfy the requirements provided in the clarification email, instantaneous PTS impact ranges using the highest hammer energy and following constant conversion factors 1% , 4% and 10% constant were provided for information in volume 3, appendix 10.5. However, the instantaneous injury ranges for all species are smaller than injury range for minke whale based on SEL_{cum} and 4% reducing to 0.5% conversion factor (2,319 m).
30 September 2022	Further clarifications following Road Map Meeting 4 (via email)	For assessment of UXO clearance, NatureScot acknowledged the use of Soloway and Dahl (2014) as the commonly used method but, based on the results of noise monitoring at Seagreen, NatureScot advise consideration of other models (Weston model, Arons, Cole and Weston model) as cited by Robinson *et al.* (2022).	Soloway and Dahl (2014) uses the same modelling methodology as those set out in Arons (1954), Cole (1948) and Weston (1960). The Soloway and Dahl paper clearly references the Arons and Cole papers as the source for the equations for peak SPL and therefore the approach to the assessment follows the advice of NatureScot in this respect.
		NatureScot advise to review Seagreen UXO monitoring reports to tailor the UXO mitigation based on lessons learned to date, including the use of scare charges and the efficacy of low-order techniques. The use of low order charges should make the need for scare charges redundant although NatureScot suggest that if required (in the event of a high order detonation) scare charges can be used at depths which restrict the use of noise abatement. .	The Applicant has committed to the use of low order clearance of UXOs although this Chapter also provides an assessment for high order as a worst case as per advice from NatureScot and in line with the joint SNCB/DEFRA statement. The assessment considers the use of ADD and scare charges as secondary mitigation in the event that high order detonation could occur (in the event that low order leads to accidental high order) as a widely accepted and applied approach in the UK. As described in detail in paragraph 346, given the lack of detailed information about anticipated UXO sizes at the submission phase, prior to the commencement of UXO clearance works, a more detailed assessment will be produced as a part of the EPS licence supporting information. Appropriate secondary mitigation measures, tailored to the UXO size and specific clearance technique, will be agreed as a part of a UXO specific MMMP post-consent particularly with regards to emerging scientific evidence regarding the efficacy currently used techniques. Further to NatureScot's advice the Applicant will seek to review types of secondary mitigation applicable and agree the most appropriate with the SNCBs.
		NatureScot is content with the approach taken for iPCoD modelling for the Proposed Development alone (subject to conversion factor used).	The results of iPCoD modelling for a range of conversion factors are presented in volume 3, appendix 10.4. The assessment in section 10.11 includes a summary of the results for these conversion factors taken forward to the assessment (see paragraph 102 *et seq.* for more details about conversion factors).
		NatureScot suggest application of iPCoD modelling for cumulative assessment based on data available in the public domain and proposed piling schedule approach (distributing piling evenly over the total piling period where information on the specific piling schedule is not publicly available). Moray West should be included. For bottlenose dolphin, harbour seal and grey seal assessment it was suggested to use all projects within relevant MUs. For minke whale and harbour porpoise a quantitative assessment should be conducted for nearby projects for which information is known, and a qualitative assessment is recommended for those projects further afield.	The cumulative iPCoD modelling included projects as per the cumulative assessment presented in section 10.12.2. Please note, that the cumulative assessment considered potential connectivity on species-by-species basis. Projects to be considered for each impacts and species were presented during the Road Map Meeting #4, and subsequently included Moray West which was added to the cumulative assessment and cumulative iPCoD as requested,. The iPCoD modelling was undertaken on a quantitative basis for all projects screened in within the agreed cumulative study areas. As a summary, cumulative assessment and iPCoD considered: - projects located within the wider Firth of Forth and Tay area for harbour seal and grey seal; - projects located within the CES MU for bottlenose dolphin; - all projects located within the regional marine mammal study area for harbour porpoise and minke whale. Results of cumulative iPCoD modelling are presented in section 10.12.2 and volume 3, appendix 10.4.

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		NatureScot suggest potential monitoring – in-field noise monitoring for piling and UXO.	Proposed monitoring has been presented for the project alone. Specific details on the scope and approach to monitoring will be agreed and approved by MS-LOT post-consent.

10.6. METHODOLOGY TO INFORM BASELINE

10.6.1. DESKTOP STUDY

13. Information on marine mammals within the regional marine mammal study area was collected through a detailed desktop review of existing studies and datasets. Some of the key data sources are summarised in Table 10.10. A comprehensive list of all literature and data reviewed is provided in volume 3, appendix 10.2 Marine Mammals Technical Report.

Table 10.10: Summary of Key Desktop Reports

Title	Source	Year	Author
SCANS II.	SCANS data project publication	2006	Hammond *et al.*
Assessment of The Crown Estate Aerial survey marine mammal data for the Firth of Forth development areas	The Crown Estate (TCE) commissioned report by SMRU Limited (Ltd)	2011	Macleod and Sparling
Analysis of The Crown Estate aerial survey data for marine mammals for the Forth and Tay Offshore Wind Developers Group.	The Crown Estate (TCE) commissioned report by SMRU Ltd	2011	Grellier and Lacey
Cetacean Baseline Characterisation for the Firth of Tay: Bottlenose dolphins.	Firth of Tay Offshore Wind Developer Group (FTOWDG) commissioned report produced by SMRU Ltd	2011	Quick and Cheney
Forth and Tay Offshore Wind Developers Group cetacean survey data analysis report.	Report produced by DMP Stats for SMRU	2012	Mackenzie *et al.*; King and Sparling
Seagreen 1 Volume 1 Chapter 13: Marine Mammals.	Seagreen Wind Energy Ltd Environmental Statement	2012	Seagreen Wind Energy Ltd
Integrating multiple data sources to assess the distribution and abundance of bottlenose dolphins *Tursiops truncatus* in Scottish waters.	Publication from work funded by Scottish Natural Heritage and the Scottish Government	2013	Cheney *et al.*
East Coast Marine Mammal Acoustic Study Passive Acoustic Monitoring (PAM) data.	Correspondence with MSS	2013 to present	MSS
The east coast of Scotland bottlenose dolphin population: Improving understanding of ecology outside the Moray Firth SAC.	Report produced by SMRU and University of Aberdeen under the UK Department of Energy and Climate Change (DECC) Strategic Environmental Assessment programme	2014	Quick *et al.*
Joint Nature Conservation Committee (JNCC) Report 544: Harbour Porpoise Density.	Joint Nature Conservation Committee Report 544	2015	Heinänen and Skov
JCP Phase III.	Joint Nature Conservation Committee Report 517	2016	Paxton *et al.*
Updated Seal Usage Maps: The Estimated at-sea Distribution of Grey and Harbour Seals.	MSS publication	2017	Russel *et al.*
Site Condition Monitoring of bottlenose dolphins within the Moray Firth Special Area of Conservation: 2014-2016.	Scottish Natural Heritage Report No. 1021	2018	Cheney *et al.*
Neart na Gaoithe EIA Chapter 8 Marine Mammals.	Neart na Gaoithe Environmental Statement	2018	Pelagica Environmental Consultancy Ltd.
Seagreen 1 Volume 1 Chapter 10 Marine Mammals	Seagreen Wind Energy Ltd Environmental Statement	2018	Seagreen Wind Energy Ltd
Changing distribution of the east coast of Scotland bottlenose dolphin population and the challenges of area-based management.	Aquatic Conservation Marine and Freshwater Ecosystems	2019	Arso Civil *et al.*
Habitat-based predictions of at-sea distribution for grey and harbour seals in the British Isles.	UK Department for Business, Energy and Industrial Strategy's (BEIS) Offshore Energy SEA study produced by SMRU	2020	Carter *et al.*
Regional Baselines for marine mammal knowledge across the North Sea and Atlantic areas of Scottish waters.	Scottish Marine and Freshwater Science report	2020	Hague *et al.*
Marine Ecosystems Research Program cetacean density surfaces.	Journal of Applied Ecology	2020	Waggitt *et al.*
Improving understanding of bottlenose dolphin movements along the east coast of Scotland.	European Offshore Wind and Deployment Centre Environmental Research and Monitoring Programme report produced by SMRU Consulting.	2021	Arso Civil *et al.*
SCANS III.	SCANS III data project publication (revised in 2021)	2021	Hammond *et al.*
Seal haul-out and telemetry data in relation to the Berwick Bank Offshore Wind Farm.	Annex to volume 3, appendix 10.2 Marine Mammals Technical Report	2022	Sinclair

10.6.2. IDENTIFICATION OF DESIGNATED SITES

14. All designated sites within the regional marine mammal study area and qualifying interest features that could be affected by the construction, operation and maintenance, and decommissioning phases of the Proposed Development were identified using the three step process described here:

- Step 1: All designated sites of international, national and local importance within the regional marine mammal study area were identified using a number of sources. These sources included JNCC, SCOS, National Marine Plan Interactive (NMPI) and European Nature Information System (EUNIS) websites.
- Step 2: Information was compiled on the relevant features for each of these sites as follows:
  - The known occurrence of species within the regional marine mammal study area was based on relevant desktop information (section 10.6.1) and site-specific surveys presented within volume 3, appendix 10.2.
- Step 3: Using the above information and expert judgement, sites were included for further consideration if:
  - A designated site directly overlaps with the regional marine mammal study area such that:

- sites and associated features were located within the potential ZoI for impacts associated with the Proposed Development (e.g. potential effect ranges of underwater noise as a result of piling activities during construction; see section 10.11); and
- features of a designated site were either recorded as present during historic surveys or recent DAS within the Proposed Development array area and Proposed Development export cable corridor, or identified during the desktop study as having the potential to occur within the Proposed Development array and Proposed Development export cable corridor.

10.6.3. SITE-SPECIFIC SURVEYS

15. To inform the marine mammal Offshore EIA Report chapter, site-specific surveys were undertaken, in accordance with the methodology as presented during Road Map Meeting 1 (volume 3, appendix 10.3). A summary of the surveys undertaken to inform the marine mammal assessment of effects is outlined in Table 10.11.

Table 10.11: Summary of Site-Specific Survey Data

Title	Extent of Survey	Overview of Survey	Survey Contractor	Date	Reference to Further Information
Digital Aerial Surveys	Proposed Development array area and Proposed Development export cable corridor plus approximate 16 km buffer.	Aerial digital survey	HiDef	Monthly surveys (typically one survey per month) between March 2019 to April 2021	Aerial Data Report (volume 3, appendix 10.2, annex A)

10.7. BASELINE ENVIRONMENT

10.7.1. OVERVIEW OF BASELINE ENVIRONMENT

16. The distribution of marine mammals in the North Sea is patchy, however historic and recent sightings indicate that it regularly supports 11 species of cetaceans and two species of pinnipeds (Weir, 2001; Hammond *et al*., 2013; Hammond *et al*., 2021; and NMPI, 2021). The distribution and abundance of marine mammals is highly correlated with the distribution of prey. Marine mammal species are highly mobile; however some areas hold a consistently higher number of individuals than others (e.g. the deep trench running parallel to the Aberdeenshire coast attracts minke whales due to abundance of prey species; NatureScot, 2020).

17. Cetacean and pinniped distribution is species specific and not all species are likely to occur within the Proposed Development marine mammal study area. Aerial digital surveys carried out for the Proposed Development from March 2019 to April 2021 (the ‘Digital Aerial Surveys (DAS)) showed that the most common cetacean species within the Proposed Development marine mammal study area (Figure 10.1) was harbour porpoise. Grey seal were also sighted frequently. Marine mammals which were sighted regularly during the DAS (2019-2021) included minke whale, white-beaked dolphin, bottlenose dolphin and harbour seal (please refer to volume 3, appendix 10.2 for details about marine mammal species visiting the area occasionally).

18. A summary of the marine mammal baseline within the Proposed Development marine mammal study area, in the context of the regional marine mammal study area, is presented in Figure 10.12 and volume 3, appendix 10.2.

Table 10.12: Summary of Marine Mammals Baseline Ecology

Species	Baseline Summary	Conservation Importance
Harbour porpoise	Widely distributed throughout the northern North Sea and sighted every month of the DAS (2019-2021) within the Proposed Development aerial survey area. It was the most commonly identified cetacean during historic aerial surveys in the Firth of Forth region (Grellier and Lacey, 2011; Sparling, 2012). IAMMWG (2021) presented estimated abundance for the NS MU as 346,601 individuals. SCANS III data estimated the density in block R as 0.599 harbour porpoise per km^2 and presented an abundance of 38,646 individuals (Hammond *et al.,* 2021). Site-specific modelled estimates from the DAS provided an encounter rate of 0.037 animals per km with a monthly peak of 0.277 animals per km in April 2020 and mean corrected density was estimated as 0.298 animals per km^2 (densities were higher in spring and summer months with lower values in late autumn and winter).	Annex II species protected under the Habitats Regulations within a European Marine Site, PMF and EPS Harbour porpoise is a qualifying interest of the following SACs (distances provided are measured from Proposed Development array area): Southern North Sea SAC, 144 km south; Doggerbank SAC, 292 km south; Doggerbank SCI, 311 km south and Klaverbank SAC, 330 km south. .These sites are all within/overlapping the Regional study area.
Bottlenose dolphin	Northern North Sea supports the world's most northerly resident population, with main distributional range from Moray Firth to Firth of Forth with approx. 53.8% of the East Coast population using the Tay and adjacent waters during summer (Cheney *et al.,* 2013; Arso Civil *et al.,* 2021). In recent years distributional range started to stretch further south (to Northumberland coast). IAMMWG (2021) presented estimated abundance for the Costal East Scotland (CES) MU as 189 individuals, however we were advised by consultees to use estimated abundance as 224 individuals based on 5-year average from Arso Civil *et al.* (2019). SCANS III estimated their offshore abundance for block R as 1,924 individuals (Hammond *et al.* 2021). Bottlenose dolphins are known to occur in coastal waters, hence their coastal density has been calculated based on recent estimates provided by Arso Civil *et al.* (2021) and habitat preference modelling (Arso Civil *et al.,* 2019) data as 0.197 animals per km^2 across 2 m to 20 m depth contour between Peterhead and Farne Islands, except the outer Firth of Tay waters with a density of 0.294 animals per km^2. Sightings of bottlenose dolphins during DAS were low with encounter rate of 0.0001 animals per km. The offshore density of bottlenose dolphin was taken as 0.0298 from SCANS III (Hammond *et al.,* 2021).	Annex II species protected under the Habitats Regulations within a European Marine Site, PMF and EPS. Bottlenose dolphin is a qualifying interest of Moray Firth SAC, located approximately 120 km north from the Proposed Development array area.
White-beaked dolphin	Second most numerous cetaceans in the North Sea, with seasonal occurrence patterns within the coastal waters of eastern Scotland and highest rates of sightings during summer months (Weir *et al.* 2007). IAMMWG (2021) presented estimated abundance for the CGNS MU of 43,951 individuals. SCANS III estimated abundance for block R was 15,694 white-beaked dolphins with an estimated density of 0.243 individuals per km^2 (Hammond *et al*., 2021). During the DAS encounter rate was relatively small with 0.0007 animals per km and a monthly peak of 0.0096 animals per km in September 2020; absolute density was estimated as 0.05 animals per km^2.	Scottish PMF and EPS.
Minke whale	Widely distributed in northern North Sea and around Scotland, these species display seasonal occurrence patterns with inshore movements during summer and returns to offshore waters in winter (dictated by availability of prey species). During historic and recent surveys the vicinity of the Proposed Development array area, minke whales were encountered mostly during summer months (April to September). IAMMWG (2021) presented estimated abundance for the CGNS MU of 20,118 individuals. SCANS III estimated abundance for block R was 2,498 minke whales with an estimated density of 0.0387 individuals per km^2 (Hammond *et al*., 2021). During the DASencounter rate was relatively small with 0.001 animals per km and a monthly peak of 0.0059 animals per km in July 2019; overall mean density was estimated as 0.007 animals per km^2.	Scottish PMF and EPS.
Harbour seal	Areas of particular importance for harbour seal in Scottish waters are north-east Scotland, specifically the Dornoch Firth and Morrich More SAC. The nearest designated haul out sites for harbour seals in the MU in the vicinity of the Proposed Development are Kinghorn Rocks and Inchmickery and Cow and Calves. The most recent UK wide harbour seal count is for the count period 2016 to 2019 and gave an estimated population size of 44,100 individuals, of which 37,200 animals located in Scotland. Populations along the east coast of Scotland have generally declined since the early 2000s; continuous declines are not evident in Moray Firth, however there is no sign of recovery. The Proposed Development is located within the ES and North East England (NEE) MUs with most recent harbour seal population estimates of 476 and 110 individuals respectively. Carter *et al.* (2020) at-sea usage maps estimate an average density of 0.003 animals per km^2 and highest density of 0.002 animals per km^2 within the Proposed Development array area. Telemetry data confirmed that 25 harbour seals (tagged in the ES MU) had telemetry track data recorded within the Proposed Development Maine Mammal study area and all 25 of these harbour seals also showed connectivity with the Firth of Tay and Eden Estuary SAC.	Annex II species protected under the Habitats Regulations within a European Marine Site, and a qualifying interest of the Firth of Tay and Eden Estuary SAC and Dornoch Firth and Morrich More SAC, located approx. 42.5 km and 136 km north from the Proposed Development array area, respectively.

Species	Baseline Summary	Conservation Importance
Grey seal	Grey seals have favourable conservation status in the UK and coastal waters of Scotland are internationally important centres of grey seal abundance. The closest designated haul-out sites for grey seals in the vicinity of the Proposed Development are Kinghorn Rocks and Inchmickery and Cow and Calves (for August survey counts) and Fast Caste, Inchkeith and Craigleith for breeding colonies. The most recent UK wide grey seal count is for the count period 2016 to 2019 and gave an estimated population size of 179,000 individuals, of which 106,300 animals located in Scotland. Based on this most recent pup count (2016 to 2018) the adult population size in the UK at the start of the 2019 breeding season was estimated to be 149,700 (SCOS, 2020). The Proposed Development is located within the ES and NEE MUs with most recent grey seal population estimates of 15,400 and 27,200 individuals respectively. Carter *et al.* (2020) at-sea usage maps (mean) estimate an average density of 1.2 animals per km^2 within the Proposed Development array area. Site-specific modelled estimates from DAS provided a mean monthly density of 0.276 animals per km^2 and peak seasonal (spring) density of 0.321 animals per km^2 (grey seal plus seal species, see volume 3, appendix 10.2 for details). Tagging data illustrated connectivity between the Proposed Development Marine Mammal study area and Berwickshire and North Northumberland Coast SAC and Isle of May SAC, with 73% and 41% of tagged individuals being tracked within these SACs respectively.	Annex II species protected under Habitats Regulations within a European Marine Site, and a qualifying interest of the Berwickshire and North Northumberland Coast SAC located approx. 30.1 km south from the Proposed Development and Isle of May SAC, which lies approx. 42.5 km northwest of the Proposed Development array area.

19. Table 10.13 presents density estimates and population assessments for marine mammals in the Proposed Development marine mammal study area for use in quantifying the scale of effects as part of the assessment of effects. For practical management purposes, the IAMMWG has identified MUs for cetaceans in UK and Irish waters and has provided an estimated abundance for each (IAMMWG, 2021). The Proposed Development marine mammal study area lies within the NS MU for harbour porpoise, the CES MU for bottlenose dolphin and the CGNS MU for white-beaked dolphin and minke whale (details are provided in volume 3, appendix 10.2; Figure 10.2). SCOS has defined MUs for both species of seals. Given that the Proposed Development marine mammal study area overlaps with the ES and NEE MUs, the population assessments are based on the latest abundance estimates for both MUs (Figure 10.3). To provide context within the regional marine mammal study area, SCANS III Block R population estimates are presented along abundance estimates for relevant MUs harbour porpoise, bottlenose dolphin, white-beaked dolphin and minke whale (Figure 10.4).

Table 10.13: Density Estimates and Population Assessments for Marine Mammals in the Proposed Development Marine Mammal Study Area

Species	Density (Animals per km^2)	Management Unit	Population in MU	SCANS-III Block R (Hammond *et al.*, 2021)
Harbour porpoise	0.299 to 0.826[1]	North Sea	346,601 (IAMMWG, 2021)	38,646
Bottlenose dolphin	Coastal: 0.197 to 0.294[2] Offshore: 0.0298[3]	CES	224 (Arso Civil *et al.,* 2021)	1,924
White-beaked dolphin	0.243[3]	CGNS	43,951 (IAMMWG, 2021)	15,694
Minke whale	0.0387[3]	CGNS	20,118 (IAMMWG, 2021)	2,498
Harbour seal	0.0001 to 0.002[4]	ES plus North-east England	476 + 110 = 586 (Sinclair, 2022; SCOS, 2020)	Not Applicable (N/A)
Grey seal	0.276 to 1.2[5]	ES and North-east England	15,400 + 27,200 = 42,600 (Sinclair, 2022; SCOS, 2020)	N/A

[1] Site-specific densities (mean and seasonal peak) estimated from Proposed Development aerial digital survey data (2019 to 2021).
[2] Average coastal density derived from five-year average from Arso Civil *et al.* (2021) with proportion at the outer Firth of Tay assigned using habitat preference modelling data from Arso Civil *et al.* (2019).
[3] SCANS-III (Hammond *et al.*, 2021).
[4] Mean and maximum across the Proposed Development marine mammal study area based on at-sea mean density maps (Carter *et al*., 2020).
[5] Mean monthly density based on site-specific Proposed Development aerial digital survey data (2019 to 2021) and density based on at-sea mean usage maps (Carter *et al*., 2020) across the Proposed Development marine mammal study area.

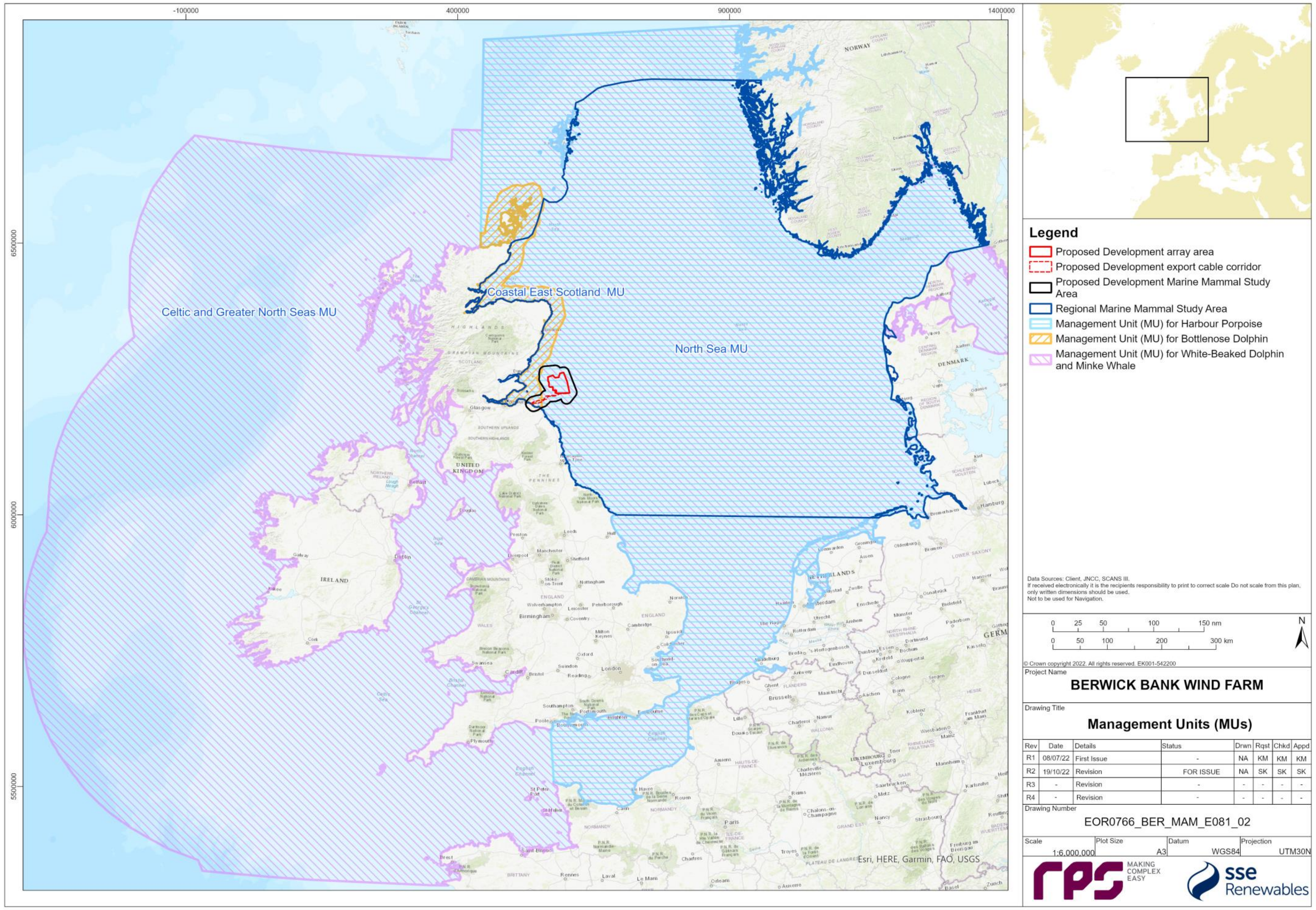


Figure 10.2: **Management Units for Cetaceans**

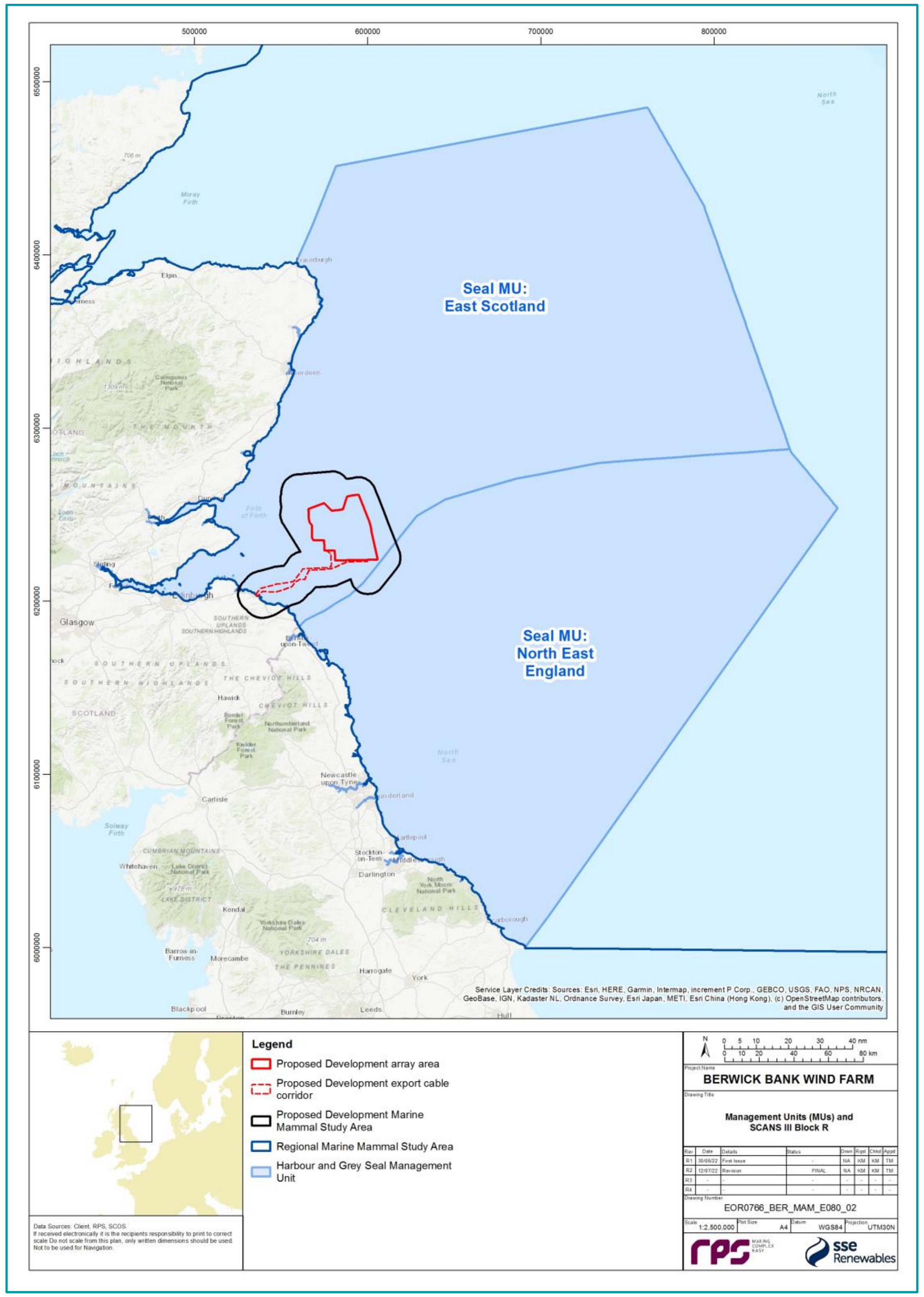


Figure 10.3: Management Units for Seals

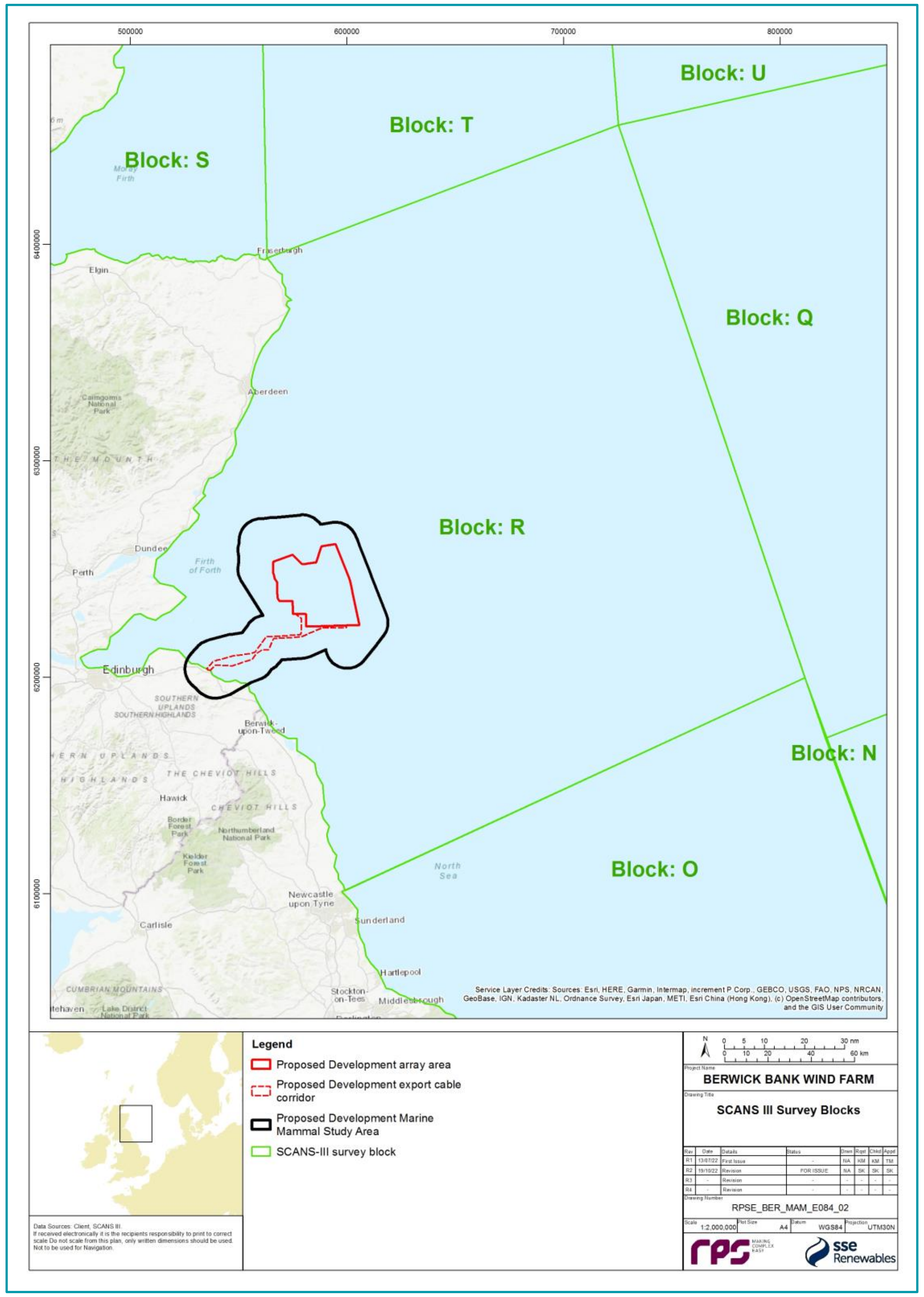


Figure 10.4: Scans III Survey Blocks

10.7.2. DESIGNATED SITES

20. Table 10.14 summarises the designated sites presented in Figure 10.5, that have been identified as having potential connectivity with marine mammal receptors identified in section 10.7.1 (agreed with MS-LOT through pre-Application consultation – see Table 10.9).

Table 10.14: Designated Sites and Relevant Qualifying Interest Features Considered in the Marine Mammals Assessment

Designated Site	Closest Distance to Proposed Development Array Area or Offshore Cable Corridor (km)	Relevant Qualifying Interest Feature
Berwickshire and North Northumberland Coast SAC	4	Grey seal
Isle of May SAC	21	Grey seal
Firth of Tay and Eden Estuary SAC	45	Harbour Seal
Moray Firth SAC	167	Bottlenose dolphin
Dornoch Firth and Morrich More SAC	195	Harbour seal
Southern North Sea SAC	146	Harbour porpoise
Doggersbank SAC	295	Harbour porpoise
Doggerbank SCI	314	Harbour porpoise
Klaverbank SAC	332	Harbour porpoise

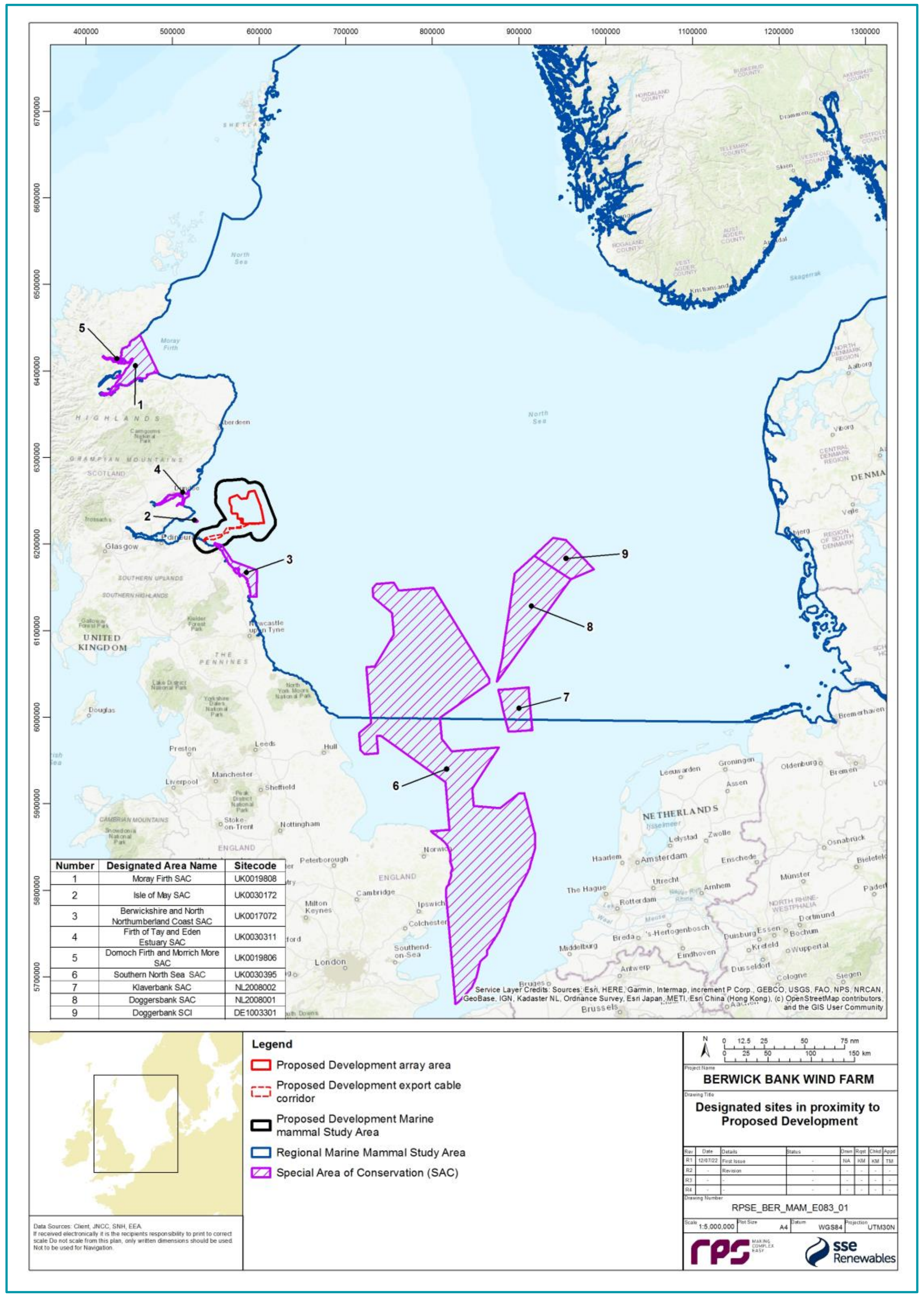


Figure 10.5: Designated Sites

10.7.3. IMPORTANT ECOLOGICAL FEATURES

21. The IEFs are those marine mammal receptors that have the potential to be affected by the Proposed Development. The importance of ecological features is dependent upon their biodiversity, social, and economic value within a geographic framework of appropriate reference (CIEEM, 2019). Marine mammal IEFs have been identified based on biodiversity importance, recognised through international or national legislation, conservation status/plans and on assessment of value according to the functional role of the species within the context of the regional marine mammal study area. Relevant legislation/conservation plans for marine mammals would include, for example: Annex II species under the Habitats Directive; Annex IV(a) of the Habitats Directive as EPS; species listed as threatened and/or declining by OSPAR; International Union for Conservation of Nature (IUCN) Red List species; UK Biodiversity Action Plan (BAP) priority species either alone or under a grouped action plan; and PMFs in Scotland. Table 10.15 presents the value/importance that has been assigned to each ecological feature All marine mammals with the potential to be affected by the Proposed Development are protected under some form of international legislation and/or are important from a conservation perspective in an international/national context and therefore the value of all marine mammal IEFs was determined to be international.

Table 10.15: Marine Mammal IEFs and their Importance Within the Regional Marine Mammal Study Area

IEF	Value	Justification
Cetaceans		
Harbour porpoise	International	Annex II species that is a designated feature of Southern North Sea SAC, Doggersbank SAC, Doggerbank SCI and Klaverbank SAC. EPS. OSPAR protected species. IUCN Red List Least Concern. Scottish PMF.
Bottlenose dolphin	International	Annex II species that is a designated feature of Moray Firth SAC. IUCN Red List Least Concern. EPS. Scottish PMF.
White-beaked dolphin	International	Scottish PMF. EPS. IUCN Red List Least Concern.
Minke whale	International	Scottish PMF. EPS. IUCN Red List Least Concern.
Pinnipeds		
Harbour seal	International	Annex II species that is a designated feature of Firth of Tay and Eden Estuary SAC. IUCN Red List Least Concern. Scottish PMF.
Grey seal	International	Annex II species that is a designated feature of Berwickshire and Northumberland Coast SAC and Isle of May SAC. IUCN Red List Least Concern. Scottish PMF.

10.7.4. FUTURE BASELINE SCENARIO

22. The EIA Regulations ((The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017, The Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017, the Marine Works (Environmental Impact Assessment) Regulations 2007, and The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017)), require that a "*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*" is included within the Offshore EIA Report.

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

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

25. Marine mammal species are known to be impacted by various anthropogenic activities, including offshore developments but also fisheries, anthropogenic noise and transportation. Avila *et al*. (2020) reported that between 1991 and 2016, globally almost all species of marine mammals (98%) were documented to be affected by at least one threat. Catch of marine mammals in active fishing gear (by-catch) was the most common threat category for odontocetes and mysticetes, followed by pollution (solid waste), commercial hunting and boat-collisions. Ghost-net entanglements, solid and liquid wastes, and infections were reported to be the main threats for pinnipeds.

26. In addition to anthropogenic impacts, marine mammals are also vulnerable to indirect impacts, including global warming which can result in increasing sea temperatures. One of the most common responses of marine mammals to temperature changes are shifts in their spatial distribution, which has the potential to modify the ranges of certain species. Additionally, changes in water temperatures are likely to alter the life cycles of marine mammal prey species and may result in discrepancy between the abundances of prey species and those of marine mammals, affecting migratory marine mammal species and these displaying some site fidelity. Additionally, global warming could affect survival rates of marine mammals by affecting reproductive success, increasing the stress of the animal and fostering the development of pathogens (Albouy *et al*., 2020).

27. Given that anthropogenic pressures are now superimposed by climatic changes, it is challenging to predict future trajectories of marine mammal populations in the absence of the project. In terms of data, for some species monitoring is not in place at the relevant temporal or spatial scales in order to assess the baseline dynamics of some marine mammal populations, especially for minke whale and white-beaked dolphin. Therefore, paragraph 28 *et seq.* is a summary of current and future pressures and where data is available, information about population dynamics is presented.

Harbour Porpoise

28. In the North Sea, the harbour porpoise is considered vulnerable to bycatch in gillnets (Calderan and Leaper, 2019). Assuming that fishing vessel of 12 m or over follow the obligation to use pingers, Northridge *et al*. (2019) estimated UK porpoise bycatch in 2018 to be between 845 and 1,633 individuals with a best estimate of 1,150 individuals (CV=0.087), which is an increase comparing to 2017 with an estimate of 1,098 animals (Northridge *et al*., 2018).

29. Another driver for harbour porpoise abundance is prey availability. Given that harbour porpoise has a high metabolic rate (Rojano-Doñate *et al*., 2018) and therefore has to feed regularly, it is thought to be highly dependent on year round proximity to food sources and harbour porpoise distribution and condition is considered likely to reflect the availability and energy density of prey (Santos and Pierce,

2003). Therefore, any changes in the abundance and density of harbour porpoise prey species have the potential to affect harbour porpoises foraging in an area.

30. IAMMWG *et al*. (2015) reported that necropsies associated with harbour porpoise strandings have revealed parasite infections that may suggest adverse effects in harbour porpoises with an anthropogenic origin, such as contaminant discharges of Persistent Organic Pollutants (POPs). The impact of climate change on harbour porpoise remains poorly understood. Data from SCANS II and SCANS III suggested that the abundance of harbour porpoise in the NS MU is stable (IAMMWG, 2015; IAMMWG, 2021).

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

Bottlenose Dolphin

32. Over the last 20 years, the size of the population of bottlenose dolphins off the east coast of Scotland has increased (Cheney *et al*., 2014; Cheney *et al*., 2018; Arso Civil *et al*. 2021) and their distribution has undergone a marked change with southern range expansion as recognisable individuals regularly occurring off eastern England (Arso Civil *et al*., 2019; Arso Civil *et al*., 2021). In the late 1980s and early 1990s the inner Moray Firth was assessed as the core area of occurrence, albeit surveys over the past ten years have shown that around 50% of the population use the Tay estuary and adjacent waters during summer months. The movement of individuals could be driven by environmental and biological factors, including seasonal changes in prey presence as well as social bonds within the population (Arso Civil *et al*., 2021). These findings are in line with study by Lusseau *et al*. (2004) which reported that bottlenose dolphin group sizes in Moray Firth were significantly related to prey abundance and that changes in the abundance of fish prey result in interannual variation in grouping patterns. Therefore, this study suggested that extrinsic factors could influence the structure of social community and parameters such as dispersal rate. Changes in prey abundance as a result of global warming are therefore likely to be major factor driving changes in bottlenose dolphin distribution.

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

White-beaked Dolphin

34. Given that white-beaked dolphin is a species endemic to cold temperate waters of North Sea, increasing water temperature may lead to reduced areas suitable for foraging, and habitat loss (IJsseldijk *et al*., 2018). Macleod *et al*. (2005) reported that there has been a decline in the relative frequency of white-beaked dolphin strandings and sightings in north-west Scotland and attributed climate change as a major cause of this decline. Large scale population survey results of SCANS revealed no significant change in abundance of white-beaked dolphins in the North Sea between 1994 and 2016 (Hammond *et al*., 2013; Hammond *et al*., 2018). However, analysis of strandings data also suggested potential change in their distribution along North Sea coastline, with fewer animals being present in the more southern regions and stable numbers within the northern regions of the North Sea (IJsseldijk *et al*., 2018). The status of white-beaked dolphin is evaluated as 'least concern' due to its widespread abundance, however their range is expected to shrink in response to increasing sea temperature (Macleod *et al*., 2018).

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

Minke Whale

36. In coastal waters off east Scotland, sandeels are the main constituent of minke whale diet, however fish species such as pelagic herring and sprat are equally important for foraging whales in offshore waters (Robinson *et al*., 2009). The results of analysis of minke whales stomach contents in Icelandic waters suggested that a decrease in the proportion of sandeel and cold water species in the diet and an increase in gadoids and herring may reflect responses of minke whales to a changed environment, possibly driven by global warming (Víkingsson *et al*., 2014). Studies also suggest that minke whales are likely to shift their distribution as a response to the decrease in the abundance of the preferred prey species (Víkingsson *et al*., 2015).

37. Major threats affecting minke whales in UK waters include direct and indirect interactions with fisheries. In Scotland, for example, evidence of entanglement in static fishing gear was present in as many as 50% of stranded minke whales examined from 1990 to 2010 (Northridge *et al*., 2010). Other impacts include boat strikes, exposure to anthropogenic noise, ingestion of contaminants and debris and the loss or degradation of critical habitat (Gill *et al*., 2000; Robinson *et al*., 2009). Data from SCANS II and SCANS III suggested that the abundance of minke whales in the CGNS is stable (IAMMWG, 2015; IAMMWG, 2021).

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

Harbour Seal

39. The UK population of harbour seal has increased since the 2000s, however populations along the east coast of Scotland have generally declined and current population size is at least 40% below the pre-2002 level (SCOS, 2020). Continued declines are not evident in the Moray Firth, although there is no indication of recovery. At the time of writing, Hanson *et al*., 2017 reported that the ES MU the population is manly concentrated in the Forth of Tay and Eden Estuary SAC and therefore suggested that continuation of this trend in the SAC could result in the species disappearing from this area within next 20 years. There was not a clear single factor, which would explain the decline. It has been suggested that one of the factors driving this decline is reduction in food availability that could cause increased competition between conspecifics and with grey seals, followed by reduction in harbour seal condition as a result of this competition (reduced fecundity and/or pup survival) (Hanson *et al*., 2017; Damseaux *et al*., 2021; SCOS, 2020). Other studies also suggested that harbour seals might be exposed to domoic acid via consumption of contaminated prey at levels that may have the potential to cause harmful and lethal effects that would disrupt population dynamics (Jansen *et al*., 2015; SCOS, 2020). However, Sinclair *et al.* (2020) estimated that by 2016, the Forth of Tay and Eden Estuary SAC counts represented only approximately 15% of the ES MU. This has been corroborated by SCOS (2020) report, where the decline has been described as localised within the Forth of Tay and Eden Estuary SAC and not representative of the trends in overall MU population. However, more frequent count data from Firth of Forth is required in order to support this assumption (SCOS, 2020).

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

Grey Seal

41. UK grey seal numbers are currently stable or increasing throughout their monitored range (SMRU, 2020), suggesting that their population status is not under threat. Population dynamics depend on a colony, however, pup production at colonies in the North Sea continued to increase rapidly up to 2016 with annual increase of 11.5% per annum (p.a.). Increase in pup production between 2014 and 2018 was 7.5% p.a. and it has been suggested that some of the colonies are approaching carrying capacity (SCOS, 2020). Production at the Isle of May increased exponentially to 9.9% p.a. since surveys began in 1979, before reaching an asymptote of c.2,000 pups in the late 1990s (SCOS, 2020). Pup production in the Berwickshire and North Northumberland Coast SAC is continuing to increase and does not show any indication of reaching an asymptote (SCOS, 2020). The analysis of POPs in blubber from weaned grey seal pups on the Isle of May detected POP concentrations below the values that could cause severe toxic effect, however highlighted that even low concentrations are likely to cause endocrine disruption with unknown consequence for individual health and survival (Robinson *et al*., 2019). Other threats to grey seals include entanglement in marine and plastic debris, particularly discarded fishing gear, disturbance and climate change affecting availability of prey.

42. Any changes that may occur during the design life span of the Proposed Development have been considered in the context of both greater variability and sustained trends occurring on national and international scales in the marine environment. While there is an indication that some populations are increasing (i.e. bottlenose dolphin, grey seal) or declining in numbers (i.e. harbour seal), it is challenging to define a future trajectory of marine mammal populations, especially without regular survey data (i.e. white-beaked dolphin, minke whale).

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

10.7.5. DATA LIMITATIONS AND ASSUMPTIONS

44. The data assumptions and limitations (detailed in volume 3, appendix 10.2, annex A) are typical of difficulties encountered with undertaking field surveys of marine mammals using aerial digital methods. A summary is provided in paragraph 45 *et seq*.

45. DAS have been conducted monthly, however, due to unforeseen circumstances, the survey was not conducted in some months. For example, the April surveys in both 2019 and 2020 were not carried out, however, an additional survey was undertaken in early May 2020 to represent the delayed April 2020 survey and the survey programme was subsequently extended to include two surveys flown in April 2021 to provide additional data set for the month of April and compensate missed April 2019 survey. Similarly, there were some months when not all transects could be flown (e.g. due to technical issues or weather conditions) and so full coverage of the site was not possible. Additional camera data were analysed to compensate for this and to ensure the minimum percentage cover requirement was met. Another potential limitation is that the single survey day each month represents only a snapshot of marine mammal distribution and therefore it could not be assessed whether environmental conditions influenced sightings rates and only seasonal changes were considered. Additionally, detection probability was a limiting factor in recording marine mammals with weather conditions playing a significant role in the ability to detect a marine mammal. Identification to species-level can sometimes be difficult, particularly when distinguishing between grey sea and harbour seal at sea. Since there were a number of sightings recorded as 'seal species' and 'cetacean species', unidentified animals were allocated to grey seal and harbour porpoise respectively, based on the prevalence of this species in the vicinity of the Proposed Development. Finally, availability bias - the time when an animal is available for the detection either at the sea surface or just below the surface - is also a limiting factor. However, the relative density (harbour porpoise, grey seal, minke whale and white-beaked dolphin) calculated from data collected during the DAS was corrected for availability bias using a published correction factors based on the proportion of time individuals are likely to be at or near the surface and available for detection.

46. The surveys were conducted based on the original boundary for Berwick Bank, which was subsequently refined. Since the refinement was a reduction of the Proposed Development array area, the coverage of the aerial surveys remains valid.

47. Despite the limitations described above, the baseline assessment provides a comprehensive account of the marine mammals within the Proposed Development marine mammals study area as these site-specific data were corroborated by information collated via a detailed desktop review. It is therefore concluded that the data limitations presented above are not expected to affect the conclusions of the

assessment, and the baseline presented provides a robust and appropriate characterisation of the area against which to undertake this assessment.

10.8. KEY PARAMETERS FOR ASSESSMENT

10.8.1. MAXIMUM DESIGN SCENARIO

48. The maximum design scenarios identified in Table 10.16 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. These scenarios have been selected from the details provided in volume 1, chapter 3 of the Offshore EIA Report. Effects of greater adverse significance than assessed in this chapter are not predicted to arise should any other development scenario, based on details within the Project Design Envelope (e.g. different infrastructure layout), be taken forward in the final design scheme.

49. The maximum design scenario informing the assessment of potential impacts on marine mammals from 'changes in fish and shellfish communities affecting prey availability' is based on the maximum design scenario embedded in volume 2, chapter 9.

Table 10.16: Maximum Design Scenario Considered for Each Impact as Part of the Assessment of Likely Significant Effects on Marine Mammals

Potential Impact	Phase[2] C	O	D	Maximum Design Scenario	Justification
Injury and disturbance from elevated underwater noise during piling (fixed foundations)	✓	×	×	**Construction Phase** Wind turbines: • up to 179 piled jacket foundations, with up to 4 legs per foundation and up to 2 x 5.5 m diameter piles per leg (1,432 piles); • maximum hammer energy up to 4,000 kJ, with realistic maximum hammer energy of 3,000 kJ (based on average of up to 75% maximum hammer energy); • up to 2 concurrent piling of wind turbine foundations with 2 vessels; • minimum 950 m and maximum 49.43 km distance between concurrent piling events; • up to 10 hours absolute maximum piling per pile (9 hours realistic maximum); • total duration of piling = 12,888 hours (realistic maximum) to 14,320 hours (absolute maximum); and • maximum piles installed within 24 hours (concurrent piling) = 5. Offshore Substation Platforms (OSPs)/Offshore convertor station platforms: • up to 8 jacket foundations with up to 6 legs per foundation and 4 x 3.0 m diameter piles per leg (192 piles) and up to 2 jacket foundations with up to 8 legs per foundation and 4 x 4.0 m diameter piles per leg (64 piles); • maximum hammer energy up to 4,000 kJ, with realistic maximum hammer energy of 3,000 kJ (based on average of up to 75% maximum hammer energy); • up to 8 hours absolute maximum (7 hours realistic maximum) piling per pile; • total duration of piling = 1,792 hours (realistic maximum) to 2,048 hours (absolute maximum); and • maximum piles installed within 24 hours (based on single piling) = 3. The maximum scenario for concurrent piling is maximum of 2 piling events at any one time. Number of days when piling may occur within piling phase (OSPs/Offshore convertor station platforms and wind turbines) = 372 days. Total piling phase of 52 months over a construction period of 96 months.	The largest hammer energy and the maximum spacing between concurrent piling vessels could lead to the largest area of ensonification at any one time. Minimum spacing between concurrent piling represents the highest risk of injury to animals. Note that the absolute maximum hammer energy is the maximum achieved at any one location whilst the 'realistic maximum' is taken as the average of the maximum energy likely to be achieved across all 179 locations (and is estimated as 75% of the maximum). The longest duration of piling at any location results in the greatest number of days when piling could occur. The maximum number of piles installed within 24 hours will result in the greatest impact over 24 hours. Maximum number of piles for wind turbines installed within 24 hours is based on the realistic maximum duration of piling and assuming up to 2 concurrent piling vessels for wind turbines, with an assumption that there will be a maximum of 2 piling events at any one time. Note that maximum design scenario assumes concurrent piling for wind turbine foundations as the maximum design scenario but it may occur as a combination of wind turbines and OSPs/Offshore convertor station platforms. Figures have been rounded to nearest whole number. The maximum number of days when piling occurs will result in the greatest potential impact. Total number of days when piling may occur is based on the total number of piles divided by the number of piles that can be installed within 24 hours for wind turbines and OSPs/Offshore convertor station platforms s. Duration of piling at wind turbines assumes 2 concurrent vessels. OSPs/Offshore convertor station platforms s only assume a single vessel for pile installation. In total, a maximum of 2 piling vessels will be piling at any one time.
Injury and disturbance to marine mammals from elevated underwater noise during site investigation surveys	✓	✓	×	**Pre-Construction phase** Geophysical site investigation activities include: • Multi-beam echo-sounder (MBES) (200 kHz to 400 kHz; 180-240 dB re 1 1µPa); • Sidescan Sonar (SSS) (200 kHz to 900 kHz; 190-245 dB re 1 1µPa); • Single Beam Echosounder (SBES) (200 kHz to 400 kHz; 180-240 dB re 1 1µPa); • Sub-Bottom Profiler (SBP) (0.5 kHz to 12 kHz chirp, 4 kHz pinger, 100 kHz pinger; 200-240 chirp dB re 1 1µPa, 200-235 pinger (both) dB re 1 1µPa.); • Ultra High Resolution Seismic (UHRS) (19.5 kHz to 33.5 kHz; 170-200 dB re 1 1µPa); and • magnetometer. Geotechnical site investigation activities include: • boreholes; • Cone penetration tests (CPTs); and • vibrocores.	Maximum range of geophysical and geotechnical activities likely to be undertaken using equipment typically employed for these types of surveys will result in the greatest potential impact.

[2] Impacts with a potential to occur during: C = Construction, O = Operation and maintenance, D = Decommissioning

Potential Impact	Phase[2] C	O	D	Maximum Design Scenario	Justification
				Site investigation surveys will involve the use of up to 2 geophysical/geotechnical survey vessels and take place over a period of up to 3 months with up to 70 return trips. **Operation and maintenance phase** Routine geophysical surveys of wind turbine foundations, estimated to occur every six months for first two years and annually thereafter (approximately 37 surveys over the 35-year life cycle of the Proposed Development). It is assumed that approximately 10% of the inter-array cable length will require inspections each year (more if issues are found). Export cables surveyed annually.	
Injury and disturbance to marine mammals from elevated underwater noise during UXO clearance	✓	×	×	**Pre-Construction phase** • clearance of 14 UXOs within the Proposed Development array area or offshore export cable route; • maximum UXO size of up to 300 kg; • surveys will involve the use of up to 7 vessels on site at any one time with up to 30 vessel movements in total; • intention for low order clearance of all UXOs using low order techniques (subsonic combustion) with a single donor charge of up to 80 g net explosive quantity (NEQ) for each clearance event; • up to 500 g NEQ clearance shot for neutralisation of residual explosive material at each location; • small risk of potential for unintended consequence of low order techniques to result in high order detonation of UXO (as per paragraph 297, approximately 10% of the total number of UXOs could result in high order detonation); and • up to 2 detonations within 24 hours. Clearance during daylight hours only.	Maximum number and maximum size of UXOs encountered in the project area based on UXO Hazard Assessment undertaken for Seagreen will result in the greatest potential impact. Donor charge is maximum required to initiate low order detonation. Assumption of a clearance shot of up to 500 g at all locations although noting that this may not always be required.
Injury and disturbance to marine mammals from elevated underwater noise due to vessel use and other activities	✓	✓	✓	**Construction phase** Vessels used for a range of construction activities associated with site preparation, inter-array cables and offshore export cables, including boulder clearance, sand wave clearance, drilling and trenching; maximum vessels on site at any one time including: • up to 9 pre-installation boulder clearance vessels with up to 316 return trips throughout the construction period; and • up to 3 sandwave clearance vessels with up to 104 return trips over a throughout the construction period. Vessels associated with site preparation, foundation installation, OSPs/Offshore convertor station platforms installation, inter-array cables, offshore export cables, and landfall works, with up to 11,484 vessel round trips over the construction phase; maximum vessels on site at any one time including: • up to 9 main installation vessels making up to 297 return trips; • up to 14 cargo barges making up to 194 return trips; • up to 9 support vessels making up to 714 return trips; • up to 22 tug/anchor handlers making up to 794 return trips; • up to 6 cable installation vessels making up to 36 return trips; • up to 22 guard vessels making up to 1,488 return trips; • up to 8 survey vessels making up to 464 return trips; • up to 14 crew transfer vessels (CTVs) making up to 3,342 return trips; • up to 10 scour/cable protection installation vessels making up to 3,390 return trips; and • up to 20 resupply vessels making up to 245 return trips. Other activities: • up to 10% of piles are anticipated to require drilling at wind turbine foundations (144 piles) with a maximum drilling duration of 96 days; • up to 32 piles will require drilling at OSPs/Offshore convertor station platforms foundations with a maximum drilling duration of up to 39 days; and • burial of 1,225 km of inter-array cables and 828 km of offshore export cable via jet trenching; along with cable laying and jack up rigs. Maximum offshore construction duration of up to 96 months. **Operation and Maintenance Phase** Vessels used during routine inspections, repairs and replacement of equipment, major component replacement, painting or other	Maximum numbers of vessels on site at any one and largest numbers of round trips during each phase of the Proposed Development and broad range of vessel types representative of vessels to be used during construction, operation and maintenance and decommissioning will result in the greatest potential impact. Range of other activities including maximum timescales (where available) during which activities are conducted.

Potential Impact	Phase[2] C	O	D	Maximum Design Scenario	Justification
				coatings, removal of marine growth, replacement of access ladders, and geophysical surveys; maximum vessels on site at any one time including: • up to 4 CTVs making up to 832 return trips per year; • up to 1 jack up vessel making up to 2 return trips per year; • up to 2 support vessels making up to 26 return trips per year; • up to 1 cable repair vessel making up to 5 return trips per operational lifetime; • up to 2 service operations vessels (SOV, daughter craft) making up to 4 movements within Proposed Development array area per day; • up to 1 cable survey vessel making one return trip per year; and • up to 1 excavator/backhoe dredger making up to 5 return trips over operational lifetime. **Decommissioning Phase** Vessels used for a range of decommissioning activities such as removal of foundations, cables and cable protection. Noise from vessels assumed to be as per vessel activity described for construction phase above.	
Increased risk of injury of marine mammals due to collision with vessels	✓	✓	✓	**Pre-construction Phase** As described for vessel disturbance above. **Construction Phase** As described for vessel disturbance above. **Operation and Maintenance Phase** As described for vessel disturbance above. **Decommissioning Phase** As described for vessel disturbance above.	Maximum numbers of vessels on site at any one and largest numbers of round trips during each phase of the Proposed Development and broad range of vessel types representative of vessels to be used during construction, operation and maintenance and decommissioning will result in the greatest potential impact.
Changes in fish and shellfish communities affecting prey availability[3]	✓	✓	✓	**Construction Phase** Up to 113,974,700 m^2 of temporary subtidal habitat loss/disturbance due to: • use of jack-up vessels during foundation installation, with up to 4 jack-up events per wind turbine and 4 jack-up events per OSPs/Offshore convertor station platforms; • installation of up to 1,225 km of inter-array cables, up to 94 km of interconnector cable, up to 872 km offshore export cables with seabed disturbance width of: up to 25 m for sandwave clearance, up to 25 m for boulder clearance and up to 15 m for cable burial; • sandwave clearance for up to 20% of the Proposed Development export cable corridor length, up to 30% of inter-array cables and OSPs/Offshore convertor station platforms interconnector cables; • Boulder clearance for up to 20% of offshore export cable length, inter-array cables and OSPs/Offshore convertor station platforms interconnector cables; • anchor placement; • offshore export cables installation at the landfall via trenchless burial techniques; • up to 8 exit punches out, each 20 m x 5 m, for removal of up to 8 cables from the landfall; and • clearance of up to 14 UXO. Other impacts on fish and shellfish communities include: • increased SSC and associated deposition from construction activities, such as drilling of 179 foundations, installation of up to 1,225 km of inter-array and up to 872 km of offshore export cables;	Maximum design scenarios described for fish and shellfish receptors (chapter 9) will result in the greatest potential impact.

[3] As presented in maximum design scenario table for the assessment of potential impacts on fish and shellfish ecology (see Table 9.15, volume 2, chapter 9).

Potential Impact	Phase[2] C	O	D	Maximum Design Scenario	Justification
				• injury and/or disturbance to fish and shellfish from underwater noise and vibration as a result of the clearance of up to 14 UXOs and installation of 179 offshore wind turbines and up to 10 OSPs/Offshore convertor station platforms; and. • up to 7,798,856 m^2 of long term habitat loss due to presence of wind turbine and OSPs/Offshore convertor station platforms foundations as well as cable protection for cable crossing. Maximum duration of the offshore construction phase is up to 96 months up to 372 days piling. **Operation and Maintenance Phase** • up to 989,000 m^2 temporary subtidal habitat loss/disturbance due to: major component replacements for wind turbines and OSPs/Offshore convertor station platforms; inter-array, interconnector and offshore export cable repair/reburial events; • increased SSCs and associated sediment deposition from cable repair/reburial events; • up to 7,798,856 m^2 of long term subtidal habitat loss due to presence of: wind turbines on suction caisson foundations and 10 OSPs/Offshore convertor station platforms on jacket foundations with associated scour protection; cable protection associated with inter-array, interconnector and offshore export cables; cable protection for cable crossings; • EMF from subsea electrical cabling due to presence of inter-array and offshore export cables; • colonisation of foundations, scour protection and cable protection leading to long term habitat creation of up to 10,198,971 m^2; and • EMF from presence of up to 1,225 km of 66 kV inter-array cables and up to 872 km of 275 kV High Voltage Alternating Current (HVAC) offshore export cables. **Decommissioning Phase** • up to 34,571,200 m^2 temporary subtidal habitat loss/disturbance due to: use of jack up vessels during decommissioning of wind turbine and OSPs/Offshore convertor station platform foundations; complete removal of inter-array, interconnector and offshore export cables; anchor placement during cable decommissioning; • increased SSCs and associated sediment deposition from: cutting and removal of piled jacket foundations and decommissioning of inter-array, interconnector and offshore export cables; and • up to 7,562,609 m^2 permanent subtidal habitat loss due to complete removal of cable protection and scour protection for inter-array, OSPs/Offshore convertor station platform interconnector and offshore export cables.	

10.8.2. IMPACTS SCOPED OUT OF THE ASSESSMENT

50. Pre-Application consultation (Table 10.9) has been used to facilitate stakeholder engagement on potential impacts to be scoped out of the marine mammal assessment. On the basis of these discussions, baseline environment and the project description outlined in volume 1, chapter 3 of the Offshore EIA Report, a number of potential impacts are proposed to be scoped out of the assessment for Marine Mammals. These have been agreed with key stakeholders through consultation as discussed in volume 1, chapter 5.

51. Additionally, impacts were proposed to be scoped-out in The Berwick Bank Wind Farm Offshore Scoping Report (SSER, 2021a) and no concerns were raised by key consultees. Where discussions with consultees took place after the publication of the Berwick Bank Wind Farm Scoping Opinion (MS-LOT, 2022), these have been discussed with key stakeholders through further consultation (e.g. via Road Map Meetings). These post-scoping discussions are audited in the Marine Mammal Road Map (volume 3, appendix 10.3) or the Audit Document (SSER, 2022d).

52. These impacts are outlined, together with a justification for scoping them out, in Table 10.17. An indication of a phase of the development during which those impacts have a potential to occur is given by ticks and crosses (i.e. during scoping the accidental pollution has been considered as a potential impact during construction and decommissioning (tick), but not during the operation and maintenance phase (cross)).

Table 10.17: Impacts Scoped Out of the Assessment for Marine Mammals (tick confirms the impact is scoped out)

Potential Impact	Phase[4] C	O	D	Justification
Accidental pollution	✓	✗	✓	The impact of pollution including accidental spills and contaminant releases associated with the construction and decommissioning of infrastructure and use of supply/service/decommissioning vessels may lead to direct mortality of marine mammals or a reduction in prey availability, either of which may affect species' survival rates. With implementation of an Environmental Management Plan (including Marine Pollution Contingency Plan (MPCP), see volume 4, appendix 22) and based on evidence from other offshore wind farm consent applications (for example Moray West (Moray West (2018), Inch Cape (Inch Cape Offshore Limited, 2018), Neart Na Gaoithe (Pelagica Environmental Consultancy Ltd., 2018) it is considered that a significant impact within the equivalent extent of a windfarm's array plus buffer area is very unlikely to occur, and a major incident that may impact any species at a population level is considered very unlikely. It was predicted that any impact would be of local spatial extent, short-term duration, intermittent and medium reversibility within the context of the regional populations and therefore not significant in EIA terms. This is considered to be equally applicable to the Proposed Development for which construction will be comparable in scale and operation within the same environment, whilst implementing an appropriate pollution prevention plan. Consultees agreed to scope out this impact for all stages of the Proposed Development during marine mammals Road Map Meeting 1 and Berwick Bank Wind Farm Scoping Opinion (MS-LOT, 2022).
Increased suspended sediment concentrations and associated sediment deposition	✓	✗	✓	Disturbance to water quality as a result of construction and decommissioning operations can have both direct and indirect impacts on marine mammals. Direct impacts include the impairment of visibility and therefore foraging ability of marine mammals which might be expected to reduce foraging success. Marine mammals are well known to forage in tidal areas where water conditions are turbid and visibility conditions poor. For example, harbour porpoise and harbour seals in the UK have been documented foraging in areas with high tidal flows (e.g. Pierpoint, 2008; Marubini *et al*., 2009; Hastie *et al*., 2016); therefore, low light levels, turbid waters and suspended sediments are unlikely to negatively impact marine mammal foraging success. When the visual sensory systems of marine mammals are compromised, they are able to sense the environment in other ways, for example, seals can detect water movements and hydrodynamic trails with their mystacial vibrissae; while odontocetes primarily use echolocation to navigate and find food in darkness. Whilst elevated levels of SSC arising during construction of the offshore wind farm may decrease light availability in the water column and produce turbid conditions, the maximum impact range is expected to be localised with sediments rapidly dissipating over one tidal excursion. In addition, there is likely to be large natural variability in the SSC within the Proposed Development marine mammal study area due to proximity to the Firth of Forth estuary, so marine mammals living here are considered likely to be tolerant of any small scale increases, such as those associated with the construction activities. In summary, the ZoI of increased SSC will be small, particularly in the context of the wider available habitat, and the duration of effects will be short (one tidal excursion). Marine mammal receptors in the Proposed Development marine mammal study area are not considered to be sensitive to increases in SSC as they are likely to be adapted to high natural variation in sediment levels. Therefore, it is proposed that this impact is scoped out of the EIA. Consultees agreed to scope out this impact for all stages of the Proposed Development during marine mammals Road Map Meeting 1 and Berwick Bank Wind Farm Scoping Opinion (MS-LOT, 2022).
Disturbance to seals on land (hauled out) from construction and pre-construction activities	✓	✗	✗	As advised by NatureScot and MS-LOT in their advice on the 2020 Berwick Bank Offshore EIA Scoping Report, it is considered that that the proposed construction activities at the landfall locations and those associated with the cable installation are unlikely to affect any individual seals hauled out at the nearest designated seal haul out site, namely Fast Castle and this impact is proposed to be scoped out of further assessment. This advice was maintained in the 2021 Scoping Opinion provided by MS-LOT.
EMF (from surface laid or buried cables)	✗	✓	✗	Based on the data available to date, there is no evidence of EMF related to marine renewable devices having any impact (either positive or negative) on marine mammals (Copping, 2018). There is no evidence that seals can detect or respond to EMF, however, some species of cetaceans may be able to detect variations in magnetic fields (Normandeau *et al*., 2011). To date, 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, which uses the vibrissal crypts on their rostrum to detect electrical stimuli similar to those generated by small to medium sized fish. However, this has not been shown in any other species of marine mammal and this species does not occur within the Proposed Development marine mammal study area. Consultees agreed to scope out this impact during marine mammals Road Map Meeting 1 and Berwick Bank Wind Farm Scoping Opinion (MS-LOT, 2022).

[4] Ticks indicate impacts with a potential to occur during: C = Construction, O = Operation and maintenance, D = Decommissioning

Potential Impact	Phase[4] C	O	D	Justification
Disturbance to marine mammals from operational noise	×	✓	×	The Marine Management Organisation (Marine Management Organisation, 2014) reviewed post-consent monitoring at offshore wind farms. The Marine Management Organisation found that available data on operational wind turbine noise, from the UK and abroad, in general showed that noise levels from operational wind turbines are low. Further, that the spatial extent of the potential impact of the operational wind turbine noise on marine mammal receptors is generally estimated to be small, with behavioural responses 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 offshore wind farms in Denmark, long term monitoring has shown that both harbour porpoise and harbour seals were sighted regularly within the operational offshore wind farms, 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 offshore wind farm in the Netherlands reported that significantly more porpoise activity was recorded within the offshore wind farm compared to the reference area during the operational phase (Scheidat *et al*., 2011). Other studies at Dutch and Danish offshore wind farms (Lindeboom *et al*., 2011) also suggest that harbour porpoise may be attracted to increased foraging opportunities within operating offshore wind farms. In addition, tagging work by Russell *et al*. (2014) found that some tagged harbour and grey seals demonstrated grid-like movement patterns as these animals moved between individual wind turbines, strongly suggestive of these structures being used for foraging. Other reviews have also concluded that operational wind farm noise will have negligible effects (Madsen *et al*.,2006; Teilmann *et al*., 2006a; Teilmann *et al*., 2006b; CEFAS, 2010; Brasseur *et al*., 2012). In addition, previous modelling by Subacoustech (e.g. Hornsea Project Three EIA, GoBe (2018)) concluded that underwater noise during the operational phase is expected to have a negligible range of influence on any marine receptors. Consultees agreed to scope out this impact during marine mammals Road Map Meeting 1.

10.9. METHODOLOGY FOR ASSESSMENT OF EFFECTS

10.9.1. OVERVIEW

53. The marine mammals assessment of effects has followed the methodology set out in volume 1, chapter 6 of the Offshore EIA Report. Specific to the marine mammals EIA, the following guidance documents have also been considered:

- Guidance for Ecological Impact Assessment in the UK and Ireland. Terrestrial, Freshwater, Coastal and Marine (Chartered Institute of Ecology and Environmental Management (CIEEM), 2018) - these guidelines combine the Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater and Coastal, 2nd edition (2016) and the Guidelines for Ecological Impact Assessment in Britain and Ireland: Marine and Coastal (2010); and
- Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects (Judd, 2012).

54. In addition, the marine mammals assessment of effects has considered the legislative framework as set out in volume 1, chapter 2 of the Offshore EIA Report.

10.9.2. CRITERIA FOR ASSESSMENT OF EFFECTS

55. The process for determining the significance of effects is a two-stage process that involves defining the magnitude of the potential impacts and the sensitivity of the receptors. This section describes the criteria applied in this chapter to assign values to the magnitude of potential impacts and the sensitivity of the receptors. The terms used to define magnitude and sensitivity are based on those which are described in further detail in volume 1, chapter 6 of the Offshore EIA Report.

56. The criteria for defining magnitude in this chapter are outlined in Table 10.18. In determining magnitude within this chapter, each assessment considered the spatial extent, duration, frequency and reversibility of impact and these 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 10.18: Definition of Terms Relating to the Magnitude of an Impact

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

57. The sensitivity of marine mammal IEFs has been defined by an assessment of the ability of a receptor to adapt to a given impact, its tolerance to that impact and its ability to recover back to pre-impact conditions. Tolerance is defined as the susceptibility of a species to disturbance, damage or death, from a specific external factor. Recoverability is the ability of the same species to return to a state close to that which existed before the activity or event which caused change. It is dependent on the ability of the individuals to recover subject to the extent of disturbance/damage incurred. Information on these aspects of sensitivity of the marine mammal IEFs to given impacts has been informed by the best available evidence from scientific research on marine mammals (studies on captive animals as well as observations from field studies). In particular, evidence from field studies of marine mammals during the construction and operation of offshore wind farms (and analogous activities such oil and gas surveys) has been used to inform this assessment of effects. The review of vulnerability 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 10.19.

Table 10.19: Definition of Terms Relating to the Sensitivity of the Receptor

Sensitivity of the Receptor	Description
Very High	No ability to adapt behaviour so that survival and reproduction rates may be affected. No tolerance; effect is very likely to cause a change in both reproduction and survival of individuals. No ability for the animal to recover from the effect.
High	Limited ability to adapt behaviour so that survival and reproduction rates may be affected. Limited tolerance; effect may cause a change in both reproduction and survival of individuals. Limited ability for the animal to recover from the effect.
Medium	Ability to adapt behaviour so that reproduction rates may be affected but survival rates not likely to be affected. Some tolerance; effect unlikely to cause a change in both reproduction and survival rates. Ability for the animal to recover from the effect.
Low	Receptor is able to adapt behaviour so that survival and reproduction rates are not affected. Receptor is able to tolerate the effect without any impact on reproduction and survival rates. Receptor is able to return to previous behavioural states/activities once the impact has ceased.
Negligible	Very little or no effect on the behaviour of the receptor.

58. 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 10.20. As per Guidelines for Ecological Impact Assessment in the UK and Ireland (CIEEM, 2018), the significance of effect is considered with regard to impacts on the structure and function of defined sites, habitats or ecosystems and the conservation status of habitats and species (including extent, abundance and distribution). Assessment of significant effects provided in section 10.11 is quantified with reference to appropriate geographic scales (e.g. species-specific MUs and SCANS III Block R).

59. 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 conclusion is based upon the author's professional judgement as to which outcome delineates the most likely effect. Where professional judgement is applied to quantify final significance from a range, the assessment will set out the factors that result in the final assessment of significance. These factors may include the likelihood that an effect will occur, data certainty and relevant information about the wider environmental context.

60. For the purposes of this assessment:

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

61. 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 10.20: Matrix Used for the Assessment of the Significance of the Effect

		Magnitude of Impact			
Sensitivity of Receptor		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

10.9.3. DESIGNATED SITES

62. Where Natura 2000 sites (i.e. nature conservation sites in Europe designated under the Habitats or Birds Directives[5]) or sites in the UK that comprise the National Site Network (collectively termed 'European sites') are considered, this chapter makes an assessment of the likely significant effects in EIA terms on the qualifying interest feature(s) of these sites as described within section 10.10 of this chapter. The assessment of the potential impacts on the site itself are deferred to the RIAA for the Proposed Development; SSER, 2022d). A summary of the outcomes reported in the RIAA is provided in section 10.15 of this chapter.

63. 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 features of the European site have 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 features of the European site (i.e. a separate assessment for the local or national site features is not undertaken). However, where a local or nationally designated site falls outside the boundaries of a European site, but within the regional marine mammals study area, an assessment of the likely significant effects on the overall site is made in this chapter using the EIA methodology.

10.10. MEASURES ADOPTED AS PART OF THE PROPOSED DEVELOPMENT

64. As part of the Project design process, a number of measures have been proposed to reduce the potential for impacts on marine mammals (see Table 10.21). As there is a commitment to implementing these measures, they are considered inherently part of the design of the Proposed Development 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). These measures are considered standard industry practice for this type of development.

[5] Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora) and Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds.

Table 10.21: Designed in Measures Adopted as Part of the Proposed Development

Designed in Measures Adopted as Part of the Proposed Development	Justification
An outline MMMP (volume 4, appendix 23) will be consulted on and approved by NatureScot and/or MSS approved by MS-LOT and implemented prior to construction, as described in volume 3, appendix 6.3. For the purpose of developing the MMMP, a mitigation zone will be defined based on the maximum predicted injury range from the dual metric noise modelling for any of the modelled scenarios (4,000 kJ for concurrent piling of wind turbines and 4,000 kJ for single piling OSPs/Offshore convertor station platforms) and across all marine mammal species. The MMMP will set out the designed-in measures to apply in advance of and during piling activity. A MMMP will also include geophysical surveys to ensure that appropriate measures are followed in line with JNCC guidance (JNCC, 2017).	The implementation of an approved MMMP will mitigate for the risk of physical or permanent auditory injury to marine mammals within a 'mitigation zone'. The potential to mitigate for injury was considered with respect to the largest potential injury zone across all species (2,319 m based on predictions of injury for minke whale using the 4% reducing to 0.5% conversion factor). The use of an approved MMMP will also minimise the potential for collision risk, or potential injury to, marine mammals. Measures such as visual and acoustic monitoring will be applied. The measures outlined in JNCC guidelines (JNCC, 2017) are designed to reduce the risk of injury to marine mammals during geophysical survey activities.
Implementation of piling soft start and ramp up measures. During piling operations, soft starts will be used. This will involve the implementation of lower hammer energies (i.e. approximately 15% of the maximum hammer energy; see paragraph 85 *et seq.)* at the beginning of the piling sequence before energy input is 'ramped up' (increased) over time to required higher levels.	This measure will minimise the risk of injury to marine mammal and fish species in the immediate vicinity of piling operations, allowing individuals to flee the area before noise levels reach a level at which injury may occur. It is considered that compliance with these guidelines will, in most cases, reduce the risk of injury to marine mammals to negligible levels. More details about piling soft start and ramp up procedure are presented in MMMP (volume 4, appendix 23).
Detonation of UXO using low order techniques.	Low order techniques will be adopted where practicable. Given the small risk that a low order could unintentionally arise in a high order detonation (as per paragraph 297, approximately 10% of the total number of UXOs could result in high order detonation), the MMMP (volume 4, appendix 23) will also include secondary mitigation to reduce the risk of injury from UXO clearance. Measures such as visual and acoustic monitoring will be applied.
Code of Conduct (volume 4, appendix 25) will be issued to all Project vessel operators, requiring them to: • not deliberately approach marine mammals; • keep vessel speed to a minimum; and • avoid abrupt changes in course or speed should marine mammals approach the vessel to bow-ride. Code of Conduct will be adhered to at all times.	To minimise the potential for collision risk, or potential injury to, marine mammals and megafauna.
Development of, and adherence to, an EMP, including MPCP.	To ensure that the potential for release of pollutants during construction, operation and maintenance, and decommissioning phases are minimised. These will likely include designated areas for refuelling where spillages can be easily contained, storage of chemicals in secure designated areas in line with appropriate regulations and guidelines, double skinning of pipes and takes containing hazardous substances, and storage of these substances in impenetrable bunds. The MPCP will ensure that in the unlikely event that a pollution even occurs, that plans are in place to respond quickly and effectively to ensure any spillage is minimised and effects on the environment are ideally avoided or minimised. Implementation of these measures will ensure that accidental release of contaminants from vessels will be avoided or minimised, thus providing protection for marine life across all phases of the Proposed Development.
Development of, and adherence to, an appropriate Code of Construction Practice (CoCP).	Measures within the CoCP have been identified during the design of the onshore and intertidal elements of the Proposed Development as part of the EIA process. They include strategies, control measures and monitoring procedures for managing the potential environmental impacts of constructing the Proposed Development and limiting disturbance from construction activities as far as reasonably practicable.
Development of, and adherence to, a Decommissioning Plan.	The aim of this plan is to adhere to the existing UK and international legislation and guidance. Overall, this will ensure the legacy of the Proposed Development will result in the minimum amount of long-term disturbance to the environment. While this measure has been committed to as part of the Proposed Development, the maximum adverse scenario for the decommissioning phase has been considered in each of the assessments of effects presented in section 10.11.

65. In some cases, particularly where potentially significant effects are identified, there may be additional mitigation measures required that are not "built in" to the Project design ahead of the assessment (secondary mitigation). These are discussed in "Further mitigation and residual effect" and "Future monitoring" paragraphs in section 10.11.

10.11. ASSESSMENT OF SIGNIFICANCE

66. The potential effects arising from the construction, operation and maintenance and decommissioning phases of the Proposed Development are listed in Table 10.16 along with the maximum design scenario against which each impact has been assessed.

67. An assessment of the likely significance of the effects of the Proposed Development on marine mammal receptors caused by each identified impact is given below. As many of the impacts identified for marine mammals relate to underwater noise, the assessment has been informed by subsea noise modelling, the scope of which was agreed through the pre-application consultation (Table 10.9). An overview of the

potential effects of underwater noise on marine mammals as well as the sensitivity of marine mammal groups is provided in paragraph 68 *et seq.* with the approach to the noise modelling assessment given in each impact section. Further detail about noise modelling is provided in volume 3, appendix 10.1.

10.11.1. MARINE MAMMALS AND UNDERWATER NOISE

68. Marine mammals, particularly cetaceans, are capable of generating and detecting sound (Au *et al*., 1974; Bailey *et al*., 2010) and are dependent on sound for many aspects of their lives (i.e. prey identification; predator avoidance; communication and navigation). Increases in anthropogenic noise may consequently lead to a potential effect within the marine environment (Parsons *et al*., 2008; Bailey *et al*., 2010). Richardson *et al*. (1995) described four zones of noise influence which vary with the distance from the source, including: audibility (sound is detected); masking (interfere with detection of sounds and communication); responsiveness (behavioural or physiological response) and injury/hearing loss (tissue damage in the ear).

69. For this study, it is the zones of injury (auditory) and disturbance (i.e. responsiveness) that are considered in the assessment (there is insufficient scientific evidence to properly evaluate masking). The following sections summarise the relevant thresholds for onset of effects and describe the evidence base used to derive them.

Injury

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

71. For the purposes of the assessment of injury the emphasis is on PTS as the appropriate threshold due to the irreversible nature of the effect whereas TTS is temporary and reversible. A likely response of an animal exposed to noise levels that could induce TTS is to flee the ensonified area. It is therefore considered that there is also a behavioural response (disturbance) that overlaps with potential TTS ranges, and animals exposed to noise levels that have the potential to induce TTS are likely to actively avoid hearing damage by moving away from the area. Since derived thresholds for the onset of TTS are based on the smallest measurable shift in hearing (paragraph 70), TTS thresholds are likely to be very precautionary and could result in overestimates of effect ranges. In addition, the assumptions and limitations of subsea noise modelling (e.g. equal energy rule, reduced sound levels near the surface, conservative swim speeds, and use of impulsive sound thresholds at large ranges; see paragraph 94) also lead to an overestimation of effect ranges. Notably, Hastie *et al*. (2019) found that during pile driving there were range dependant changes in signal characteristics with received sound losing its impulsive characteristics at ranges of several kilometres, especially beyond 10 km. For these reasons TTS is not considered a useful predictor of the impacts of underwater noise on marine mammals where ranges exceed more than c. 10 km and therefore, where this is the case (i.e. piling and UXO clearance) TTS is not included in the assessment of significance. To support this reasoning a synthesis of the use of impulsive sound thresholds at large ranges is presented volume 3, appendix 10.1. Ranges for TTS were, however, modelled for completeness for all noise-related impacts and are presented in volume 3, appendix 10.1.

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

- Low frequency (LF) cetaceans (i.e. marine mammal species such as baleen whales with an estimated functional hearing range between 7 Hz and 35 kHz); minke whale is the marine mammal IEF in the LF cetacean group.
- High frequency (HF) cetaceans (i.e. marine mammal species such as dolphins, toothed whales, beaked whales and bottlenose whales with an estimated functional hearing range between 150 Hz and 160 kHz); bottlenose dolphin and white-beaked dolphin are the marine mammal IEFs in the HF cetacean group.
- Very High frequency (VHF) cetaceans (i.e. marine mammal species such as true porpoises, Kogia, river dolphins and cephalorhynchid with an estimated functional hearing range between 275 Hz and 160 kHz); harbour porpoise is the marine mammal IEF in the HF cetacean group.
- Pinnipeds in water (PW) (i.e. true seals with an estimated functional hearing range between 50 Hz and 86 kHz); grey seal and harbour seal are the marine mammal IEFs in the PW group.

73. Injury criteria are proposed in Southall *et al*. (2019) for both impulsive and non-impulsive (continuous) sound and are summarised in Table 10.22 and Table 10.23.

Table 10.22: Summary of PTS Criteria for Impulsive and Non-Impulsive Noise

Hearing Group	Parameter	Impulsive	Non-impulsive
LF cetaceans (minke whale)	Peak, unweighted	219	-
	SEL, LF weighted	183	199
HF cetaceans (bottlenose and white-beaked dolphin)	Peak, unweighted	230	-
	SEL, HF weighted	185	198
VHF cetaceans (harbour porpoise)	Peak, unweighted	202	-
	SEL, VHF weighted	155	173
Phocid Carnivores in Water (PCW) (grey and harbour seal)	Peak, unweighted	218	-
	SEL, PW weighted	185	201

Table 10.23: Summary of TTS Criteria for Impulsive and Non-impulsive Noise

Hearing Group	Parameter	Impulsive	Non-impulsive
LF cetaceans (minke whale)	Peak, unweighted	213	-
	SEL, LF weighted	168	179
HF cetaceans (bottlenose and white-beaked dolphin)	Peak, unweighted	224	-
	SEL, HF weighted	170	178
VHF cetaceans (harbour porpoise)	Peak, unweighted	196	-
	SEL, VHF weighted	140	153
PCW (grey and harbour seal)	Peak, unweighted	212	-

Hearing Group	Parameter	Impulsive	Non-impulsive
	SEL, PW weighted	170	181

74. To carry out exposure calculations (SEL_{cum} metric) the noise modelling assessment made a simplistic assumption that an animal would be exposed over a 24-hour period and that there would be no breaks in activity during this time. It was assumed that an animal would swim away from the noise source at the onset of activity at a constant rate and subsequently, conservative species specific swim speeds were incorporated into the model following agreement with statutory nature conservation bodies (swim speeds presented during Road Map Meeting 2 with no queries raised - see volume 3, appendix 10.2; Table 10.24).

Table 10.24: Swim Speeds Assumed for Exposure Modelling (SEL_{cum}) for Marine Mammal IEFs

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

Disturbance

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

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

77. For the assessment of piling noise, subsea noise modelling was undertaken using the dose-response approach with $SEL_{single\text{-}strike}$ (SEL_{ss}) contours modelled in 5 dB increments. For all other noise impacts the simple threshold approach using the NMFS criteria (NMFS, 2005) was adopted. Disturbance criteria are presented in the following table (Table 10.31).

Table 10.25: Disturbance Criteria for Marine Mammals Used in this Study

Effect	Non-Impulsive Threshold	Impulsive Threshold (other than Piling)	Impulsive Threshold (Piling)
Mild disturbance (all marine mammals)	-	140 dB re 1µ Pa (rms)	Based on SEL 5 dB contours
Strong disturbance (all marine mammals)	120 dB re 1µ Pa (rms)	160 dB re 1µ Pa (rms)	Based on SEL 5 dB contours

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

79. For these reasons, neither a threshold approach nor a dose-response function was provided in the original guidance (Southall *et al*., 2007) and subsequently the recent recommendations by Southall *et al*. (2021) also steer away from a single overarching approach. Instead, Southall *et al*. (2021) proposes a framework for developing probabilistic response functions for future studies. The paper suggests different contexts for characterising marine mammal responses for both free ranging and captive animals with distinctions made by sound sources (i.e. active sonar, seismic surveys, continuous/industrial noise 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; and
- foraging – search, pursuit, capture and consumption.

80. Even where studies have been able to assign responses to these categories based on acute exposure there is still limited understanding of how longer term (chronic) exposure could translate into population-level effects. To explore this, Southall *et al*. (2021) reported observations from long term whale watching studies and suggested that there were differences in the ability of marine mammals to compensate for long term disturbance which related to their breeding strategy. Mysticetes are capital breeders -

accumulating energy in their feeding grounds and transferring this to calves in their breeding ground – and their ability to compensate for chronic exposure to noise will depend on a range of ecological factors. Such factors include the relative importance of the disturbed area and prey availability within their wider home range, individual exposure history, and the presence of concurrent disturbances in other areas of their range. Animals may be able to compensate for short term disturbances by feeding in other areas, for example, which would reduce the risk of longer-term population consequences. Christiansen and Lusseau (2015) studied the effect of whale watching on minke whales in Faxafoi Bay, Iceland and found no significant long-term effects on vital rates although years with low sandeel density led to increased exposure to whale watching as whales were forced to move into disturbed areas to forage. Odontocetes, however, may be more vulnerable to whale watching compared to mysticetes due to their more localised, and often, coastal home ranges. Bejder *et al*. (2006) documented a decrease in local abundance of bottlenose dolphin which was associated with an increase in whale watching in a tourist area compared to a control area.

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

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

- Conservative assumptions in the marine mammal baseline (e.g. use of seasonal density peaks) (Table 10.13);
- Conservative assumptions in the maximum design scenario for the project parameters (Table 10.16), and;
- Conservative assumptions in the subsea noise modelling (paragraph 94).

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

10.11.2. ASSESSMENT OF IMPACTS AND MITIGATION

INJURY AND DISTURBANCE FROM ELEVATED UNDERWATER NOISE DURING PILING

84. Pile driving during the construction phase of the Proposed Development has the potential to result in elevated levels of underwater noise that are detectable by marine mammals above background levels, and could result in injury or behavioural effects on marine mammal IEFs. A detailed underwater noise modelling assessment has been carried out to investigate the potential for injury and behavioural effects on marine mammal IEFs as a result of piling (impulsive sounds), using the latest assessment criteria (volume 3, appendix 10.1).

Summary of Noise Modelling (Piling)

85. With respect to the SPL_{pk} metric, the soft start initiation is the most relevant noise source and period, as this is the range at which animals may potentially experience injury from the initial strike of the hammer, after which point it is assumed that they will move away from the noise source. Secondly, injury ranges were predicted for marine mammals exposed to impulsive noise from multiple hammer strikes over a prolonged period (i.e. using the SEL_{cum} metric); the assumption being that a marine mammal exposed to lower noise levels over a prolonged period (as it moves away from the source) could experience auditory injury. The maximum injury ranges for each species have been provided with reference to the largest impact range from the dual criteria approach as outlined in paragraph 72 *et seq.*, and a proposed marine mammal mitigation zone has been determined on the basis of the largest range across all species (see paragraph 243 *et seq.*).

86. Taking a precautionary approach, in line with SNCBs advice as discussed during Road Map Meetings (volume 3, appendix 10.3) and via the Scoping Opinion (Marine Scotland, 2022), the Subsea Noise assessment considered a range of different conversion factors (the amount of hammer energy converted into received sound by marine mammal receptors): 1% constant, 4% reducing to 0.5% and 10% reducing to 1%.

87. A detailed study was undertaken reviewing noise modelling methodologies across different UK offshore wind farms and investigating energy conversion factors for determining sound source levels during piling. Published literature on energy conversion factors were explored together with available noise measurements taken during offshore wind farm construction and the results presented as an evidence-based, peer-reviewed report (volume 3, appendix 10.1, annex A). The study recommended that the most representative and precautionary conversion factor was 4% reducing to 0.5% as piling progresses. However, a sensitivity assessment was also undertaken to compare the results of noise modelling for different conversion factors requested by consultees (volume 3, appendix 10.1, annex B). Subsequently, considering the evidence-base and the results of the sensitivity assessment, a precautionary approach was adopted for the marine mammal assessment of effects whereby both a conversion factor of 4% reducing to 0.5% and the 1% constant throughout the piling period has been taken forward to the quantitative assessment for marine mammals. As requested by consultees, a third conversion factor of 10% reducing to 1% was also quantified with respect to effects on marine mammal receptors, although not taken forward to the assessment of effects as it was determined to be overly conservative and therefore not realistic. Volume 3, appendix 10.5 to this chapter presents a comparison of the numbers of animals affected for all three conversion factors scenarios. Additionally, as requested by consultees during Road Map Meeting 4 (volume 3, appendix 10.3), supplementary information with results for 4% constant and 10% constant conversion factor was added to the sensitivity analysis (volume 3, appendix 10.1, annex B) and conversion factor appendix (volume 3, appendix 10.5). A more detailed overview of conversion factors is provided in paragraph 102 *et seq*.

88. The scenarios modelled were based on the absolute maximum hammer energy (4,000 kJ) and a realistic maximum hammer energy (3,000 kJ). The assessment has been carried out at two locations on opposite sides of the Proposed Development array area, chosen to represent extremes of location (points closest and furthest away from the shoreline; see volume 3, appendix 10.1 for more details). These are represented by the indicative wind turbine foundation locations wind turbine 40 and wind turbine 135 (used in the assessment of underwater noise impacts for all species, except bottlenose dolphin, as these represent the largest area of impact, Figure 10.10) or wind turbine 1 and wind turbine 179 (used in the assessment of underwater noise impacts for bottlenose dolphin due to proximity to the areas of high coastal density, Figure 10.13).

89. For piling at wind turbines it is assumed that two vessels would pile concurrently, and two scenarios were modelled in this respect:

- separation distance of 1.78 km (minimum distance between foundations) would result in the greatest potential for injury since animals could be exposed to sound from both rigs at relatively high levels; and
- separation distance of c. 50 km (maximum separation distance between vessels) would result in the maximum area of disturbance since the overlap between disturbed areas would be smaller compared to vessels piling close together.

90. Using the equation below (see volume 3, appendix 10.1), a broadband source level value was evaluated for the noise emitted during impact pile driving operation in each operation window.

$$\text{SEL} = 120 + 10\,log_{10}\left(\frac{\beta E C_0 \rho}{4\pi}\right).$$

91. In this equation, β is the energy transmitted from the pile into the water column, E is the hammer energy employed in joules, C_0 is the speed of sound in the water column, and ρ is the density of the water. From the SEL result calculated using the equation above, source-level spectra can also be calculated for different third octave frequency bands.

92. Following a noise modelling workshop to test sensitivities of different scenarios, the piling campaign was developed with a low hammer energy and slow initiation phase in order to provide designed in measures to reduce the potential risk of injury. Four scenarios were investigated in the subsea noise modelling assessment and are summarised as follows:

- wind turbine foundations (piled jacket) maximum design scenario - 24 MW wind turbines using an absolute maximum hammer energy of 4,000 kJ for the longest possible duration (up to ten hours);
- wind turbine foundations (piled jacket) realistic design scenario - 24 MW wind turbine using a realistic average maximum hammer energy of 3,000 kJ for a realistic maximum duration (up to nine hours);
- OSPs/Offshore convertor station platform foundations (jacket) maximum design scenario – using a maximum hammer energy of 4,000 kJ for a duration of up to eight hours; and
- OSPs/Offshore convertor station platform foundations (jacket) realistic design scenario – using a maximum hammer energy of 3,000 kJ for a duration of up to seven hours.

93. The marine mammal assessment was based on the maximum design scenario with piling at a maximum energy of 4,000 kJ for both wind turbine foundations and OSPs/Offshore convertor station platform foundations. However, since piling is unlikely to reach and maintain the absolute maximum hammer energy of 4,000 kJ at all locations, results for a realistic design scenario were also provided for context using an average maximum hammer energy of 3,000 kJ for both foundations. Results for all scenarios presented in paragraph 92 including details of the hammer energies, strike rate and duration, are presented in Tables 5.7 to 5.8 in volume 3, appendix 10.1. There will be a maximum of two piling events at any one time and subsea noise modelling assumed concurrent piling at two wind turbine foundations as a maximum design scenario. This was due to the distances between wind turbines (i.e. maximum spatial separation) as well as the longer duration of piling at wind turbine foundations compared to OSPs/Offshore convertor station platform foundations (Table 10.16). Installation does not, however, preclude a concurrent piling at a wind turbine foundation and OSPs/Offshore convertor station platform foundation but this scenario is captured in the maximum design scenario for concurrent piling at two wind turbine foundations. Results presented in the chapter are therefore for concurrent piling at two wind turbine foundations and single piling at wind turbine or OSPs/Offshore convertor station platform foundations.

94. A number of conservative assumptions were adopted in the subsea noise model that resulted in a precautionary assessment (volume 3, appendix 10.1). These are summarised here:

- The modelling assumed that the maximum hammer energy would be reached and maintained for 195 minutes at all locations, whereas this is unlikely to be the case based on examples from other offshore wind farms (e.g. Beatrice Offshore Wind Farm where the mean actual hammer energy averages were considerably lower than the maximum design scenario assessed in the ES and only six out of 86 asset locations reached maximum hammer energy (Beatrice, 2018)).
- The soft start procedure simulated does not allow for short pauses in piling (e.g. for realignment) and therefore the modelled SEL_{cum} is likely to be an overestimate since, in reality, these pauses will reduce the noise exposure that animals experience whilst fleeing.
- The modelling assessment assumed that animals swim directly away from the noise source at constant and conservative average speeds based on published values (Table 10.30). This is likely to lead to overestimates of the potential range of effect where animals exceed these speeds. For example, Otani *et al.* (2000) note that horizontal speed for harbour porpoise can be significantly faster than vertical speed and cite a maximum speed of 4.3 m/s. Similarly, Leatherwood *et al.* (1988) reported harbour porpoise swim speeds of approximately 6.2 m/s. For minke whale speeds of up to 4.2 m/s have been reported during acoustic deterrent exposure experiments on free ranging animals (McGarry *et al.*, 2017).
- The use of the SEL_{cum} metric is described as an equal energy rule where exposures of equal energy are assumed to produce the same noise-induced threshold shift regardless of how the energy is distributed over time. This means that for intermittent noise, such as piling, the equal-energy rule overestimates the effects since the quiet periods between noise exposures will allow some recovery of hearing compared to continuous noise.
- The model overestimates the noise exposure an animal receives since it does not account for any time that marine mammals spend at the surface and the reduced sound levels near the surface.
- Due to a combination of factors (e.g. dispersion of the waveform, multiple reflections from sea surface and seafloor, and molecular absorption of high frequency energy), impulsive sounds are likely to transition into non-impulsive sounds at distance from the sound source with empirical evidence suggesting such shifts in impulsivity could occur markedly within 10 km from the sound source (Hastie *et al.,* 2019) (see volume 3, appendix 10.1). Since the precise range at which this transition occurs is unknown, noise models still adopt the impulsive thresholds at all ranges which is likely to lead to an overestimate of effect ranges at larger distances (tens of kilometres) from the sound source.

95. A final scenario was modelled to include the use of an ADD activated for a period of 30 minutes prior to initiation of piling to illustrate the potential efficacy of using this as a secondary mitigation measure (see paragraph 243 *et seq.* in section 10.11). The injury scenarios with and without use of ADDs were suggested by NatureScot in representations for the 2020 Berwick Bank Scoping Opinion (MS-LOT, 2021).on 07 October 2020. Therefore, additional noise modelling was undertaken to determine whether the potential for injury to marine mammals would be reduced through the application of ADDs.

Dose response

96. Empirical evidence from monitoring at offshore wind farms during construction suggests that pile driving is unlikely to lead to 100% avoidance of all individuals exposed, and that there will be a proportional decrease in avoidance at greater distances from the pile driving source (Brandt *et al*., 2011). This was demonstrated at Horns Rev Offshore Wind Farm, where 100% avoidance occurred in harbour porpoises at up to 4.8 km from the piles, whilst at greater distances (10 km plus) the proportion of animals displaced reduced to < 50% (Brandt *et al*., 2011). Similarly, Graham *et al*. (2019) used empirical evidence collected during piling at the Beatrice Offshore Wind Farm (Moray Firth, Scotland) to demonstrate that the probability of occurrence of harbour porpoise (measured as porpoise positive minutes) increased exponentially moving further away from the noise source (Figure 10.6). Importantly, Graham *et al*. (2019) demonstrated that the response of harbour porpoise to piling diminished over the piling phase such that, for a given received noise level or at a given distance from the source, there were more detections of animals at the last piling location compared to the first piling location (Figure 10.6).

97. Similarly, a telemetry study undertaken by Russell *et al*. (2016) investigating the behaviour of tagged harbour seals during pile driving at the Lincs Offshore Wind Farm in the Wash found that there was a proportional response at different received noise levels. Dividing the study area into a 5 km x 5 km grid, the authors modelled SEL_{ss} levels and matched these to corresponding densities of harbour seals in the same grids during non-piling versus piling periods to show change in usage. The study found that there was a significant decrease in usage (abundance) during piling at predicted received SEL levels of between 142 dB and 151 dB re 1 µPa²s.

98. A dose response curve was applied to this assessment to determine the number of animals that may potentially respond behaviourally to received noise levels during piling. Unweighted SEL_{ss} contours were plotted in 5 dB isopleths in decreasing increments from 180 dB to 120 dB re.1 µPa²s using the highest modelled received noise level for 4% reducing to 0.5% conversion factor and 1% constant conversion factor.

99. To adopt the most precautionary approach, the dose response contours were plotted in Geographical Information System (GIS) for all modelled locations and the location selected for assessment was the one whereby the contours covered the greatest spatial area, thereby representing the maximum adverse scenario. The areas within each 5 dB isopleth were calculated from the spatial GIS map and a proportional expected response, derived from the dose response curve for each isopleth area, was used to calculate the number of animals potentially disturbed. These numbers were subsequently summed across all isopleths to estimate the total number of animals disturbed during piling. The number of animals predicted to respond was based on species specific densities as agreed with statutory consultees (Table 10.13).

100. For harbour porpoise the dose-response curve was applied from the first location modelled as shown by Graham *et al*. (2017) where the probability of response approaches zero at c. 120 dB SEL_{ss}. In the absence of species-specific data for other cetacean species the same dose response curve was assumed to apply to all cetacean IEFs in this assessment (Figure 10.6).

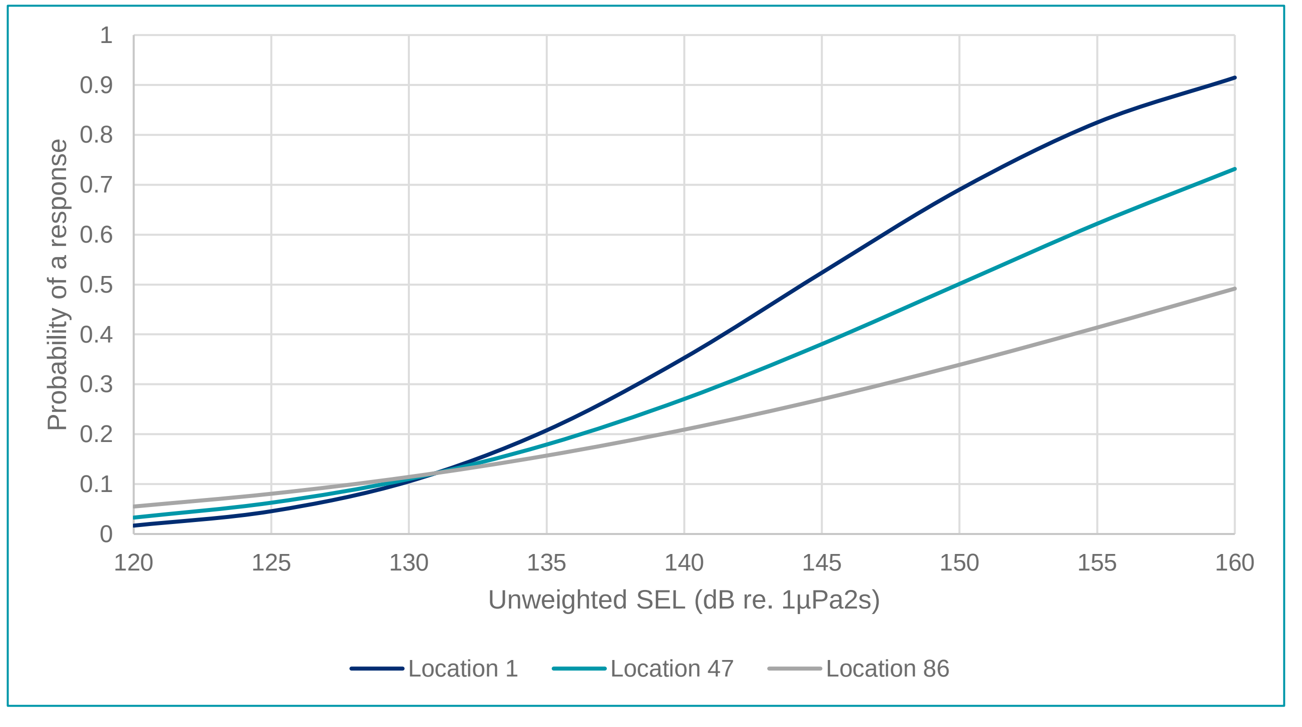


Figure 10.6: The Probability of a Harbour Porpoise Response (24 h) in Relation to the Partial Contribution of Unweighted Received Single-Pulse SEL for the First Location Piled (Purple Line), the Middle Location (Teal Line) and the Final Location Piled (Grey Line). Reproduced with Permission from Graham *et al*. (2019)

101. For harbour seal and grey seal the most appropriate dose response curve was derived from the Russell *et al*. (2017) study which has been previously applied to other Offshore Wind Farm assessments in the UK (e.g. Hornsea Project Three (GoBe, 2018a) and Seagreen optimised design (Seagreen Wind Energy, 2018)). In the Russell *et al*. (2017) study the highest received level at which a response was detected was at 135 dB SEL_{ss} with a zero probability of response measured at 130 dB SEL_{ss} (Figure 10.7).

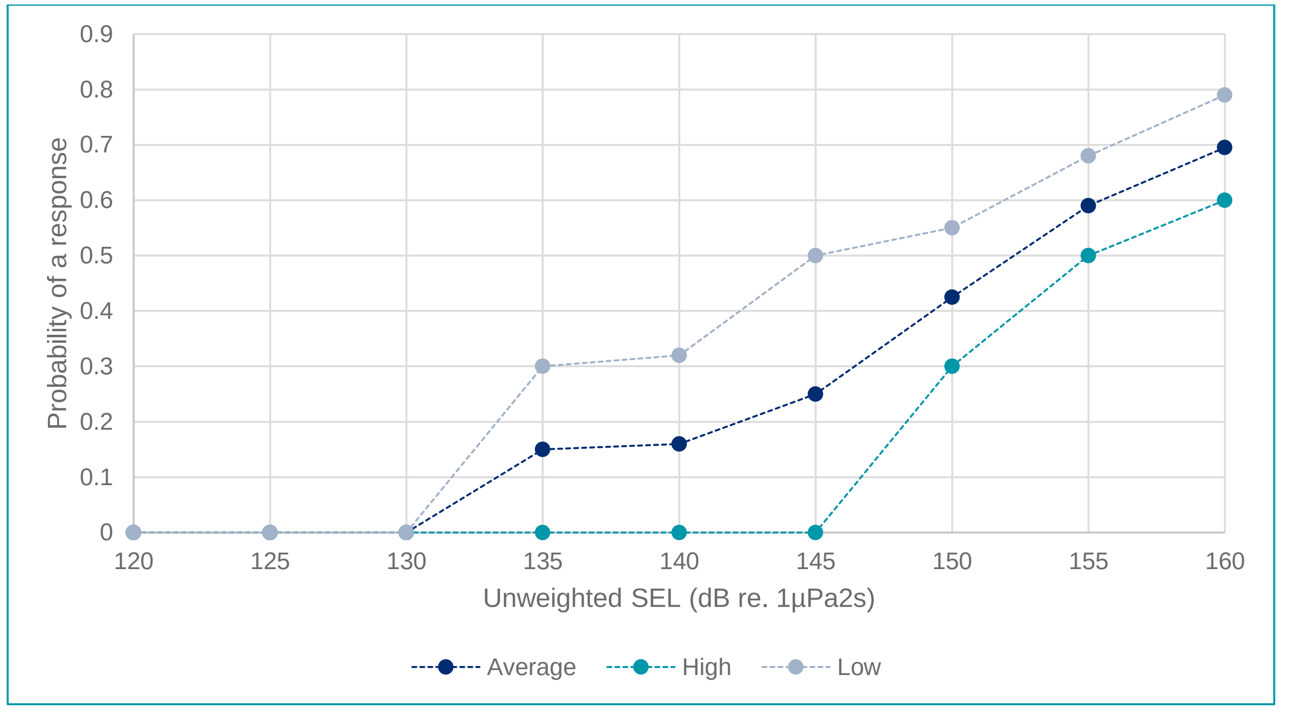


Figure 10.7: The Predicted Percentage Change in Seal Usage During Piling (Compared to Non-piling Periods) in Relation to Unweighted SEL at 5 dB Increments. Source: Russell *et al*. (2017)

<u>Conversion Factors</u>

102. At the request of MS-LOT, a range of conversion factors – 1% constant, 4% reducing to 0.5% and 10% reducing to 1% - have been modelled with respect to how much of the hammer energy is converted into received sound. Based on a comprehensive, peer-reviewed study, it was recommended that 4% reducing to 0.5% is most representative of a precautionary estimate of the conversion factor for the type of hammer to be used at the Proposed Development. A summary of the reasoning behind this conclusion is provided in paragraph 103 *et seq.* with full detail given in the Subsea Noise Technical Report (volume 3, appendix 10.1, annex A).

103. The study on conversion factors (volume 3, appendix 10.1, annex A) found that theoretical values for representative conversion factors were likely to reach an upper limit of 1.5% for an above water hammer throughout a piling sequence with a conversion factor of 1% being typical throughout the majority of the piling (as estimated from in field measurements e.g. Dahl and Reinhall, 2013). Several of the offshore wind farms in Scotland assessed impacts on marine mammals based on subsea noise modelling using 0.5% constant conversion factor (Inch Cape Offshore Ltd, 2018; Moray West, 2018). However, the 1% constant conversion factor is deemed representative of the theoretical average based on field measurements and was also included more recently alongside a 0.5% conversion factor for the

Seagreen Offshore Wind Farm (revised design) in the outer Firth of Forth (although noting it was presented for context only with 0.5% conversion factor adopted in the main assessment) (Seagreen, 2018).

104. There is, however, likely to be differences in conversion factors depending on the type of hammer used. The use of a submersible hammer, as opposed to an above water hammer, can result in a conversion factor that varies with pile penetration depth. Since the piling at the Proposed Development is likely to involve a partially submersible hammer, the literature review explored the conversion factors that may be applicable in this situation. A key study cited in the review was by Lippert *et al.,* (2017) where both modelled and measured data were used to estimate a conversion factor of between 2% and 0.5% for a partially submersible hammer. In this study the modelled and measured data were strongly correlated suggesting that the estimated conversion factors were very representative. Nevertheless, it was recognised that for the Lippert *et al*. (2017) study a significant proportion of the pile was above water at the start of the piling sequence which could have reduced the apparent conversion factor compared to a situation where the pile starts just above the water line. Assuming that the energy radiated into the water is approximately proportional to the length of pile which is exposed to the water then the conversion factor at the start of piling from the Lippert study can be estimated to be approximately 3.5% (see volume 3, appendix 10.1, annex A). Thus, the 4% conversion factor requested by SNCBs is considered to be close to, but more precautionary, than the empirically derived value based on the Lippert *et al.,* (2017) study.

105. The study on conversion factors (volume 3, appendix 10.1, annex A) found that a conversion factor of 10% was likely to be over precautionary and therefore more likely to lead to an overestimate of effect ranges, particularly considering the transition from impulsive to continuous noise over distance from the source. The 10% reducing conversion factor was based upon a study conducted at the Beatrice Offshore Wind Farm for a fully submersible hammer which suggested that higher conversion factors were found for longer exposed lengths of pile towards the start of the piling and reduced to 1% as the pile penetrated further into the seabed (Thompson *et al.,* 2020). However, there were large discrepancies between the noise modelling and real-world propagation particularly at further distances from the pile. By reanalysing the data from the Beatrice Offshore Wind Farm, it was determined that, at closer distances the modelled and measured levels were closer in value and suggested a conversion factor closer to 5% rather than the 10% cited in the study (see section 3.3.2 of volume 3, appendix 10.1, annex A for more details)

106. Acknowledging that the conversion factor of 10% reducing to 1% as unrealistic and likely to be over precautionary, the sensitivity assessment found that for the peak pressure metric (SPL_{pk}) the maximum injury ranges for all species were derived using the 1% conversion factor as opposed to the 4% reducing to 0.5% conversion factor. This is because the higher conversion rate for the 4% reducing to 0.5% conversion factor occurs when the hammer is at its lowest energy at the start of the piling sequence, so the highest estimated SPL_{pk} levels are later in the piling sequence once the conversion factor has reduced. In contrast, with a constant 1% conversion factor throughout the piling sequence, the SPL_{pk} ranges increase throughout the piling sequence with increasing hammer energy.

107. As previously, discounting the conversion factor of 10% reducing to 1% as over-precautionary for the cumulative exposure metric (SEL_{cum}), the maximum injury ranges for all species were derived using both the 4% reducing to 0.5% conversion factor and 1% constant conversion factor. Since the noise modelling for injury adopts a dual metric approach using both SPL_{pk} and SEL_{cum} the most precautionary approach was to assess the greatest injury range using either metric and considering both conversion factors. With the exception of minke whale, the maximum injury ranges for all species were predicted using the 1% constant conversion factor throughout the piling period and were based on the SPL_{pk} metric. For minke whale (a low frequency cetacean) the maximum injury range was predicted using the SEL_{cum} metric on the basis of the 4% reducing to 0.5% conversion factor. The number of animals affected were subsequently estimated on this basis and differs by species hearing group. This was to ensure that for mitigation purposes the most precautionary approach was adopted. The topic of different hearing frequencies is covered in volume 3, appendix 10.2.

108. In terms of behavioural effects, the 1% constant conversion factor was found to result in the highest SEL_{ss} at any point over the piling sequence compared to the 4% reducing to 0.5% conversion factor and therefore resulted in the largest potential effect area (Figure 10.8). The reason for this is that the maximum SEL for the 1% constant scenario is at the end of the piling sequence, which is when the hammer energy is maximum (i.e. up to 4,000 kJ) because for a constant conversion factor of 1% the SEL will increase with increasing hammer energy (Figure 10.9). This is not the case for the 4% reducing to 0.5% scenario as in this instance, the highest SEL occurs during initiation as the 4% conversion factor at this point leads to a higher SEL_{ss} than at any other point during the piling sequence (Figure 10.9). The SEL_{ss} is an unweighted metric and therefore there is no difference in modelled contours by marine mammal hearing group.

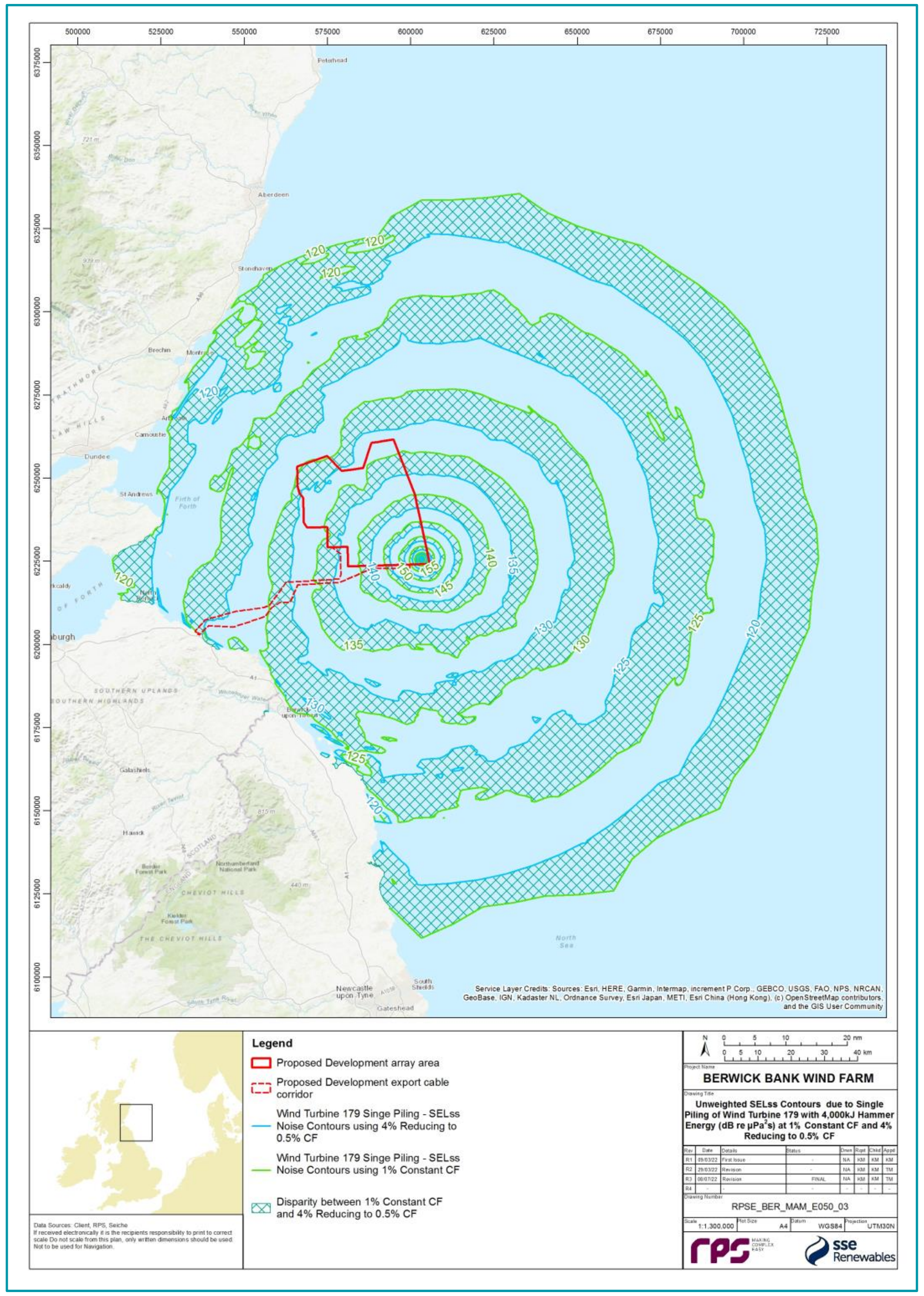


Figure 10.8: An Example of Unweighted SEL_{ss} Contours due to Single Piling with 4,000 kJ Hammer Energy at 1% Constant Conversion Factor and 4% Reducing to 0.5% Conversion Factor

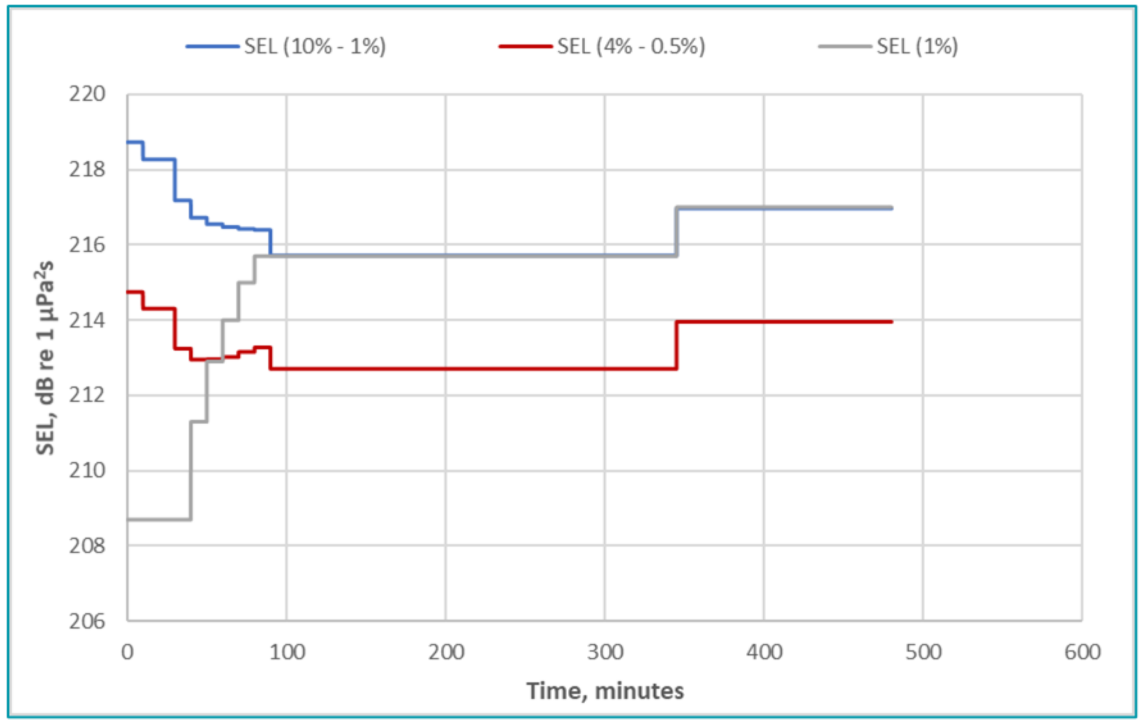


Figure 10.9: SEL_{ss} Throughout the Piling for 1% Constant Conversion Factor, 4% Reducing to 0.5% Conversion Factor and 10% Reducing to 1% Conversion Factor

109. Although not considered as part of the assessment of effects for the reasons described above (paragraph 105), for completeness the dose-response contours were also plotted for the 10% reducing to 1% conversion factor to allow estimates of the numbers of animals potentially disturbed by this scenario. The results are presented in volume 3, appendix 10.5.

Summary of Interim Population Consequences of Disturbance (iPCoD) modelling

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

111. Expert elicitation is a widely accepted process in conservation science whereby the opinions of many experts are combined when there is an urgent need for decisions to be made but a lack of empirical data with which to inform them. In the case of iPCoD, the marine mammal experts were asked for their opinion on how changes in hearing resulting from PTS and behavioural disturbance (equivalent to a score of 5* or higher on the 'behavioural severity scale' described by Southall *et al*. (2007)) associated with offshore renewable energy developments affect calf and juvenile survival and the probability of giving birth (Harwood *et al*., 2014). Experts were asked to estimate values for two parameters which determine the shape of the relationships between the number of days of disturbance experienced by an individual and its vital rates, thus providing parameter values for functions that form part of the iPCoD model (Harwood *et al*., 2014).

112. The iPCoD model simulates the mean population difference over time for an impacted *versus* and unimpacted population to provide comparison of the type of changes that could occur resulting from natural environmental variation, demographic stochasticity[6] and human-induced disturbance. The results are summarised in relation to the forecasted population size over time with forecasts made at certain timepoints (e.g. two, seven, 13, 19 and 25 years) after piling commences. In addition, the model calculates the ratio of the unimpacted to the impacted population size at these timepoints. A caveat of this model, however, is that the model does not account for density dependence and therefore the forecasts may be unrealistic as they assume that vital rates in the population will not alter as a result of density dependent factors (e.g. competition).

113. Whilst there are many limitations to this process, iPCoD modelling was requested by statutory consultees as part of the offshore EIA Scoping process as it represents the best available approach for the species considered in this assessment (Table 10.9). In addition, any uncertainties have been offset as far as possible by adopting a precautionary approach at all stages of the assessment from the maximum design parameters in the project envelope, conservatism in the subsea noise model and adoption of precautionary estimates to represent the densities of key species. Thus, the result from the iPCoD modelling undertaken for the Proposed Development is considered to be inherently cautious and should be interpreted as such.

114. Population modelling using iPCoD was carried out for the following species (agree through with marine mammal Road Map process) due to the potential number of animals affected relative to the relevant MU populations (and SCANS III abundances for harbour porpoise and minke whale):

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

Construction Phase

Magnitude of Impact

115. The assessment of magnitude with respect to auditory injury is presented paragraph 116 *et seq.* based on a species-specific basis, where the maximum adverse scenario is identified for each species (i.e. based on the dual metrics (SPL_{pk} and SEL_{cum}) and whichever of the two conversion factors (1% constant and 4% reducing to 0.5%) results in the largest effect range). The effect ranges for injury presented in the quantitative assessment considered designed-in measures in the form of low hammer initiation and soft start ramp up. The assessment of magnitude for behavioural disturbance presented in paragraph 137 *et seq.* is based on the 1% constant conversion factor.

Auditory injury

Harbour porpoise

116. The maximum range for injury to harbour porpoise was estimated as 449 m based on SPL_{pk} and using the 1% constant conversion factor (Table 10.26; see volume 3, appendix 10.5 for estimates using a range of conversion factors). The effect range is based on SPL_{pk} for the maximum hammer energy but noting that during soft start initiation this range will be considerably smaller. The most conservative number of individuals that could be potentially injured within the maximum range of 449 m, based on the peak seasonal densities from site-specific survey data and concurrent piling of wind turbines at 4,000 kJ, was estimated as less than one harbour porpoise.

117. To further reduce the potential for injury, designed-in measures will be adopted as part of a MMMP (Table 10.21). These measures will involve the use of visual and acoustic searches over a pre-defined mitigation zone (see volume 4, appendix 23). The 449 m falls within the standard JNCC mitigation zone of 500 m (JNCC, 2010a). There are, however, often difficulties in detecting marine mammals (particularly harbour porpoise) over large ranges (McGarry *et al*., 2017). Visual surveys note that there is often a significant decline in detection rate with increasing sea state (Embling *et al*., 2010; Leaper *et al*., 2015).Additional mitigation applied in the form of ADDs will be applied as secondary mitigation further minimise any residual risk of injury subject to the limitations highlighted above (see paragraph 243 *et seq.* for further details).

118. The total duration of piling is estimated at over 16,368 hours (wind turbines and OSPs/Offshore convertor station platforms) for the absolute maximum temporal scenario. Up to five piles per 24-hour period will be installed at wind turbine foundations (assuming concurrent piling with two vessels) and up to three piles will be installed per 24 hours at OSPs/Offshore convertor station platforms/ Offshore convertor station platform foundations (assuming a single piling vessel). It is anticipated that piling could occur for up to 372 days during construction of foundations (wind turbines and OSPs/Offshore convertor station platform). This will be intermittent over a 52-month piling phase within the total construction period of 96 months.

119. Harbour porpoise typically live between 12 and 24 years and give birth once a year (Fisher and Harrison, 1970). The duration of piling could potentially overlap with a maximum of five breeding cycles. However, it is worth noting that piling will be intermittent and will occur over small timespan (372 days) within piling phase (52 months). The duration of the effect in the context of the life cycle of harbour porpoise is classified as medium term, as the risk could occur over a meaningful proportion of the lifespan of these species.

Table 10.26: Summary of SPL_{pk} and SEL_{cum} Injury Ranges and Areas of Effect for Harbour Porpoise due to Impact Piling for Wind Turbine and OSPs/Offshore Convertor Station Platform Jacket Foundations (Absolute Maximum Hammer Energy) Using 1% Constant Conversion Factor

Scenario (4,000 kJ)/Threshold	Spatial Scale: Range of Effect (m)	Spatial Scale: Area of Effect (km^2)	Temporal Scale: Duration per Pile (hours)	Temporal Scale: Total Number of Piling Days
Concurrent Piling (Wind Turbine)				
SPL_{pk} 202 dB re 1 µPa	449	0.633	10	286.4
SEL_{cum} 155 dB re 1 µPa^{2}s	201	0.127		
Single Piling (Wind Turbine/OSPs/Offshore convertor station platform)				
SPL_{pk} 202 dB re 1 µPa	449	0.633	8	85.3
SEL_{cum} 155 dB re 1 µPa^{2}s	104/103	0.033		

120. With designed-in measures in place including soft start and an MMMP, the magnitude of the impact would result in a low risk of injury as the scale of effects (range and number of animals potentially injured) is small (paragraph 116). Considering the duration of the impact the risk (albeit very low) could occur over the medium term. The magnitude of the assessment has been, conservatively, concluded considering the limitations in the efficacy of the pre-start visual and acoustic monitoring within respect to the potential variability of the sea conditions (sea state and visibility) at the time of piling.

[6] Demographic stochasticity refers to variability in population growth rates arising from random differences among individuals in survival and reproduction.

121. The impact (elevated underwater noise from piling) is predicted to be of local spatial extent, medium term duration, intermittent and low reversibility (PTS). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Bottlenose dolphin and white-beaked dolphin

122. The maximum range for injury to bottlenose and white-beaked dolphin was estimated as 43 m based on SPL_{pk} and using the 1% constant conversion factor (Table 10.27; see volume 3, appendix 10.5 for estimates using a range of conversion factors). Therefore, the spatial extent of PTS will be localised for all piling scenarios. Considering the most conservative scenario, which is the highest coastal bottlenose dolphin density (for outer Firth of Tay region, see volume 3, appendix 10.2) and full hammer energy, there will be less than one animal that could be potentially injured within the maximum range of 43 m. The same applies to white-beaked dolphins, as considering the most conservative scenario (concurrent piling of wind turbines at 4,000 kJ), less than one animal could be potentially injured.

123. It is worth noting that this injury range will not overlap with the coastal areas where the highest density of bottlenose dolphins is encountered. To further reduce the potential to experience injury, designed-in measures, involving visual and acoustic monitoring, will be adopted as part of a MMMP (Table 10.21). For all marine mammals, secondary mitigation will be applied in a form of ADDs to minimise residual risk of injury (see paragraph 243 *seq*. for further details).

124. The total duration of piling is presented in paragraph 118. Bottlenose dolphin typically live between 20 and 30 years, females reproduce every three to six years. Given that gestation takes 12 months followed by calves suckling of 18 to 24 months, the duration of piling could potentially overlap with a maximum of two breeding cycles. Less is known about reproductive behaviour of white-beaked dolphins; however, it has been reported that females are pregnant for about 11 months and give birth to a single calf (Reid *et al*., 2003). Therefore, the duration of piling could potentially overlap with approximately five breeding cycles of white-beaked dolphin. However, it is worth noting that piling will be intermittent and will occur over small timespan (372 days) within piling phase (52 months). Considering the above, the duration of the effect in the context of life cycle of bottlenose dolphin and white-beaked dolphin is classified as medium term.

Table 10.27: Summary of SPL_{pk} and SEL_{cum} Injury Ranges and Areas of Effect for Bottlenose Dolphin and White-Beaked Dolphin due to Impact Piling for Wind Turbine and OSPs/Offshore Convertor Station Platform Jacket Foundations (Absolute Maximum Hammer Energy) Using 1% Constant Conversion Factor

Scenario (4,000 kJ)/Threshold	Spatial Scale		Temporal Scale	
	Range of Effect (m)	Area of Effect (km^2)	Duration per Pile (hours)	Total Number of Piling Days
Concurrent Piling (Wind Turbine)				
SPL_{pk} 202 dB re 1 µPa	43	0.006	10	286.4
SEL_{cum} 155 dB re 1 µPa²s	N/E[1]	N/E[1]		
Single Piling (Wind Turbine/OSPs/Offshore convertor station platform)				
SPL_{pk} 202 dB re 1 µPa	43	0.006	8	85.3
SEL_{cum} 155 dB re 1 µPa²s	N/E[1]	N/E[1]		

[1] N/E = Threshold not exceeded

125. With designed-in measures in place including soft start and an MMMP, the magnitude of the impact would result in a negligible risk of injury to bottlenose dolphin and white-beaked dolphin as the scale of effects (range and number of animals potentially injured) is very small. Considering the duration of the impact, the risk (albeit negligible) could occur over a meaningful proportion of the lifespan of these species and therefore is classed as medium term.

126. The impact (elevated underwater noise from piling) is predicted to be of local spatial extent, medium term duration, intermittent and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Minke whale

127. The maximum range for injury to minke whale was estimated as 2,319 m based on SEL_{cum} and using the 4% reducing to 0.5% conversion factor (Table 10.28; see volume 3, appendix 10.5 for estimates using a range of conversion factors). Injury ranges predicted using SEL_{cum} are considered very precautionary for reasons described in paragraph 94 and therefore may be an overestimate of the effect range. The most conservative number of individuals that could be potentially injured within the maximum range of 2,319 was estimated as less than one minke whale. In comparison, maximum instantaneous injury ranges predicted using different conversion at the maximum 4,000 kJ hammer energy were: 83 m for 4% reducing to 0.5%, 109 m for 1% constant and 359 m for 10% constant (as requested by consultees during Road Map Meeting #4, see Table 10.9). In addition, the 2,319 m range is based on a concurrent scenario of two adjacent piling vessels; for single piling the injury range would be reduced to a maximum of 1,030 m (Table 10.28). Taking into account the most conservative scenario (concurrent piling of wind turbines at 4,000 kJ), it is estimated there will be less than one animal that could be potentially injured within the maximum range of 2,319 m.

128. To reduce the potential to experience injury, designed-in measures will be adopted as part of a MMMP (see Table 10.21). These measures will involve the use of visual and acoustic searches over a pre-defined mitigation zone (see volume 4, appendix 23). Given that injury could occur over ranges greater than the standard 500 m mitigation zone (JNCC, 2010a) and subject to the limitations of standard approaches (paragraph 117), secondary mitigation will be applied in a form of ADDs to minimise residual risk of injury (see paragraph 243 *et seq.* for further details).

129. The total duration of piling is presented in paragraph 118. Minke whale typically lives up to 60 years and the gestation period is believed to be around ten months. As females give birth to a calf every 12 to 14 months, the duration of piling could potentially overlap with a maximum of five breeding cycles. However, it is worth noting that piling will be intermittent and will occur over small timespan (372 days) within piling phase (52 months). Considering the above, the duration of the effect in the context of life cycle of minke whale is classified as medium term, as the risk could occur over a meaningful proportion of the lifespan of this species.

Table 10.28: Summary of SPL_{pk} and SEL_{cum} Injury Ranges and Areas of Effect for Minke Whale due to Impact Piling for Wind Turbine and OSPs/Offshore Convertor Station Platform Jacket Foundations (Absolute Maximum Hammer Energy) Using 4% Reducing to 0.5% Conversion Factor

Scenario (4,000 kJ)/Threshold	Spatial Scale		Temporal Scale	
	Range of Effect (m)	Area of Effect (km^2)	Duration per Pile (hours)	Total Number of Piling Days
Concurrent Piling (Wind Turbine)				
SPL_{pk} 202 dB re 1 µPa	83	0.022	10	286.4
SEL_{cum} 155 dB re 1 µPa²s	2,319	16.886		
Single Piling (Wind Turbine/OSPs/Offshore convertor station platform)				
SPL_{pk} 202 dB re 1 µPa	83	0.022	8	85.3
SEL_{cum} 155 dB re 1 µPa²s	1,030/1,023	3.286		

130. With designed-in measures in place including soft start and an MMMP, the magnitude of the impact would result in a low risk of injury to minke whale as the scale of effects (range and number of animals potentially injured) is small. There may, however, be a residual risk of injury to some individuals of this species as the radius of effect for PTS (up to 2,319 m) is likely to exceed the range over which effective visual and acoustic monitoring of minke whale can occur.

131. The impact (elevated underwater noise from piling) is predicted to be of local spatial extent, medium term duration, intermittent and low reversibility. It is predicted that the impact will affect the receptor directly. Given that the maximum injury range may not be fully mitigatable by designed-in measures only (see Table 10.21), the magnitude is considered to be medium.

Harbour seal and grey seal

132. The maximum range for injury to harbour and grey seal was estimated as 118 m based on SPL_{pk} and using the 1% constant conversion factor (Table 10.29; see volume 3, appendix 10.5 for estimates using a range of conversion factors). The ranges are low due to the soft-start initiation of piling which is likely to reduce the probability of marine mammals being in proximity to piling activities on full power. Therefore, the spatial extent of PTS will be localised for all piling scenarios. Taking into account the most conservative scenario, maximum density for both species (based on mean at-sea seal usage from Carter *et al*. 2020) as well as concurrent piling of wind turbines at 4,000 kJ, there will be less than one animal (of each species) that could be potentially injured within the maximum range of 118 m.

133. To reduce the potential to experience injury, designed-in measures, involving visual and acoustic monitoring, will be adopted as part of a MMMP (see Table 10.21). For all marine mammals, secondary mitigation will be applied in a form of ADDs to minimise residual risk of injury (see paragraph 243 *et seq*. for further details).

134. The total duration of piling is presented in paragraph 118. Both species of seal typically live between 20 to 30 years with gestation lasting between ten to 11 months (SCOS, 2015; SCOS, 2018), thus the duration of piling could potentially overlap with a maximum of five breeding cycles. However, it is worth noting that piling will be intermittent and will occur over small timespan (372 days) within piling phase (52 months). Considering the above, the duration of the effect in the context of life cycle of harbour and grey seal is classified as medium term.

Table 10.29: Summary of SPL_{pk} and SEL_{cum} Injury Ranges and Areas of Effect for Harbour Seal and Grey Seal due to Impact Piling for Wind Turbine and OSPs/Offshore Convertor Station Platform Jacket Foundations (Absolute Maximum Hammer Energy) Using 1% Constant Conversion Factor

Threshold	Spatial Scale		Temporal Scale	
	Range of Effect (m)	Area of Effect (km^2)	Duration per Pile (hours)	Total Number of Piling Days
Wind Turbine –4,000 kJ – Concurrent Piling with Two Vessels				
SPL_{pk} 202 dB re 1 µPa	118	0.044	10	286.4
SELcum 155 dB re 1 µPa²s	25	0.002		
Wind Turbine/OSPs/Offshore convertor station platform – 4,000 kJ – Single Piling Vessel				
SPLpk 202 dB re 1 µPa	118	0.044	8	85.3
SELcum 155 dB re 1 µPa²s	N/E[1]	N/E[1]		

[1] N/E = Threshold not exceeded

135. With designed-in measures in place including soft start and an MMMP, the magnitude of the impact would result in a negligible risk of injury to harbour and grey seal as the scale of effects (range and number of animals potentially injured) is very small. Considering the duration of the impact, the risks (albeit negligible) could occur over a meaningful proportion of the lifespan of these species.

136. The impact (elevated underwater noise from piling) is predicted to be of local spatial extent, medium term duration, intermittent and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Behavioural disturbance

137. The numbers of animals predicted to experience potential disturbance as a result of different piling scenarios is presented in this section (Table 10.30 to Table 10.35). Predictions are based on the assumptions of the dose response relationship described in paragraphs 96 *et seq.* using the SEL_{ss} metric. The estimated numbers of animals potentially disturbed are based on the maximum adverse piling scenario which describe the maximum potential impact for each species. This has been defined with reference to either the extent of the effect, or spatial overlap with abundance hotspots (e.g. areas near the coast).

138. Scientific literature suggests that inshore and offshore populations of bottlenose dolphins are often ecologically and genetically discrete (Hoelzel *et al*., 1998). Therefore, this assessment considered two separate populations of bottlenose dolphin; those distributed in coastal waters as well as offshore.

139. Assessment of magnitude for behavioural disturbance presented in this section is based on 1% constant conversion factor unless stated otherwise.

Harbour porpoise

140. Up to 2,822 animals (based on seasonal peak density) are predicted to experience potential disturbance from concurrent piling at a maximum hammer energy of 4,000 kJ (Figure 10.10). This equates to 0.81% of the NS MU population and 7.3% of SCANS III Block R estimated abundance (Table 10.30). For comparison, the number of animals that could be potentially disturbed during the same piling scenario but using a 4% reducing to 0.5% conversion factor has been conservatively assessed as up to 2,090 harbour porpoises. This equates to 0.60% of the NS MU population and 5.41% of SCANS III Block R estimated abundance (see volume 3, appendix 10.5 for estimates using a range of conversion factors).

141. The estimated numbers of individuals potentially impacted are based on conservative densities. Although the distribution of harbour porpoise across the Proposed Development marine mammal study area was found to be uneven (see volume 3, appendix 10.2 for more details), it was assumed that the peak seasonal density of 0.826 animals per km^2 is uniformly distributed within all noise contours to provide a precautionary assessment. Comparison of the estimated number of harbour porpoise potentially disturbed using the mean monthly density derived from the Proposed Development aerial digital survey data (0.299 animals per km^2) or using the modelled density estimate for SCANS III for this area (0.599 animals per km^2) demonstrates that the peak seasonal density estimates generate highly precautionary results. For example, based on the mean monthly density from aerial data or SCANS III data, the number of harbour porpoise affected by possible disturbance for the maximum adverse scenario (concurrent piling at 4,000 kJ) would be 1,021 animals (0.29% of the NS MU) or 2,047 animals (0.59% of the NS MU) respectively compared to 2,822 animals (0.81% of the NS MU) using peak seasonal density.

142. Additionally, there is a number of conservative assumptions in subsea noise model, as the maximum hammer energy of 4,000 kJ is unlikely to be reached at all piling locations (see paragraph 94 for more details). It is therefore reasonable to consider the number of animals potentially disturbed could be based on estimates for a realistic average maximum hammer energy of 3,000 kJ (using 1% constant conversion factor) (volume 3, appendix 10.5), where up to 2,378 animals have the potential to

experience disturbance, which represents 0.69% of the NS MU population 6.15% of SCANS III Block R estimated abundance (Table 10.30).

143. Harbour porpoise could also be potentially disturbed within the zone of possible disturbance during single piling at a wind turbine or an OSPs/Offshore convertor station platform at a maximum hammer energy of 4,000 kJ (Figure 10.11), with up to 1,754 (0.51% of the NS MU population and 4.54% of SCANS III Block R estimated abundance) animals affected based on the seasonal peak density (using 1% constant conversion factor, Table 10.30).

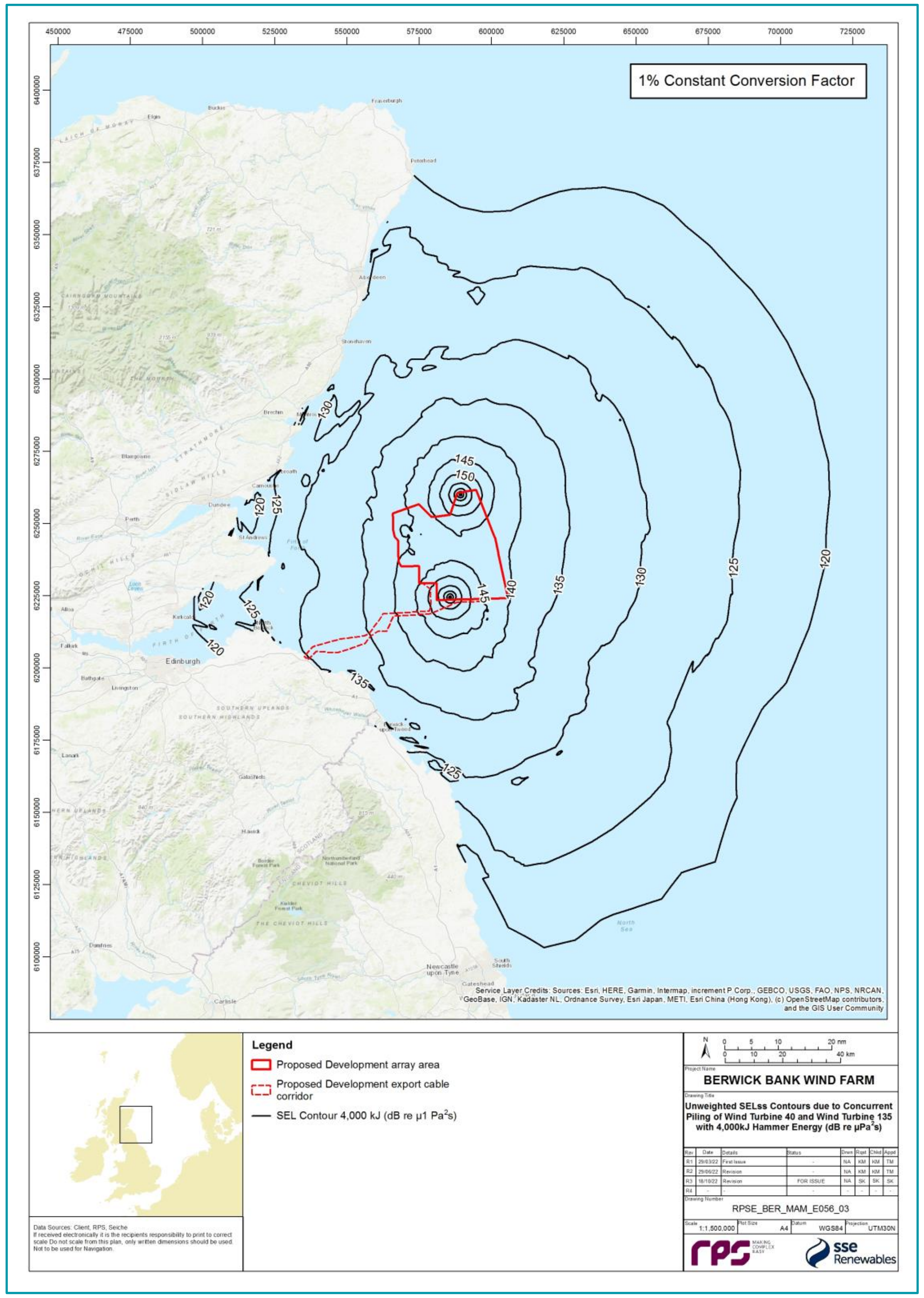


Figure 10.10: Unweighted SELss Contours Due to Concurrent Impact Piling of Wind Turbine Piles at Maximum Hammer Energy (4,000 kJ) Using 1% Constant Conversion Factor

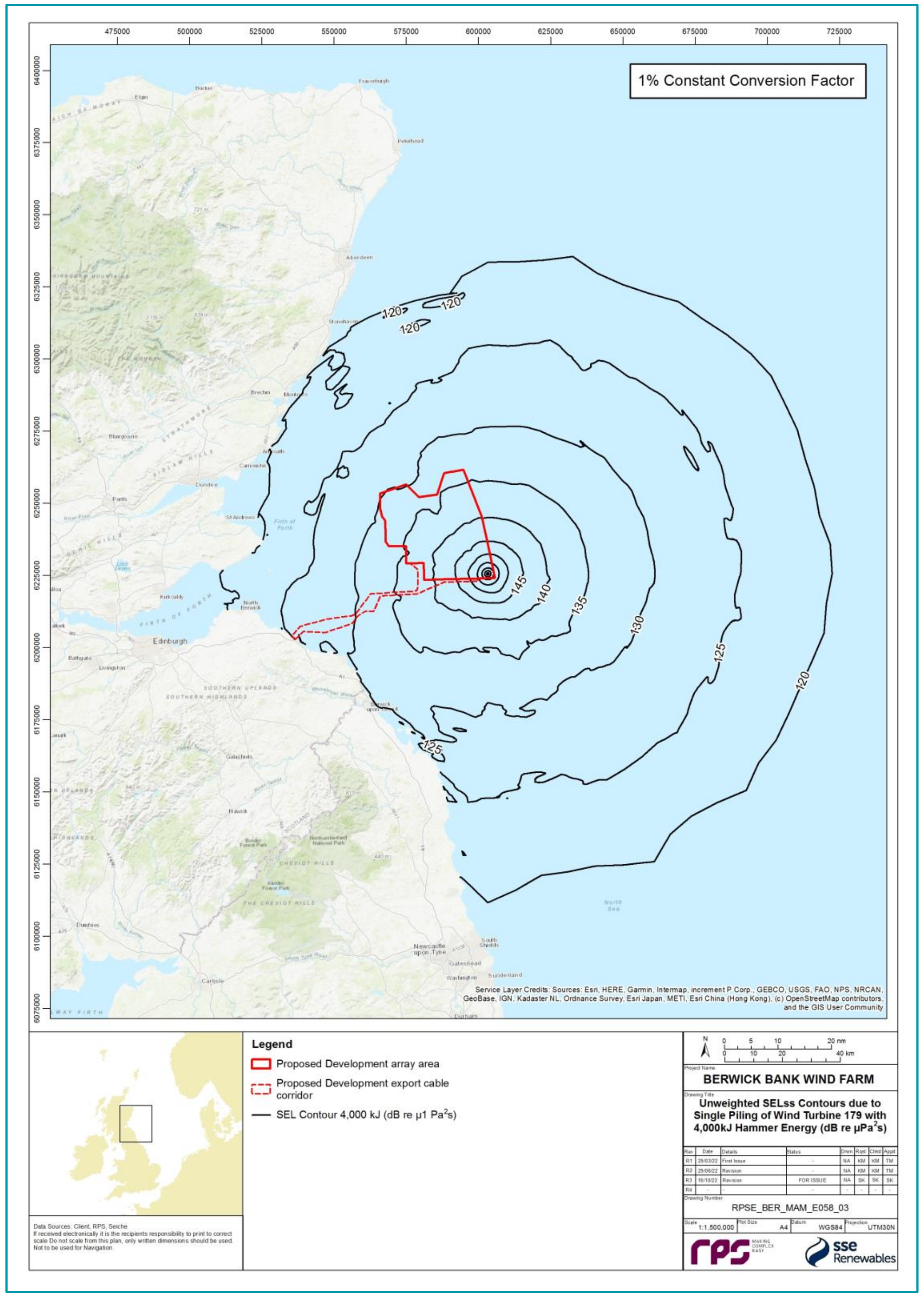


Figure 10.11: Unweighted SEL_{ss} Contours Due to Single Piling at Maximum Hammer Energy (4,000 kJ) Using 1% Constant Conversion Factor

Table 10.30: Number of Harbour Porpoises Predicted to be Disturbed within Unweighted SEL_{ss} Noise Contours as a Result of Different Piling Scenarios. Average Number is Based on the Monthly Average Density whilst Maximum is Based on the Seasonal Peak Density Using 1% Constant Conversion Factor

Scenario (4,000 kJ)	Number of Animals		% Reference Population (MU)		% SCANS III Block R	
	Average	Maximum	Average	Maximum	Average	Maximum
Concurrent piling (wind turbine)	1,021	2,822	0.29	0.81	2.6	7.3
Single piling (wind turbine/OSPs/Offshore convertor station platform)	635	1,754	0.18	0.51	1.6	4.5

144. As identified in appendix 10.2, four European marine sites designated for protection of harbour porpoise are located within the regional marine mammal study area. The Southern North Sea is located in the closest proximity to the Proposed Development array area (i.e. 146 km as crow flies). Doggersbank SAC, Doggerbank SCI and Klaverbank SAC are located 295 km, 314 km and 332 km from the Proposed Development array area, respectively. There is no potential for overlap of noise disturbance contours with any of these designated sites. Given that harbour porpoise can travel over large distances, there is a possibility that a small number of individuals from these SACs/SCI populations may be occasionally present within the disturbance contours. For the closest European marine site (the Southern North Sea SA), the population is estimated at between 20,237 and 41,538 individuals (see volume 2, appendix 10.2). Full consideration of potential for AeoI is also given in RIAA (SSER, 2022d).

145. As previously described in paragraph 119 *et seq.*, the duration of piling could potentially affect harbour porpoise over a maximum of five breeding cycles. The magnitude of the impact could also result in a small but measurable alteration to the distribution of marine mammals during piling only (372 days over 52 months) and may affect the fecundity of small proportion of the population (up to 0.81% of the NS MU at any one time) over the medium term.

146. As agreed with consultees (Table 10.9) population modelling was carried out to explore the potential of disturbance during piling to affect the population trajectory over time and provide additional certainty in the predictions of the assessment of effects. Results of the iPCoD modelling for harbour porpoise against the MU population showed that the median of the ratio of the impacted population to the unimpacted population was 99.9% at 25 years regardless of the conversion factor scenario assessed (1% constant, 4% reducing to 0.5% or 10% reducing to 1% conversion factors). Small differences in population size over time between the impacted and unimpacted population falls within the natural variance of the population as can be seen in Figure 10.12, where results of simulated population number (y axis) are similar on either side of the median line for both, impacted and unimpacted population. Therefore, it was considered that there is no potential for a long-term effect on this species (see volume 3, appendix 10.4 for more details). This was also the case when considered against the SCANS III Block R as a vulnerable subpopulation (Figure 10.12).

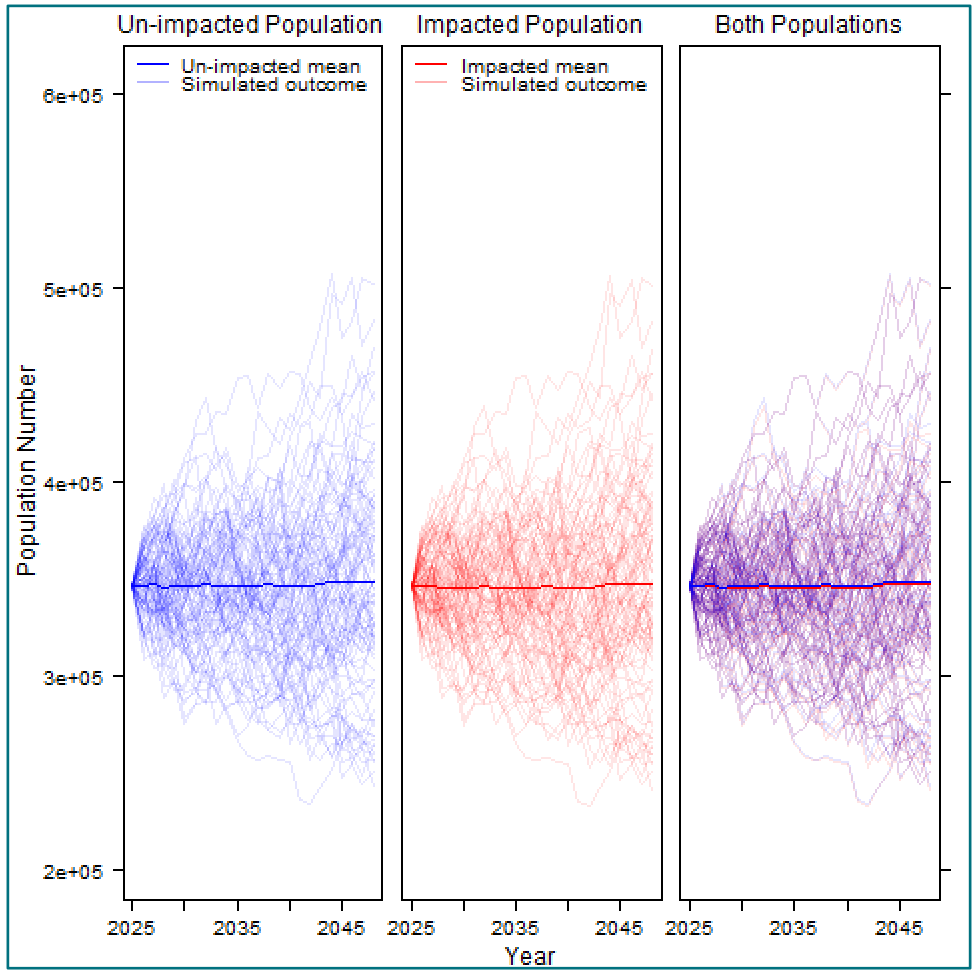


Figure 10.12: Simulated Harbour Porpoise Population Sizes for Both the Baseline and the Impacted Populations Under the Maximum Adverse Scenario Using 1% Conversion Factor and 11.1% Vulnerable Subpopulation.

147. The impact (elevated underwater noise from piling) 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 results suggest that in short to medium term the magnitude would be low. Recovery is considered likely to occur soon after cessation of piling and there were predicted to be no long-term population-level effects on harbour porpoise as corroborated by the population modelling. The magnitude is therefore considered to be low.

Bottlenose dolphin

148. Given that bottlenose dolphin distribution may be coastal or offshore, a dual approach has been taken to estimate the number of animals potentially disturbed. The noise contours predicted to result from piling were overlaid with 2 m to 20 m depth contours and the number of animals potentially disturbed within those areas was calculated. Estimates were based on the area of overlap and an average density of 0.197 animals per km^2 from Peterhead to Farne Islands. This is with the exception of the outer Firth of Tay, where the density is higher with 0.294 animals per km^2 (Figure 10.13). For the purpose of this assessment it has been assumed that density of 0.294 animals per km^2 is uniformly distributed within the 2 m to 20 m depth contour of outer Firth of Tay. This approach is based on the assumption that half of the CES MU population is present within the Firth of Tay and adjacent waters and therefore this approach is highly precautionary. Given that both densities, 0.197 and 0.294 animals per km^2, were obtained from coastal distribution studies, the number of bottlenose dolphins potentially disturbed during piling in offshore areas was calculated using densities from SCANS III Block R data with 0.0298 animals per km^2 (Table 10.31).

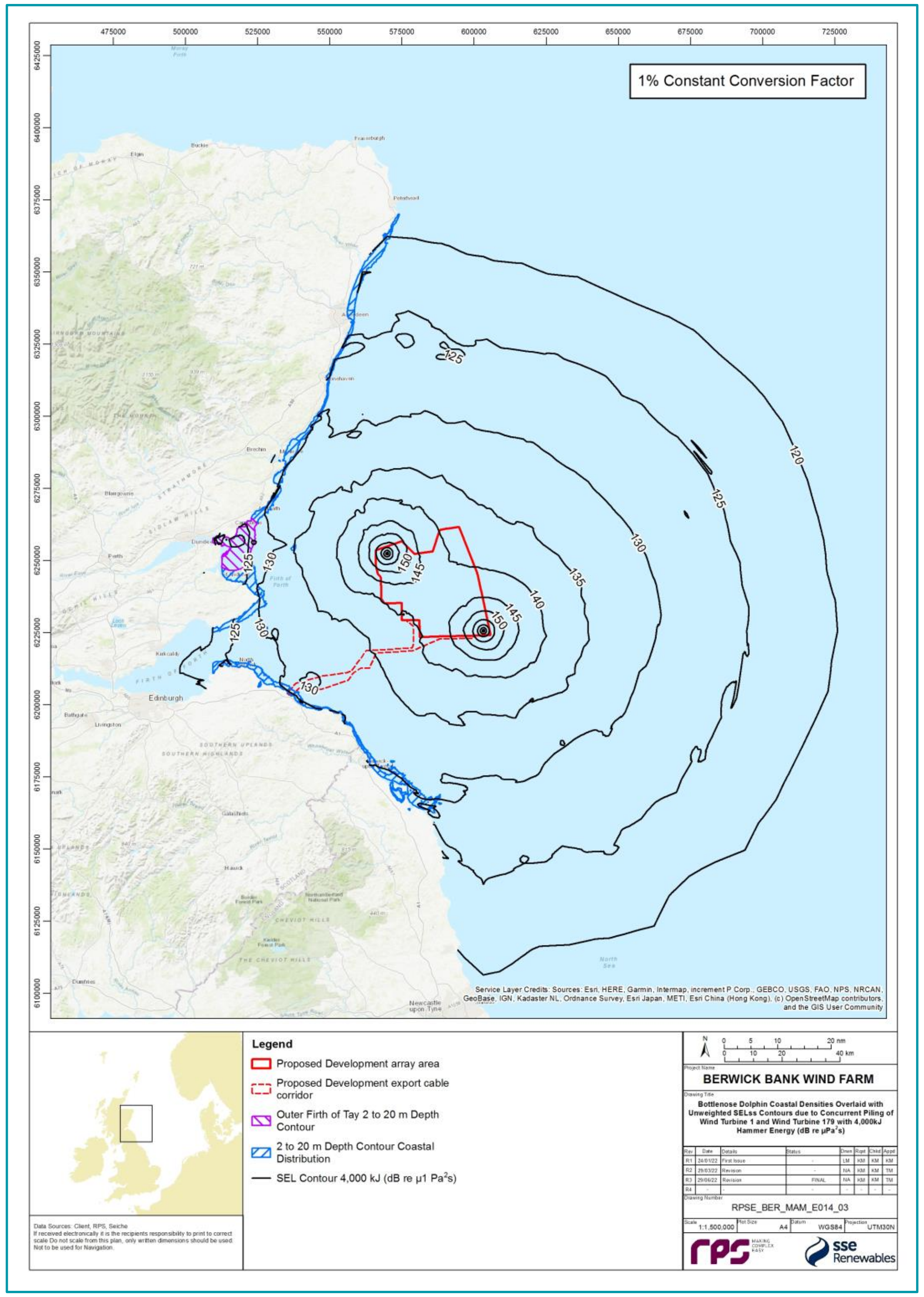


Figure 10.13: Proposed Development and Bottlenose Dolphin Coastal Densities Overlaid with Unweighted SEL_{ss} Contours Due to Concurrent Impact Piling of Wind Turbine Piles at Maximum Hammer Energy (4,000 kJ) Using 1% Constant Conversion Factor

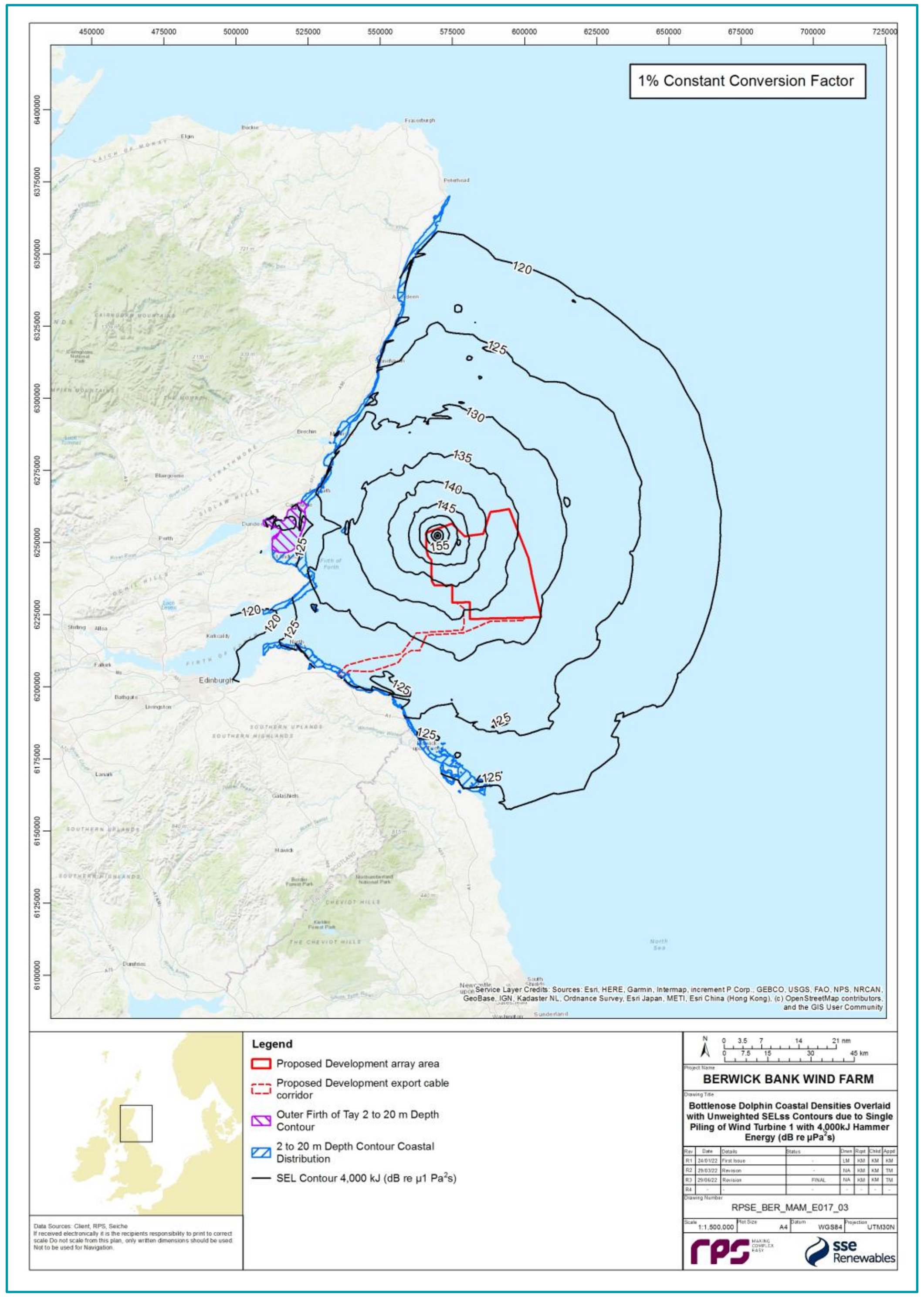


Figure 10.14: Proposed Development and Bottlenose Dolphin Coastal Densities Overlaid with Unweighted SEL_{ss} Noise Contours Due to Single Piling at Maximum Hammer Energy (4,000 kJ) Using 1% Constant Conversion Factor

149. As seen in Figure 10.13, the outermost noise contours predicted from the maximum hammer energy of 4,000 kJ reach the coastal areas and therefore overlap with the key distribution of bottlenose dolphin. Up to five animals are predicted to have the potential to experience disturbance from concurrent piling in coastal waters, which equates to 2.25% of the CES MU population (Table 10.31). For comparison, the number of animals that could potentially be disturbed during the same piling scenario but using 4% reducing to 0.5% conversion factor has been conservatively assessed as up to four bottlenose dolphins, which equates to 1.38% of the CES MU population (volume 3, appendix 10.5 for estimates using a range of conversion factors).

150. It is reasonable to consider that disturbance could be predicted by a realistic average maximum hammer energy of 3,000 kJ (see paragraph 142), where up to four animals could potentially be disturbed during concurrent piling at wind turbine foundations, representing 1.71% of the CES MU population (volume 3, appendix 10.5).

151. Coastal bottlenose dolphin could also be potentially disturbed during single piling at a wind turbine or an OSPs/Offshore convertor station platform, with up to four (1.49% of the CES MU population) animals affected for the 4,000 kJ hammer energy (Figure 10.14, Table 10.31).

152. Since the outer contours reach areas occupied by the coastal bottlenose dolphin population, the potential for barrier effects (e.g. restricting animals from moving along the coast) must also be considered for both concurrent and single piling scenarios. Received noise levels within the 2 m to 20 m depth contour are predicted to reach maximum SEL_{ss} levels of 130 dB. This is equivalent to the outer limit of the US NMFS threshold (140 dB_{rms}) for mild disturbance (NMFS, 2005) and therefore likely to elicit less severe disturbance reactions compared to higher received levels of 150 dB SEL_{ss} (=160 dB_{rms} for strong disturbance).

153. According to the behavioural response severity matrix suggested by Southall *et al*. (2021) low level disturbance (scoring between 0 to 3 on 0 to 9 scale) could lead to mild disruptions of normal behaviours but prolonged or sustained behavioural effects, including displacement are unlikely to occur. Further discussion on the sensitivity of bottlenose dolphin is provided in paragraph 218 *et seq.* (with respect to survival, feeding and reproductive behaviours) but for the purposes of assessing magnitude, it is considered that up to four or five animals from the coastal population (depending on the scenario, Table 10.31) could experience mild disturbance but that this is unlikely to lead to barrier effects as animals are unlikely to be excluded from the coastal areas.

154. Potential effects on the offshore bottlenose dolphin population were also assessed. During concurrent piling at maximum 4,000 kJ hammer energy, up to 102 individuals occurring in offshore waters have the potential to experience disturbance (Figure 10.13). This equates to 5.29% of the SCANS III Block R estimated abundance. Estimates for 4,000 kJ hammer energy are shown to be precautionary if compared with estimates based on concurrent piling at a realistic average maximum hammer energy of 3,000 kJ, where up to 86 animals could potentially be disturbed (4.46% of the SCANS III Block R estimated abundance; volume 3, appendix 10.5). For the single piling scenario with a hammer energy of 4,000 kJ, up to 64 individuals have the potential to experience disturbance offshore, which equates to 3.29% of the SCANS III Block R estimated abundance (Figure 10.14).

Table 10.31: Number of Bottlenose Dolphins Predicted to be Disturbed within Unweighted SEL_{ss} Noise Contours as a Result of Different Piling Scenarios Using 1% Constant conversion factor

Scenario (4,000 kJ)	Number of Animals		% Reference Population	
	Coastal	Offshore	Coastal [1]	Offshore[2]
Concurrent piling (wind turbine)	5	102	2.25	5.29
Single piling (wind turbine/OSPs/Offshore convertor station platform)	4	64	1.49	3.29

[1] CES MU population was used as a reference population for individuals disturbed in coastal areas.

[2] SCANS III bottlenose dolphin estimated abundance was used as a reference population individuals disturbed in coastal areas.

155. The maximum numbers presented in Table 10.31 are considered to be conservative as these are based on highly precautionary coastal and offshore density estimates (SCANS III Block R density of 0.0298 individuals per km²). As described in more detail in volume 3, appendix 10.2, bottlenose dolphins were recorded in low numbers during the DAS and only on two occasions within the 24-month survey period (encounter rate varied between 0.0005 individuals per km in October 2019 and 0.0024 individuals per km in April 2021). Considering the above, the estimated number of bottlenose dolphins with the potential to be disturbed in offshore waters, should be interpreted with caution as this is likely to be an overestimate.

156. As identified in volume 3, appendix 10.2, the Moray Firth SAC designated for protection of bottlenose dolphin is located within the regional marine mammal study area, approximately 167 km from the Proposed Development array area. There is no potential for overlap of noise disturbance contours with this designated site, however, noise contours have the potential to overlap with the main distributional range of its population. It is important to note that recent studies have shown that although the numbers of bottlenose dolphin using the Moray Firth SAC appear to be stable, the proportion of the population using these waters has declined due to overall increase in population size and expansion of range along the eastern coast (in southern direction, for more details see volume 3, appendix 10.2). Full consideration of potential for AeoI is given in RIAA (SSER, 2022d).

157. As previously described in paragraph 124 *et seq.,* the duration of piling could potentially affect bottlenose dolphin over a maximum of three breeding cycles. The magnitude of the impact could also result in a small but measurable alteration to the distribution of marine mammals during piling only (372 days over 52 months) and may affect the fecundity of some individuals (up to 2.25% of the CES MU population at any one time) over the medium term.

158. As agreed with consultees (Table 10.9) population modelling was carried out to explore the potential of disturbance during piling to affect the population trajectory over time and provide additional certainty in the predictions of the assessment of effects. Results of the iPCoD modelling for bottlenose dolphin against the MU population showed that the median of the ratio of the impacted population to the unimpacted population was between 100% at 25 years for all conversion factor scenarios assessed (1% constant, 4% reducing to 0.5% or 10% reducing to 1% conversion factors). Very small differences in population size over time between the impacted and unimpacted population fall within the natural variance of the population as can be seen in Figure 10.15, where results of simulated population number (y axis) are similar on either side of the median line for both, impacted and unimpacted population. Therefore, it was considered that there is no potential for a long-term effect on this species (Figure 10.15, see volume 3, appendix 10.4 for more details).

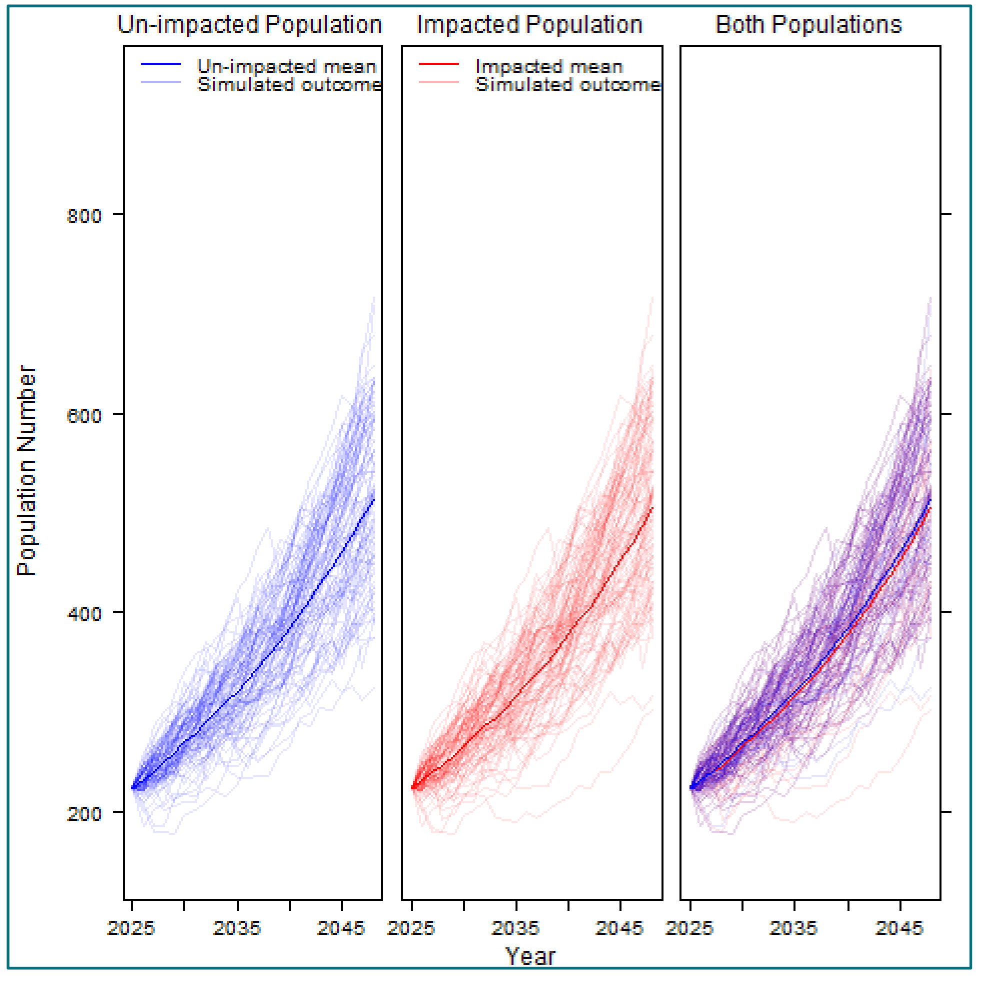


Figure 10.15: Simulated Bottlenose Dolphin Population Sizes for Both the Baseline and the Impacted Populations Under the Maximum Adverse Scenario Using 1% Conversion Factor and no Vulnerable Subpopulation.

159. The impact 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 in short to medium term could be considered as medium, however because population modelling results shown that piling activities will not have adverse effect on the bottlenose dolphin population in the long term, the magnitude is therefore considered to be low.

White-beaked dolphin

160. Based on SCANS III block R white-beaked dolphin density estimates, up to 830 animals have the potential to experience disturbance during concurrent piling at a maximum hammer energy of 4,000 kJ. This equates to 1.89% of the CGNS MU population and 5.0% of the SCANS III block R estimated population abundance (Table 10.32). The noise contours associated with maximum adverse piling scenarios (i.e. those at a maximum hammer energy of 4,000 kJ) are the same as those assessed for harbour porpoise (i.e. based on the piled location that could lead to the largest propagation ranges, Figure 10.10). For comparison, the number of animals that could be potentially disturbed during the same piling scenario as above but using 4% reducing to 0.5% conversion factor has been conservatively assessed as up to 615 white-beaked dolphins, which equates to 1.40% of the CGNS MU population (volume 3, appendix 10.5 for estimates using a range of conversion factors).

161. It is reasonable to consider that disturbance could be predicted by a realistic average maximum hammer energy of 3,000 kJ (see paragraph 142), where up to 700 animals could potentially be disturbed during concurrent piling at wind turbine foundations, representing 1.59% of the CGNS MU population and 4.3% of the SCANS III block R estimated abundance (volume 3, appendix 10.5).

162. White-beaked dolphin could also be potentially disturbed within the zone of possible disturbance during single piling at a wind turbine or OSPs/Offshore convertor station platform foundation at a maximum hammer energy of 4,000 kJ (Figure 10.11), with up to 516 (1.17% of the CGNS MU population and 3.1% of the SCANS III block R estimated abundance) animals affected (Table 10.32).

Table 10.32: Number of White-Beaked Dolphins Predicted to be Disturbed in the Vicinity of the Proposed Development as a Result of Different Piling Scenarios Using 1% Constant Conversion Factor

Scenario (4,000 kJ)	Number of Animals	% Reference Population	% Abundance in SCANS Block R
	Average	Average	Average
Concurrent piling (wind turbine)	830	1.89	5.0
Single piling (wind turbine/OSPs/Offshore convertor station platform)	516	1.17	3.1

163. The maximum numbers presented in Table 10.32 are considered to be conservative as these are based on the SCANS III block R densities (0.243 animals per km²) and assume uniform distribution. As described in more detail in volume 3, appendix 10.2, the mean monthly density of white-beaked dolphin (corrected for availability bias) estimated from the Proposed Development aerial digital data was 0.05 individuals per km². These results are in line with findings of Grellier and Lacey (2011) aerial survey analysis, where minimum density estimates for Firths of Forth and Tay waters during summer (peak) were assessed as 0.052 individuals per km². If maximum numbers were compared with estimates based on the latter density, the number of white-beaked dolphin potentially disturbed for the maximum adverse scenario (concurrent piling at 4,000 kJ) would be 177 animals (0.40% of the CGNS MU), compared to 828 animals (1.88% of the CGNS MU) based on SCANS III Block R density estimates. Therefore, the number of white-beaked dolphins that may be disturbed as a result of all piling scenarios should be interpreted with caution as these animals are likely to be present in lower densities.

164. As previously described in paragraph 124 *et seq.*, the duration of piling could potentially affect white-beaked dolphin over a maximum of five breeding cycles. The magnitude of the impact could also result in a small but measurable alteration to the distribution of marine mammals during piling only (372 days over 52 months) and may affect fecundity of some individuals (up to 1.89% of the CGNS MU population) over the medium term. The area of effect is however small in relation to the extensive distribution of the population for this species (Celtic and Greater North Seas).

165. Since iPCoD did not facilitate modelling for white-beaked dolphin, as agreed with consultees (Table 10.9) no population modelling was carried out for this species.

166. The impact 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.

Minke whale

167. Based on SCANS III block R minke whale density estimates, up to 132 animals have the potential to be disturbed as a result of concurrent piling at a maximum hammer energy of 4,000 kJ, which equates to 0.66% of the CGNS MU and 5.3% of the SCANS III block R estimated abundance (Table 10.33). The noise contours associated with maximum adverse piling scenarios (i.e. those at a maximum hammer energy of 4,000 kJ) are the same as those assessed for harbour porpoise (Figure 10.10). For comparison, the number of animals that could be potentially disturbed during the same piling scenario but using 4% reducing to 0.5% conversion factor has been conservatively assessed as up to 97 minke whales, which equates to 0.49% of the CES MU population (volume 3, appendix 10.5 for estimates using a range of conversion factors).

168. The maximum numbers presented in Table 10.33 are considered to be conservative as these are based on the SCANS III Block R densities and assume uniform distribution. Minke whale exhibit a temporal distribution, with most sightings in continental shelf waters occurring between May and September. SCANS III surveys were carried out during summer months, and therefore density values, and subsequently predicted numbers to be disturbed for minke whale will be overly conservative for piling activities occurring during winter months. As described in more detail in volume 3, appendix 10.2, mean monthly density of minke whale (corrected for availability bias) estimated from the Proposed Development aerial digital data was 0.016 individuals per km^2. If maximum numbers were compared with estimates based on this density, the number of minke whale potentially disturbed using the maximum adverse scenario (concurrent piling at 4,000 kJ) would be 55 animals (0.27% of the CGNS MU), compared to 132 animals (0.66% of the CGNS MU) based on SCANS III Block R density estimates. Therefore, the number of minke whales disturbed as a result of all piling scenarios should be interpreted with caution as these animals are likely to be present in lower densities.

169. It is reasonable to consider that disturbance could be predicted by a realistic average maximum hammer energy of 3,000 kJ (see paragraph 142) where up to 112 animals could potentially be disturbed during concurrent piling at wind turbine foundations, representing 0.55% of the CGNS MU population and 4.5% of the SCANS III Block R estimated abundance (volume 3, appendix 10.5).

170. Minke whale could also be potentially disturbed within the zone of possible disturbance during single piling at a wind turbine or an OSPs/Offshore convertor station platform at a maximum hammer energy of 4,000 kJ (noise contours presented in Figure 10.11), with up to 82 (0.41% of the CGNS MU population and 3.2% of the SCANS III Block R estimated abundance) animals affected (Table 10.33).

Table 10.33: Number of Minke Whales Predicted to be Disturbed within Unweighted SEL_{ss} Noise Contours as a Result of Different Piling Scenarios Using 1% Constant Conversion Factor

Scenario (4,000 kJ)	Number of Animals	% Reference Population	% abundance in SCANS III Block R
	Average	Average	Average
Concurrent piling (wind turbine)	132	0.66	5.3
Single piling (wind turbine/OSPs/Offshore convertor station platform)	82	0.41	3.3

171. As previously described in paragraph 129 *et seq.,* the duration of piling could potentially affect minke whale over a maximum of five breeding cycles. The magnitude of the impact could result in a small but measurable alteration to the distribution of marine mammals during piling only (372 days over 52 months) and may affect the fecundity of some individuals (up to 0.66% of the GCNS MU population at any one time) over the medium term. The area of effect is however small in relation to the extensive distribution of the population for this species (Celtic and Greater North Seas).

172. As agreed with consultees (Table 10.9) population modelling was carried out to explore the potential of disturbance during piling to affect the population trajectory over time and provide additional certainty in the predictions of the assessment of effects. Results of the iPCoD modelling for minke whale against the MU population showed that the median of the ratio of the impacted population to the unimpacted population was 98.9% at 25 years regardless of the conversion factor scenario assessed (1% constant, 4% reducing to 0.5% or 10% reducing to 1% conversion factors). Small differences in population size over time between the impacted and unimpacted population fall within the natural variance of the population as can be seen in Figure 10.16, where results of simulated population number (y axis) are similar on either side of the median line for both, impacted and unimpacted population. Therefore, it was considered that there is no potential for a long-term effect on this species (see volume 3, appendix 10.4 for more details). This was also the case when considered against the SCANS III Block R as a vulnerable subpopulation (Figure 10.16).

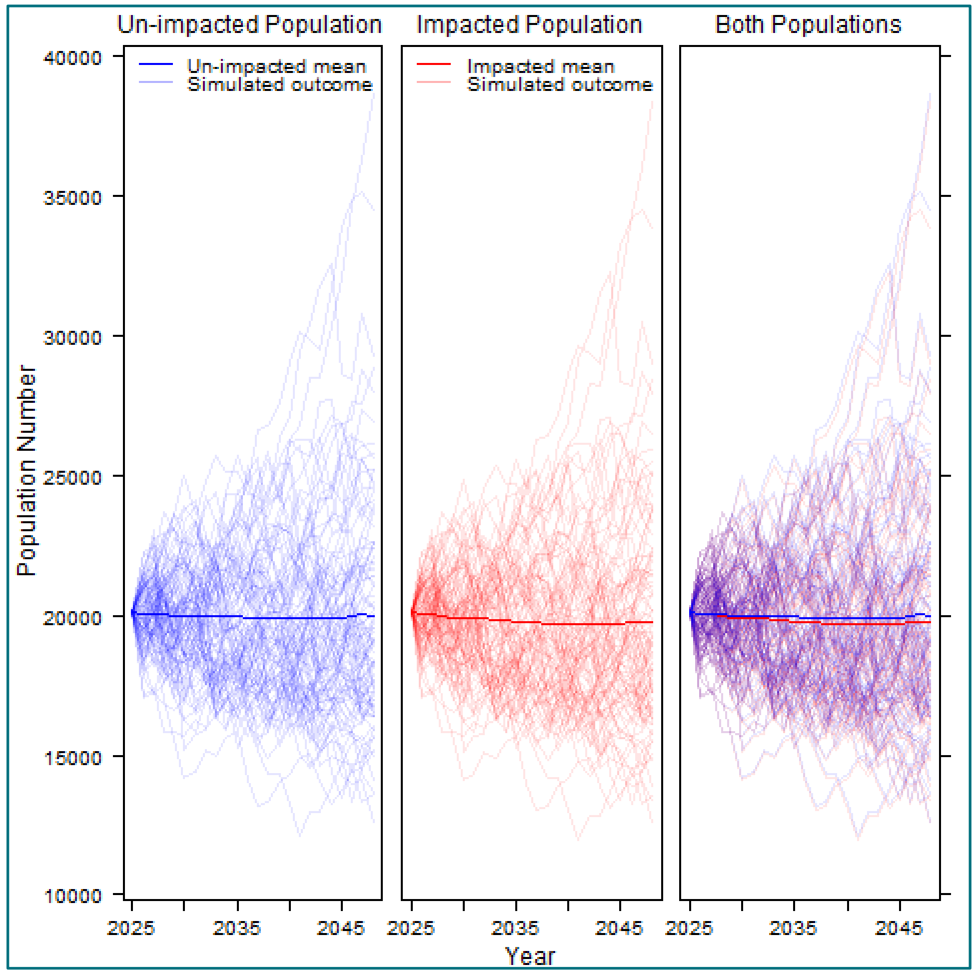


Figure 10.16: Simulated Minke Whale Population Sizes for Both the Baseline and the Impacted Populations Under the Maximum Adverse Scenario Using 1% Conversion Factor and 11.1% Vulnerable Subpopulation.

173. The impact 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 in short to medium term is predicted to be low. Recovery is considered likely to occur soon after cessation of piling and there were predicted to be no long-term population-level effects on minke whale as corroborated by the population modelling. The magnitude is therefore considered to be low.

Harbour seal

174. The magnitude of effects with respect to disturbance was initially estimated using two approaches. The first used the representative maximum species density value, derived from Carter *et al.* (2020) across Proposed Development array area and Proposed Development export cable corridor (see volume 3, appendix 10.2 for more details) and, assuming uniform densities across the site, multiplied this value by the area of effect. The second estimate was achieved by overlaying the noise contours on the spatial at-sea density map provided by Carter *et al.* (2020) and summing the values for all cells where more than 50% of the cell lay within a contour. For the first approach the most precautionary estimate was derived from the largest area of effect (i.e. whichever location and scenario leads to the maximum area disturbed at any one time). For the second approach, the modelled location was more important as, where piling occurs closer to the coast, the areas of disturbance are more likely to overlap with hotspots where higher densities of harbour seal have been predicted (i.e. inner Firth of Forth and Firth of Tay; Figure 10.17).

175. Both approaches were explored to determine which would lead to the most precautionary assessment in terms of number of individuals disturbed. Figure 10.17 to Figure 10.18 illustrates the piling locations considered in the assessment and shows that in both cases the outermost 135 dB behavioural disturbance contours do not overlap with areas of density hotspots for this species. Therefore, the most precautionary values were derived using the largest areas of effect for the single and concurrent scenarios (as presented in Figure 10.19 and Figure 10.11) multiplied by the maximum density estimate from Table 10.13 and have been presented in paragraph 176 *et seq.* The application of this approach is considered to be precautionary, as realistically the density of harbour seal will vary and therefore will not reach a maximum value across all parts of the Proposed Development marine mammal study area

176. Up to three animals were predicted to experience potential disturbance from concurrent piling at a maximum hammer energy of 4,000 kJ (Figure 10.10). This equates to 0.39% of the ES plus North-east England (NE) Mus population (Table 10.34). For comparison, the number of animals that could be potentially disturbed during the same piling scenario but using 4% reducing to 0.5% conversion factor has been conservatively assessed as up to two harbour seals, which equates to 0.27% of the ES plus NE MU population (volume 3, appendix 10.5 for estimates using various conversion factor).

177. The maximum numbers of harbour seal individuals that could be potentially disturbed are considered conservative as they are based on the most precautionary density values (0.002 animals per km^2) taken from Carter *et al*. (2020). As described in more detail in volume 3, appendix 10.2, the average density of harbour seal within the Proposed Development array area based on Carter *et al*. (2020) is 0.0001 individuals per km^2. If maximum numbers were compared with estimates based on this average density, the number of harbour seal affected by possible disturbance during concurrent piling at 4,000 kJ) would be less than one animal (0.02% of the ES plus NE Mus population), compared to less than three animals (0.41% of the ES plus NE Mus population) based on maximum densities.

178. It is reasonable to consider that disturbance could be predicted by a realistic average maximum hammer energy of 3,000 kJ (see paragraph 142), where up to two animals could potentially be disturbed during concurrent piling at wind turbine foundations, representing 0.31% of the ES plus NE Mus population (volume 3, appendix 10.5).

179. Harbour seal could also be potentially disturbed within the zone of possible disturbance during single piling at a wind turbine or an OSPs/Offshore convertor station platform at a maximum hammer energy of 4,000 kJ (Figure 10.11), with up to two (0.20% of the ES plus NE Mus population) animals affected (Table 10.34).

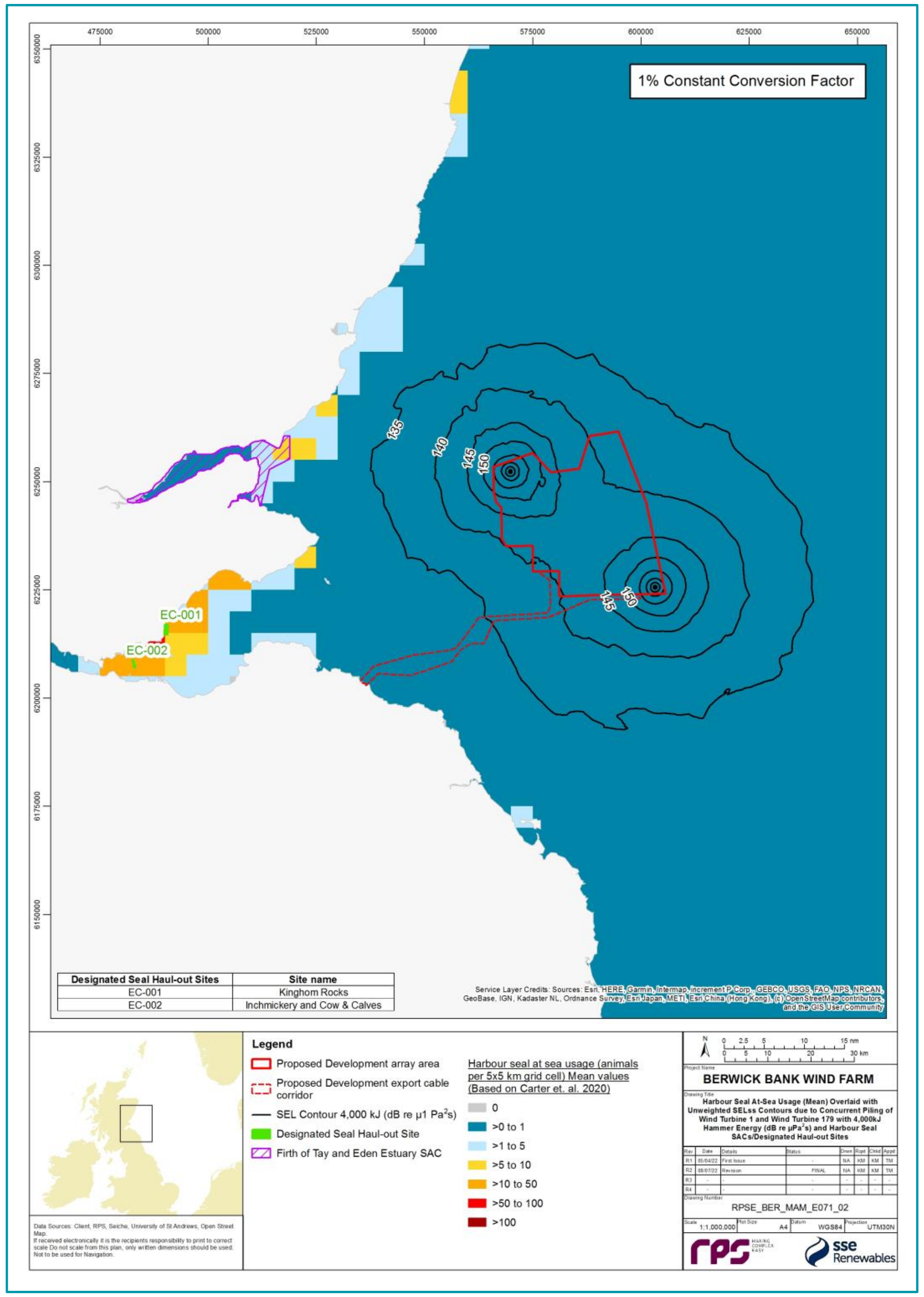


Figure 10.17: Proposed Development and Harbour Seal Mean At-Sea Usage (Carter *et al.*, 2020) Overlaid with Unweighted SEL_{ss} Contours Due to Concurrent Impact Piling of Wind Turbine Piles at Maximum Hammer Energy (4,000 kJ) Using 1% Constant Conversion Factor

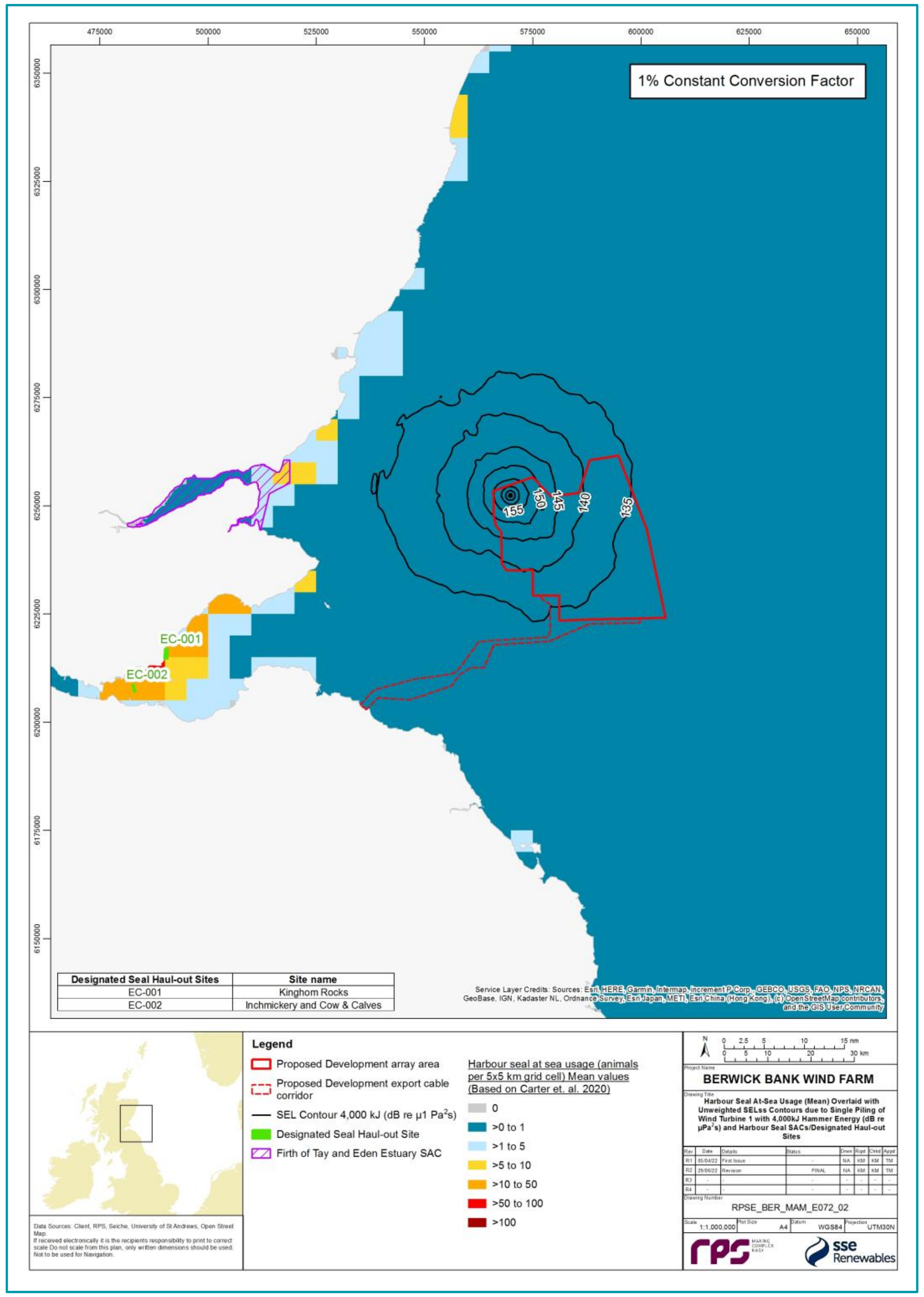


Figure 10.18: Proposed Development and Harbour Seal Mean At-Sea Usage (Carter *et al.*, 2020) Overlaid with Unweighted SEL_{ss} Noise Contours Due to Single Piling at Maximum Hammer Energy (4,000 kJ)

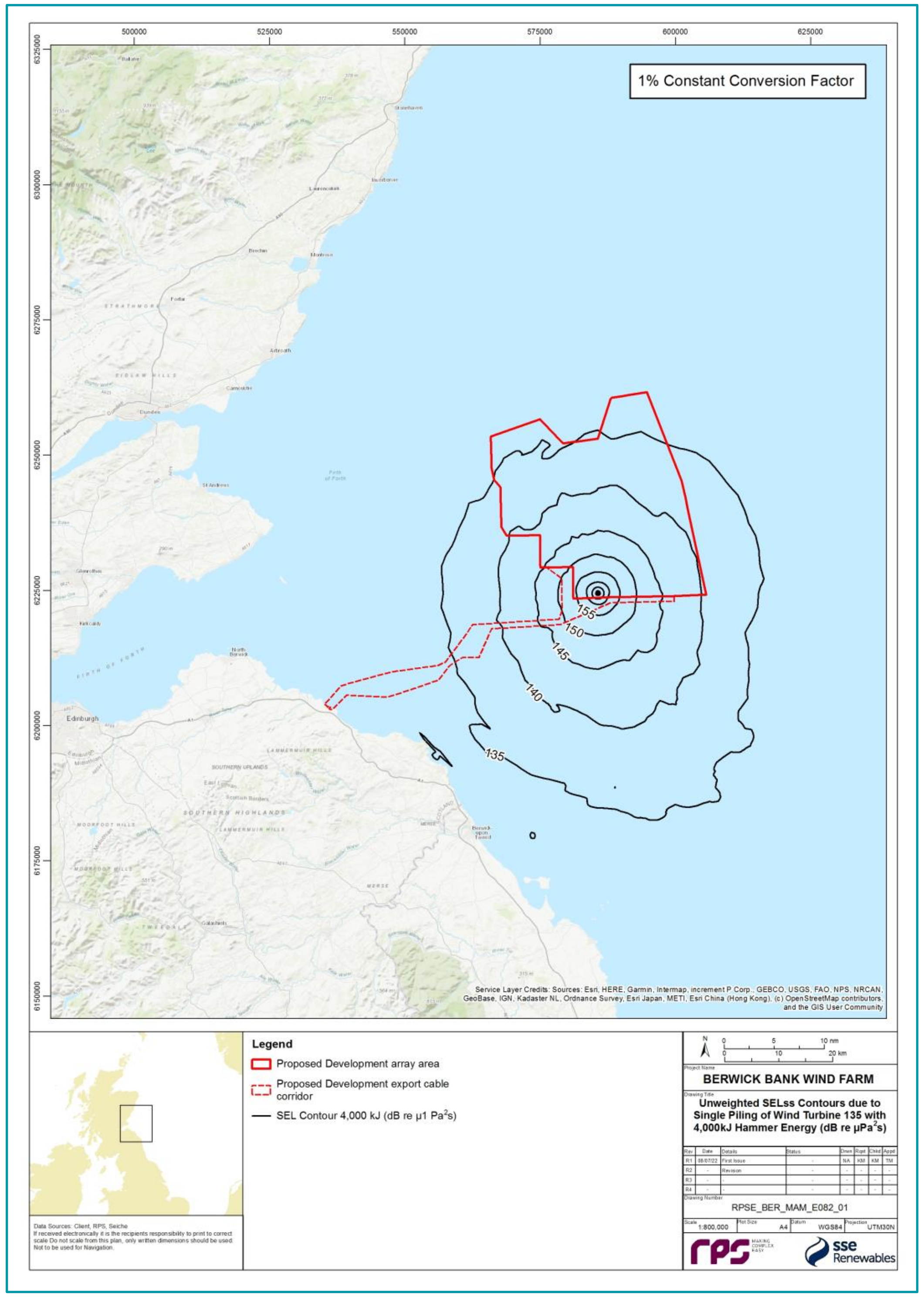


Figure 10.19: Unweighted SEL_{ss} Noise Contours Due to Single Piling at Maximum Hammer Energy (4,000 kJ)

Table 10.34: Number of Harbour Seals Predicted to be Disturbed within Unweighted SEL_{ss} Noise Contours as a Result of Different Piling Scenarios Using 1% Constant Conversion Factor

Scenario (4,000 kJ)	Number of Animals		% Reference Population	
	Average	Maximum	Average	Maximum
Concurrent piling (wind turbine)	<1	<3	0.021	0.39
Single piling (wind turbine/OSPs/Offshore convertor station platform)	<1	<2	0.010	0.20

< = less than

180. As identified in volume 3, appendix 10.2, two sites designated for protection of harbour seal are located within the regional marine mammal study area. There is no potential for overlap of noise contours with the Dornoch Firth and Morrich More SAC, as it is located approximately 195 km from the Proposed Development array area. Given that harbour seal forage mostly within approximately 50 km from the haul out site, it is also very unlikely that individuals from this population will travel as far south. The behavioural disturbance contours during piling at location closest to the shore do not reach the coastal areas where the highest density of harbour seal is encountered (Figure 10.17). There will be no overlap of noise disturbance contours with Forth of Tay and Eden Estuary SAC (located approximately 47 km from the Proposed Development array area) or any of the haul-out sites designated for harbour seals (Figure 10.17). However, given that the outer behavioural disturbance contours (135 dB for seals) extend towards the coast, there is a potential that some of the animals within the impacted area may be associated with the Forth of Tay and Eden Estuary SAC, which has a breeding colony of approximately 41 individuals (SCOS, 2020). Full consideration of potential for AeoI is given in RIAA (SSER, 2022d).

181. The potential for barrier effects (i.e. the ability to move between key areas such as haul-out sites and foraging areas offshore) is considered for both concurrent and single piling scenarios. The level at which a measurable response is predicted to occur in seal species is at a maximum received noise level of SEL_{ss} 135 dB (= 145 dB_{rms}) which was predicted over a shorter range compared to the NMFS (2005) threshold for mild disturbance (140 dB_{rms} = 130 dB_{ss}). Animals exposed to lower noise levels in the outer disturbance contours are likely to experience mild disruptions of normal behaviours but prolonged or sustained behavioural effects, including displacement, are unlikely to occur (Southall *et al.*, (2021). Further discussion on the sensitivity of harbour seal is provided in paragraph 226 *et seq.* (with respect to survival, feeding and reproductive behaviours) but for the purposes of assessment, it is considered that harbour seal close to the coast could experience mild disturbance but that this is unlikely to lead to barrier effects, (i.e. preventing animals from using the foraging grounds in waters along the coast) as animals are unlikely to be excluded from the coastal areas. However, when piling occurs, these is a potential for some animals to be temporarily deterred from the offshore areas. Animals would therefore need to find alternative foraging grounds and there may be an energetic cost associated with longer foraging trips.

182. As previously described in paragraph 134 *et seq.,* the duration of piling could potentially affect harbour seal over a maximum of five breeding cycles. The magnitude of the impact could also result in a small but measurable alteration to the distribution of marine mammals during piling only (372 days over 52 month piling phase) and may affect the fecundity of some individuals (up to 0.39% of the ES plus NE MU population at any one time) over the medium term.

183. As agreed with consultees (Table 10.9) population modelling was carried out to explore the potential of disturbance during piling to affect the population trajectory over time and provide additional certainty in the predictions of the assessment of effects. Results of the iPCoD modelling for harbour seal against the MU population showed that the median of the ratio of the impacted population to the unimpacted

population was 100% at 25 years regardless of the conversion factor scenario assessed (1% constant, 4% reducing to 0.5% or 10% reducing to 1% conversion factors). Very small differences in population size over time between the impacted and unimpacted population fall within the natural variance of the population as can be seen in Figure 10.20, where results of simulated population number (y axis) are similar on either side of the median line for both, impacted and unimpacted population. Therefore, it was considered that there is no potential for a long-term effects on this species (Figure 10.20, see volume 3, appendix 10.4 for more details). These results are not in agreement with findings of Hanson *et al*. (2017), who suggested that the continuation of current decline trend in the Forth of Tay and Eden Estuary SAC could result in the species disappearing from this area within next 20 years. The reason for this discrepancy is that the revised demographic parameters to inform iPCoD models (Sinclair *et al.,* 2020) indicate that with inclusion of the Firth of Forth counts, the total East Scotland (ES) MU counts appear to be relatively stable. Additionally, sporadic counts in the area indicate that the decline is localised within the SAC and may not represent the trends in the overall MU population (SCOS, 2020; Sinclair *et al.,* 2020).

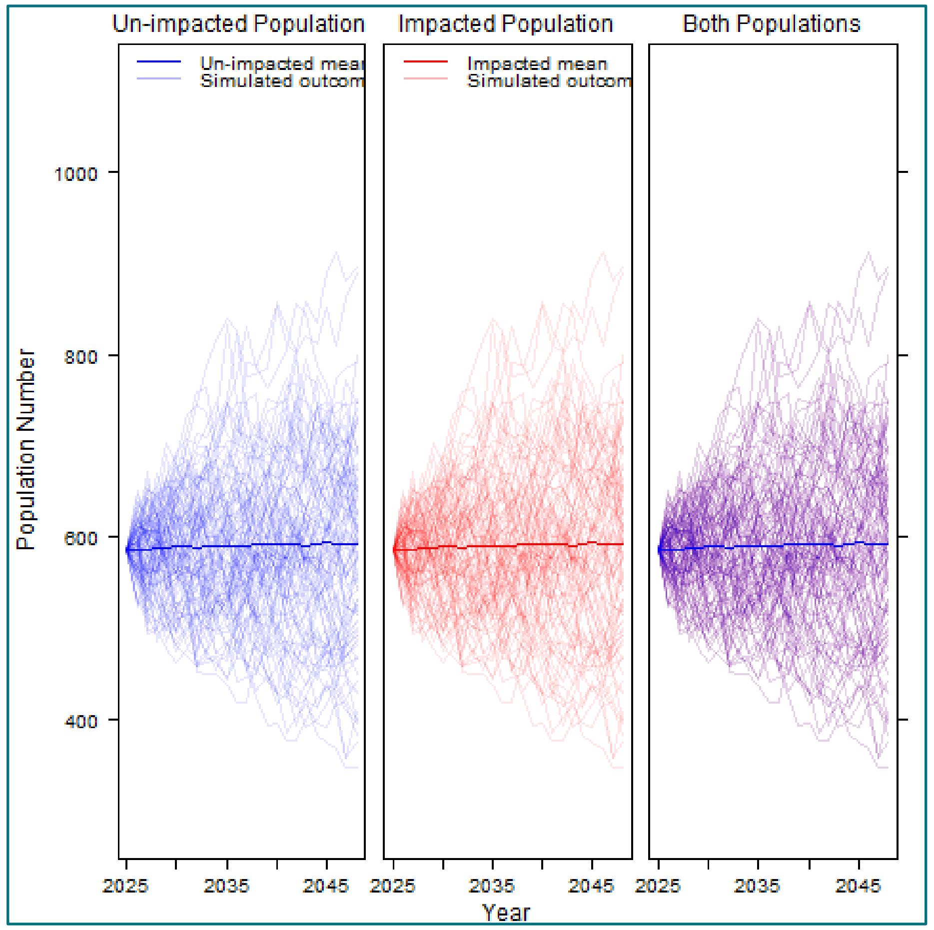


Figure 10.20: Simulated Harbour Seal Population Sizes for Both the Baseline and the Impacted Populations Under the Maximum Adverse Scenario Using 1% Conversion Factor and no Vulnerable Subpopulation.

184. The impact 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 results suggest that in short to medium term the magnitude would be low. Recovery is considered likely to occur soon after cessation of piling and there were predicted to be no long-term population-level effects on harbour seal as corroborated by the population modelling. The magnitude is therefore considered to be low.

Grey seal

185. As previously described in paragraph 174 *et seq.,* there were two main approaches used to calculate the magnitude of effects with the potential to cause disturbance to marine mammals. As with harbour seal the approach using the uniformly distributed maximum density estimate (Table 10.13) multiplied by the largest predicted areas of effect for single/concurrent piling (as presented in Figure 10.19 and Figure 10.11) resulted in the most precautionary assessment. To reiterate, this is a precautionary approach, as realistically the density of grey seal will vary (as presented in Figure 10.21 to Figure 10.22 showing grey seal at-sea usage based on Carter *et al.* (2020) study), and therefore will not represent a mean value across the Proposed Development marine mammal study area.

186. Using the most precautionary approach up to 1,358 animals were predicted to have the potential to be disturbed from concurrent piling at a maximum hammer energy of 4,000 kJ (Figure 10.10). This equates to 3.19% of the ES plus NE Mus population (Table 10.35). For comparison, the number of animals that could be potentially disturbed during the same piling scenario but using 4% reducing to 0.5% conversion factor has been conservatively assessed as up to 935 grey seals, which equates to 2.19% of the ES plus NE MU population (see volume 3, appendix 10.5 for estimates using various conversion factor).

187. Grey seal could also be potentially disturbed within the zone of possible disturbance during single piling at a wind turbine or an OSPs/Offshore convertor station platform at a maximum hammer energy of 4,000 kJ (Figure 10.11), with up to 705 (1.66% of the ES plus NE Mus population) animals affected (Table 10.35).

188. The maximum numbers presented in Table 10.35 are considered conservative as these are based on the mean at-sea usage estimates (1.2 animals per km^2) from Carter *et al*. (2020). If maximum numbers were compared with estimates of the number of potentially disturbed grey seals using the mean monthly (0.276 animals per km^2) or even the peak seasonal densities (0.321 animals per km^2), derived from the Proposed Development aerial digital survey data, these estimates would be shown to be highly precautionary. For example, based on the mean and peak densities from aerial data, the number of grey seals affected by possible disturbance for the maximum adverse scenario (concurrent piling at 4,000 kJ) would be 312 animals (0.73% of the ES plus NE Mus population) and 364 animals (0.85% of the ES plus NE Mus population), respectively, compared to 1,358 animals (3.19% of the ES plus NE Mus population) estimated for mean at sea usage from Carter *et al.* (2020). Similarly, for the single piling at 4,000 kJ scenario, the estimates using the mean and peak densities from aerial data, would be 166 animals (0.39% of the ES plus NE Mus population and 193 animals (0.45% of the ES plus NE Mus population), respectively, compared to 720 animals (1.69% of the ES plus NE Mus population) using Carter *et al.* (2020) mean at-sea usage estimates.

189. It is reasonable to consider that disturbance could be predicted by a realistic average maximum hammer energy of 3,000 kJ (see paragraph 142), where up to 1,095 animals could potentially be disturbed during concurrent piling at wind turbine foundations, representing 2.57% of the ES plus NE Mus population (volume 3, appendix 10.5).

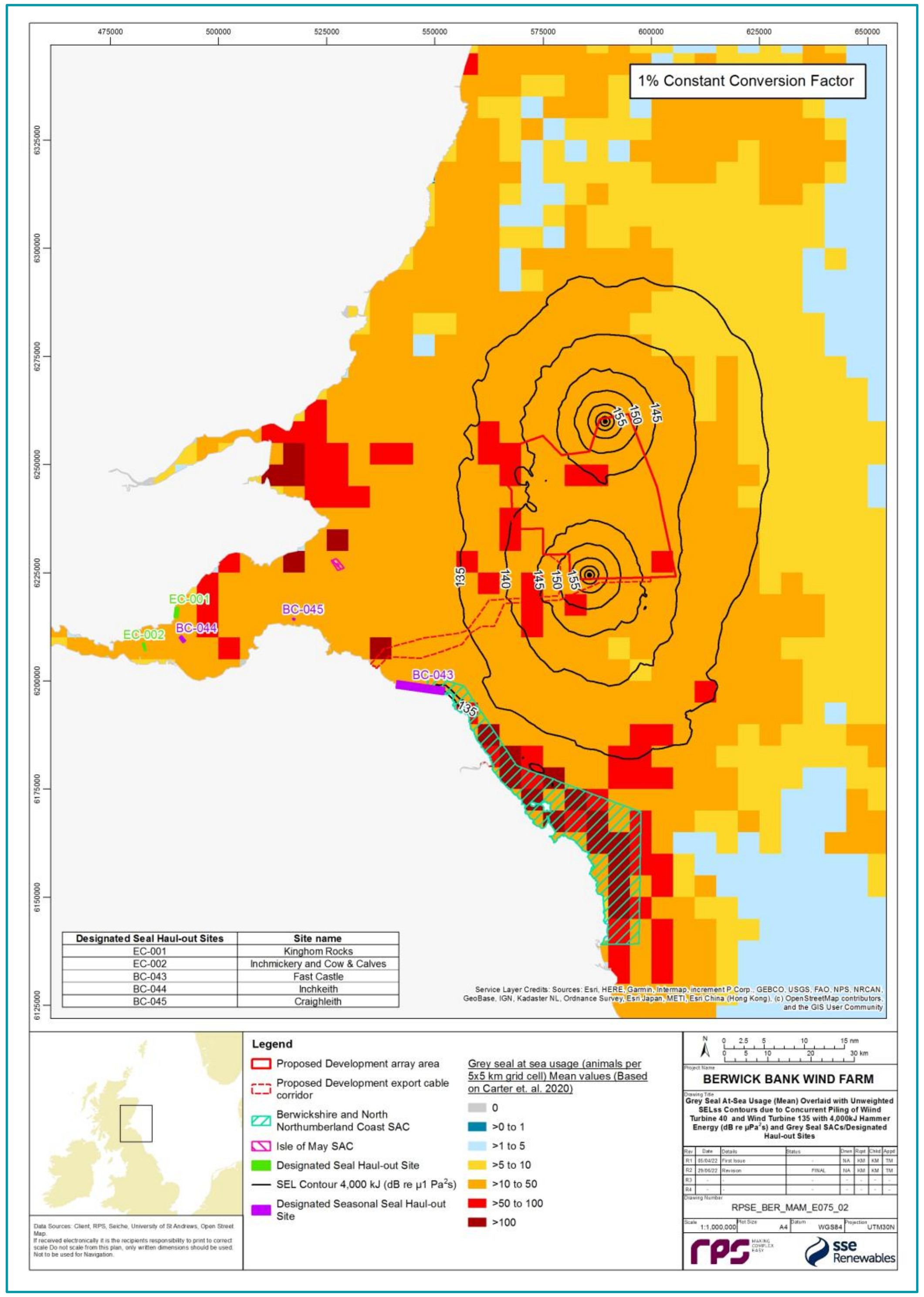


Figure 10.21: Proposed Development and Grey Seal At-Sea Usage (Mean) Overlaid with Unweighted SEL_{ss} Contours Due to Concurrent Impact Piling of Wind Turbine Piles at Maximum Hammer Energy (4,000 kJ) Using 1% Constant Conversion Factor

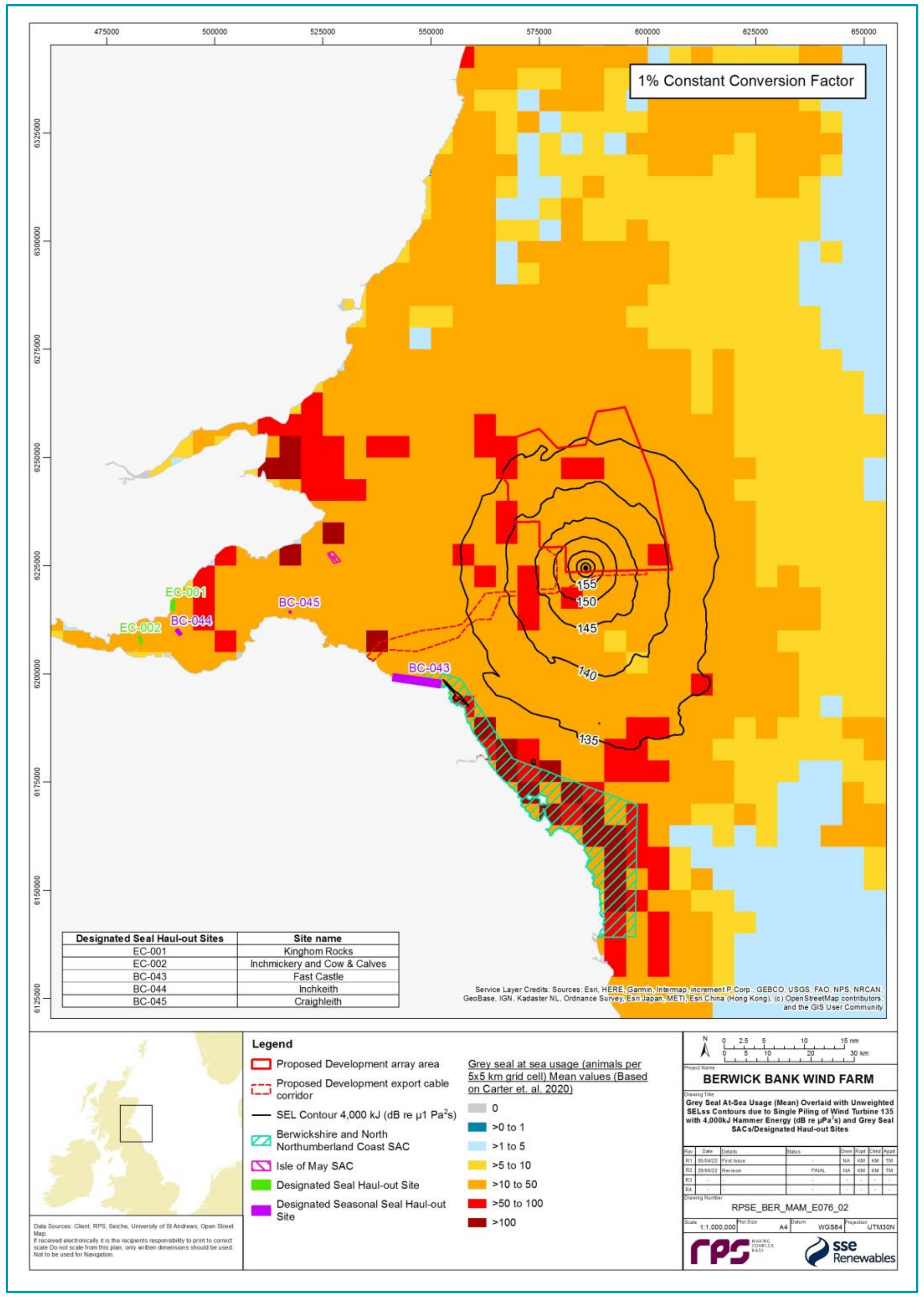


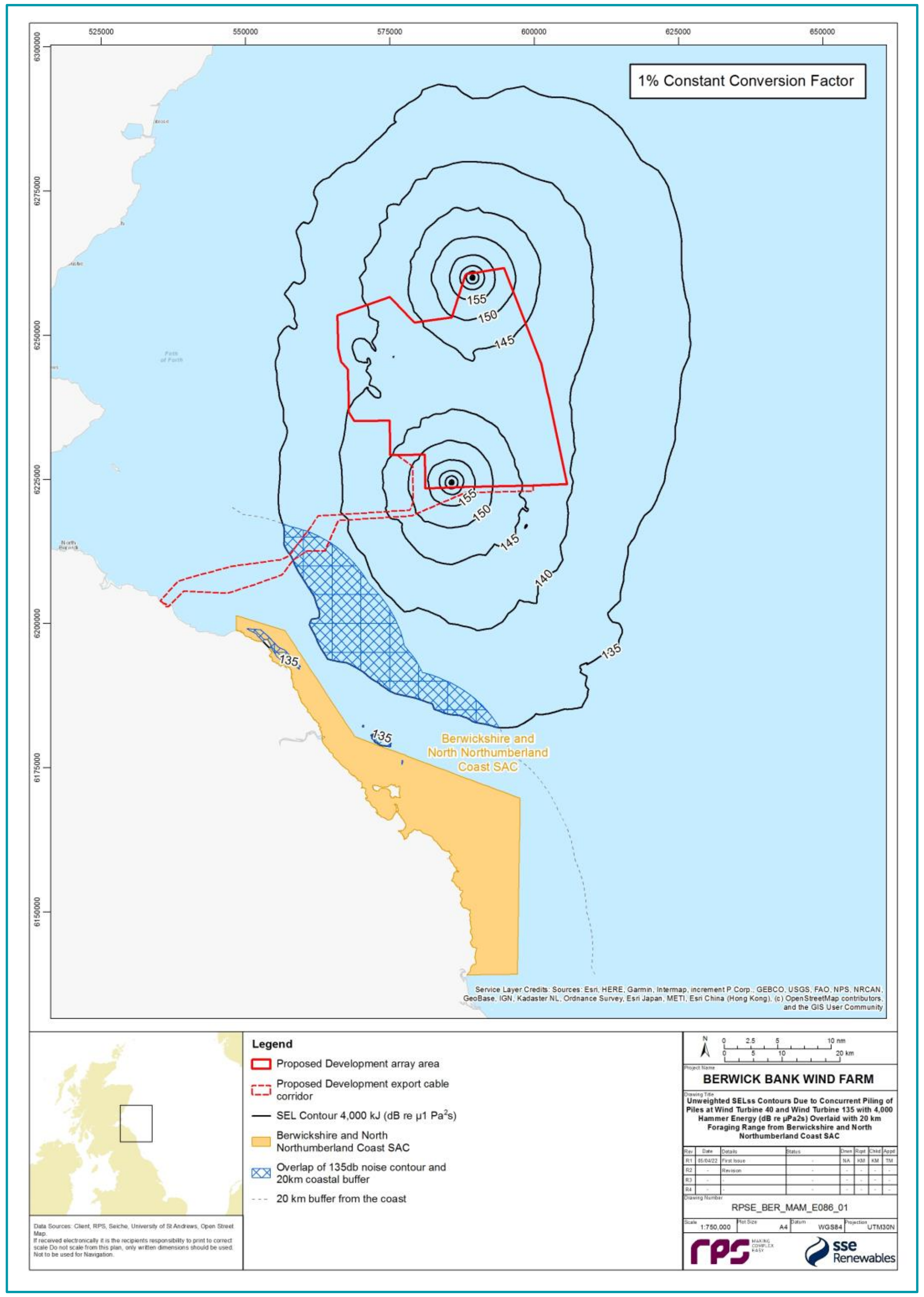
Figure 10.22: Proposed Development and Grey Seal At-Sea Usage (Mean) Overlaid with Unweighted SEL_{ss} Noise Contours Due to Single Piling at Maximum Hammer Energy (4,000 kJ) Using 1% Constant Conversion Factor

Table 10.35: Number of Grey Seals Predicted to be Disturbed within Unweighted SEL_{ss} Noise Contours as a Result of Different Piling Scenarios Using 1% Constant Conversion Factor

Scenario (4,000 kJ)	Number of Animals		% Reference Population	
	Average	Maximum	Average	Maximum
Concurrent piling (wind turbine)	312	1,358	0.73	3.19
Single Piling (wind turbine/OSPs/Offshore convertor station platform)	162	705	0.38	1.66

190. As identified in volume 3, appendix 10.2, two sites designated for protection of grey seal are located within the regional marine mammal study area, the Berwickshire and North Northumberland Coast SAC and the Isle of May SAC. As water depth is getting shallower closer to land, the outer behavioural disturbance contours (135 dB) overlap only slightly with coastal areas south of the Proposed Development and therefore there is a small overlap with northern part of the Berwickshire and North Northumberland Coast SAC (Figure 10.21). However, although there is a potential for overlap of disturbance contours with northern section of the SAC, it is the southern half of the SAC which is an important breeding site for grey seals (SCOS, 2020; see Figure 6.21 in volume 3, appendix 10.2, where grey seal telemetry tracks are concentrated in waters around Farne Islands). There is no direct overlap of the outer behavioural noise contours with Isle of May SAC, located approximately 40 km from the Proposed Development array area (Figure 10.24). As the outer behavioural disturbance contours extend towards Fife and Berwickshire coasts, it is assumed that some of the animals in the impacted area could be associated with both, Isle of May SAC and Berwickshire and North Northumberland Coast SAC. These sites support breeding populations of 5,900 and 1,000 individuals, respectively. As these SACs represent areas of higher density for grey seal (and near to coastal haul-outs), the potential for barrier effects (i.e. the ability to move between key areas such as haul-out sites and foraging areas offshore) has also been considered in paragraph 191. As advised by consultees for the HRA purposes (SSER, 2022d), grey seal foraging trips extend out to 20 km from the haul-out site during breeding season. Based on Carter *et al.* (2020) seal at-sea density grids and the area of overlap between the maximum foraging range and the outer disturbance contour, a maximum of 532 individuals within the foraging range from Berwickshire and North Northumberland Coast SAC (Figure 10.23) and 18 individuals within the foraging range from Isle of May (Figure 10.24) could potentially experience mild disturbance (i.e. received levels of no greater than 135 dB SEL_{ss}). It must be noted that behavioural disturbance contours presented in Figure 10.23 and Figure 10.24 represent the maximum adverse scenario for concurrent piling at the closest wind turbine locations to the designated sites. Therefore, it is likely that for most wind turbine/OSPs/Offshore convertor station platform locations the disturbance contours will not reach as far towards the SACs during the piling and thus smaller numbers of animals would be disturbed. Full consideration of potential adverse effects on the integrity on European Sites (AeoI) is also given in RIAA (SSER, 2022d).

191. The level at which a measurable response is predicted to occur in seal species is at a maximum received noise level of SEL_{ss} 135 dB (≡ 145 dB_{rms}) which was predicted over a shorter range compared to the NMFS (2005) threshold for mild disturbance (140 dB_{rms} ≡ 130 dB SEL_{ss}). Animals exposed to lower noise levels in the outer disturbance contours are likely to experience mild disruptions of normal behaviours but prolonged or sustained behavioural effects, including displacement are unlikely to occur (Southall *et al*., 2021). Further discussion on the sensitivity of grey seal is provided in paragraph 226 *et seq.* (with respect to survival, feeding and reproductive behaviours). For the purposes of assessment, it is considered that grey seal close to the coast could experience mild disturbance but that this is unlikely to lead to barrier effects (i.e. prevent animals from using the foraging grounds in waters along the coast), as animals are unlikely to be excluded from the area. However, when piling occurs, there is the potential for some animals to be temporarily deterred from the offshore areas. Animals would therefore need to find alternative foraging grounds and there may be an energetic cost associated with longer foraging trips.



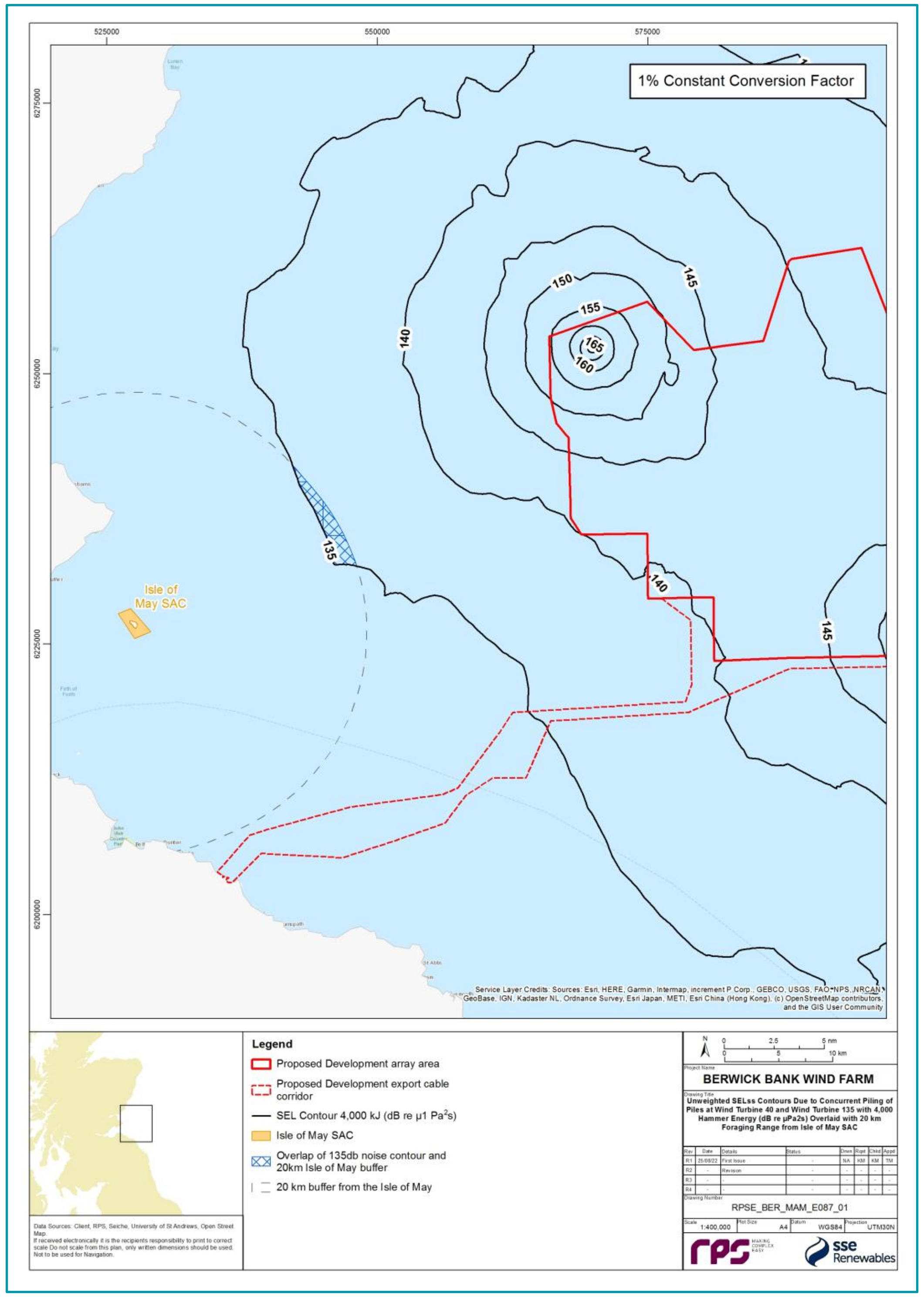


Figure 10.23: Unweighted SEL_{ss} Contours Due to Concurrent Piling Overlaid with 20 km Buffer from the Coast Along the Berwickshire and North Northumberland Coast SAC

Figure 10.24: Unweighted SELss Contours Due to Concurrent Piling Overlaid with 20 km Buffer from the Isle of May SAC

192. As previously described in paragraph 134 *et seq.,* the duration of piling could potentially affect grey seal over a maximum of five breeding cycles. The magnitude of the impact could also result in a small but measurable alteration to the distribution of marine mammals during piling only (372 days over 52 months) and may affect the fecundity of relatively large numbers in the context of the reference population (up to 3.19% of the ES plus NE MU population at any one time) over the medium term.

193. As agreed with consultees (Table 10.9) population modelling was carried out to explore the potential of disturbance during piling to affect the population trajectory over time and provide additional certainty in the predictions of the assessment of effects. Results of the iPCoD modelling for grey seal against the MU population showed that the median of the ratio of the impacted population to the unimpacted population was 100% at 25 years regardless of the conversion factor scenario assessed (1% constant, 4% reducing to 0.5% or 10% reducing to 1% conversion factors). Very small differences in population size over time between the impacted and unimpacted population fall within the natural variance of the population as can be seen in Figure 10.25, where results of simulated population number (y axis) are similar on either side of the median line for both, impacted and unimpacted population. Therefore, it was considered that there is no potential for a long-term effect on this species. (Figure 10.25, see volume 3, appendix 10.4 for more details).

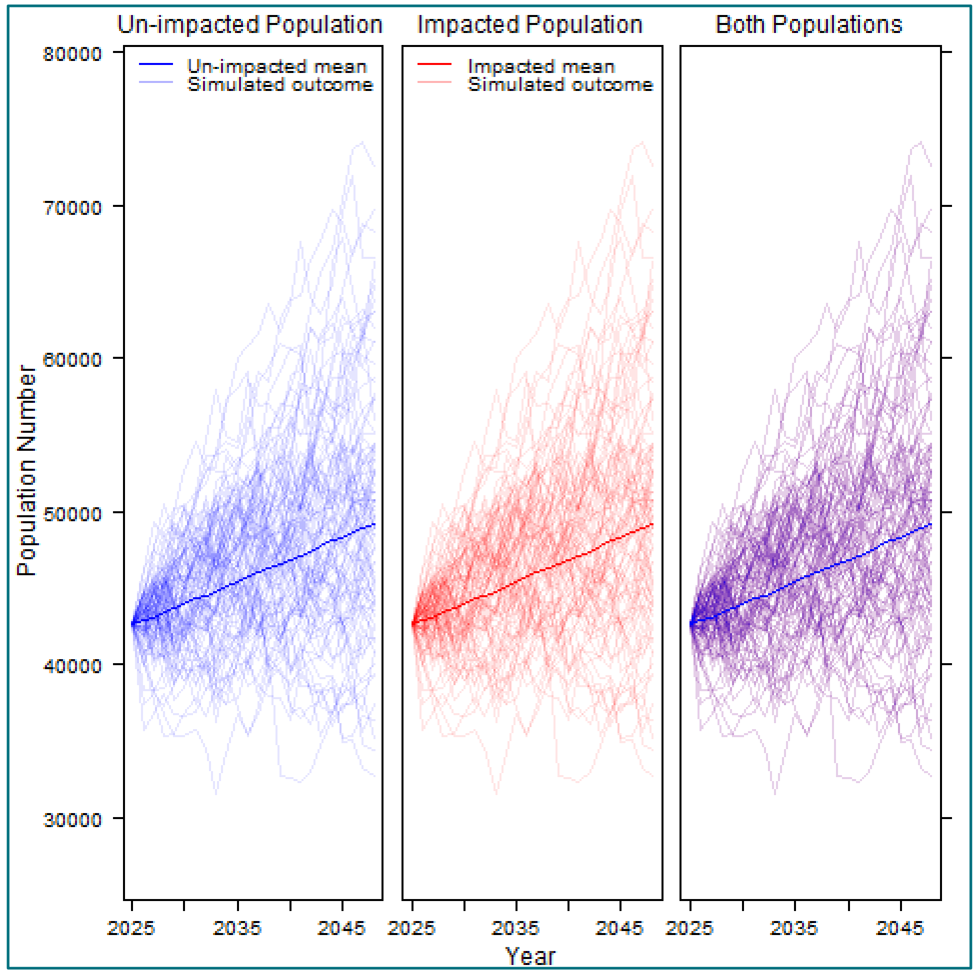
194. 

Figure 10.25: Simulated Grey Seal Population Sizes for Both the Baseline and the Impacted Populations Under the Maximum Adverse Scenario Using 1% Conversion Factor and no Vulnerable Subpopulation.

195. The impact 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 in short to medium term could be considered as medium, however, behavioural effects are likely to be short-lived with recovery occurring soon after cessation of piling and because population modelling results shown that piling activities will not have adverse effect on grey seal population in the long term, the magnitude is therefore considered to be low.

<u>Sensitivity of the Receptor</u>

Auditory Injury

Harbour porpoise

196. Scientific understanding of the biological effects of threshold shifts is limited to the results of controlled exposure studies on small numbers of captive animals (reviewed in Finneran *et al*., 2015) where TTS are

experimentally induced (since it is unethical to induce PTS in animals) and thresholds for PTS extrapolated using TTS growth rates (see paragraph 70).

197. Studies of auditory injury in relation to a typical piling sequence have suggested that hearing impairment as a result of exposure to piling noise is likely to occur where the source frequencies overlap the range of peak sensitivity for the receptor species rather than across the whole frequency hearing spectrum (Kastelein *et al.,* 2013). Kastelein *et al*. (2013) demonstrated experimentally that for simulated piling noise (broadband spectrum), harbour porpoise's hearing around 125 kHz (the key frequency for echolocation) was not affected. Instead, a measurable threshold shift in hearing was induced at frequencies of 4 kHz to 8 kHz, although the magnitude of the hearing shift was relatively small (2.3 dB to 3.6 dB at 4 kHz to 8 kHz) due to the lower received SELs at these frequencies. This was due to most of the energy from the simulated piling occurring in lower frequencies (Kastelein *et al*., 2013). Subsequently, Kastelein *et al*. (2017) confirmed sensitivity declined sharply above 125 kHz. The susceptibility of harbour porpoise to threshold shifts was further corroborated in a series of studies measuring temporary shifts in hearing in harbour porpoise at high amplitude frequencies of 0.5 kHz to 88.4 kHz. Here the greatest shift in mean TTS occurred at 0.5 kHz, which is very close to the lower bound of porpoise hearing (Kastelein *et al.,* 2021). Hearing always recovered within 60 minutes after the fatiguing sound stopped.

198. In addition to the frequency characteristics of the source, the duty cycle of fatiguing sounds is also likely to affect the magnitude of a hearing shift. Kastelein *et al*. (2014) suggested that hearing may recover to some extent during inter-pulse intervals. Similarly, Finneran (2015) highlighted that whilst a threshold shift can accumulate across multiple exposures, the resulting shift will be less than the shift from a single, continuous exposure with the same total SEL.

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

200. Extrapolating the results from captive bred studies to how animals may respond in the natural environment should, however, be treated with caution as it is not possible to exactly replicate natural environmental conditions. In addition, the small number of test subjects would not account for intraspecific differences (i.e. differences between individuals) or interspecific differences (i.e. extrapolating to other species) in response. However, based on our current understanding, since PTS is a permanent and irreversible hearing impairment it is expected that harbour porpoise is sensitive to this effect as the loss of hearing would affect key life functions (e.g. communication, predator detection, foraging, mating and maternal fitness) and could lead to a change in an animal's health (if chronic) or vital rates (if acute) (Erbe *et al*., 2018). Morell *et al*. (2021) showed the first case of presumptive noise-induced hearing loss, based on inner ear analysis in a free-ranging harbour porpoise. Subject to the limitations of available empirical evidence a potential consequence of a disruption in key life functions is that the health of impacted animals would deteriorate and potentially lead to reduced birth rate in females and mortality of individuals (Costa, 2012).

201. Given the uncertainty surrounding the effects of PTS on survival and reproduction and the importance of sound for echolocation, foraging and communication in all cetaceans, harbour porpoise, an IEF of international value, is deemed to be of high vulnerability and low recoverability. The sensitivity of the receptor to PTS is therefore, considered to be high.

Bottlenose dolphin and white-beaked dolphin

202. Individual dolphins experiencing PTS would suffer a biological effect that could impact the animal's health and vital rates (Erbe *et al*., 2018). Bottlenose and white-beaked dolphin are both classed as high-frequency cetaceans (Southall *et al*., 2019). As described for harbour porpoise in paragraph 196 *et seq.* there are frequency-specific differences in the onset and growth of a noise-induced threshold shift in relation to the characteristics of the noise source and hearing sensitivity of the receiving species. For example, exposure of two captive bottlenose dolphins to an impulsive noise source between 3 kHz and 80 kHz found that there was increased susceptibility to auditory fatigue between frequencies of 10 to 30 kHz (Finneran and Schlundt, 2013). The SEL_{cum} threshold incorporates hearing sensitivities of marine mammals and the magnitude of effects were considerably smaller compared to the VHF (e.g. harbour porpoise) and LF (e.g. minke whale) species, highlighting that HF species are less sensitive to the frequency components of the piling noise signal. The assessment considered the irreversibility of the effects (i.e. as noted for harbour porpoise) and importance of sound for echolocation, foraging and communication in small, toothed cetaceans.

203. Given the uncertainty surrounding the effects of PTS on survival and reproduction and the importance of sound for echolocation, foraging and communication in all cetaceans, bottlenose dolphin and white-beaked dolphin, IEFs of international value, are deemed to be of high vulnerability and low recoverability. The sensitivity of both receptors to PTS is therefore, considered to be high.

Minke whale

204. Although very little is known about minke whale hearing, their vocalisation frequencies are likely to overlap with anthropogenic sounds. Minke whale does not echolocate but likely use sound for communication and, like other mysticete whales, are able to detect sound via a skull vibration enabled bone conduction mechanism (Cranford and Krysl, 2015). As a baleen whale with estimated functional hearing range between 17 Hz and 35 kHz, it is likely that they rely on low frequency hearing (Ketten and Mountain, 2011). A controlled exposure study on free ranging minke whale in Iceland found that minke whales reacted strongly to a 15 kHz ADD; a frequency considered to be at the likely upper limit of their hearing sensitivity (Boisseau *et al.,* 2021). As described for harbour porpoise in paragraph 196 *et seq.,* there are likely to be frequency-specific differences in the onset and growth of a noise-induced threshold shift in relation to the characteristics of the noise source and hearing sensitivity of the receiving species.

205. Given the uncertainty surrounding the effects of PTS on survival and reproduction and the importance of sound for echolocation, foraging and communication in all cetaceans, minke whale, an IEF of international value, is deemed to be of high vulnerability and low recoverability. The sensitivity of the receptor to PTS is therefore, considered to be high.

Harbour seal and grey seal

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

conservative and therefore predicted numbers of individuals likely to be affected by PTS would also have been highly conservative.

207. There is some evidence of noise-induced PTS in harbour seals, with the first confirmed report of PTS following a known acoustic exposure event in a marine mammal (Reichmuth *et al.,* 2019). The underwater hearing sensitivity of a trained harbour seal was evaluated before and immediately following exposure to 4.1 kHz tonal fatiguing stimulus, and rather than the expected pattern of TTS onset and growth, an abrupt threshold shift of > 47 dB was observed half an octave above the exposure frequency. While hearing at 4.1 kHz recovered within 48 h, there was a PTS of at least 8 dB at 5.8 kHz, and hearing loss was evident for more than ten years.

208. Despite the uncertainty in the ecological effects of PTS on seals, seals rely on hearing much less than cetaceans and therefore would exhibit some tolerance (i.e. the effect is unlikely to cause a change in either reproduction or survival rates). In addition, it has been proposed that seals may be able to self-mitigate (i.e. reduce their hearing sensitivity in the presence of loud sounds in order to reduce their perceived SPL) (Kastelein *et al*., 2018a). Although this evidence suggests a lower sensitivity of pinnipeds to PTS, based on uncertainties a precautionary approach has been taken.

209. The telemetry data confirmed connectivity between Firth of Tay and Eden Estuary SAC, designated for harbour seal, and the Proposed Development marine mammal study area. The population of harbour seal is mostly concentrated within the Firth of Tay and Eden Estuary SAC and Firth of Forth, however the population within the Tay SAC is continuing to decline without indication of recovery within last 20 years (see volume 3, appendix 10.2 for more information). Population modelling work conducted for the Firth of Tay and Eden Estuary SAC population has concluded that if this declining trend continues, the population may become extinct within the next 20 years (Hanson *et al*., 2017). Although it is unknown what is the reason for this decline, this population is deemed sensitive to any additional anthropogenic disturbance, especially during the breeding season (spring and summer). No population trajectory is available for Firth of Forth, although sporadic counts in the area indicate that the decline is localised within the SAC and may not represent the trends in the overall MU population (SCOS, 2020; Sinclair *et al.,* 2020). Harbour seals are generalist feeders and can forage on variety of species, usually within 50 km from the coast. Individuals may be particularly sensitive to anthropogenic disturbance or changes in prey distribution especially during breeding season.

210. Grey seal and harbour seals, IEFs of international value, are deemed to be of medium vulnerability and low recoverability. The sensitivity of the receptor is therefore considered to be high.

Behavioural disturbance

211. Studies have shown that acoustic disturbance to marine mammals may lead to the interruption of normal behaviours (such as feeding or breeding) and avoidance, leading to displacement from the area and exclusion from critical habitats (Goold, 1996; Weller *et al.,* 2002; Castellote *et al*., 2010, 2012). Noise may also cause stress which in turn can lead to a depressed immune function and reduced reproductive success (Anderson *et al*., 2011; 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 (paragraph 78 *et seq*.). A summary of known behavioural sensitivities of different species to underwater noise from piling at other wind farm sites is provided in paragraph 212 *et seq.,* noting that the conclusions drawn are subject to the limitations of extrapolating results from one project to another.

Harbour porpoise

212. Harbour porpoise, as a small cetacean species, is vulnerable to heat loss through radiation and conduction. As a species with a high metabolic requirement, it needs to forage frequently to lay down sufficient fat reserves for insulation. A study of six, non-lactating, harbour porpoise found that they require between 4% and 9.5% of their body weight in fish per day (Kastelein *et al*., 1997). In the wild, porpoises forage almost continuously day and night to achieve their required calorific intake (Wisniewska *et al.,* 2016). This means that they are vulnerable to starvation if their foraging is interrupted. Harbour porpoise were recorded year-round and frequently within the Proposed Development marine mammal study area and therefore could be vulnerable to piling at any time of year.

213. The variance in behavioural responses to increased subsea noise is well documented and is context specific. Factors such as the activity state of the receiving animal, the nature and novelty of the sound (i.e. previous exposure history), and the spatial relation between sound source and receiving animal are important in determining the likelihood of a behavioural response and therefore their sensitivity (Ellison *et al*., 2012). Empirical evidence from monitoring at offshore wind farms during construction suggests that pile driving is unlikely to lead to 100% avoidance of all individuals exposed, and that there will be a proportional decrease in avoidance at greater distances from the pile driving source (Brandt *et al*., 2011). This was demonstrated at Horns Rev Offshore Wind Farm, where 100% avoidance occurred in harbour porpoises at up to 4.8 km from the piles, whilst at greater distances (10 km plus) the proportion of animals displaced reduced to < 50% (Brandt *et al*., 2011). A recent study on piling at the Beatrice Offshore Wind Farm suggests that harbour porpoise may adapt to increased noise disturbance over the course of the piling phase, thereby showing a degree of tolerance and behavioural adaptation (Graham *et al*., 2019). This study also demonstrated that the probability of occurrence of harbour porpoise (measured as porpoise positive minutes) increased exponentially moving further away from the noise source. Similarly, at a study of seven offshore wind farms constructed in the German Bight, Brandt *et al.*, (2018) also showed that detections of harbour porpoise declined several hours before the start of pling within the vicinity (up to 2 km) of the construction site and were reduced for about one to two hours post-piling, whilst at the maximum effect distances (from 17 km out to approximately 33 km) avoidance only occurred during the hours of piling. In this study, porpoise detections during piling were found at sound levels exceeding 143 dB re 1 $\mu Pa^2 s$ and at lower received levels – at greater distances from the source – there was little evident decline in porpoise detections (Brandt *et al.,* 2018). These studies demonstrate the dose-response relationship between received noise levels and declines in porpoise detections although noting that the extent to which responses could occur will be context-specific such that, particularly at lower received levels (i.e. 130 dB -140 dB re 1 $\mu Pa^2 s$), detectable responses may not be apparent from region to region.

214. A recent article by Southall *et al*. (2021) introduces a behavioural response severity spectrum, building on earlier work presented in Southall *et al*. (2007) and the expanding literature in this area. Southall *et al*. (2021) illustrates the progressive severity of possible responses within three response categories: survival (e.g. resting, navigation, defence), feeding (e.g. search, consumption, energetics), and reproduction (e.g. mating, parenting). For example, at the most severe end of the spectrum (scored 7 to 9), where sensitivity is highest, displacement could occur resulting in movement of animals to areas with an increased risk of predation and/or with sub-optimal feeding grounds. A failure of vocal mechanisms to compensate for noise and interruption of key reproductive behaviour including mating and socialising could occur. In these instances, there would likely be a reduction in an individual's fitness leading to potential breeding failure and impact on survival rates.

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

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

217. Harbour porpoise, an IEF of international value, is deemed to be of medium vulnerability and high recoverability. The sensitivity of the receptor to disturbance is therefore considered to be medium.

Bottlenose dolphin and white-beaked dolphin

218. Bottlenose dolphin and white-beaked dolphin are not thought to be as vulnerable to disturbance as harbour porpoise; with larger body sizes – and lower metabolic rates – the necessity to forage frequently is lower in comparison. White-beaked dolphin have a largely offshore distribution and their presence in the Proposed Development marine mammal study area is likely to be very seasonal. Weir *et al*. (2007) reported that white-beaked dolphins within the coastal North Sea area in Aberdeenshire were typically recorded only between June and August, with a peak in occurrence during August. Bottlenose dolphin is largely coastally distributed in relation to the Proposed Development marine mammal study area and are more abundant during spring and summer compared to autumn and winter months (Paxton *et al.*, 2016). Offshore sightings during the recent DAS recorded sightings within the Proposed Development marine mammal study area during the months of October and April (see volume 3, appendix 10.2).

219. There is limited information regarding the specific sensitivities of bottlenose dolphin and white-beaked dolphin to disturbance from piling noise as most studies have focussed on harbour porpoise. A study of the response of bottlenose dolphin to piling noise during harbour construction works at the Nigg Energy Park in the Cromarty Firth (north-east Scotland) found that there was a measurable (albeit weak) response to impact and vibration piling with animals reducing the amount of time they spent in the vicinity of the construction works (Graham *et al.,* 2017). Another study investigating dolphin detections in the Moray Firth during impact piling at the Moray East and Beatrice Offshore Wind Farms found surprising results at small temporal scales with an increase in dolphin detections on the southern Moray coast on days with impulsive noise compared to days without (Fernadez-Betelu *et al.*, 2021). Predicted maximum received levels in coastal areas were 128 dB re. 1 µPa²s and 141 dB re. 1 µPa²s during piling at Beatrice Offshore Wind farm Ltd (BOWL) and Moray Offshore Renewables Ltd (MORL) respectively (Fernadez-Betelu *et al.*, 2021). The authors of this study warn that caution must be exercised in interpreting these results as increased click changes do not necessarily equate to larger groups sizes but may be due to a modification in behaviour (e.g. an increase in vocalisations during piling) (Fernadez-Betelu *et al.*, 2021). The results of this study do, however, suggest that impulsive noise generated during piling at the offshore wind farms did not cause any displacement of bottlenose dolphins from their population range. Notably, the received levels during piling at MORL are higher than those predicted for the outer isopleths (130 dB and 135 dB re. 1 µPa²s) that overlap with the CES MU 2 m – 20 m depth contour during piling at the Proposed Development suggesting that disturbance at these lower noise levels is unlikely to lead to displacement effects.

220. The Southall *et al*. (2021) severity spectrum applies across all marine mammals and therefore it is expected that, as described for harbour porpoise, strong disturbance in the near field could result in displacement whilst mild disturbance over greater ranges would result in other, less severe behavioural responses (see paragraph 214).

221. White-beaked dolphin and bottlenose dolphin may be able to avoid the disturbed area and whilst there may some impacts on reproduction in closer proximity to the source (i.e. within the area of ‘strong disturbance’), these are unlikely to impact on survival rates as some tolerance is expected to build up over the course of the piling. It is anticipated that animals would return to previous activities once the impact had ceased.

222. Bottlenose dolphin and white-beaked dolphin, IEFs of international value, are deemed to be of medium vulnerability and high recoverability. The sensitivity of both receptors to disturbance is therefore considered to be medium.

Minke whale

223. Minke whale occurs seasonally within the Proposed Development marine mammal study area, moving into inshore waters during the summer months to exploit sandeel as a key prey resource (Robinson *et al.,* 2009; Tetley *et al.,* 2008). Minke whale is able to adopt a low energy feeding strategy by exploiting prey herded by other species, however, its reliance on sandeel as the primary energy resource (up to 70% of its diet in Scotland, Tetley *et al*, 2008) means that disturbance from areas that are important for sandeel could have implications on the health and survival of disturbed individuals. Sandeel habitat in the vicinity of the Proposed Development is described in volume 2, chapter 9. There are high intensity spawning grounds and low intensity nursery grounds for the lesser sandeel *Ammondytes tobianus* within the Proposed Development fish and shellfish ecology study area and Rait’s sandeel *A. marinus* is also present within the area. Therefore, displacement of minke whales could lead to reduced foraging for disturbed individuals particularly since minke whales maximise their energy storage whilst on feeding grounds (Christiansen *et al.,* 2013a). Christiansen *et al.* (2013b) found that the presence of whale-watching boats within an important feeding ground for minke whale led to a reduction in foraging activity and as a capital breeder such a reduction could lead to reduced reproductive success since female body condition is known to affect foetal growth (Christiansen *et al.*, 2014). However, it is worth noting that the study was conducted in Faxafloi Bay in Iceland where baseline noise levels (compared to the North Sea) are very low (McGarry *et al.,* 2017). In addition, a subsequent study conducted by Christiansen and Lusseau (2015) in the same study area found no significant long-term effects of disturbance from whale watching on vital rates since whales moved into disturbed areas when sandeel numbers were lower across their wider foraging area.

224. It is expected that for minke whale, as described by the Southall *et al*. (2021) strong disturbances in the nearfield could result in displacement whilst mild disturbance over larger ranges would result in other, less severe behavioural responses. In terms of context the Proposed Development is situated in region of relatively high levels of shipping, fishing and other vessel activity with up to 16 vessels on average per day recorded within a 10 nm buffer of the Proposed Development array area and 15 commercial shipping routes crossing the Proposed Development array area (volume 3, chapter 13). Therefore, minke whales that occur within the Proposed Development marine mammal study area are subject to underwater noise from existing activities and may to some extent be desensitised to increased noise levels, particularly in the far field where mild disturbance could occur.

225. Minke whale, an IEF of international value, is deemed to be of medium vulnerability and high recoverability. The sensitivity of the receptor to disturbance is therefore considered to be medium.

Harbour seal and grey seal

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

227. A study of the movements of tagged harbour seals during piling at the Lincs Offshore Wind Farm in the Greater Wash showed significant avoidance of the wind farm by harbour seals (Russell *et al*., 2016). Within this study, seal abundance significantly reduced over a distance of up to 25 km from the piling

activity and there was a 19% to 23% decrease in usage within this effect range. However, the displacement was limited to pile driving activity only, with seals returning rapidly to baseline levels of activity within two hours of cessation of the piling (Russell *et al.,* 2016).

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

229. Recorded reactions of tracked grey seals to pile driving during construction of the Luchterduinen wind farm in 2014 and Gemini wind farm in 2015 have been diverse, and have ranged from altered surfacing and diving behaviour, changes in swimming direction, or coming to a halt (Aarts *et al*., 2018). In some cases, however, no apparent changes in diving behaviour or movement were observed (Aarts *et al*., 2018). Similar to the conclusions drawn by Hastie *et al*., (2021) the study at the Luchterduinen and Gemini wind farms suggested animals were balancing risk with profit. Whilst approximately half of the tracked seals were absent from the pile-driving area altogether, this may be because animals were drawn to other more profitable areas as opposed to active avoidance of the noise, although a small sample size (n=36 animals) means that no firm conclusions could be reached. It was notable that, in some cases, seals exposed to pile-driving at distances shorter than 30 km returned to the same area on subsequent trips. This suggests that the incentive to go to the area was stronger than potential deterrence effect of underwater noise from pile driving in some seals.

230. Barrier effects and altered behaviour could affect the ability of phocid seals to accumulate the energy reserves prior to both reproduction and lactation (Sparling *et al.,* 2006). Female seals exhibit clear patterns of increased foraging effort (including increased diving behaviour) towards the breeding season as a strategy to maximise energy allocation to reproduction. Especially during the third trimester of pregnancy, grey seals accumulate reserves of subcutaneous blubber which they use to synthesize milk during lactation (Hall *et al.,* 2001). They may be most vulnerable to reduced foraging during this period, as maternal energy storage is extremely important to offspring survival and female fitness (Mellish *et al.,* 1999; Hall *et al.,* 2001). Therefore, potential exclusion from foraging grounds during this time has the potential to affect reproduction rates and probability of survival.

231. Phocid seals may be vulnerable to disturbance during the lactation period also, although the extent to which this occurs depends on their breeding strategy. Changes in behaviour could have a particular impact on harbour seal – an income breeder – during lactating periods (June to August), when female harbour seals spend much of their time in the water with their pups, and foraging is more restricted than during other periods (Thompson and Härkönen, 2008). Consequences of disturbance may include reduced fecundity, reduced fitness, and reduced reproductive success. Although harbour seal may be able to avoid the disturbed area and forage elsewhere, there may be an energetic cost to having to move greater distances to find food, and therefore there may be a potential effect on reproductive success of some individuals. For grey seal – a capital breeder – the lactation period lasts around 17 days (Sparling *et al.,* 2006) during which time the females remain mostly on shore, fasting. As grey seal females do not forage often during lactation, it is expected that they may exhibit some tolerance to disturbance and the effect is less likely to cause a change in both reproduction and survival rates during lactation compared to harbour seal. Note, however, that following lactation female grey seals return to the water and must forage extensively to build up lost energy reserves.

232. Grey seal and harbour seals, IEFs of international value, are deemed to be of medium vulnerability and high recoverability. The sensitivity of the receptor is therefore considered to be medium.

<u>Significance of the Effect</u>

Auditory injury

Harbour porpoise

233. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be high. The potential risk of injury will be reduced by appropriate designed-in measures and the scale of effect (injury radius and number of animals affected) was predicted to be very small. The effect on harbour porpoise will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Bottlenose dolphin and white-beaked dolphin

234. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be high. Given that the potential risk of injury is reduced by appropriate designed-in measures, the effect on bottlenose dolphin and white-beaked dolphin will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Minke whale

235. Overall, the magnitude of the impact is deemed to be medium and the sensitivity of the receptor is considered to be high. Although the risk will to some extent be reduced through appropriate designed-in measures there still remains a risk of injury (as the risk of injury may occur beyond the mitigatable zone for Marine Mammal Observer (MMOs) and PAM) and therefore the effect on minke whale will be of **moderate** adverse significance, which is significant in EIA terms. Secondary mitigation has been proposed to reduce the significance of this effect (see paragraph 243 *et seq.*).

Grey seal and harbour seal

236. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be high. Given that the potential risk of injury is reduced by appropriate designed-in measures, the effects on grey seal and harbour seal will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Behavioural disturbance

Harbour porpoise

237. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. Given that only small proportion of NS MU harbour porpoise population could be potentially disturbed at any one time and population modelling indicates that there is no potential for a long-term effect on this species, the effect on harbour porpoise will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Bottlenose dolphin

238. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. Given that only small proportion of CES MU bottlenose dolphin population could be potentially disturbed at any one time and population modelling indicates that there is no potential for a long-term effect on this species, the effect on bottlenose dolphin will, therefore, be of **minor** adverse significance, which is not significant in EIA terms

White-beaked dolphin

239. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. Given that only small proportion of CGNS MU white-beaked dolphin population could be potentially disturbed at any one time, the effect on white-beaked dolphin will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Minke whale

240. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. Given that only small proportion of CGNS MU minke whale population could be potentially disturbed at any one time and population modelling indicates that there is no potential for a long-term effect on this species, the effect on minke whale will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Harbour seal

241. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. Given that only small proportion of ES plus NE MU harbour seal population could be potentially disturbed at any one time and population modelling indicates that there is no potential for a long-term effect on this species, the effect on harbour seal will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Grey seal

242. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. Given that only small proportion of ES plus NE MU harbour seal population could be potentially disturbed at any one time and population modelling indicates that there is no potential for a long-term effect on this species, the effect on grey seal will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

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

243. Given that potential injury impacts were predicted to be significant in EIA terms for minke whale, an IEF of international value, secondary mitigation will be applied in the form of an ADD to deter animals from the area of impact. This additional mitigation will also reduce any risk of injury (albeit very low risk) to individuals of other marine mammal species which may arise due to the inherent uncertainties in applying the standard measures (visual and acoustic approaches), for example, problems with detecting animals in high sea states or low visibility due to adverse weather conditions.

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

245. There are various ADDs available with different sound source characteristics (see McGarry *et al*., 2020) and a suitable device will be selected based on the key species requiring mitigation for the Proposed Development. The selected device will typically be deployed from the piling vessel and activated for a pre-determined duration to allow animals sufficient time to move away from the sound source whilst also minimising the additional noise introduced into the marine environment. The type of ADD and approach to mitigation (including activation time and procedure) will be included in the MMMP, being previously discussed and agreed with relevant stakeholders.

246. Noise modelling was carried out to determine the potential efficacy of using this device to deter marine mammals from the injury zone (see volume 3, appendix 10.1). The results suggest that the use of an ADD for a duration of 30 minutes before the piling commences would further reduce the potential to experience injury to marine mammal receptors. For example, the maximum injury zones for species based on SPL_{pk} metric for piling of the wind turbines and OSPs/Offshore convertor station platform foundations at a maximum hammer energy of 4,000 kJ using 1% constant conversion factor are shown in Table 10.36. Assuming conservative swim speeds, it was demonstrated that activation of an ADD for 30 minutes would deter all animals beyond the maximum injury zone (Table 10.36). This corroborates findings of other studies that reported that ADDs deter different marine mammals over several hundreds of metres or indeed several kilometres from the source (reviewed in McGarry *et al*., 2020).

Table 10.36: Summary of Peak Pressure Injury Ranges for Marine Mammals due to Single Piling of Wind Turbine and OSPs/Offshore Convertor Station Platform at 4,000 kJ Hammer Energy Using 1% Constant Conversion Factor, Showing Whether the Individual Can Flee the Injury Range During the 30 Minutes of ADD Activation

Species	Threshold (Unweighted Peak)	Injury Range	Swim Speed (m/s)	Swim Distance (m)	Flee?
Bottlenose dolphin White-beaked dolphin	PTS – 230 dB re 1 µPa (pk)	43	1.52	2,736	Yes
Harbour porpoise	PTS – 202 dB re 1 µPa (pk)	449	1.5	2,700	Yes
Minke whale	PTS – 219 dB re 1 µPa (pk)	83	2.3	4,140	Yes
Harbour seal Grey seal	PTS – 218 dB re 1 µPa (pk)	118	1.8	3,240	Yes

247. The assessment found that the maximum injury zone for minke whale alone was based on SEL_{cum} metric for concurrent piling of the wind turbines foundations at a maximum hammer energy of 4,000 kJ using 4% reducing to 0.5% conversion factor. Modelling for SEL_{cum} scenario demonstrated that the use of ADD is useful for reducing PTS injury ranges, as the activation of an ADD 30 minutes prior to commencement of piling reduced PTS to a level not exceeding the injury thresholds (Table 10.37). Thus, even assuming this very conservative range of effect (i.e. using the SEL_{cum} metric which may be an overestimate of PTS; paragraph 94), the noise modelling demonstrated that the risk of injury can be mitigated through use of an ADD.

Table 10.37: Injury Ranges for Marine Mammals due to Concurrent Piling of Wind Turbine at 4,000 kJ Hammer Energy Using 4% Reducing to 0.5% Conversion Factor with and without 30 Minutes of ADD

Species/Group	Threshold (Weighted SEL)	Range (m)	
		Without ADD	With ADD
Minke whale	PTS – 183 dB re 1 $\mu Pa^2 s$	2,319	N/E[1]

[1] N/E = Threshold not exceeded

Residual Effect – Auditory Injury

248. Overall, following application of secondary mitigation, the magnitude of the impact for all species is deemed to be low and the sensitivity of the receptors is considered to be high. Considering the significance matrix presented in Table 10.20, the significance of the effect can be assessed as either minor or moderate. Given that the potential risk of injury for all species is reduced by secondary mitigation measures, the effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Residual Effect – Behavioural Disturbance

249. Overall, the magnitude of the impact for all species is deemed to be low and the sensitivity of the receptors is considered to be medium. Given that only small proportion of each regional/national marine mammal population could be potentially disturbed, it is highly unlikely that this impact will alter the structure and functions of populations in question and population modelling suggest that there is no potential for a long-term effect on trajectories of assessed species (all species except white-beaked dolphin as iPCoD do not facilitate modelling for this species). The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

INJURY AND DISTURBANCE TO MARINE MAMMALS FROM ELEVATED UNDERWATER NOISE DURING SITE INVESTIGATION SURVEYS

250. Site investigation surveys during the construction phase as well as the operation and maintenance phase have the potential to cause direct or indirect effects (including injury or disturbance) on marine mammal IEFs. A detailed underwater noise modelling assessment has been carried out to investigate the potential for injurious and behavioural effects on marine mammals as a result of geophysical and geotechnical surveys, using the latest criteria (volume 3, appendix 10.1), which is drawn upon in the assessment presented in paragraph 251 *et seq.*

Summary of Noise Modelling

Geophysical Surveys

251. It is understood that several sonar-based survey types will potentially be used for the geophysical surveys. That includes MBES, SSS, SBES and SBS. The equipment likely to be used can typically work at a range of signal frequencies, depending on the distance to the bottom and the required resolution. The signal is highly directional, acts like a beam and is emitted in pulses. Sonar-based sources are considered as continuous (non-impulsive) because they generally compromise a single (or multiple discrete) frequency as opposed to a broadband signal with high kurtosis, high peak pressures and rapid rise times. Unlike the sonar-based surveys, the UHRS is likely to utilise a sparker, which produces an impulsive, broadband source signal.

252. A full description of the source noise levels for geophysical survey activities is provided in volume 3, appendix 10.1.

Geotechnical Surveys

253. Source levels for borehole drilling ahead of standard penetration testing are in a range of 142 dB to 145 dB re 1 µPa re 1 m (rms). SEL measurements conducted during CPTs showed that it is characterised by broadband sound with levels measured generally 20 dB above the acoustic ocean noise floor (Erbe and McPherson, 2017). For the purpose of assessment of effects, these sources are considered as impulsive sounds. Measurements of a vibro-core test (Reiser *et al*., 2011) show underwater source SPLs of approximately 187 dB re 1 µPa re 1 m (rms). The vibro-core sound is considered to be continuous (non-impulsive).

254. Full description of the source noise levels for geotechnical survey activities is provided in volume 3, appendix 10.1.

Construction Phase

Magnitude of Impact

Auditory injury

255. Potential impacts of site investigation surveys will depend on the characteristic of the activity, frequency bands and water depth. The impact ranges presented in this section are rounded to the nearest 5 m. It should be noted that, for the sonar-based surveys, many of the injury ranges are limited to approximately 65 m as this is the approximate water depth in the area. Sonar based systems have very strong directivity which effectively means that there is only potential for injury when a marine mammal is directly underneath the sound source. Once the animal moves outside of the main beam, there is no potential for injury. This section provides estimated ranges for injury of marine mammals in the construction phase of the Proposed Development.

256. The noise modelling assessment showed that ranges within which there is a potential to experience PTS by marine mammals as a result of geophysical investigation activities (based on comparison to Southall *et al*. (2019) SEL thresholds) are relatively low (Table 10.38). For harbour porpoise PTS could occur out to 360 m during sub-bottom profiles surveys. However, impact ranges within which PTS could occur are smaller for other marine mammal species at maximum of 65 m.

Table 10.38: PTS Impact Ranges for Marine Mammals During the Geophysical Site Investigation Surveys

Threshold	PTS Impact Ranges (m)				
	Harbour Porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale	Seal Species
Multi-beam echosounder					
180-240 dB re 1 µPa re 1 m (rms)	70	65	65	20	40
Sidescan sonar (SSS)					
190-245 dB re 1 µPa re 1 m (rms)	100	65	65	65	65
Single beam echosounder					
180-400 dB re 1 µPa re 1 m (rms)	65	65	65	60	65
Sub-bottom profiler					
200-240 dB re 1 µPa re 1 m (rms)	360	65	65	65	65
Ultra-high-resolution seismic					
170-200 dB re 1 µPa re 1 m (rms)	15	N/E[1]	N/E[1]	N/E[1]	N/E[1]

[1] N/E = Threshold Not Exceeded

257. With respect to the ranges within which there is a potential of PTS occurring to marine mammals as a result of geotechnical investigation activities, PTS threshold was not exceeded for almost all marine mammal species, except harbour porpoise and minke whale (

258. Table 10.39). PTS is only expected to occur during cone penetration test, out to a maximum of 60 m and 5 m for harbour porpoise and minke whale, respectively.

Table 10.39: PTS Impact Ranges for Marine Mammals During the Geotechnical Site Investigation Surveys

Threshold	Harbour porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale	Seal Species
Borehole drilling					
142–145 dB re 1 µPa rms @ 1 m	N/E[1]	N/E[1]	N/E[1]	N/E[1]	N/E[1]
Core Penetration Test					
189 dB re 1 µPa²s re 1 m (rms)	60	N/E[1]	N/E[1]	5	N/E[1]
Vibro-coring					
223 dB re 1 µPa²s re 1 m (based on 1 hr operation for single core sample)	5	N/E[1]	N/E[1]	N/E[1]	N/E[1]

[1] N/E = Threshold Not Exceeded

259. The number of marine mammals potentially injured within the modelled ranges for PTS presented in Table 10.39 and Table 10.40 were estimated using the most up to date species-specific density estimates (Table 10.13). Where ranges for density estimates have been applied (harbour porpoise, bottlenose dolphin, minke whale, grey seal and harbour seal), numbers of animals potentially injured have been based on the maximum density value as a precautionary approach. It should be noted that since sonar-based systems have strong directivity, there is only potential for injury when marine mammal is directly underneath the sound source.

260. Due to low impact ranges, for all marine species, there is the potential for less than one animal to experience PTS (and no animals where the threshold is not exceeded) as a result of geophysical and geotechnical site investigation surveys. The site-investigation surveys are considered to be short term as they will take place over up to a period of up to three months. Standard designed in measures to reduce the risk of injury to marine mammals will be implemented for the geophysical surveys (JNCC, 2017). With such measures in place the risk is deemed to be negligible.

261. Site investigation surveys will also involve the use of up to two geophysical/geotechnical survey vessels with up to 70 round trips. Noise impacts associated with vessel movements are identified in paragraph 384 *et seq.* as well as paragraph 403 *et seq.*

262. The impact of site investigation surveys leading to PTS is predicted to be of very local spatial extent, short-term duration, intermittent and whilst the impact will occur during piling only, the effect of PTS will irreversible. It is predicted that the impact will affect the receptor directly. With designed-in measures in place, involving visual and/or acoustic monitoring, the risk is likely to be negligible, however, given the potential permanence of the effect (PTS) if it did occur, the magnitude is, conservatively, considered to be low.

Behavioural disturbance

263. The estimated maximum ranges for onset of disturbance are based on exceeding the 120 dB re 1 µPa (rms) threshold applicable for all marine mammals, noting that this threshold is for 'mild disturbance' and therefore is not likely to result in displacement of animals. The disturbance ranges as a result of geophysical and geotechnical site-investigation surveys (Table 10.40) will be higher than those presented for PTS. Most of the predicted ranges are within hundreds of meters, however the largest distance over which the disturbance could occur is out to approximately 7.5 km during vibro-coring.

Table 10.40: Disturbance Ranges for Marine Mammals During the Geophysical and Geotechnical Site Investigation Surveys

	Disturbance Ranges (m)							
	MBES	SSS	SBES	SBP	UHRS	Borehole	CPT	Vibro-coring
All species	865	675	735	2,045	585	20	1,500 (mild)	7,459

264. The number of marine mammals potentially disturbed within the modelled ranges for behavioural response are estimated using the most up to date species specific density estimates (Table 10.13) and presented in Table 10.41. Where ranges for density estimates have been applied (harbour porpoise, minke whale, grey seal and harbour seal), numbers of animals affected have been based on the maximum density value as a precautionary approach. The number of bottlenose dolphins potentially disturbed has been assessed based on the density for offshore populations.

Table 10.41: Number of Animals Potentially Likely to be Disturbed due to the Geophysical and Geotechnical Site Investigation Surveys

Threshold	Estimated Number of Animals with the Potential to be Disturbed					
	Harbour Porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale	Harbour Seal	Grey Seal
MBES						
180-240 dB re 1 µPa re 1 m	2	<1	<1	1	<1	3
SSS						
190-245 dB re 1 µPa re 1 m	1	<1	<1	<1	<1	2
SBES						
180-400 dB re 1 µPa re 1 m	1	<1	<1	<1	<1	2
SBP						
200-240 dB re 1 µPa re 1 m	11	<1	<1	3	<1	16
UHRS						
170-200 dB re 1 µPa re 1 m	1	<1	<1	<1	<1	1
Borehole drilling						
142–145 dB re 1 µPa rms @ 1 m	<1	<1	<1	<1	<1	<1
CPT						
189 dB re 1 µPa²s re 1 m	6	<1	<1	<1	<1	8
Vibro-coring						
223 dB re 1 µPa²s re 1 m	144	5	<1	<1	1	210

265. The data presented in Table 10.41 is considered to be conservative, especially for harbour porpoise as the number of animals likely to be disturbed is based on the peak seasonal density estimates from the Proposed Development aerial digital survey data during spring months. If these numbers were compared with estimates of the number of harbour porpoise potentially disturbed using the mean monthly density derived from the Proposed Development aerial digital survey data (0.299 animals per km²) or using the

modelled density estimate for SCANS III for this area (0.599 animals per km^2) these estimates would be shown to be highly precautionary. For example, based on the mean monthly density from aerial data or SCANS III data, the number of harbour porpoise affected by possible disturbance during vibro-core testing, would be 52 animals (0.02% of the NS MU) or 105 animals (0.03% of the NS MU), respectively, compared to 144 animals (0.04% of the NS MU) estimated for peak seasonal density estimates.

266. The same applies to grey seal, where the numbers of potentially disturbed animals presented in Table 10.41 (based on Carter *et al.,* 2020) were shown to be precautionary compared with estimates of the number of grey seal using the mean monthly or seasonal peak densities derived from the Proposed Development aerial digital survey data (0.276 animals per km^2 and 0.321 animals per km^2). For example, based on the mean monthly and seasonal peak density from aerial data, the number of grey seal affected by possible disturbance during vibro-core testing, would be 48 animals (0.11% of the ES and NE Mus) and 56 animals (0.13% of the ES and NE Mus), respectively, compared to 210 animals (0.49% of the relevant Mus) estimated by Carter *et al*. (2020) for mean at sea usage.

267. The number of bottlenose dolphins that could be exposed to potential disturbance (Table 10.41) relate to their offshore populations and accounts for 0.27% of the SCANS III Block R estimated abundance. Given that the vibro-core sampling locations are currently unknown and coastal distribution of bottlenose dolphin is spatially limited, any quantitative assessment of the disturbance to coastal populations would be an overestimation. All geotechnical and geophysical surveys will be very short duration (up to three months) and animals are expected to recover quickly after cessation of the survey activities. The magnitude of the impact could result in a negligible alteration to the distribution of marine mammals. In addition, the proportion of the MU populations affected at any one time by disturbance is likely to be very small.

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

<u>Sensitivity of the Receptor</u>

Auditory injury and behavioural disturbance

269. There is no direct evidence for a causal link between geophysical survey noise and physical injury or disturbance to marine mammals, but there is some evidence for short-term behavioural responses.

Auditory injury

270. For geotechnical surveys, injury to marine mammals is unlikely to occur beyond a few tens of metres (i.e. up to 60 m for harbour porpoise) and noise from vessels themselves is likely to deter marine mammals beyond this range. The maximum range for PTS from geophysical surveys (SBP) is 360 m. Sills *et al*. (2020) evaluated TTS onset levels for impulsive noise in seals following exposure to underwater noise from a seismic air gun and found transient shifts in hearing thresholds at 400 Hz were apparent following exposure to four to ten consecutive pulses (SEL_{cum} 191 dB – 195 dB re 1 µPa^2s; 167 dB – 171 dB re 1 µPa^2s with frequency weighting for phocid carnivores in water).

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

Behavioural disturbance

272. The transmission frequencies of many commercial sonar systems (approximately 12 kHz – 1800 kHz) overlap with the hearing and vocal ranges of many species (Richardson *et al*., 1995), and whilst many are high frequency sonar systems with peak frequencies well above marine mammal hearing ranges, it is possible that relatively high levels of sound are also produced as sidebands at lower frequencies (Hayes and Gough, 1992) so may elicit behavioural responses in marine mammals. Fine-scale data from porpoises equipped with high-resolution location and dive loggers when exposed to airgun pulses at ranges of 420 m – 690 m with noise level estimates of 135 dB–147 dB re 1 µPa^2s (SEL) show different responses to noise exposure (van Beest, *et al*., 2018). One individual displayed rapid and directed movements away from the exposure site whilst two individuals used shorter and shallower dives (compared to natural behaviour) immediately after exposure. This noise-induced movement typically lasted for eight hours or less, with an additional 24-hour recovery period until natural behaviour was resumed.

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

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

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

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

Significance of the Effect

277. Overall, the magnitude of the impact of PTS is deemed to be low and the sensitivity of the receptor is considered to be high. The potential risk of injury will be reduced by appropriate designed-in measures and the scale of effect (injury radius and number of animals affected) was predicted to be very small. The effect on marine mammals will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

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

Secondary Mitigation and Residual Effect

279. The PTS thresholds are not exceeded for most surveys and for most species. This is with the exception of cone penetration testing where the PTS range is so small (60 m predicted for harbour porpoise only) that it is considered that animals are likely to be deterred beyond this range (i.e. out to 300 m) by the vessel noise itself (see Table 10.53). Additionally, as a part of designed-in measures (Table 10.21), Standard JNCC (2017) mitigation will be adhered to for the geophysical surveys which will involve the use of MMOs/PAM monitoring of a standard 500 m mitigation zone for a period of no < 30 minutes prior to the start of surveys (Table 10.21). No secondary marine mammal mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the designed in measures outlined above and in Table 10.21) is not significant in EIA terms.

Residual Effect – Auditory Injury

280. Overall, the magnitude of the impact for all species is deemed to be low and the sensitivity of the receptors is considered to be high. The potential risk of injury will be reduced by appropriate designed-in measures and the scale of effect (injury radius and number of animals affected) was predicted to be very small. The effect on marine mammals will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Residual Effect – Behavioural Disturbance

281. Overall, the magnitude of the impact for all species is deemed to be low 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.

Operation and Maintenance Phase

Magnitude of Impact

Auditory injury and behavioural disturbance

282. Elevated underwater noise due to site investigation activities during the operation and maintenance phase of the Proposed Development may lead to injury and/or disturbance to marine mammals. The maximum design scenario comprises of routine geophysical surveys estimated to occur every six months for first two years and annually thereafter. This equates to up to 37 surveys over the 35-year life cycle of Proposed Development (Table 10.16).

283. An overview of potential impacts from auditory injury due to elevated underwater noise during geophysical site investigation surveys is described in paragraph 255 *et seq.* for the construction phase and has not been reiterated here for the operation and maintenance phase. Similarly, the magnitude of potential impacts for behavioural disturbance to marine mammals is described in paragraph 263 *et seq.* The magnitude of the impact of underwater noise from geophysical surveys during operation and maintenance phase could result in a negligible alteration to the distribution of marine mammals. Surveys are anticipated to be short-term in nature (weeks to a few months) and occur intermittently over the operation and maintenance phase. In addition, the proportion of the MU populations affected at any one time by disturbance is likely to be very small.

284. The impact of site investigation surveys leading to PTS is predicted to be of very local spatial extent, short-term duration, intermittent and whilst the impact will occur during piling only, the effect of PTS will irreversible. It is predicted that the impact will affect the receptor directly. With designed-in measures in place, involving visual and/or acoustic monitoring, the risk is likely to be negligible, however, given the potential permanence of the effect (PTS) if it did occur, the magnitude is, conservatively, considered to be low.

Sensitivity of the Receptor

285. The sensitivity of the receptors during the operation and maintenance phase is not expected to differ from the sensitivity of the receptors during the construction phase. Therefore, the sensitivity of marine mammal receptors to elevated underwater noise during site investigation surveys (PTS and behavioural disturbance) is as described previously in paragraph 269 *et seq.*, where it has been assessed as high for PTS and medium for behavioural disturbance.

Significance of the Effect

286. Overall, the magnitude of the impact of PTS is deemed to be low and the sensitivity of the receptor is considered to be high. The potential risk of injury will be reduced by appropriate designed-in measures and the scale of effect (injury radius and number of animals affected) was predicted to be very small. The effect on marine mammals will, therefore, be of minor adverse significance, which is not significant in EIA terms.

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

Secondary Mitigation and Residual Effect

288. As described above for the construction phase (paragraph 279 *et seq.*), the PTS thresholds are not exceeded for most surveys and for most species (with exception of CPT). Designed-in measures (Table 10.21) in the form of standard JNCC (2017) mitigation will be adhered to for the geophysical surveys. This will involve the use of MMOs/PAM monitoring of a standard 500 m mitigation zone for a period of no < 30 minutes prior to the start of surveys (Table 10.21). No secondary marine mammal mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 10.10) is not significant in EIA terms

Residual Effect – Auditory Injury

289. Overall, the magnitude of the impact for all species is deemed to be low and the sensitivity of the receptors is considered to be high. The potential risk of injury will be reduced by appropriate designed-in measures and the scale of effect (injury radius and number of animals affected) was predicted to be very small. The effect on marine mammals will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Residual Effect – Behavioural Disturbance

290. Overall, the magnitude of the impact for all species is deemed to be low 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.

INJURY AND DISTURBANCE TO MARINE MAMMALS FROM ELEVATED UNDERWATER NOISE DURING UXO CLEARANCE

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

Summary of Noise Modelling

Detonation

292. Noise modelling for UXO clearance (both low order and high order detonation) has been undertaken using the methodology described in Soloway and Dahl (2014), which provides a simple relationship between distance from an explosion and the weight of the charge (or equivalent trinitrotoluene (TNT) weight). Since the charge is assumed to be freely standing in mid-water, unlike a UXO which would be resting on the seabed and could potentially be buried, degraded or subject to other significant attenuation, this estimation of the source level can be considered conservative. Marine mammal hearing weighted thresholds were compared by application of the frequency dependent weighting functions at each distance from the source. Based on findings presented in Robinson *et al*. (2020), noise modelling for low order techniques followed the same methodology as for high order detonation, with a smaller donor charge size.

293. Further detail on noise modelling of UXO clearance are provided in volume 3, appendix 10.1.

Construction Phase

Magnitude of Impact

294. Potential effects of underwater noise from high order UXO clearance on marine mammals include mortality, physical injury or auditory injury. The duration of effect for each UXO detonation is less than one second. Behavioural effects are therefore considered to be negligible in this context. TTS is presented as a temporary auditory injury but also represents a threshold for the onset of the fleeing response. Proposed Development specific noise modelling was carried out using published and peer-reviewed criteria to determine the potential magnitude (range) of effect on marine mammal receptors. A project specific MMMP will be developed in order to reduce the potential to experience injury (see Table 10.21).

295. It is anticipated that up to 70 UXOs are likely to be found within the Proposed Development array area and the Proposed Development export cable corridor, however, only 14 of these will require clearance. The maximum design scenario is based on experience of UXO clearance at Seagreen offshore wind farm (in close proximity to the Proposed Development). For Seagreen, of the 20 UXOs estimated to be present for the purposes of the marine mammal risk assessment (Seagreen Wind Energy, 2021), only four (20%) were found to require clearance within the proposed development site, one of which was relocated rather than cleared by high order techniques (SSE *pers. Comm.*). The estimate of 70 UXOs for Berwick Bank Offshore Wind Farm was extrapolated from the same study carried out for Seagreen (Ordtek, 2017; Ordtek, 2019) and therefore it is considered likely that the number of UXOs requiring disposal will be significantly less than assessed here (i.e. based on the same proportion cleared for Seagreen, there may only be 14 UXOs requiring clearance for the Proposed Development). The precise details and locations of potential UXOs is unknown at this time. During the UXO clearance campaign at Seagreen Offshore Wind Farm the maximum UXO size identified was 250 kg NEQ. Given that Seagreen Offshore Wind Farm is located approximately 4 km from the Proposed Development array area, a similar maximum size of munition is expected to be encountered in the same region. Therefore, for the purposes of this assessment, it has been assumed that the maximum design scenario is UXO size up to 300 kg. The maximum frequency would be up to two detonations within 24 hours. The clearance activities will be tide and weather dependant. The aim is to enable clearance of at least one UXO per tide, during the hours of daylight and good visibility.

296. Low order techniques will be applied as the intended methodology for clearance of UXO. The technique uses a single charge of up to 80 g NEQ which is placed in close proximity to the UXO to target a specific entry point. When detonated, a shaped charge penetrates the casing of the UXO to introduce a small, clinical plasma jet into the main explosive filling. The intention is to excite the explosive molecules within the main filling to generate enough pressure to burst the UXO casing, producing a deflagration of the main filling and neutralising the UXO. Recent controlled experiments showed low-order clearance using deflagration to result in a substantial reduction in acoustic output over traditional high-order methods, with SPL_{pk} and SEL_{cum} being typically significantly lower for the low order techniques of the same size munition, and with the acoustic output being proportional to the size of the shaped charge, rather than the size of the UXO itself (Robinson *et al*., 2020). Using this low-order clearance method, the probability of a low-order outcome is high; however, there is a small inherent risk with these clearance methods that the UXO will detonate or deflagrate violently. It is also possible that there will be residual explosive material remaining on the seabed following low order clearance. In this case, recovery will be performed, including the potential need of a small (500 g NEQ) 'clearing shot'.

297. There is a small risk that a low order clearance could result in high order detonation of UXO. In addition, some UXOs may be deemed to be too unstable to warrant a low order approach and therefore for safety reasons would need to be cleared using high order methods. At Neart na Gaoithe Offshore Wind Farm in the Firth of Forth, a total of 53 items of UXO required detonation and four of the 37 (c. 10%) monitored UXO clearance events resulted in a high order detonation, largely as a result of the age, condition and type of munition (Seagreen Wind Energy, 2021).

298. UXO clearance activities will also involve the use of up to seven vessels on site at any one time with up to 30 vessel movements in total. Noise impacts associated with vessel movements are identified in paragraph 384 *et seq.* as well as paragraph 403 *et seq.*

Auditory injury

299. An explosive mass of 300 kg (maximum design scenario due to high order detonation) yielded the largest potential PTS ranges for all species, with the greatest effect ranges seen for harbour porpoise (Table 10.42). As described in paragraph 297, there is just a small (10%) chance that low order detonation could result in a high order detonation event. Therefore, whilst this assessment considers the most likely scenario to be based on a detonation of 0.08 kg donor change (maximum size of donor charge used for low order techniques) and a detonation of 0.5 kg clearance shot (maximum size of clearing shot to neutralise any residual explosive material (Table 10.43), the assessment will consider both high order and low order techniques for the purposes of secondary mitigation. With regard to UXO detonation (low order techniques as well as high order events), due to a combination of physical properties of high

frequency energy, the sound is unlikely to still be impulsive in character once it has propagated more than a few kilometres (see volume 3, appendix 10.1). The NMFS (2018) guidance suggested an estimate of 3 km for transition from impulsive to continuous (although this was not subsequently presented in the later guidance (Southall *et al.*, 2019). For other impulsive noise sources (pile driving and airguns) Hastie *et al.,* (2019) suggests that some measures of impulsiveness change markedly within c. 10 km of the source. Therefore, great caution should be used when interpreting any results with predicted injury ranges in the order of tens of kilometres as the impact ranges are likely to be significantly lower than predicted.

Table 10.42: Potential PTS Impact Ranges for Marine Mammals Due to UXO High Order Detonation

Threshold	PTS Impact Ranges (m)				
	Harbour Porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale	Seal Species
Charge Size 300 kg					
SPL Peak	10,630	615	615	1,885	2,085
SEL (Weighted)	3,805	150	150	4,175	790

Table 10.43: Potential PTS Impact Ranges for Marine Mammals Due to Low Order Techniques

Threshold	PTS Impact Ranges (m)				
	Harbour Porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale	Seal Species
Charge Size 0.08 kg					
SPL Peak	685	40	40	120	135
SEL (Weighted)	310	5	5	80	15
Charge Size 0.5 kg					
SPL Peak	1,265	75	75	225	250
SEL (Weighted)	650	5	5	195	40

300. The subsea noise assessment found that the maximum injury (PTS) range estimated for harbour porpoise using the SPL_{pk} metric is 685 m for the detonation of charge size of 0.08 kg and 1,260 m for the detonation of 0.5 kg clearance shot (Table 10.43). Conservatively, the number of individuals that could be potentially injured, based on the peak seasonal densities from site-specific survey data, was estimated as one and four harbour porpoises for 685 m and 1,265 m respectively (Table 10.44).

301. The subsea noise assessment found that the maximum injury (PTS) range estimated for bottlenose dolphin and white-beaked dolphin using the SPL_{pk} metric is 40 m for the detonation of charge size of 0.08 kg and 75 m for the detonation of 0.5 kg clearance shot (Table 10.43). Conservatively, the number of bottlenose dolphins that could be potentially injured within the maximum range of 75 m, based on the peak densities in the outer Firth of Tay from the probability of occurrence model (Arso Civil *et al.*, 2019), was estimated as less than one individual (Table 10.44). In the case of white-beaked dolphin, the most conservative number of animals that could be potentially injured within that range (based on SCANS III densities) was also estimated as less than one individual (Table 10.44).

302. The subsea noise assessment found that the maximum injury (PTS) range estimated for minke whale using the SPL_{pk} metric is 120 m for the detonation of charge size of 0.08 kg and 225 m for the detonation of 0.5 kg clearance shot (Table 10.43). Conservatively, the number of minke whales that could be potentially injured within the maximum range of 225 m, based on the SCANS III densities, was estimated as less than one individual (Table 10.44).

303. Both seal species (harbour and grey seal) could experience potential injury at the maximum range of 135 m due to detonation of charge size of 0.08 kg and 250 m due to detonation of 0.5 kg clearance shot (Table 10.43). Taking into account the most conservative scenario, maximum density for both species (based on mean at-sea seal usage from Carter *et al*. (2020)), there will be less than one animal of each species that could be potentially injured within the maximum range of 250 m.

Table 10.44: Number of Animals with the Potential to Experience PTS due to Low Order Techniques

Threshold	Estimated Number of Animals with the Potential to be Injured				
	Harbour Porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale	Seal Species
Charge Size 0.08 kg					
SPL Peak	1	<1	<1	<1	<1
SEL (Weighted)	<1	<1	<1	<1	<1
Charge Size 0.5 kg					
SPL Peak	4	<1	<1	<1	<1
SEL (Weighted)	1	<1	<1	<1	<1

304. As discussed previously, whilst the preferred approach is to clear UXOs using low order techniques, this assessment also presents the number of animals potentially injured by high order detonation (Table 10.45).

305. Harbour porpoise is likely to be the most sensitive species to potential injury from high order UXO clearance. The subsea noise assessment found that the maximum injury (PTS) range estimated for harbour porpoise using the SPL_{pk} metric is 10,630 m for the high order detonation of charge size of 300 kg (Table 10.42). Conservatively, the number of harbour porpoise that could be potentially injured during each high order detonation of UXO is greater (up to 293 individuals) compared with other species. A maximum of 0.08% of the NS MU population and 0.76% of SCANS III Block R could be potentially injured during each high order detonation of the UXO. The second most sensitive marine mammal that could be affected by the high order UXO clearance event is grey seal with up to 16 animals with the potential to be injured during each high order detonation of the UXO (0.04% of the ES plus NE Mus). Less than one individual has the potential to be injured for all other species considered in the assessment (Table 10.42).

306. To reduce the potential of experiencing injury, designed-in measures will be adopted as part of a MMMP (see Table 10.21). However, mitigation zones of c. 10 km are considerably larger than the standard 1,000 m mitigation zone recommended for UXO clearance (JNCC, 2010b) and there are often difficulties in detecting marine mammals (particularly harbour porpoise) over such large ranges (McGarry *et al.*, 2017). Visual surveys note that there is often a significant decline in detection rate with increasing sea state (Embling *et al*., 2010; Leaper *et al*., 2015). Therefore, additional mitigation will be applied in the form of soft start charges and ADDs to minimise residual risk of injury and the assessment of effects therefore considers the deployment of these as a secondary mitigation measure (see paragraph 337 *et seq.* for further details).

Table 10.45: Number of Animals with the Potential to Experience PTS due to High Order Detonation

Threshold	Estimated Number of Animals with the Potential to be Injured					
	Harbour Porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale	Harbour Seal	Grey Seal
Charge Size 300 kg						
SPL Peak	293	<1	<1	<1	<1	16
SEL (Weighted)	38	<1	<1	<1	<1	2

307. Due to the small numbers of marine mammals potentially injured from low order techniques (Table 10.44) the magnitude of the impact could result in a negligible alteration to the distribution of marine mammals. In addition, the proportion of the MU populations affected at any one time by PTS is likely to be very small. For low order techniques the impact of PTS is predicted to be of local spatial extent, very short-term duration, intermittent and of low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude for low order techniques is therefore considered to be low.

308. In comparison, larger numbers of marine mammal could potentially be injured by high order detonation which could lead to a minor alteration in the distribution of marine mammals with up to 0.08% of the NS MU harbour porpoise population affected for each high order detonation of the UXO. Grey seals could also be affected with a maximum of 0.04% of the ES plus NE Mus potentially injured for each high order detonation of the UXO. For high order detonation the impact of PTS is predicted to be of local to regional spatial extent, very short-term duration, intermittent and the effect of injury is of low reversibility. It is predicted that the impact will affect the receptor directly. Only a small proportion (c. 10% of the UXO) are considered likely to result in high order detonation. The magnitude is therefore considered to be low (bottlenose dolphin, white-beaked dolphin, minke whale, harbour seal) to medium (harbour porpoise and grey seal).

Temporary threshold shift

309. A second threshold assessed was the onset of TTS where the resulting effect would be a potential temporary loss in hearing. Whilst similar ecological functions would be inhibited in the short term due to TTS, these are reversible on recovery of the animal's hearing and therefore not considered likely to lead to any long-term effects on the individual. The onset of TTS also corresponds to a 'fleeing response' as this is the threshold at which animals are likely to flee from the ensonified area. Thus, the onset of TTS reflects the threshold at which behavioural displacement could occur. As previously described in paragraph 299, the sound is unlikely to be impulsive in character once it has propagated more than a few kilometres. It is particularly important when interpreting results for TTS with impact ranges of up to 51 km as these are likely to be significantly lower than predicted. As before, the assessment of TTS will consider a most likely scenario of the detonation of a 0.08 kg donor change (maximum size of donor charge used for low order techniques) and the detonation of a 0.5 kg clearance shot (maximum size of clearing shot to neutralise any residual explosive material), as presented in Table 10.46. Due to the potential for a low order detonation technique to result in a high order detonation (as per paragraph 297) the assessment also considers high order detonation of 300 kg UXO munition size.

Table 10.46: Potential TTS Impact Ranges for Marine Mammals Due to Low Order Techniques

Threshold	Potential TTS Impact Ranges (m)				
	Harbour Porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale	Seal Species
Charge Size 0.08kg					
SPL Peak	1,265	75	75	225	250
SEL (Weighted)	2,015	40	40	1,110	210
Charge Size 0.5 kg					
SPL Peak	2,325	135	135	415	455
SEL (Weighted)	3,110	95	95	2,645	505

310. The subsea noise assessment found that temporary hearing impairment and behavioural displacement from the area (TTS) may affect harbour porpoise at a maximum range of 2,015 m for the detonation of charge size of 0.08 kg and 3,110 m for the detonation of 0.5 kg clearance shot. Up to 11 animals (0.003% of the MU population) have the potential to be affected by TTS due to the low order techniques (charge size of 0.08 kg) and up to 25 animals (0.01% of the MU population) have the potential to experience TTS from the detonation of 0.5 kg clearance shot (Table 10.47).

311. The subsea noise assessment found that temporary hearing impairment and behavioural displacement from the area (TTS) may affect bottlenose dolphin and white-beaked dolphin at a maximum range of 75 m for the detonation of charge size of 0.08 kg and 135 m for the detonation of 0.5 kg clearance shot. The maximum range of 135 m is only slightly larger when compared to PTS (75 m) and therefore less than one animal of each species has the potential to be affected by TTS.

312. The subsea noise assessment found that temporary hearing impairment and behavioural displacement from the area (TTS) may affect minke whale at a maximum range of 1,110 m for the detonation of charge size of 0.08 kg and 2,645 m for the detonation of 0.5 kg clearance shot. Up to one animal (0.004% of the MU population) have the potential to be affected by TTS due to the detonation of charge size of 0.08 kg and less than one animal (0.01% of the MU population) has the potential to experience TTS from the detonation of 0.5 kg clearance shot.

313. The subsea noise assessment found that temporary hearing impairment and behavioural displacement from the area (TTS) may affect harbour and grey seal at a maximum range of 250 m for the low order techniques (charge size of 0.08 kg) and 505 m for the detonation of 0.5 kg clearance shot. Less than one harbour seal and one grey seal have the potential to be affected by TTS due to the detonation of charge size of 0.08 kg as well as the detonation of 0.5 kg clearance shot.

Table 10.47: Number of Animals with the Potential to Experience TTS due to Low Order Techniques

Threshold	Estimated Number of Animals with the Potential to be Affected					
	Harbour Porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale	Harbour Seal	Grey Seal
Charge Size 0.08kg						
SPL Peak	4	<1	<1	<1	<1	<1
SEL (Weighted)	11	<1	<1	<1	<1	<1
Charge Size 0.5 kg						
SPL Peak	14	<1	<1	<1	<1	1
SEL (Weighted)	25	<1	<1	1	<1	1

314. High order detonation has the potential to impact animals over larger ranges when compared to low order techniques. The maximum range for TTS across all species was for minke whale where the potential for TTS was predicted to occur out to 34,135 m for detonation of charge size of 300 kg (Table 10.48). Second largest ranges were modelled for harbour porpoise with the maximum range of 19,590 m due to high order detonation of charge size of 300 kg. Seals are also anticipated to experience TTS across relatively large range of up to 6,430 m as a result of detonation of charge size of 300 kg.

Table 10.48: TTS Impact Ranges for Marine Mammals Due to High Order Detonation

Threshold	TTS Impact Ranges (m)				
	Harbour Porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale	Seal Species
Charge Size 300 kg					
SPL Peak	19,590	1,130	1,130	3,470	3,840
SEL (Weighted)	8,900	1,137	1,137	34,135	6,430

315. Due to relatively large ranges of potential impacts presented in Table 10.48, up to 995 harbour porpoises (0.29% of the NS MU population) have the potential to be affected by TTS due to detonation of the 300 kg charge size (Table 10.54). Up to 142 minke whales (0.07% of the CGNS MU population) have the potential to be affected by TTS due to the high order detonation of 300 kg charge. Taking into account the most conservative scenario, up to 156 grey seals could potentially experience TTS due to the high order detonation of charge size of 300 kg. As described previously in paragraph 70 *et seq.* the duration of effect is very short-lived and since TTS is a temporary hearing impairment, animals are likely to fully recover from the effects (reversible).

Table 10.49: Number of Animals with the Potential to Experience TTS due to High Order Detonation

Threshold	Estimated Number of Animals with the Potential to be Affected					
	Harbour Porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale	Harbour Seal	Grey Seal
Charge Size 300 kg						
SPL Peak	995	<1	1	1	<1	56
SEL (Weighted)	205	<1	1	142	<1	156

316. The impact of TTS for low order techniques is predicted to be of local spatial extent, very 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 negligible.

317. The impact of TTS high order detonation is predicted to be of regional spatial extent, very 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.

<u>Sensitivity of the Receptor</u>

Auditory injury (PTS)

318. The acoustical properties of explosives are characterised by 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, appendix 10.1). The interactions of the shock and acoustic waves create a complex pattern in shallow water, and this was investigated further by Von Benda-Beckmann *et al*. (2015). As harbour porpoises have high sensitivity to noise, impacts on these species are most often assessed in a scientific literature.

319. Von Benda-Beckmann *et al*. (2015) investigated the range of effects of explosives on harbour porpoise in the southern North Sea. The study measured SEL and peak overpressure (in kPa) at distances up to 2 km from the explosions of seven aerial bombs detonated at approximately 26 m to 28 m depth, on a sandy substrate. Six bombs had a charge mass of 263 kg (580 lb) and one had a charge mass of 121 kg (267 lb). The study looked at the potential for injury to occur as an ear trauma caused by the blast wave at a peak overpressure of 172 kPa (190 dB re. 1 µPa). Furthermore, the potential for noise-induced PTS to occur was based on a threshold of 190 dB re. 1 µPa^{2}s (PTS 'very likely to occur') and an onset threshold of 179 dB re. 1 µPa^{2}s (SEL) (PTS 'increasingly likely to occur') (Lucke *et al*., 2009 criteria). The results suggested that the largest distance at which a risk of ear trauma could occur was at 500 m and that noise-induced PTS was likely to occur greater than the 2 km range that was measured during the study since the SEL recorded at this distance was 191 dB re. 1 µPa^{2}s (i.e. 1 dB above the 'very likely to occur' threshold).

320. In the same study Von Benda-Beckmann *et al*. (2015) modelled possible effect ranges for 210 explosions (of up to 1,000 kg charge mass) that had been logged by the Royal Netherland Navy (RNLN) and the Royal Netherlands Meteorological Institute (RNMI) over a two year period (2010 and 2011). Using the empirical measurements of SEL out to 2 km to validate the model (described above in paragraph 319), the authors found that the effect distances ranged between hundreds of metres to just over 10 km (for charges ranging from 10 kg up to 1,000 kg). Near the surface, where porpoises are known to spend a large proportion of time (e.g. 55% based on Teilmann *et al*., 2007) the SELs were predicted to be lower with effect distances for the onset of PTS just below 5 km. The authors caveat these results as, whilst the model could provide a reasonable estimate of the SEL within 2 km (since the empirical measurements were made out to this point), estimates above this distance required further validation since the uncorrected model systematically overestimated SEL. Salomons *et al*. (2021) analysed the sound measurements performed near two detonations of UXO (charge masses of 325 kg and 140 kg). From the weighted SEL values and threshold levels from Southall *et al*. (2019), a PTS effect distance in the range 2.5 km – 4 km has been derived (Salomons *et al*., 2021).

321. By comparing experimental data and model predictions, Salomons *et al*. (2021) found thar harbour porpoises are at risk of permanent hearing loss at distances of several kilometres from large explosives, i.e. distance between 2 km and 6 km based on 140 kg and 325 kg charge masses. Following clearance of ground mines in the Baltic Sea in 2019, 24 harbour porpoises were found dead in the period after those clearing events along the coastline (Siebert *et al*., 2022). The post-mortem examination found that in ten cases the cause of death was associated with a blast injury, however the charge masses of the explosives in this study are unknown (Siebert *et al*., 2022).

322. Not much is known about sensitivity of bottlenose dolphin, white-beaked dolphin and minke whale to blasting. However, during a clearance of relatively small explosive (35 kg charge) at an important feeding area for a resident community of bottlenose dolphin in Portugal, acoustic pressure levels in excess of 170 dB e 1 µPa were measured. Despite pressure levels being 60 dB higher than ambient noise, no adverse effects were recorded in the behaviour or appearance of resident community (Santos *et al*., 2010). Nonetheless, other studies reported that external injuries consistent with inner ear damage have been found in dolphins subjected to explosives, with little change in surface animal behaviour near blast areas (Ketten, 1993).

323. Robinson *et al*. (2020) described a controlled field experiment and compared the sound produced by high-order detonations with a low-order disposal method, i.e. deflagration. He found that using low order techniques offers a substantial reduction in acoustic output over traditional high-order methods, with the peak SPL_{pk} and SEL_{cum} observed being typically > 20 dB lower for the deflagration of the same sized munition (a reduction factor of just over ten in SPL_{pk} and 100 in acoustic energy). The study also reported that the acoustic output depends on the size of the shaped charge, rather than the size of the UXO itself. Considering the above, compared to high-order methods, Robinson *et al*. (2020) provided the

evidence that low order techniques offers the potential for greatly reduced acoustic noise exposure of marine mammals.

324. The sensitivity of the receptors to the injury from impulsive underwater noise has been described previously for piling and is presented in paragraphs 196 to 210.

325. All marine mammals, which are IEFs of international value, are deemed to be of high vulnerability and low recoverability. The sensitivity of the receptor to PTS is therefore considered to be high.

Temporary threshold shift

Harbour porpoise

326. Explosions during UXO clearance activities and associated underwater noise have the potential to produce behavioural disturbance, however there are no agreed thresholds for the onset of a behavioural response generated as a result of explosion. Given different nature of the sound, using noise levels and probability of a response to pile driving would not be appropriate. Southall *et al.* (2007) suggests that the use of TTS onset as a auditory effect may be most appropriate for single pulses (such as UXO detonation) and therefore it has been used in other assessments where the impacts of UXO clearance on marine mammals have been investigated. TTS is a temporary and reversible hearing impairment and therefore, it is anticipated that any animals experiencing this shift in hearing would recover after they are no longer exposed to elevated noise levels (i.e. they may have moved beyond the injury zone or piling has ceased). The implication of animals experiencing TTS, leading to potential displacement, is not fully understood, but it is likely that aversive responses to anthropogenic noise could temporarily affect life functions as described for PTS. However, due to the reversible nature of TTS, this is less likely to lead to acute effects and will largely depend on recoverability. The degree and speed of hearing recovery will depend on the characteristics of the sound the animal is exposed to, and on the degree of shift in hearing experienced. A study measuring recovery rates of harbour porpoise following exposure to sound source of 75 db re 1 µPa (SEL) over 120 minutes found that recovery to the pre-exposure threshold was estimated to be complete within 48 minutes following exposure (the higher the hearing threshold shift, the longer the recovery) (SEAMARCO, 2011).

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

328. 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) (Kastelein *et al*., 2021). In a series of studies measuring TTS occurrence in harbour porpoise at a range of frequencies typical of high amplitude anthropogenic sounds (0.5 kHz to 88.4 kHz) the greatest shift in mean TTS occurred at 0.5 kHz, which is very close to the lower bound of porpoise hearing (Kastelein *et al*., 2021). Hearing always recovered within 60 minutes after the fatiguing sound stopped. Scientific understanding of the biological effects of TTS is limited to the results of controlled exposure studies on small numbers of captive animals (reviewed in Finneran, 2015). Extrapolating these results to how animals may respond in the natural environment should be treated with caution as it is not possible to exactly replicate natural environmental conditions, and the small number of test subjects would not account for intraspecific differences (i.e. differences between individuals) or interspecific differences (i.e. extrapolating to other species) in response.

Bottlenose dolphin and white-beaked dolphin

329. Whilst there are no available species-specific recovery rates for mid-frequency cetaceans to TTS, there is no evidence to suggest that recovery will be significantly different to harbour porpoise recovery rates therefore animals can recover their hearing after they are no longer exposed to elevated noise levels (i.e. they may have moved beyond the injury zone or piling has ceased). The assessment considered that both white-beaked dolphin and bottlenose dolphin would be able to tolerate the effect without any impact on reproduction or survival rates and would be able to return to previous behavioural states or activities once the impacts had ceased.

Minke whale

330. As above for high-frequency cetaceans (paragraph 329), whilst there are no available species-specific recovery rates for minke whale to TTS, there is no evidence to suggest that recovery will be significantly different to harbour porpoise recovery rates. There is evidence that minke whales avoiding a 15 kHz ADD and clearly react to signals at the likely upper limit of their hearing sensitivity (Boisseau *et al*., 2021). In addition, minke whale exhibit a temporal distribution, with most sightings in continental shelf waters occurring between May and September. The assessment considered that minke whale would be able to tolerate the effect without any impact on reproduction or survival rates and would be able to return to previous behavioural states or activities once the impacts had ceased.

Harbour seal and grey seal

331. A study measuring recovery rates of harbour seal following exposure to a sound source of 193 dB re 1 µPa^{2}s (SEL_{cum}) over 360 minutes found that recovery from TTS to the pre-exposure baseline was estimated to be complete within 72 minutes following exposure (Kastelein *et al*., 2018a). These results are similar to recovery rates found in SEAMARCO (2011), which showed that for small TTS values, recovery in seals was very fast (around 30 minutes) and the higher the hearing threshold shift, the longer the recovery. Kastelein *et al*. (2019a) also demonstrated recovery was rapid, with hearing recovered fully within two hours. Therefore, in most cases, reduced hearing for such a short time probably has little effect on the total foraging period of a seal. If hearing is impaired for longer periods (hours or days) the impact is likely to be ecologically significant (SEAMARCO, 2011). The results indicate that harbour seal (and therefore grey seal, using harbour seal as a proxy) are less vulnerable to TTS than harbour porpoise for the noise bands tested. In addition, it is expected that animals would move beyond the injury range prior to the onset of TTS. The assessment considered that both grey seal and harbour seal are likely to be able to tolerate the effect without any impact on both reproduction and survival rates and would be able to return to previous behavioural states or activities once the impacts had ceased.

332. All marine mammals, which are IEFs of international value, are deemed to be of medium vulnerability and high recoverability. The sensitivity of the receptor to TTS is therefore considered to be low.

Significance of the Effect

Auditory injury

333. Although the preferred approach is the use of low order techniques to clear UXO, in the case that a low order technique results in a high order detonation (as per paragraph 297, approximately 10% of the total number of UXOs could result in high order detonation) conclusions presented in paragraph 334 *et seq.* are based on the assessment for high order clearance.

334. For bottlenose dolphin, white-beaked dolphin, minke whale and harbour seal, the magnitude of the impact is deemed to be low and the sensitivity of the receptors is considered to be high. The potential risk of injury will be reduced by appropriate designed-in measures, including visual and/or acoustic monitoring, and the scale of effect (injury radius and number of animals affected) was predicted to be

very small. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

335. For harbour porpoise and grey seal, the magnitude of the impact is deemed to be medium and the sensitivity of the receptors is considered to be high. Given that the injury zone is too large to be mitigated by designed-in measures (visual and/or acoustic monitoring) and the proportion of respective MU populations potentially injured is moderate, the effect will, therefore, be of moderate adverse significance, which is significant in EIA terms. Secondary mitigation and residual significance is discussed in paragraph 337 *et seq.*

Temporary threshold shift

336. As described for PTS in paragraph 333, the preferred approach is the use of low order techniques to clear UXOs, however in the case that a low order technique results in a high order detonation, the magnitude of the impact for all species is deemed to be negligible to low and the sensitivity of the receptor is considered to be low., The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Secondary Mitigation and Residual Effect

337. Secondary mitigation will be applied to reduce the potential for injury occurring during UXO clearance. As previously described in paragraph 296 *et seq*., low order techniques will be applied as the intended methodology for clearance of UXO, however there is a small risk that a low order clearance could result in high order detonation of UXO (as per paragraph 297, approximately 10% of the total number of UXOs could result in high order detonation). The secondary mitigation has been therefore tailored based on the size of the UXO and high order detonation scenario. A range of UXO munitions sizes have been considered for purpose of determining effective mitigation measure, up to a maximum scenario of a UXO size of 300 kg. This approach follows a similar strategy to what was done for Seagreen EPS Risk Assessment and MMMP (Seagreen Wind Energy Ltd, 2021).

338. A MMMP will be developed for the purpose of mitigating the risk of auditory injury (PTS) to marine mammals from the proposed UXO clearance activities at the Proposed Development. As previously mentioned, an approach used in Seagreen EPS Risk Assessment and MMMP (Seagreen Wind Energy Ltd, 2021) has been followed for the Proposed Development. The MMMP will be provided as a stand-alone document, however this section provides an overview of the procedures prior to making conclusions on the potential for residual effects.

339. The designed-in measures included as a part of the MMMP (Table 10.21) are in line with JNCC guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC, 2010b). Details of ADD use and soft-start charges application are specific for each of the anticipated UXO sizes. A flow-chart, originally presented in Figure 2 of Seagreen EPS Risk Assessment and MMMP (Seagreen Wind Energy Ltd, 2021), has been used to inform the mitigation procedures. Prior to the commencement of UXO clearance works, a more detailed assessment will be produced as a part of the EPS licence supporting information, including an evaluation of the most appropriate measures to employ particularly with respect to emerging evidence on the use of scare charges as the most widely applied approach alongside ADDs. During Road Map Meeting 4 stakeholders were informed that appropriate mitigation measures will be agreed via consultation as a part of a UXO specific MMMP and this will include consideration of the efficacy of noise abatement measures (Table 10.9).

340. The approach to mitigating injury to marine mammals involves the monitoring of a 1 km radius mitigation zone. Monitoring will be carried out by suitably qualified and experienced personnel within a mitigation team, comprising two dedicated MMOs and one dedicated PAM operator. The purpose of this monitoring is to ensure that the mitigation zone is clear of marine mammals prior to detonation.

341. Given that there is a potential to experience auditory injury by harbour porpoise and minke whale at a greater range than can be mitigated by monitoring of the 1 km mitigation zone alone (Table 10.42), an ADD will be deployed for a pre-determined length of time to deter marine mammals to a greater distance prior to any detonation. The assessment of effects provided above in paragraph 296 *et seq.* determine the auditory injury range based on high order detonation of a 300 kg UXO (Table 10.42). At the time of writing, the number and size of the UXOs within the Proposed Development array area and the Proposed Development export cable corridor are unknown and therefore, the secondary mitigation has been designed for a range of UXO munitions sizes so that the most appropriate approach can be applied to balance the risk of injury from UXO detonation with any additional noise introduced into the marine environment as deterrent measures (Table 10.50). The assumption is that the animals swim in a straight line away from the ADD at a speed agreed in consultation with NatureScot and MSS for the Proposed Development. Swim speeds are summarised in Table 10.24 along with the source papers for the assumptions. Therefore, the duration of the application of the ADD prior to UXO detonation will determine whether the animal can move out of the injury zone prior to UXO detonation (Table 10.50).

342. Activation of an ADD will commence within the 60 minutes pre-detonation search, providing no marine mammals have been observed within the mitigation zone for a minimum of 20 minutes. Summaries provided in this paragraph refer to harbour porpoise and minke whale only, however, deterrence distances are provided for all marine mammal IEFs in Table 10.50. Based on the UXO clearance flow chart (Figure 10.26 ; informed by Seagreen Wind Energy Ltd, 2021), for UXO size up to 3 kg, the required time of ADD activation is 22 minutes and this is expected to displace harbour porpoise and minke whale to 1,980 m and 3,036 m range, respectively (Table 10.50). If UXO size of up 6.5 kg is identified during the survey, then ADD will be activated for 30 minutes and this is expected to deter harbour porpoise and minke whale to 2,700 m and 4,140 m, respectively. For UXO mass charge of up to 15 kg, the required time of ADD activation is 40 minutes and this is expected to displace harbour porpoise and minke whale to 3,600 m and 5,520 m range, respectively. For larger UXO sizes up to 50 kg, an ADD will be activated for 60 minutes and this is expected to deter harbour porpoise and minke whale to 5,400 m and 8,280 m, respectively.

343. For UXO sizes up to 300 kg, to reduce the risk of PTS, there is a need to deter animals from larger ranges that cannot be achieved using an ADD alone. Therefore, following an ADD activation period of 60 minutes, a 'soft start' will be undertaken, using a sequence of small explosive charges, detonated at five minutes intervals, over a total of maximum 20 minutes (Table 10.50). It is expected that 80 minutes of combined ADD/soft start procedure will displace harbour porpoise and minke whale to ranges of 7,200 m and 11,040 m, respectively. Whilst this secondary mitigation is considered to be sufficient to deter most animals, there may be a residual effect for harbour porpoise for this largest UXO size, as the maximum predicted PTS impact range for this species was 10,630 m (Table 10.42).

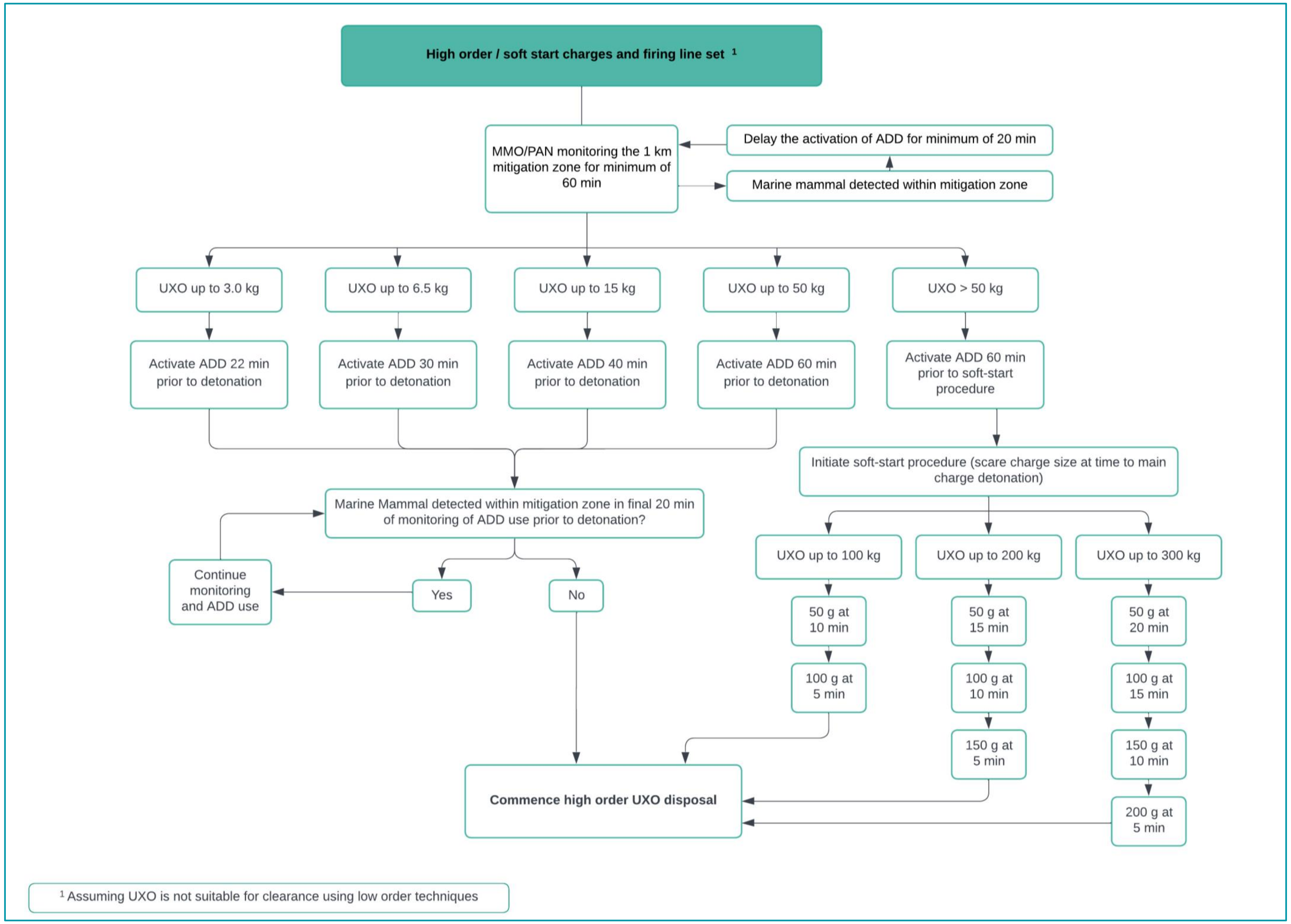


Figure 10.26: Proposed Development UXO Clearance Mitigation Flow Chart

Table 10.50: Recommended ADD Duration for High Order UXO Clearance and Sizes, and Associated Displacement Distance

UXO Size	Minimum duration prior to detonation	Displacement Distance (m)				
		Harbour Porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale	Seals
Up to 3 kg	22 min of ADD	1,980	2,006	2,006	3,036	2,376
Up to 6.5 kg	30 min of ADD	2,700	2,736	2,736	4,140	3,240
Up to 15 kg	40 min of ADD	3,600	3,648	3,648	5,520	4,320
Up to 50 kg	60 min of ADD	5,400	5,472	5,472	8,280	6,480
Up to 300 kg	60 min of ADD plus soft start charges for 20 minutes	7,200	7,296	7,296	11,040	8.640

344. The analysis presented in Table 10.50 suggests that for UXO sizes of up to 300 kg, pre-detonation search and use of ADD will be sufficient to reduce the potential of experiencing PTS by bottlenose dolphin, white-beaked dolphin, minke whale, harbour seal and grey seal to negligible magnitude. As presented in paragraph 343, it has been estimated that harbour porpoises could potentially experience an auditory injury at distances that cannot be fully mitigated by application of ADD and soft start charges. The maximum mitigation zone has been assessed as 7,200 m and PTS range for this species has been modelled as 10,630 m. To assess the residual effect, the average and maximum number of animals that may potentially be present within an area of 192 km² (difference between the area across which effects could be mitigated and area of effect) could be calculated using harbour porpoise density range (Table 10.13). However, this approach is considered likely to lead to an overestimate and may result in unrealistic predictions for the numbers of animals potentially injured. For example, for highly impulsive sounds such as piling, at ranges from the source in the order of tens of kilometres, the sound changes from being impulsive in character to being non-impulsive. At even greater ranges, the sound will not only be non-impulsive but can be characterised as being continuous (i.e. each pulse will merge into the next one). As presented in volume 3, appendix 10.1, annex D, assessment of transition range is an area of ongoing research but it is considered that any predicted injury ranges in the tens of kilometres are almost certainly an overly precautionary interpretation of existing criteria (Southall *et al.*, 2021).

345. There is also a likelihood that the range over which the animals are anticipated to be displaced during 60 minutes of ADD plus application of soft start charges (Table 10.50) is underestimated. Firstly, strong and far-reaching responses to an ADD have been recorded by Thompson *et al.* (2020) at approximately 10 km to the ADD source. Moreover, to assess the range of 7,200 m, an average harbour porpoise swim speed has been applied (i.e. 1.5 m/s). Various scientific papers provided significantly faster speeds with a maximum speed of 4.3 m/s and 6.2 m/s cited by Otani *et al*. (2000) and Leatherwood *et al.* (1988), respectively.

346. For harbour porpoise, it is expected that small numbers of animals could be exposed to potential PTS. Given that details about UXO clearance technique to be used and charge sizes will not be available until after the consent is granted (pre-construction period, following UXO survey), it is not possible to quantify the effects of UXO detonations and therefore the residual number of animals is not presented within this chapter. At a later stage, when details about UXO sizes and specific clearance techniques to be used become available, it will be possible to provide detailed assessment and tailor the secondary mitigation to specific UXO sizes and species to reduce the risk of injury. Therefore, prior to the commencement of UXO clearance works, a more detailed assessment will be produced as a part of the EPS licence supporting information for the UXO clearance works. Appropriate secondary mitigation measures will be agreed with stakeholders as a part of a UXO specific MMMP. It is therefore anticipated that following the application of secondary mitigation measures following receipt of more detail regarding size and number of UXO, the magnitude of this impact will be reduced to low.

Residual Effect – Auditory Injury

347. Overall, following secondary mitigation, the magnitude of the impact for all species, except harbour porpoise, is deemed to be negligible and the sensitivity of the receptors is considered to be high. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

348. For harbour porpoise, following secondary mitigation, the magnitude of the impact is deemed to be low and the sensitivity of the receptors is considered to be high. Given that only a small proportion of population could be potentially injured (PTS), the effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Residual Effect – Temporary threshold shift

349. Overall, following secondary mitigation, the magnitude of the impact for all species is deemed to be negligible to low and the sensitivity of the receptors is considered to be low. Given that temporary loss in hearing is reversible and therefore not considered likely to lead to any long-term effects on the individual and only small proportion of respective populations could be potentially injured (TTS), the effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

INJURY AND DISTURBANCE TO MARINE MAMMALS FROM ELEVATED UNDERWATER NOISE DUE TO VESSEL USE AND OTHER ACTIVITIES

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

351. The assessment of impacts from elevated underwater noise due to vessel use and other activities is based on vessel and/or activity basis, considering the maximum injury/disturbance range as assessed in volume 3, appendix 10.1. However, several activities could be potentially occurring at the same time and therefore ranges of effects may extend from several vessels/locations where the activity is carried out and potentially overlap.

Construction Phase

<u>Magnitude of Impact</u>

Auditory injury

352. During the construction phase of the Proposed Development, the increased levels of vessel activity will contribute to the total underwater noise levels. The maximum design scenario for construction activities associated with site preparation and inter-array and offshore export cables is up to 316 return trips of up to nine boulder clearance vessels and 104 return trips of up to three sandwave clearance vessels, throughout the construction period. 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 (see Table 10.16 for full list of construction vessels and volume 3, appendix 10.1 for SPLs associated with each vessel type). 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.

353. The main drivers influencing the magnitude of the impact are vessel type, speed and ambient noise levels (Wilson *et al*., 2007). Based on information presented in volume 2, chapter 13, baseline levels of vessel traffic in the Proposed Development marine mammal study area are relatively high. An average of 14 vessels per day were recorded within a 10 nm buffer around the Proposed Development array area (hereinafter Proposed Development shipping and navigation study area) over a 14-day survey period in August 2022. The vessel traffic surveys also showed an average of three to four vessels intersecting the Proposed Development array area per day, over summer. Throughout the season, a maximum of 25 vessels were recorded within the Proposed Development array shipping and navigation study area over one day. For the winter survey period (January 2021), there was an average of 16 unique vessels per day recorded within the Proposed Development array area shipping and navigation study area.

354. As described in the Navigational Risk Assessment (NRA) (volume 3, appendix 13.1), occasional vessel traffic movements associated with jack-ups, semi-submersibles and other platforms also occur in the region.

355. Other noise generating activities for the Proposed Development will include drilled piling, with a maximum of 176 piles over the period of 135 days (Table 10.16). Rotatory drilling is non-impulsive in character and the source sound levels associated with this activity have been based on pile drilling for the Oyster 800 project. The other noise sources potentially active during the construction phase are related to cable installation (i.e. trenching and cable laying activities), and their related operations such as the jack-up rigs. See volume 3, appendix 10.1 for more information about SELs associated with above construction activities.

356. A detailed underwater noise modelling assessment has been carried out to investigate the potential for injurious and behavioural effects on marine mammals resulting from elevated underwater noise (non-impulsive sound), using the latest criteria (volume 3, appendix 10.1). A conservative assumption has been made that all individual marine mammals will respond aversively to increases in vessel noise (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 noise levels, hearing ability, vertical space use and behavioural response differences. SELs have been estimated for each vessel type based on 24 hours continuous operation, although it is important to note that it is highly unlikely that any marine mammal would stay at a stationary location or within a fixed radius of a vessel for 24 hours. Therefore, the acoustic modelling has been undertaken based on an animal swimming away from the source (or the source moving away from an animal). The noise modelling results indicate that ranges (within which there is a risk of PTS occurring to marine mammals as a result of elevated underwater noise due to vessel use) are either not exceeded or relatively low (Table 10.51). The maximum range within which the PTS could occur across all species has been estimated for harbour porpoise at 525 m for a rock placement vessel (Table 10.51).

Table 10.51: Vessels Involved in the Construction of the Proposed Development and Estimated PTS Ranges for Marine Mammals

Threshold	Range of Effect (m)				
	Harbour porpoise	Bottlenose Dolphin	White-beaked dolphin	Minke Whale	Seal Species
Installation vessel, construction vessel	280	10	10	N/E	N/E
Rock placement vessel	525	15	15	N/E	5
Anchor handling vessel, survey vessel, support vessels	N/E	N/E	N/E	N/E	N/E
Misc. small vessel (e.g. tugs, vessels carrying remotely operated vehicles (ROVs), CTVs, dive boats, barges and rigid inflatable boats (RIBs)	N/E	N/E	N/E	N/E	N/E
Excavator, Backhoe dredger, pipe laying, geophysical survey vessel, jack up vessel	N/E	N/E	N/E	N/E	N/E

N/E = Not Exceeded

357. Of the other noise-producing activities, cable laying is most likely to result in PTS compared to drilling, trenching and jack-up rigging (Table 10.52). As before, the modelled effect ranges for cable laying suggest that harbour porpoise is the most sensitive species with PTS predicted up to 525 m from the source (Table 10.52). The same activity is likely to result in a PTS to bottlenose dolphin and white-beaked dolphin within 15 m from the source and to seal species within only 5 m from the source. The jack-up rig has the potential to result in PTS to harbour porpoise within 5 m from the source. For all other activities and for all other species, the thresholds for PTS will not be exceeded as a result of underwater noise during construction activities.

Table 10.52: Estimated PTS Ranges for Marine Mammals During Other Activities

Threshold	Range of Effect (m)				
	Harbour porpoise	Bottlenose Dolphin	White-beaked dolphin	Minke Whale	Seal Species
Drilled Piling (SEL 160 dB re 1 μPa^{2}s)	N/E	N/E	N/E	N/E	N/E
Cable Trenching	N/E	N/E	N/E	N/E	N/E
Cable laying	525	15	15	N/E	5
Jack-up rig	5	N/E	N/E	N/E	N/E

358. The number of marine mammals potentially injured within the modelled ranges for PTS from vessels (Table 10.51) and other activities (Table 10.52), were calculated and found to be less than one individual for all species. Whilst the numbers of animals likely to be affected at any one time are extremely low, the maximum duration of the piling phase is up to 52 months.

359. The impact is predicted to be of local spatial extent, medium term duration, intermittent and the effect of PTS on sensitive receptors is of low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Behavioural disturbance

360. Disturbance from vessel noise is likely to occur only where vessel noise associated with the construction of the Proposed Development exceeds the background ambient noise level. As discussed in paragraph 353 *et seq.*, the Proposed Development is located in a relatively busy shipping area and therefore background noise levels are likely to be relatively high.

361. A detailed underwater noise modelling assessment has been carried out to investigate the potential for behavioural effects on marine mammals resulting from increased vessel noise and other activities. The

estimated ranges within which there is a potential for disturbance to marine mammals are presented in Table 10.53. Estimated impact ranges are presented for different vessel types in isolation. It is likely that during construction, operation and maintenance and decommissioning phases, there will be a number of different types of vessels present within the Proposed Development marine mammal study area at the same time. However, given that the exact type, numbers and distances between vessels are unknown at this stage, the cumulative areas of effect were not quantified. Therefore, the discussion presented in paragraph 362 *et seq*. are based on worst-case scenario for each type of vessel at any given time.

362. Installation and construction vessels as well as rock placement vessels result in the greatest modelled disturbance out to 4,320 m for all marine mammal species. Similar ranges for behavioural effects are predicted to occur due to underwater noise from cable laying activities with disturbance ranges of 4,389 m. In comparison, vessels such as excavator, backhoe dredger, pipe laying, geophysical survey vessel and jack up vessel as well as jack-up rig were predicted to result in disturbance ranges out to 300 m.

Table 10.53: Estimated Disturbance Ranges for Marine Mammals and Number of Animals Potentially Disturbed as a Result of Vessels and Other Activities

Threshold	Estimated Number of Animals with the Potential to be Disturbed						
	Disturbance Range (m)	Harbour Porpoise	Bottlenose Dolphin (Offshore)	White-beaked Dolphin	Minke Whale	Harbour Seal	Grey Seal
Vessels							
Installation vessel, construction vessel (DP)	4,320	48	<2	14	2	<1	70
Rock placement vessel	4,320	48	<2	14	2	<1	70
Anchor handling vessel, Survey vessel, Support vessels	2,980	23	<1	7	1	<1	33
Misc. small vessel	1,100	3	<1	1	<1	<1	5
Excavator, Backhoe dredger, Pipe laying, Geophysical survey vessel, jack up vessel	300	<1	<1	<1	<1	<1	<1
Other Activities							
Drilled Piling (SEL 160 dB re 1 µPa^{2}s)	1,900	9	<1	3	<1	<1	14
Cable Trenching	2,580	17	<1	5	1	0	25
Cable laying	4,389	50	<2	15	2	0	73
Jack-up rig	300	<1	<1	<1	<1	<1	<1

363. As discussed previously in paragraph 356, there is likely to be a proportionate response of animals within the modelled contours (i.e. not all animals will be disturbed to the same extent). The life history of an individual and the context will also influence the likelihood of an individual to exhibit an aversive response to noise.

364. Numbers of animals with the potential to be disturbed are presented in Table 10.53, based on the most precautionary species-specific density estimates (Table 10.13) with offshore density estimates applied for bottlenose dolphin (see paragraph 366). Grey seal is likely to be the most sensitive species to disturbance from vessel traffic with potentially the greatest numbers of individuals disturbed compared with other species. The second most sensitive marine mammal (based on numbers of animals potentially affected) is harbour porpoise.

365. The numbers of animals with the potential to be disturbed (as presented in Table 10.53) are considered to be highly conservative, especially for harbour porpoise and grey seal, as these estimates were based on the peak seasonal densities from the Proposed Development aerial digital survey data during spring months and maximum density based on at-sea mean usage maps (Carter *et al*., 2020), respectively.

366. Given that activities with the largest disturbance ranges, including installation, construction, rock placement and cable laying vessels, will be operating at distances from the outer Firth of Tay (the highest bottlenose dolphin densities) and are unlikely to affect coastal bottlenose dolphin population, bottlenose dolphins that could be exposed to potential disturbance (Table 10.53) would belong to offshore populations.

367. The impact is predicted to be of local spatial extent, medium term duration, intermittent and the effect of behavioural disturbance is of high reversibility. 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>

368. Increased vessel movement during all phases of Proposed Development have the potential to result in a range of impacts on marine mammal including injury as a result of elevated underwater noise; avoidance behaviour or displacement; and masking of vocalisations or changes in vocalisation rate.

Auditory injury

369. The sensitivity of marine mammal receptors to auditory injury has been assessed in paragraph 196 *et seq.,* and is not reiterated here.

370. All marine mammals, which are IEFs of international value, are deemed to be of medium vulnerability and low recoverability. The sensitivity of the receptor is therefore, considered to be high.

Behavioural disturbance

371. Disturbance levels for marine mammal receptors will be dependent on individual hearing ranges and background noise levels within the vicinity. Sensitivity to vessel noise is most likely related to the marine mammal activity at the time of disturbance (IWC, 2006; Senior *et al*., 2008).

372. Cetaceans can both be attracted to, and disturbed by, vessels. For example, resting dolphins are likely to avoid vessels, foraging dolphins will ignore them, and socialising dolphins may approach vessels (Richardson *et al*., 1995).

373. Harbour porpoise is particularly sensitive to high frequency noise and likely to avoid vessels; Heinänen and Skov (2015) identified that the occurrence of harbour porpoise declines significantly when the number of vessels in a 5 km^2 area exceeds 80 in one day. Wisniewska *et al*. (2018) studied the change in foraging rates of harbour porpoise in response to vessel noise in highly trafficked coastal waters. The results show that occasional high-noise levels coincided with vigorous fluking, bottom diving, interrupted foraging and even cessation of echolocation, leading to significantly fewer prey capture attempts at received levels greater than 96 dB re 1 µPa (16 kHz third-octave). Heinänen and Skov (2015) found that the occurrence of harbour porpoise declines significantly when the number of vessels in a 5 km^2 area exceeds 20,000 ships per year (approximately 80 ships per day or 18 ships per km^2).

374. Other species of dolphin (e.g. common dolphin) are regularly sighted near vessels and may also approach vessels (e.g. bow-riding). However, dolphins are also known to show aversive behaviours to vessel presence, including increased swimming speed, avoidance, increased group cohesion and longer dive duration (Miller *et al*., 2008). Reactions of marine mammals to vessel noise are often linked to changes in the engine and propeller speed (Richardson *et al*., 1995). Watkins (1986) reported avoidance behaviour in baleen whales from loud or rapidly changing noise sources, particularly where a boat approached an animal. Disturbance in dolphins and porpoises is likely to be associated with the presence of small, fast-moving vessels as they are more sensitive to high frequency noise, whilst baleen whales, such as minke whale, are likely to be more sensitive to slower moving vessels emitting lower frequency noise. Pirotta *et al*. (2015) found that transit of vessels (moving motorised boats) in the Moray Firth resulted in a reduction (by almost half) of the likelihood of recording bottlenose dolphin prey capture buzzes. They also suggest that vessel presence, not just vessel noise, resulted in disturbance. Anderwald *et al*. (2013) suggested that in the study of displacement responses to construction-related vessel traffic, minke whale and grey seal were avoiding the area due to noise rather than vessel presence. In the same study, the presence of bottlenose dolphin was positively correlated with overall vessel numbers, as well as the number of construction vessels. It was, however, unclear whether the bottlenose dolphins were attracted to the vessels themselves or to particularly high prey concentrations within the study area at the time. Richardson (2012) investigated the effect of disturbance on bottlenose dolphin community structure in Cardigan Bay and found that group size was significantly smaller in areas of high vessel traffic.

375. There is, however, evidence of habituation to boat traffic and therefore a slight increase from the existing levels of traffic in the vicinity of the Proposed Development may not result in high levels of disturbance. For example, Lusseau *et al*. (2011) (Scottish Natural Heritage commissioned report) undertook a modelling study which predicted that increased vessel movements associated with offshore wind development in the Moray Firth did not have a adverse effect on the local population of bottlenose dolphin, although it did note that foraging may be disrupted by disturbance from vessels.

376. Seals are particularly sensitive to disturbances in regions where vessel traffic overlaps with productive coastal waters (Robards *et al*., 2016). Richardson *et al*. (2005) reported avoidance behaviour or alert reactions in harbour seal when vessels approach within 100 m of a haul-out (Richardson *et al*., 2005); when disturbed, seals that are hauled-out typically flush into the water which could be detrimental during pupping season (e.g. Terhune and Almon, 1983; Johnson and Acevedo-Gutiérrez, 2007). The presence of vessels in foraging grounds could result in reduced foraging success, particularly in harbour seals given reduced foraging ranges (c. 50 km from haul-outs) when compared to grey seals (c. 150 km from haul-outs) (SCOS, 2017). However, seals can be curious and have been recorded approaching tour boats that regularly visit an area and may habituate to sounds from tour vessels (Bonner, 1982). Mikkelsen *et al*. (2019) used long term sound and movement tagging data to study reaction to ship noise in grey seals in the North Sea and found that animals were exposed to audible vessel noise 2.2% – 20.5% of their time when in water and that high vessel noise coincided with interruption of functional behaviours such as resting.

377. As mentioned previously, a study on grey seals by Hastie *et al*. (2021) demonstrated how foraging context is important when interpreting avoidance behaviour and should be considered when predicting the effects of anthropogenic activities, with avoidance rates depending on the perceived risk (e.g. silence, pile driving noise, operational noise from tidal turbines) versus the quality of the prey patch. It highlights that sound exposure in different prey patch qualities may result in markedly different avoidance behaviour, and should be considered when predicting impacts in EIAs. Given the existing levels of vessel activity in the Proposed Development shipping and navigation study area (see volume 2, chapter 13) it is expected that marine mammals could tolerate the effects of disturbance without any impact on reproduction and survival rates and would return to previous activities once the impact had ceased.

378. All marine mammals, which are IEFs of international value, are deemed to be of low vulnerability and high recoverability. The sensitivity of the receptor is therefore considered to be medium.

Significance of the Effect

Auditory injury

379. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be high. The potential risk of injury will be reduced by appropriate designed-in measures (vessels following Code of Conduct) and the scale of effect (injury radius and number of animals affected) was predicted to be very small. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Behavioural disturbance

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

Secondary Mitigation and Residual Effect

Auditory injury and behavioural disturbance

381. No secondary marine mammal mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore, the residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

Operation and Maintenance Phase

Magnitude of Impact

382. Vessel use during operation and maintenance phase of the Proposed Development may lead to injury and/or disturbance to marine mammals. Vessel types which will be required during the operation and maintenance phase include those used during routine inspections, repairs and replacement of equipment, major component replacement, painting or other coatings, removal of marine growth, replacement of access ladders, and geophysical surveys (Table 10.16).

383. 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 in the Proposed Development marine mammal study area described in paragraphs 353 *et seq.* Presence of the operational wind farm may divert some of the shipping routes and therefore current traffic within the Proposed Development array area, which is not associated with Proposed Development, is likely to be reduced. The extent of that change can not be quantified at the time of writing, however, it is anticipated this reduction will be ultimately counterbalanced by the presence of maintenance vessels. Vessel movements will be within the Proposed Development array area and the Proposed Development export cable corridor and will follow existing shipping routes to/from the ports. In addition, Codes of Conduct will be issued to all project vessel operators to minimise the potential for collision risk as described in Table 10.21.

384. The size and noise outputs from vessels during the operation and maintenance phase will be similar to those used in the construction phase and therefore will result in a similar maximum design spatial scenario (paragraph 356 *et seq*.). However, the number of vessel round trips and their frequency is much lower for the operation and maintenance phase compared to the construction phase.

Auditory injury

385. An overview of potential impacts for auditory injury to marine mammals from elevated underwater noise due to vessel use and other activities is described in paragraph 352 *et seq*. for the construction phase with effect ranges presented in Table 10.51 and Table 10.52 and have not been reiterated here for the operation and maintenance phase. The impact is predicted to be of local spatial extent, long term duration, intermittent and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Behavioural disturbance

386. An overview of potential impacts for behavioural disturbance to marine mammals from elevated underwater noise due to vessel use and other activities is described in paragraph 360 *et seq.* for the construction phase with impact ranges presented in Table 10.53 and have not been reiterated here for the operation and maintenance phase. The impact is predicted to be of local spatial extent, long term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of the Receptor

Auditory injury

387. The sensitivity of marine mammal receptors to auditory injury has been assessed in paragraph 196 *et seq.* and is not reiterated here. PTS ranges that are a result of vessels involved in the construction phase (non-impulsive sound) are lower than PTS ranges for piling (impulsive sound) and the numbers of animals potentially injured are very low for all species.

388. All marine mammals, which are IEFs of international value, are deemed to be of medium vulnerability and low recoverability. The sensitivity of the receptor is therefore considered to be high.

Behavioural disturbance

389. The sensitivity of the receptors during the operation and maintenance is not expected to differ from the sensitivity of the receptors during the construction phase. The sensitivity of marine mammal receptors to elevated underwater noise due to vessel use and other activities is as described previously in paragraph 371 *et seq.* and is deemed to be medium.

Significance of the Effect

Auditory injury

390. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be high. The potential risk of injury will be reduced by appropriate designed-in measures (vessels following Code of Conduct) and the scale of effect (injury radius and number of animals affected) was predicted to be very small. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Behavioural disturbance

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

Secondary Mitigation and Residual Effect

Auditory injury and behavioural disturbance

392. No secondary marine mammal mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore, the residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

Decommissioning Phase

Magnitude of Impact

393. Vessel use during the decommissioning phase of Proposed Development may lead to injury and/or disturbance to marine mammals. Vessel types which will be required during the decommissioning phase include those used during removal of foundations, cables and cable protection (Table 10.16).

394. Since the numbers and types of vessel used to remove infrastructure (and hence their size and outputs) are expected to be similar to those used for installation, this impact is expected to result in a similar maximum design spatial scenario as the construction phase. The magnitude of the impact of the decommissioning phase for both auditory injury and disturbance as a result of elevated underwater noise due to vessel use, for all marine mammal receptors, is therefore not expected to differ or be greater than that assessed for the construction phase, where it has been assessed as low.

Auditory injury

395. An overview of potential impacts for auditory injury to marine mammals from elevated underwater noise due to vessel use and other activities is described in paragraph 352 *et seq*. for the construction phase and has not been reiterated here for the decommissioning phase. The impact is predicted to be of local spatial extent, medium term duration, intermittent and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Behavioural disturbance

396. An overview of potential impacts for behavioural disturbance to marine mammals from elevated underwater noise due to vessel use and other activities is described in paragraph 360 *et seq.* for the construction phase and have not been reiterated here for the decommissioning phase. The impact is predicted to be of local spatial extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of the Receptor

Auditory injury

397. The sensitivity of marine mammal receptors to auditory injury has been assessed in paragraph 196 *et seq.* and is not reiterated here. PTS ranges that are a result of vessels involved in the construction phase (non-impulsive sound) are in majority lower than PTS ranges for piling (impulsive sound), so auditory damage is likely to be less severe. PTS ranges that are a result of vessels involved in the decommissioning phase (non-impulsive sound) are in majority lower than PTS ranges for piling (impulsive sound) and the numbers of animals potentially injured are very low for all species.

398. All marine mammals, which are IEFs of international value, are deemed to be of medium vulnerability and low recoverability. The sensitivity of the receptor is therefore considered to be high.

Behavioural disturbance

399. The sensitivity of the receptors during the decommissioning phase is not expected to differ from the sensitivity of the receptors during the construction phase. The sensitivity of marine mammal receptors to elevated underwater noise due to vessel use and other activities is as described previously in paragraph 371 *et seq.* and is deemed to be medium.

Significance of the Effect

Auditory injury

400. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be high. The potential risk of injury will be reduced by appropriate designed-in measures (vessels following Code of Conduct) and the scale of effect (injury radius and number of animals affected) was predicted to be very small. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Behavioural disturbance

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

Secondary Mitigation and Residual Effect

Auditory injury and behavioural disturbance

402. No secondary marine mammal mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore the residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

INCREASED RISK OF INJURY OF MARINE MAMMALS DUE TO COLLISION WITH VESSELS

Construction Phase

Magnitude of Impact

403. Vessel traffic associated with the Proposed Development has the potential to lead to an increase in vessel movements within the Proposed Development marine mammal study area. This increase in vessel movement could lead to an increase in interactions between marine mammals and vessels during offshore construction. Whilst a broad range of vessel types are involved in collisions with marine mammals (Laist *et al*., 2001), vessels travelling at higher speeds pose a higher risk because of the potential for a stronger impact (Schoeman *et al.*, 2020).

404. Collisions of vessels with marine mammals have the potential to result in both fatal and non-fatal injuries (Laist *et al*., 2001; Vanderlaan and Taggart, 2007; Cates *et al*., 2017). Evidence for fatal collisions has been gathered from carcasses washing up on beaches (Laist *et al*., 2001; Peltier *et al*., 2019), carcasses caught on vessel bows (Laist *et al*., 2001; Peltier *et al*., 2019) and floating carcasses; injuries including propeller cuts, significant bruising, oedema, internal bleeding radiating from a specific impact site, fractures and ship paint marks have strongly suggested ship strike as cause of death (Jensen and Silber, 2004; Jensen and Silber, 2003; Douglas *et al*., 2008). Fatalities from ship strikes, however, often go unreported (Authier *et al*., 2014). For non-fatal injuries there is evidence of animals which have survived ship strikes with no discernible injury; animals which survive with non-fatal injuries from propellers have been widely documented (Wells *et al*., 2008; Luksenburg, 2014).

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

406. Vessel traffic associated with the construction activities will result in an increase in vessel movements within the Proposed Development marine mammal study area as up to 11,484 return trips by construction vessels may be made throughout the construction phase. This increase, described in more detail in paragraph 352 *et seq.*, could lead to an increase in interactions between marine mammals and vessels. Vessels travelling at 7 m/s or faster are those most likely to cause death or serious injury to marine mammals (Laist *et al*., 2001; Wilson *et al*., 2007). With the exception of CTVs, vessels involved in the construction phase are likely to be travelling considerably slower than this, and all vessels will be required to follow a Project Code of Conduct, included as a part of the NSPVMP (volume 4, appendix 25), The Code of Conduct outlines instructions for vessel behaviour and vessel operators, including advice to operators to not deliberately approach marine mammals and to avoid sudden changes in course or speed. (Table 10.21). Therefore, with Project designed in measures in place, the risk of

collision is anticipated to be reduced and would only be present for transiting vessels (as opposed to stationary).

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

408. 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. With designed-in measures in place the risk of collision will be reduced, however, given the potential for a collision to lead to injury the magnitude is, conservatively, considered to be low.

Sensitivity of the Receptor

409. Marine mammals are generally able to detect and avoid vessels, however, it is unclear why some individuals do not always move out of the path of an approaching vessel (Schoeman *et al*., 2020). It has been suggested that behaviours such as resting, foraging, nursing, and socialising could distract animals from detecting the risk posed by vessels (Dukas, 2002). There can be consequences to a lack of response to disturbance for all marine mammals; behavioural habituation can result in decreased wariness of vessel traffic, which has the potential to result in an increased collision risk (Cates *et al*., 2017). Vessel strikes are known to be a cause of mortality in marine mammals (Carrillo and Ritter, 2010), and it is possible that mortality from vessel strikes is under-recorded (Van Waerebeek *et al*., 2007). Laist *et al*. (2001) reported that collisions between vessels and large whales tended to lead to death, but non-lethal collision has also been reported by Van Waerbeek *et al*. (2007). As described above in paragraph 403, collisions between cetaceans and vessels, are not necessarily lethal on all occasions.

410. Harbour porpoise, as the most abundant cetacean species in the study area, are small and highly mobile and considering their potential avoidance responses to vessel noise (see paragraph 373), it can be assumed that they will largely avoid vessel collisions. UK Cetacean Stranding's Investigation Programme (CSIP) (CSIP, 2015) reported results of post-mortem analysis conducted on 53 harbour porpoise strandings in 2015. A cause of death was established in 51 examined individuals (approximately 96% of examined cases) and, of these, only four (8%) had died from physical trauma of unknown cause, which could have been vessel strikes (CSIP, 2015).

411. 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). The Onoufriou *et al*. (2016) study in the Moray Firth, Scotland showed that seals utilise the same areas as vessels during trips between haul-outs and foraging sites but that seals tended to remain beyond 20 m from vessels with only three instances over 2,241 days of seal activity resulted in passes at < 20 m.

412. Although the potential to experience injury from construction traffic is relatively low, the consequences of collision risk could be fatal. All marine mammal receptors would have limited tolerance to a collision risk, and the effect of the impact could cause a change in both reproduction and survival of individuals, and receptors would have limited ability for the animal to recover from the effect.

413. In summary, there is a high likelihood that marine mammals will avoid vessels and therefore, collision risk. On the basis that not all collisions that do occur are lethal, there is considered to be a medium potential for recovery.

414. All marine mammals, which are IEFs of international value, are deemed to be of medium vulnerability and medium to low recoverability. The sensitivity of the receptor is therefore considered to be medium.

Significance of the Effect

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

Secondary Mitigation and Residual Effect

416. No secondary marine mammal mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore the residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

Operation and Maintenance Phase

Magnitude of Impact

417. Vessel use during operation and maintenance phase of Proposed Development may lead to injury to marine mammals due to collision with vessels. Vessel types which will be required during the operation and maintenance phase include those used during routine inspections, repairs and replacement of equipment, major component replacement, painting or other coatings, removal of marine growth, replacement of access ladders, and geophysical surveys (Table 10.16). The types of vessels are similar to those presented for the maximum design scenario for the construction phase. An overview of the potential impacts due to vessel collision are described in paragraph 403 for the construction phase and have not been reiterated here for the operation and maintenance phase.

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

Sensitivity of the Receptor

419. The sensitivity of the receptors during the operation and maintenance phase is not expected to differ from the sensitivity of the receptors during the construction phase. Therefore, the sensitivity of marine mammal receptors to collision risk is as described previously in paragraph 409 *et seq*., where it has been assessed as medium.

Significance of the Effect

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

Secondary Mitigation and Residual Effect

421. No secondary mammal mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore the residual impact is considered to be of **minor** adverse significance, which is not significant in EIA terms.

Decommissioning Phase

Magnitude of Impact

422. An overview of the potential impacts to marine mammals from vessel collision risk are described in paragraphs 403 *et seq*. for the construction phase and have not been reiterated here for the decommissioning phase.

423. Vessel use during the decommissioning phase of Proposed Development may lead to injury to marine mammals due to collision with vessels. Vessel types which will be required during the decommissioning phase include those used during removal of foundations, cables and cable protection (Table 10.16). The types of vessels used during the decommissioning will result in a similar maximum design scenario as the construction phase.

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

Sensitivity of the Receptor

425. The sensitivity of the receptors during the decommissioning phase is not expected to differ from the sensitivity of the receptors during the construction phase. Therefore, the sensitivity of marine mammal receptors to collision risk is as described previously in paragraph 409 *et seq*., where it has been assessed as medium.

Significance of the Effect

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

Secondary Mitigation and Residual Effect

427. No secondary marine mammal mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore the residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

CHANGES IN FISH AND SHELLFISH COMMUNITIES AFFECTING PREY AVAILABILITY

428. Potential effects on fish assemblages during the construction, operation and maintenance and decommissioning phases of the Proposed Development, as identified in volume 2, chapter 9, may have indirect effects on marine mammals. The assessment includes temporary and long-term habitat loss/disturbance, increased SSC and associated sediment deposition, injury and/or disturbance from underwater noise and vibration, EMF, as well as colonisation of foundations, scour protection and cable protection.

429. The key prey species for marine mammals include sandeels, gadoids (e.g. cod *Gadus morhua*, haddock *Melanogrammus aeglefinus*, whiting *Merlangius merlangus*), clupeids (herring), plaice *Pleuronectes platessa*, flatfish and mackerel. These prey species have been identified as being of regional importance within the Proposed Development fish and shellfish ecology study area (see volume 2, chapter 9). For example, there are important spawning grounds for cod, herring, plaice, sandeel, whiting and sprat within the Proposed Development array area and export cable corridor. Consequently, adverse effects on fish receptors may have indirect adverse effects on marine mammal receptors.

Construction Phase

Magnitude of Impact

430. Potential impacts on marine mammal prey species during the construction phase have been assessed in volume 2, chapter 9 using the appropriate maximum design scenarios for these receptors. Construction impacts include temporary subtidal habitat loss/disturbance, long term subtidal habitat loss, injury and/or disturbance to fish and shellfish from underwater noise and vibration and increased SSCs and associated sediment deposition.

431. The installation of infrastructure within the Proposed Development may lead to temporary subtidal habitat loss/disturbance as a result of a range of activities including use of jack-up vessels during foundation installation, installation of inter-array, interconnector and offshore export cables and associated seabed preparation, and anchor placements associated with these activities. There is the potential for temporary habitat loss/disturbance to affect up to 113,974,700 m^2 of seabed during the construction phase, which equates to 9.7% of the Proposed Development area, representing a relatively small proportion of the Proposed Development fish and shellfish ecology study area. Habitat loss/disturbance could potentially affect spawning, nursery or feeding grounds of fish and shellfish receptors. Due to the highly localised nature of the effects (i.e. spatially restricted to within the Proposed Development array area and Proposed Development export cable corridor) and the small proportion of habitats affected as a proportion of the northern North Sea fish and shellfish ecology study area and medium term duration, temporary habitat loss/disturbance during the construction phase was assessed as being of low magnitude.

432. As suggested in volume 2, chapter 9, only a small proportion of the maximum footprint of habitat loss/disturbance may be affected at any one time during the construction phase with areas starting to recover immediately after cessation of construction activities in the vicinity. Additionally, habitat disturbance during the construction phase will also expose benthic infaunal species from the sediment (see volume 2, chapter 8), potentially offering foraging opportunities to some fish and shellfish species (e.g. opportunistic scavenging species) immediately after completion of works. Most fish and shellfish receptors found within the Proposed Development fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and local to international importance and therefore sensitivity of these receptors was considered to be low. However, sensitivity of some species has been assessed as medium, including larger crustacea (e.g. *Nephrops*, European lobster *Homarus gammarus*) and sandeels. The magnitude of the impact was considered to be low. Consequently, the effect of temporary habitat loss/disturbance was assessed as being of minor adverse significance.

433. Long-term habitat loss will occur directly under all wind turbine and OSP/Offshore convertor station platform foundation structures, associated scour protection and cable protection (including at cable

crossings) where this is required. Long-term subtidal habitat loss within the Proposed Development 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 (see paragraph 447). The presence of infrastructure within the Proposed Development will result in long term habitat loss of up to 7,798,856 m^2. Many species of fish and shellfish are reliant upon the presence of suitable sediment/habitat for their survival and therefore seabed habitats removed by installation of the infrastructure will reduce the area available for foraging, spawning and nursing. However, the area that will be impacted represents a very low proportion of the available habitat (0.7% of the Proposed Development fish and shellfish ecology study area). Moreover, as presented in more detail in volume 2, chapter 9, there is scientific evidence that presence of offshore wind farms is associated with an increase in density of soft sediment-associated fish species and of species associated with hard substrate. The sensitivity of fish and shellfish receptors ranged from low to medium with the majority of fish receptors deemed to be of low vulnerability, high recoverability and local to international importance. The magnitude of the impact was considered to be low. Consequently, the effect of temporary long-term habitat loss was assessed as being of minor adverse significance.

434. An increase in SSC and associated sediment deposition as a result of the installation of all wind turbines and offshore substation foundations and the installation of inter-array, interconnector and offshore export cables may result in short-term avoidance of affected areas by fish and shellfish. The maximum design scenario assessed in volume 2, chapter 9 assumed all wind turbine and offshore substation foundations will be installed by drilling 5.5 m diameter piles and installation of inter-array cables through jet-trenching. Modelling of SSCs associated with the foundation installation showed the plume related directly to the sediment releases was < 5 mg/l and this drops to lower levels within a very short distance, typically < 500 m. Modelling of SSC for installation of inter-array and offshore export cables indicated concentrations of up to 500 mg/l and between 50 mg/l and 500 mg/l, respectively. Adult fish have high mobility and may show avoidance behaviour in areas of high sedimentation, however, there may be impacts on the hatching success of fish and shellfish larvae and consequential effects on the viability of spawning stocks due to limited mobility. Spawning grounds for sandeel overlap with the Proposed Development fish and shellfish ecology study area; eggs of these species are attached to the seabed for couple of weeks before hatching. Sandeel eggs are known to be tolerant to sediment deposition due to the nature of re-suspension and deposition within their natural high energy environment, therefore it is very likely that the effect on sandeel spawning populations will be limited. Herring spawning grounds are also found within the Proposed Development fish and shellfish ecology study area, however, herring eggs are tolerant of very high levels of SSC. Additionally, elevations in SSC during the construction phase will be of short duration, returning to background levels relatively quickly. SSC will not reach the concentrations required for an extended period for there to be any effect on survival. Additionally, deposited sediments are expected to be removed quickly by the currents resulting in small amount of sediment being deposited. It has been assessed that the impact of SSC and associated sediment deposition is likely to be localised, short term and intermittent, the magnitude of impact was deemed to be low and the sensitivity of fish and shellfish receptors was considered to be low to medium. The effect was therefore assessed as being of negligible to minor adverse significance.

435. There is the potential for underwater noise and vibration during construction pile-driving to result in injury and/or disturbance to fish and shellfish communities (see volume 2, chapter 9). For SPL_{pk} and the maximum design scenario assessed (installation of one 5.5 m diameter pile with absolute maximum hammer energy of 4,000 kJ) in volume 2, chapter 9, the maximum recoverable injury range is estimated at 138 m to 228 m from the piling location. The potential for mortality or mortal injury to fish eggs would also occur at distances of up to 228 m. However, this is considered to be highly conservative due to the implementation of soft starts during piling operations which will allow fish to move away from the areas of highest noise levels, before the received noise reaches a level that would cause an injury. As such, the maximum injury ranges predicted for soft start initiation (i.e. of the order of tens of meters) are likely to be more realistic. For SEL_{cum}, subsea noise modelling showed that TTS, from which animals will recover, was predicted to occur out to a maximum distance of 4,161 m for single piling scenario at 4,000 kJ. The potential onset of behavioural effects (such as elicitation of a startle response, disruption of feeding, or avoidance of an area) may occur to ranges of approximately 17 km to 23 km. A qualitative assessment of behavioural effects in fish to underwater noise suggested, however, that responses will differ depending on the sensitivity of the species and the presence/absence of a swim bladder. 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 noise effects was considered to be low and the sensitivity of the fish and shellfish receptors was assessed as low to medium. Therefore, the effect was of negligible to minor adverse significance.

436. With respect to indirect effects on marine mammals, no additional indirect effects other than those assessed for injury and disturbance to marine mammals as a result of elevated underwater noise during piling (see paragraph 115 *et seq.*) have been predicted. This is because if prey were to be disturbed from an area as a result of underwater noise, it is assumed that marine mammals would be disturbed from the same or greater area, and so any changes to the distribution of prey resources would not affect marine mammals as they would already be disturbed from the same (or larger) area.

437. On the basis of the assessments presented in volume 2, chapter 9, 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 the Proposed Development, which are not significant in EIA terms.

438. The impact on marine mammals is predicted to be of local spatial extent, 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

439. Marine mammals exploit a range of different prey items and can forage widely, sometimes covering extensive distances. Given that the impacts of construction to prey resources will be highly localised and largely restricted to the boundaries of the Proposed Development, only a small area will be affected when compared to available foraging habitat in the northern North Sea. Marine mammals occurring within this small impact area also have the potential to be directly affected as a result of impacts such as injury and disturbance from elevated underwater noise during piling and it is likely that the effects to prey resources (e.g. behavioural displacement) will occur over a similar, or lesser, extent and duration as those for marine mammals. There would, therefore, be no additional displacement of marine mammals as a result of any changes in prey resources during construction, as they would already be potentially disturbed as a result of underwater noise during piling. In addition, as prey resources are displaced from the areas of potential impact, marine mammals are likely to follow in order to exploit these resources.

440. The fish and shellfish communities found within the Proposed Development fish and shellfish ecology study area (see volume 2, chapter 9) are characteristic of the fish and shellfish assemblages in the northern North Sea. It is therefore reasonable to assume that, due to the highly mobile nature of marine mammals, there will be similar prey resources available in the wider area. There may be an energetic cost associated with increased travelling and two species, harbour porpoise and harbour seal, may be particularly vulnerable to this effect. Harbour porpoise has a high metabolic rate and only a limited energy storage capacity, which limits their ability to buffer against diminished food while harbour seal typically forage close to haul out sites (i.e. within nearest 50 km). Despite this, if animals do have to travel further to alternative foraging grounds, the impacts are expected to be short term in nature and reversible. It is expected that all marine mammal receptors would be able to tolerate the effect without

any impact on reproduction and survival rates and would be able to return to previous activities once the impact had ceased.

441. Minke whale has the potential to be particularly vulnerable to potential effects on sandeels, particularly if there is a potential for reduced abundance. Studies analysing the stomach contents of minke whale found that in the North Sea this species is their key food resource, followed by clupeids Clupeidae and to a lesser extent mackerel (Robinson and Tetley, 2005; Tetley *et al*., 2008; see volume 3, appendix 10.2 for more details). Minke whale moves inshore during summer months to exploit key prey species. There was a spatial overlap between positions of minke whale sightings during Firth of Forth Round 3 boat-based surveys from May 2009 to November 2011 (see volume 3, appendix 10.2) and areas of high probability of sandeel presence (Langton *et al*., 2021). Various studies reported seasonal movement of minke whales to favoured feeding grounds, optimal for sandeel (from May to August; Robinson *et al*., 2009; Risch *et al*., 2019) and suggested some degree of generality regarding their habitat preferences that would favour sandeel, including association with the 50 m isobath, gravel/sand sediments and steep slopes (de Boer, 2010). Anderwald *et al.* (2012) studied flexibility of minke whales in their habitat use and found that although significantly higher sighting rates often occur in habitats associated with sandeel presence, an area of high occupancy by minke whale, coincided with high densities of sprat during spring. Hence, the low energetic cost of swimming in minke whales and their ability to switch between different prey according to their seasonal availability indicates that these species are able to readily respond to temporal changes in pelagic prey concentrations.

442. All marine mammals, which are IEFs of international value, are deemed to be of low vulnerability and high recoverability. The sensitivity of the receptor is therefore considered to be low.

Significance of the Effect

443. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. Given that marine mammals can exploit a wide range of prey species but travelling longer distances may be associated with higher rate of energy expenditure, the effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Secondary Mitigation and Residual Effect

444. No secondary marine mammal mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore the residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

Operation and Maintenance Phase

Magnitude of Impact

445. Potential impacts on marine mammal prey species during the operation and maintenance phase have been assessed in volume 2, chapter 9 using the appropriate maximum design scenarios for these receptors. These impacts include temporary subtidal habitat loss/disturbance, long term subtidal habitat loss, increased SSC and associated sediment deposition, EMF from subsea electrical cabling and colonisation of foundations, scour protection and cable protection.

446. There is the potential for up to 989,000 m^2 of temporary habitat loss/disturbance during the operation and maintenance phase as a result of the use of jack-up vessels during any component replacement activities and during any inter-array, OSPs/Offshore convertor station platform interconnector and offshore export cable repair activities. Given that these impacts will be similar to those identified for temporary habitat loss/disturbance the construction phase (as discussed in paragraph 431) and will be highly restricted to the immediate vicinity of these operations, the magnitude was assessed as negligible. The sensitivity of fish and shellfish receptors ranged from low to medium with the majority of fish receptors deemed to be of low vulnerability and high recoverability. Consequently, the effects of temporary habitat loss/disturbance on fish and shellfish IEFs during the operation and maintenance phase were assessed as being of negligible to minor adverse significance.

447. As described in paragraph 433, the presence of infrastructure within the Proposed Development, will result in long term habitat loss of up to 7,798,856 m^2 during the operation and maintenance phase (0.7% of the Proposed Development fish and shellfish ecology study area). An overview of potential impacts to fish and shellfish receptors and sensitivity conclusions were previously presented in paragraph 433 for construction phase and will not be reiterated here for operation and maintenance phase. The effect of temporary long-term habitat loss was assessed as being of minor adverse significance.

448. Increased SSC could occur as a result of repair or remedial burial activities during the operation and maintenance phase. The maximum design scenario assessed in volume 2, chapter 9 for increased SSC and associated deposition is for the repair of cables of up to 30,000 m in length and reburial of cables of up to 10,000 m in length for inter-array cables; and repair of cables of up to 4,000 m in length and reburial of cables of up to 4,000 m in length for offshore export cables, using similar methods as those for cable installation activities (e.g. jet-trenching) undertaken at intervals over the 35 years operation and maintenance phase. The assessment in volume 2, chapter 9 considered that any suspended sediments and associated deposition will be of the same magnitude, or lower as for construction, with the sensitivity of the receptors similar to that assessed for the construction phase (see paragraph 433). The overall significance of the effect was therefore deemed to be of negligible to minor adverse significance.

449. The presence and operation of inter-array, interconnector and offshore export cables will result in emissions of localised electrical and magnetic fields, which could potentially affect the sensory mechanisms of some species of fish and shellfish. Species for which there is evidence of a response to electrical and/or magnetic fields include elasmobranchs (sharks, skates and rays), river lamprey *Lampetra fluviatilis,* sea lamprey *Petromyzon marinus*, European eel *Anguilla ecommis*, plaice and Atlantic salmon *Salmo salar* (Gill *et al*., 2005, CSA, 2019). A range of their life functions is supported by either electric or magnetic sense, including detection of prey, predator avoidance, social or reproductive behaviours, orientation, homing, and navigation (Gill *et al*., 2005; Normandeau *et al*., 2011). Given that the range over which species can detect EMF will be very localised to within a few centimetres of the buried cable, with rapid decay of the EMF with increasing distance, the magnitude of the impact was assessed as low. Most fish and shellfish species were considered to be of low sensitivity, with the exception of elasmobranchs and decapod crustaceans, which were of medium sensitivity. The significance of the effect was considered to be negligible to minor adverse.

450. Artificial structures introduced to the marine environment, such as wind turbine foundations and scour/cable protection, provide hard substrate for settlement of various organisms, including small crustaceans and polychaete worms. These communities can provide a valuable food source for fish species and therefore, hard substrate habitat is likely to be colonised within days after construction by demersal and semi-pelagic species. The maximum design scenario assessed in volume 2, chapter 9 assumes up to 10,198,971 m^2 of habitat created due to the installation of jacket foundations, associated scour protection and cable protection associated with inter-array cables, OSPs/Offshore convertor station platform interconnector cables and offshore export cables. The dominant natural substrate character (e.g. soft sediment or hard rocky seabed) will determine the number of new species found on the introduced vertical hard surface and associated scour protection. When placed on a soft seabed, most of the colonising fish tend to be associated with hard bottom habitats, thus the overall diversity of the area is expected to increase. If infrastructure is introduced to the area of rocky substrates, few species will be

added to the area, but the increase in total hard substrate could sustain higher abundance (Andersson *et al*., 2009). The magnitude of the impact was assessed as low. Most fish and shellfish species are deemed to be of low to medium vulnerability and high recoverability, therefore the sensitivity of the receptor was assessed as low. The effect is expected to be of negligible to minor adverse significance.

451. The impact on marine mammals is predicted to be of local spatial extent, long-term duration, continuous and the effect on marine mammals is of high reversibility. The magnitude is therefore, considered to be low.

Sensitivity of the Receptor

452. Following placement on the seabed, submerged parts of the wind turbines provide hard substrate for the colonisation by high diversity and biomass in the flora and fauna. Faecal deposits of dominant communities of suspension feeders are likely to alter the surrounding seafloor communities by locally increasing food availability (Degraer *et al*., 2020). Higher trophic levels, such as fish and marine mammals, are likely to profit from locally increased food availability and/or shelter and therefore have the potential to be attracted to forage within offshore wind farm array area. However, still relatively little is known about the distribution and diversity of marine mammals around offshore anthropogenic structures. Species such as harbour porpoise, minke whale, white-beaked dolphin, harbour seal and grey seal were frequently recorded around offshore oil and gas structures (Todd *et al*., 2016; Delefosse *et al*., 2018; Lindeboom *et al*., 2011). Acoustic results from a T-POD measurement within a Dutch wind farm found that relatively more harbour porpoises are found in the wind farm area compared to the two reference areas (Scheidat *et al*., 2011; Lindeboom *et al*., 2011). Authors of this study concluded that this effect is directly linked to the presence of the wind farm due to increased food availability as well as the exclusion of fisheries and reduced vessel traffic in the wind farm (shelter effect). Russell *et al.* (2014) monitored the movements of tagged harbour seals within two active wind farms in the North Sea and demonstrated that animals commonly showed grid-like movement patterns which strongly suggested that the structures were used for foraging. During research on a Danish wind farm, no statistical differences were detected in the presence of harbour porpoises between inside and outside the wind farm (Diederichs *et al*., 2008). Diederichs *et al*. (2008) suggested, 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 (Birchenough and Degrae, 2020), the statistical significance of such benefits and details about trophic interactions in the vicinity of artificial structures and their influence on ecological connectivity remain largely unknown (Petersen and Malm, 2007; Inger *et al*., 2009; Rouse *et al.,* 2020, McLean *et al.,* 2022; Elliott and Birchenough, 2022). Additional details about inter-related effects on marine organisms are provided in section 10.14

453. Overall, the sensitivity of marine mammals during the operation and maintenance phase is not expected to differ from the sensitivity of the receptors during the construction phase described in paragraph 439*et seq*. The sensitivity of the receptor is therefore, considered to be low.

Significance of the Effect

454. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. Given that marine mammals can exploit a wide range of prey species but travelling longer distances may be associated with higher rate of energy expenditure, the effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms. This is likely to be a conservative prediction as there is some evidence (although with uncertainties) that marine mammal populations are likely to benefit from introduction of hard substrates and associated fauna during the operation and maintenance phase.

Secondary Mitigation and Residual Effect

455. No secondary marine mammal mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore the residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

Decommissioning Phase

Magnitude of Impact

456. Potential impacts on marine mammal prey species during the decommissioning phase have been assessed in volume 2, chapter 9 using the appropriate maximum design scenarios for these receptors. These impacts include temporary subtidal habitat loss/disturbance, long term subtidal habitat loss and increased SSCs and associated sediment deposition.

457. Decommissioning activities such as use of jack-up vessels during foundation removal, removal of inter-array, interconnector and offshore export cables, and associated anchor placements may result in temporary habitat loss/disturbance of up to 34,571,200 m^2. The impact is predicted to be of localised extent and affect only a small proportion of this total area at any one time during the decommissioning phase, therefore the magnitude of the impact was assessed as low. The sensitivity of fish and shellfish receptors was considered to be negligible to minor. The significance of effect on marine mammal prey species was therefore deemed to be of negligible to minor adverse significance.

458. Decommissioning of infrastructure will lead to increases in SSC and associated sediment deposition. The maximum design scenario is represented by the cutting and removal of piled jacket foundations at seabed level and removal of inter-array, OSPs/Offshore convertor station platform interconnector and offshore export cables by jet dredging mobilising material from a 0.5 m deep and 2 m wide trench. Increases in SSC and associated deposition are assumed to be of a similar magnitude to the construction phase (i.e. low magnitude). The sensitivity of fish and shellfish receptors was considered to be low to medium and overall significance of the impact was deemed to be of negligible to minor adverse significance.

459. Leaving infrastructure, such as the scour protection associated with wind turbine and OSPs/Offshore convertor station platform foundations and cable protection associated with array, OSPs/Offshore convertor station platform interconnector and offshore export cables, *in situ* after decommissioning will result in permanent habitat loss with a maximum design scenario of up to 7,562,609 m^2. An overview of potential impacts to fish and shellfish receptors and sensitivity conclusions were previously presented in paragraph 10.11.2.433 *et seq*. The significance of effect was deemed to be of minor adverse.

460. The impact on marine mammals is therefore predicted to be of local spatial extent, medium term duration, intermittent and of high reversibility. The magnitude is therefore, considered to be low.

Sensitivity of the Receptor

461. The sensitivity of marine mammals during the decommissioning phase is not expected to differ from the sensitivity of the receptors during the construction phase described in paragraph 439 *et seq*. The sensitivity of the receptor is therefore, considered to be low.

Significance of the Effect

462. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. Given that marine mammals can exploit a wide range of prey species but travelling longer distances may be associated with higher rate of energy expenditure, the effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Secondary Mitigation and Residual Effect

463. No secondary marine mammal mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore, the residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

10.11.3. PROPOSED MONITORING

464. No residual significant effect on marine mammals has been identified in the assessment provided above (paragraphs 114 *et seq.).* There are a small residual number of harbour porpoise individuals that could potentially experience auditory injury during UXO clearance activities, and the Applicant will apply for an EPS licence post-consent along with EPS supporting information and UXO specific MMP for these works.

465. Noise monitoring will be carried out during UXO clearance to provide empirical data on the measured received levels as predicted in the noise model. In addition, in-field noise monitoring has been suggested by stakeholders at increasing distances from the piling location to enhance the understanding of noise characteristics from piling activities and allow comparisons between modelled predictions and real-world data (Table 10.9). Any requirement for monitoring will be approved by MS-LOT.

10.12. CUMULATIVE EFFECTS ASSESSMENT

10.12.1. METHODOLOGY

466. The Cumulative Effects Assessment (CEA) takes into account the impact associated with the Proposed Development together with other relevant plans, projects and activities. Cumulative effects are therefore the combined effect of the Proposed Development in combination with the effects from a number of different projects, on the same receptor or resource. Please see volume 1, chapter 6 for detail on CEA methodology.

467. 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, appendix 6.4 of the Offshore EIA Report). Volume 3, appendix 6.4 further provides information regarding how information pertaining to other plans and projects is gained and applied to the assessment. 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.

468. In undertaking the CEA for the Proposed Development, it is important to bear in mind 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 the Proposed Development. Therefore, a tiered approach has be adopted. This provides a framework for placing relative weight upon the potential for each project/plan to be included in the CEA to ultimately be realised, based upon the project/plan's current stage of maturity and certainty in the projects' parameters. The tiered approach which will be utilised within the Proposed Development CEA employs the following tiers:

- tier 1 assessment – Proposed Development (Berwick Bank Wind Farm offshore) with Berwick Bank Wind Farm onshore;
- tier 2 assessment – All plans/projects assessed under Tier 1, plus projects which became operational since baseline characterisation, those under construction, those with consent and submitted but not yet determined;
- tier 3 assessment – All plans/projects assessed under Tier 2, plus those projects with a Scoping Report; and
- tier 4 assessment – All plans/projects assessed under Tier 3, which are reasonably foreseeable, plus those projects likely to come forward where an Agreement for Lease (AfL) has been granted.

469. The specific projects scoped into the CEA for marine mammals, are outlined in Table 10.54. There will be no cumulative effects with onshore elements of Berwick Bank Proposed Development.

470. The range of potential cumulative impacts that are identified and included in Table 10.54.

471. Some of the potential impacts considered within the Proposed Development alone assessment are specific to a particular phase of development (e.g. construction, operation and maintenance or decommissioning). Where the potential for cumulative effects with other plans or projects only have potential to occur where there is spatial or temporal overlap with the Proposed Development 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.

472. As described in volume 1, chapter 3, the Applicant is developing an additional export cable grid connection to Blyth, Northumberland (the Cambois connection). Therefore, applications for necessary consents (including marine licenses) will be applied for separately. The CEA for the Cambois connection is based on information presented in the Cambois connection Scoping Report (SSER, 2022e), submitted in October 2022. The Cambois connection has been scoped into the CEA for marine mammals on the basis that Cambois connection will overlap spatially and temporally with the Proposed Development and the project will engage in activities such as cable burial and installation of cable protection which will impact marine mammal receptors.

Table 10.54: List of Other Developments and Plans Considered within the CEA for Marine Mammals

Development	Status	Distance from Proposed Development Array Area (km)	Distance from Offshore Export Cable Routes (km)	Description of Development	Dates of Construction (If Applicable)	Dates of Operation (If Applicable)	Overlap with the Proposed Development
Tier 1							
Offshore Wind Projects and Associated Cables							
No potential for cumulative effects on marine mammals from Proposed Development (Berwick Bank Wind Farm offshore) with Berwick Bank Wind Farm onshore.							
Tier 2							
Offshore Wind Projects and Associated Cables							
Seagreen 1	Under construction	4	35	Up to 1,075 MW (up to 114 wind turbines)	2020-2023	2024 onwards	Project Operation and Maintenance Phase overlap with Proposed Development Construction and Operation and Maintenance Phases
Seagreen 1A Project	Consented	4	36	Up to 36 wind turbines with no capacity limit	2023-2025	2026 onwards	Project Construction and Operation and Maintenance Phases overlap with Proposed Development Construction and Operation and Maintenance Phases
Neart na Gaoithe Offshore Wind	Under construction	16	15	Up to 450 MW (up to 75 wind turbines)	2020-2023	2024 onwards	Project Operation and Maintenance Phase overlaps with Proposed Development Construction and Operation and Maintenance Phases
Inch Cape Offshore Wind Farm	Consented	19	39	Up to 1,000 MW (up to 72 wind turbines)	2023-2025	2026 onwards	Project Construction and Operation and Maintenance Phases overlap with Proposed Development Construction and Operation and Maintenance Phases
Blyth Demo Phase 2	Consented	102	97	Up to 58.4 MW (up to 5 floating wind turbines)	2023-2024	2025 onwards	Project Construction and Operation and Maintenance Phases overlap with Proposed Development Construction and Operation and Maintenance Phases
Moray West	Consented	203	229	Up to 950 MW (up to 85 wind turbines)	2023-2024	2025 onwards	Project Operation and Maintenance Phases overlap with Proposed Development Construction and Operation and Maintenance Phases
Dogger Bank Creyke Beck A	Under construction	236	240	Up to 1,200 MW (up to 200 wind turbines)	2022-2024	2025 onwards	Project Operation and Maintenance Phases overlap with Proposed Development Construction and Operation and Maintenance Phases
Dogger Bank Creyke Beck B	Under construction	213	218	Up to 1,200 MW (up to 200 wind turbines)	2022-2024	2025 onwards	Project Operation and Maintenance Phases overlap with Proposed Development Construction and Operation and Maintenance Phases
Dogger Bank Teesside A[7]	Under construction	241	246	Up to 1,400 MW	2022-2026	2027 onwards	Project Construction and Operation and Maintenance Phases overlap with Proposed Development Construction and Operation and Maintenance Phases
Sofia Offshore Wind Farm[6]	Under construction	241	246	Up to 1,400 MW	2022-2026	2027 onwards	Project Construction and Operation and Maintenance Phases overlap with Proposed Development Construction and Operation and Maintenance Phases
Hornsea Project Three	Consented	328	332	Up to 2400 MW	2023-2030	2031 onwards	Project Construction and Operation and Maintenance Phases overlap with Proposed Development Construction and Operation and Maintenance Phases
Hornsea Project Four	Submitted	258	260	Up to 2,600 MW	2024-2028	2029 onwards	Project Construction and Operation and Maintenance Phases overlap with Proposed Development Construction and Operation and Maintenance Phases

[7] As per the National Infrastructure Planning website, Dogger Bank Teesside A/Sofia Offshore Wind Farm (formerly Dogger Bank Teesside B) has been consented as one development. However, Dogger Bank Teesside A and Sofia Offshore Wind Farm provided separate Environmental Reports/Appraisals for increased hammer energy to support non-material change DCO applications and therefore the assessment of impacts on marine mammals will be considered independently. See more details in paragraph 10.12.2.482.

Development	Status	Distance from Proposed Development Array Area (km)	Distance from Offshore Export Cable Routes (km)	Description of Development	Dates of Construction (If Applicable)	Dates of Operation (If Applicable)	Overlap with the Proposed Development
Oil and Gas Activities							
No oil and gas projects identified within the regional marine mammal study area.							
Aggregate Extraction							
No aggregate extraction projects identified within the regional marine mammal study area.							
Disposal Sites							
Eyemouth – FO0080	Operational	35	17	Dredged material disposal site	N/A	Ongoing	Project Operation and Maintenance Phase overlaps with Proposed Development Construction and Operation and Maintenance Phases
Coastal Protection							
No coastal protection projects identified within the regional marine mammal study area.							
Subsea Cables (Telecommunications and Interlinks)							
Eastern link 1	Scoping	28	2	Subsea cable linking Scotland and north England	2023-2027	2028	Project Construction and Operation and Maintenance Phases overlap with Proposed Development Construction and Operation and Maintenance Phases
Eastern link 2	Scoping	14	21	Subsea cable linking Scotland and north England	2023-2027	2028	Project Construction and Operation and Maintenance Phases overlap with Proposed Development Construction and Operation and Maintenance Phases
Infrastructure							
No Infrastructure projects identified within the regional marine mammal study area.							
Ministry of Defence sites							
No MoD sites identified within the regional marine mammal study area.							
Tier 3							
Offshore Wind Projects and Associated Cables							
Forthwind Demonstration Project	Scoping	69	41	Up to 20 MW (1 wind turbine)	2024	2025 onwards	Project Construction and Operation and Maintenance Phases overlap with Proposed Development Construction and Operation and Maintenance Phases
Green Volt Floating Offshore Wind Farm	Scoping	150	185	Up to 480 MW (30 wind turbines)	2024-2026	2027 onwards	Project Construction and Operation and Maintenance Phases overlap with Proposed Development Construction and Operation and Maintenance Phases
Cambois connection	Pre Application	N/A	N/A	Export cable to meet the capacity of the Proposed Development	Q1 2028 – Q4 2031	Q4 2031	*The construction and operation and maintenance phases of the Cambois connection overlap with the construction and operation and maintenance phases of the Proposed Development.*

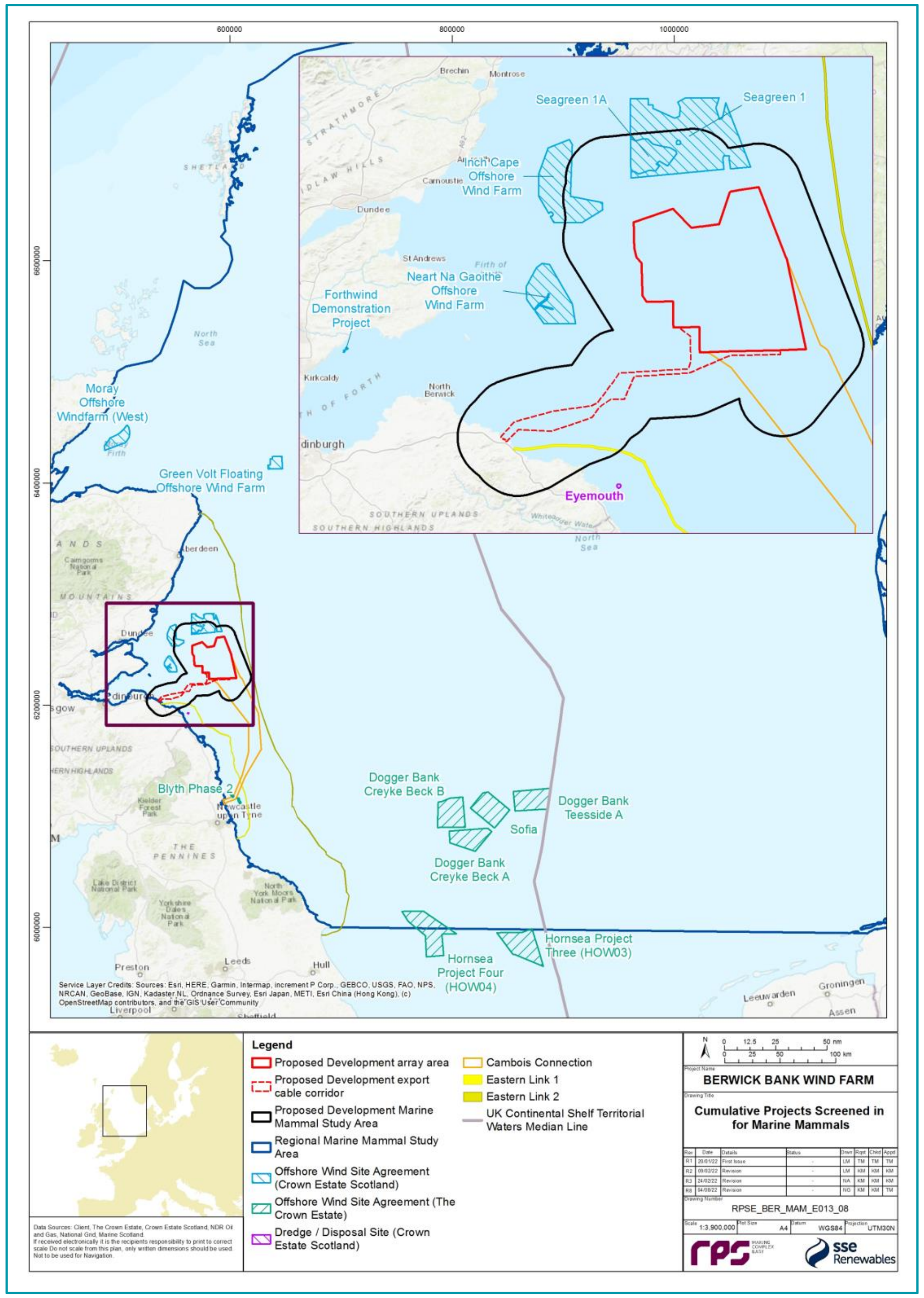


Figure 10.27: Other Projects/Plans Screened into the Cumulative Effects Assessment for Marine Mammals

473. The maximum design scenarios identified in Table 10.55 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. The cumulative effects presented and assessed in this section have been selected from the details provided in volume 1, chapter 3 of the Offshore EIA Report as well as the information available on other projects and plans (see volume 3, appendix 6.4), to inform a 'maximum design scenario'. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the Project Design Envelope (e.g. different wind turbine layout), to that assessed here, be taken forward in the final design scheme.

474. As already mentioned in paragraph 471, where there is no spatial or temporal overlap with the activities during certain phases of the Proposed Development, impacts associated with other projects listed in Table 10.54, may be excluded from further consideration. For the purposes of the marine mammal assessment of effects, cumulative effects have been screened in/out on the following basis:

- **Injury/disturbance to marine mammals from elevated underwater noise during pile driving (construction phase)** – the ZoI for pile driving can extend beyond the boundaries of proposed offshore wind farms and therefore, adopting a precautionary approach, the assessment has screened in projects within the regional marine mammal study area (harbour porpoise, white-beaked dolphin and minke whale) and within the north-east of Scotland (bottlenose dolphin, grey seal and harbour seal) whose construction phases overlap with the construction phase for the Proposed Development. Projects whose construction phase finishes in a year preceding the commencement of construction phase at the Proposed Development (2024) were screened in as the sequential piling at respective projects could lead to a longer duration of effect.
- Injury/disturbance to marine mammals from elevated underwater noise during site investigation surveys (pre-construction phase, operation and maintenance phase) – it is anticipated that the magnitude of the impacts will be of a similar scale to that described for the Proposed Development with the potential to experience disturbance by marine mammal receptors expected to be localised to within the boundaries of the respective projects. Therefore, the cumulative assessment has focussed only on site investigation surveys for those projects within the Firth of Forth and Tay region (see Figure 10.27). Of these, very few projects have considered serious injury surveys within the EIA. For pre-construction phase, where surveys are known to have been completed, this impact has been screened out of the CEA.
- Injury/disturbance to marine mammals from elevated underwater noise during UXO clearance (pre-construction phase) - the ZoI for UXO clearance can extend beyond the boundaries of other proposed offshore wind farms. Therefore, adopting a precautionary approach, the assessment has screened in projects within the regional marine mammal study area (harbour porpoise, white-beaked dolphin and minke whale) and within the north-east of Scotland (bottlenose dolphin, grey seal and harbour seal) whose construction phases (which would include pre-construction UXO clearance) overlap with the construction phase for the Proposed Development. Note, projects with completed UXO clearance campaigns are screened out of the assessment (e.g. Seagreen 1A Project). Projects whose construction phase finishes in a year preceding the commencement of construction phase at the Proposed Development (2024) were screened in as the sequential UXO clearance at respective projects could lead to a longer duration of effect.
- **Injury and disturbance to marine mammals from elevated underwater noise due to vessel use and other activities (all 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, operation and maintenance and decommissioning phases. However the potential to experience disturbance by marine mammal receptors would be expected to be localised to within the close vicinity of the respective projects and as such the assessment has focussed only on projects within the Firth of Forth and Tay region (see Figure 10.27).

- **Injury of marine mammals due to collision with vessels (all phases)** – it is expected that each project will contribute to the increase of vessel traffic and hence to the potential risk of collision during the construction, operation and maintenance and decommissioning phases. However the potential to experience disturbance by marine mammal receptors would be expected to be localised to within the close vicinity of the respective projects and as such the assessment has focussed only on projects within the Firth of Forth and Tay region (see Figure 10.27).
- **Changes in fish and shellfish communities affecting prey availability (all phases)** – potential cumulative effects on fish and shellfish assemblages, as identified in volume 2, chapter 9, may have indirect effects on marine mammals. For the purposes of the fish and shellfish ecology assessment of effects, cumulative effects have been assessed within a representative 20 km buffer of the Proposed Development fish and shellfish ecology study area. This 20 km buffer applies to all impacts considered in the assessment, except underwater noise, where a larger buffer of 100 km has been used to account for the larger ZoI of impacts. Therefore, only the projects considered in volume 2, chapter 9 are considered in the assessment of cumulative indirect impacts due to changes in fish and shellfish communities affecting prey availability.

475. The assessment of cumulative effects with relevant projects has focussed on information available in the public domain (e.g. where the impact has been identified in the scoping study (Tier 3 projects) or the environmental statement (Tier 2 projects)). In this regard, where an impact has been identified and screened in, there is considered to be a potential for cumulative effects. Therefore, the impact will be considered further in section 10.12.2. Impacts scoped out from individual assessments of respective projects are not considered further.

Table 10.55: Maximum Design Scenario Considered for Each Impact as Part of the Assessment of Likely Significant Cumulative Effects on Marine Mammals

Potential Cumulative Effect	Phase[8] C	Phase[8] O	Phase[8] D	Tier	Maximum Design Scenario
Injury and disturbance from elevated underwater noise during piling (fixed foundations).	✓	×	×	*2*	**Construction Phase** maximum design scenario as described for the construction phase in Table 10.16 assessed cumulatively with construction of the following marine projects within the regional marine mammal study area: • Inch Cape Offshore Wind Farm; • Seagreen 1A Project; • Moray West; • Blyth Demo 2; • Dogger Bank Creyke Beck A; • Dogger Bank Creyke Beck B; • Dogger Bank Teesside A; • Sofia Offshore Wind Farm; • Hornsea Project Three; and • Hornsea Project Four.
Injury and disturbance from elevated underwater noise during piling (fixed foundations).	✓	×	×	*3*	**Construction Phase** maximum design scenario as described for the construction phase in Table 10.16 assessed cumulatively with construction of the following marine project within the regional marine mammal study area: Floating Offshore Wind Farm.
Injury/disturbance to marine mammals from elevated underwater noise during site investigation surveys (pre-construction phase, operation and maintenance phase	✓	✓	×	*2*	**Construction Phase** maximum design scenario as described for the construction phase in Table 10.16, assessed cumulatively with the construction and operation and maintenance phases of the following marine projects within the regional marine mammal study area: • Eastern Link 1; and • Eastern Link 2. **Operation and Maintenance Phase** maximum design scenario as described for the operation and maintenance phase in Table 10.16, assessed cumulatively with the operation and maintenance phases of the following marine projects within the regional marine mammal study area: • Eastern Link 1; • Eastern Link 2; and • Eyemouth disposal site.
Injury and disturbance to marine mammals from elevated underwater noise during UXO clearance.	✓	×	×	*2*	**Construction Phase** maximum design scenario as described for construction phase in Table 10.16, assessed cumulatively with construction of the following marine projects within a regional marine mammal study area: • Inch Cape Offshore Wind Farm; • Moray West; • Blyth Demo 2; • Dogger Bank Creyke Beck A; • Dogger Bank Creyke Beck B; • Dogger Bank Teesside A; • Sofia Offshore Wind Farm;

[8] C = Construction, O = Operation and maintenance, D = Decommissioning

<table>
<tr><th rowspan="2">Potential Cumulative Effect</th><th colspan="3">Phase[8]</th><th>Tier</th><th>Maximum Design Scenario</th></tr>
<tr><th>C</th><th>O</th><th>D</th><th></th><th></th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>• Hornsea Project Three; and
• Hornsea Project Four.</td></tr>
<tr><td>Injury and disturbance to marine mammals from elevated underwater noise during UXO clearance.</td><td>✓</td><td>×</td><td>×</td><td>3</td><td>Construction Phase

maximum design scenario as described for the construction phase in Table 10.16 assessed cumulatively with construction of the following marine project within the regional marine mammal study area:
• Green Volt Floating Offshore Wind Farm.</td></tr>
<tr><td>Injury and disturbance to marine mammals from elevated underwater noise due to vessel use and other activities.</td><td>✓</td><td>✓</td><td>✓</td><td>2</td><td>Construction Phase

maximum design scenario as described for the construction phase in Table 10.16, assessed cumulatively with the construction and operation and maintenance phases of the following marine projects within the regional marine mammal study area:
• Inch Cape Offshore Wind Farm;
• Neart na Gaoithe Offshore Wind Fam;
• Seagreen 1;
• Seagreen 1A Project;
• Blyth Phase Demo 2;
• Eyemouth disposal site;
• Eastern Link 1; and
• Eastern Link 2.
Operation and Maintenance Phase

maximum design scenario as described for the operation and maintenance phase in Table 10.16, assessed cumulatively with the construction and operation and maintenance phases of the following marine projects within the regional marine mammal study area:
• Inch Cape Offshore Wind Farm;
• Neart na Gaoithe Offshore Wind Fam;
• Seagreen 1;
• Seagreen 1A Project;
• Blyth Phase Demo 2;
• Eyemouth disposal site;
• Eastern Link 1; and
• Eastern Link 2.
Decommissioning Phase

There are currently no known projects which will result in a cumulative effect during this phase of the Proposed Development.</td></tr>
<tr><td>Injury and disturbance to marine mammals from elevated underwater noise due to vessel use and other activities.</td><td>✓</td><td>✓</td><td>✓</td><td>3</td><td>Construction Phase

maximum design scenario as described for the construction phase in Table 10.16, assessed cumulatively with full development of the marine projects within the regional marine mammal study area:
• Cambois connection; and
• Forthwind Demonstration Project.</td></tr>
<tr><td>Injury of marine mammals due to collision with vessels.</td><td>✓</td><td>✓</td><td>✓</td><td>2</td><td>Construction Phase

maximum design scenario as described for the construction phase in Table 10.16, assessed cumulatively with the construction and operation and maintenance phases of the following marine projects within the regional marine mammal study area:
• Inch Cape Offshore Wind Farm;
• Neart na Gaoithe Offshore Wind Fam;
• Seagreen 1;
• Seagreen 1A Project;
• Blyth Phase Demo 2;</td></tr>
</table>

Potential Cumulative Effect	Phase[8] C	O	D	Tier	Maximum Design Scenario
					• Eyemouth disposal site; • Eastern Link 1; and • Eastern Link 2. **Operation and Maintenance Phase** maximum design scenario as described for the operation and maintenance phase in Table 10.16, assessed cumulatively with the construction and operation and maintenance phases of the following marine projects within the regional marine mammal study area: • Inch Cape Offshore Wind Farm; • Neart na Gaoithe Offshore Wind Fam; • Seagreen 1; • Seagreen 1A Project; • Blyth Phase Demo 2; • Eyemouth disposal site; • Eastern Link 1; and • Eastern Link 2. **Decommissioning Phase** There are currently no known projects which will result in a cumulative effect during this phase of the Proposed Development.
Injury of marine mammals due to collision with vessels.	✓	✓	✓	*3*	**Construction Phase** maximum design scenario as described for the construction phase in Table 10.16 assessed cumulatively with the full development of the following marine projects within the regional marine mammal study area: • Cambois connection; and • Forthwind Demonstration Project.
Changes in fish and shellfish communities affecting prey availability.	✓	✓	✓	*2*	**Construction Phase** maximum design scenario as described for the construction phase in Table 10.16, assessed cumulatively with construction and operation and maintenance phases of the following marine projects within the regional marine mammal study area: • Inch Cape Offshore Wind Farm; • Neart na Gaoithe Offshore Wind Fam; • Seagreen 1; • Seagreen 1A Project; • Seagreen 1A Export Cable Corridor; • Eyemouth disposal site; • Eastern Link 1; and • Eastern Link 2. **Operation and Maintenance Phase** maximum design scenario as described for the operation and maintenance phase in Table 10.16, assessed cumulatively with the construction and operation and maintenance phases of the following marine projects within the regional marine mammal study area: • Inch Cape Offshore Wind Farm; • Neart na Gaoithe Offshore Wind Fam; • Seagreen 1; • Seagreen 1A Project; • Seagreen 1A Export Cable Corridor; • Eyemouth disposal site; • Eastern Link 1; and • Eastern Link 2.

Potential Cumulative Effect	Phase[8] C	O	D	Tier	Maximum Design Scenario
					Decommissioning Phase There are currently no known projects which will result in a cumulative effect during this phase of the Proposed Development.
Changes in fish and shellfish communities affecting prey availability.	✓	✓	✓	***3***	**Construction Phase** maximum design scenario as described for the construction phase in Table 10.16, assessed cumulatively with the full development of the following marine projects within the regional marine mammal study area: • Cambois connection. **Operation and Maintenance Phase** maximum design scenario as described for the operation and maintenance phase in Table 10.16, assessed cumulatively with the full development of the following marine projects within the regional marine mammal study area: • Cambois connection. **Decommissioning Phase** There are currently no known projects which will result in a cumulative effect during this phase of the Proposed Development.

10.12.2. CUMULATIVE EFFECTS ASSESSMENT

476. An assessment of the likely significance of the cumulative effects of the Proposed Development upon marine mammal receptors arising from each identified impact is given in paragraph 477 *et seq.*

INJURY AND DISTURBANCE FROM ELEVATED UNDERWATER NOISE DURING PILING

Tier 2

Construction phase

477. The construction of the Proposed Development, together with the construction of the Tier 2 projects identified in Table 10.55, may lead to injury and/or disturbance to marine mammals from underwater noise during piling. Other projects screened into the assessment within the regional marine mammal study area include construction of Inch Cape Offshore Wind Farm, Seagreen 1A Project, Moray West and Blyth Demo 2 for bottlenose dolphin, harbour seal and grey seal and following additional projects Dogger Bank Creyke Beck A, Dogger Back Creyke Beck B, Dogger Bank Teesside A, Sofia Offshore Wind Farm, Hornsea Project Three and Hornsea Project Four for harbour porpoise, white-beaked dolphin and minke whale.

478. The potential to experience injury in terms of PTS by marine mammal receptors as a result of underwater noise due to piling would be expected to be localised to within the boundaries of the respective projects (assuming similar ranges of effect as presented for the Proposed Development). It is also anticipated that standard offshore wind industry construction methods (which include soft starts and visual and acoustic monitoring of marine mammals as standard) will be applied, thereby reducing the magnitude of the impact with respect to auditory injury occurring in marine mammals. Therefore, there is no potential for significant cumulative impacts for injury from elevated underwater noise during pilling and the cumulative assessment focuses on disturbance only.

479. Behavioural disturbance is expected to occur during piling at all offshore wind farms. Of all projects listed in paragraph 477, only construction of Dogger Bank Teesside A, Sofia Offshore Wind Farm, Hornsea Project Three and Hornsea Project Four will overlap with the piling phase for Proposed Development. Although there is an overlap of construction of Inch Cape and Seagreen 1A Project and construction of Proposed Development, the construction of both projects will be completed prior to commencement of piling at the Proposed Development and therefore could lead to a longer duration of piling operations (i.e. sequential rather than concurrent piling). The construction phases of Moray West, Blyth Demo 2, Dogger Bank Creyke Beck A and Dogger Back Creyke Beck B finish in the year following commencement of construction works at Proposed Development (i.e. two years before the commencement of the piling phase at Proposed Development). However, these projects are included in the assessment to consider temporal scenario to take account for potential disturbance to marine mammals caused by subsequent piling at Proposed Development. Where project piling phases overlap, the assessment is, conservatively, based on a maximum design scenario of all projects potentially piling at exactly the same time, however, in practice this is considered to be unlikely. For example, in order to reduce impacts on harbour porpoise within the Southern North Sea SCI, as a part of Site Integrity Plan, Hornsea Project Three have committed to schedule piling having regard to previous, ongoing and future piling associated with other offshore developments and other activities likely to act in-combination (GoBe, 2018b).

480. The cumulative assessment for Dogger Bank Creyke A (Forewind, 2013), Dogger Bank Creyke B (Forewind, 2013), Hornsea Project Three (GoBe, 2018a) and Hornsea Project Four (SMRU Consulting, 2021) is based on the original EIAs submitted alongside applications for Development Consent Orders to the Planning Inspectorate. The assessment for Moray West is based on the original EIA as submitted to Scottish Ministers under Section 36 of the Electricity Act 1989 (Moray West, 2018). Remaining projects listed in paragraph 10.12.1.471 (Blyth Demo 2, Dogger Bank Teesside A, Sofia Offshore Wind Farm and Seagreen 1A Project) had subsequent revisions of the project design. Paragraph 481 *et seq.* provide for more details about project-specific appraisals taken forward to the cumulative assessment.

481. The original Blyth Offshore Demonstration Project assessed the potential for lethality, injury and behavioural responses to anthropogenic noise based on a maximum design scenario of percussive piling of 15 monopiles (NAREC, 2012). Potential effects of anthropogenic noise impacts were concluded as probable but low in magnitude (NAREC, 2012). A review of the assessments of effects for marine mammals was undertaken as part of the 2013 Supporting Environmental Information (SEI) but this did not lead to any change in the conclusions of the original (NAREC, 2012) EIA (NAREC, 2013). Construction of Blyth Demo 2 will not require piling, as floating platforms with moorings and drag embedment will be used. Subsequently, the magnitude of the impact from subsea noise during piling as a result of the Blyth Demo 2 are considered to be less or equivalent when compared to existing consent (EDF, 2020) where the magnitude was assessed as low.

482. The assessment of underwater noise for Dogger Bank Teeside A was undertaken in the original EIA Report (Forewind, 2014), however, a non-material change application was made to increase maximum hammer energy from 3,000 kJ to 4,000 kJ (Royal HaskoningDHV, 2020). The EIA report concluded that for all marine mammal species there was no difference in the significance of the impacts for the revised application (4,000 kJ hammer) compared to the original EIA Report (3,000 kJ hammer) (Forewind, 2014). Impact ranges and number of animals potentially disturbed were, however, predicted to be larger and therefore this CEA is based on the revised application (Royal HaskoningDHV, 2020).

483. Similarly, for Sofia Offshore Wind Farm, the assessment of underwater noise was undertaken in the original EIA Report for a maximum hammer energy of 3,000 kJ (Forewind, 2014), however, Sofia Offshore Wind Farm Ltd identified that there may be a technical requirement to increase this maximum hammer energy to 4,000 kJ for monopole installation only (Innogy, 2020). The number of disturbed animals during construction of Sofia Offshore Wind Farm is based on the numbers presented as a part of the Environmental Appraisal of Increased Hammer Energy (Innogy, 2020).

484. In 2012, Seagreen submitted an original EIA Report (Seagreen Wind Energy Ltd, 2012) as a part of the application for development consent for Seagreen Offshore Wind Farm consisting of 150 wind turbines and the consent was awarded in October 2014. In 2018, Seagreen Wind Energy Ltd submitted an optimised application to Scottish Ministers for revised designs of the 2014 consented wind farms in the same area based on fewer, larger, higher capacity wind turbines including a monopile foundation option (Seagreen Wind Energy Ltd, 2018). As described in the 2020 PS, due to favourable ground conditions, locations of 114 of the 150 consented wind turbines were considered suitable for suction caisson foundations and these wind turbines are currently under construction (commenced September 2021; Seagreen Wind Energy Ltd, 2020; Seagreen Wind Energy Ltd, 2022a). Installation of the 114 suction caisson foundations does not require pile driving and this part of project is hereinafter referred to as “Seagreen 1”. The remaining 36 locations were, however, identified as requiring use of driven piles. With respect to these 36 locations, in April 2022, Seagreen Wind Energy Ltd. Applied for a variation of 2014 consent to allow for an increased size of wind turbine generators and increased weight of seabed steel deposits associated with the OSPs/Offshore convertor station platforms (Seagreen Wind Energy Ltd, 2022a). This project is hereinafter referred to as “Seagreen 1A Project”. Given that this 2022 variation does not result in a clear impact pathway to marine mammals, the Seagreen S36C Application Screening Report (Seagreen Wind Energy Ltd, 2022b) concluded that potential effects to marine mammals remain as previously assessed in the 2012 EIA Report (Seagreen Wind Energy Ltd, 2012) and 2020 PS (Seagreen Wind Energy Ltd, 2020). The cumulative assessment is based on the maximum design scenario (i.e. whichever is considered would result in the greater potential for cumulative effects between

the original and optimised designs). It is, however, worth noting that as a part of the 2020 PS, the revised project design and programme demonstrates that piling for the wind turbines at Seagreen 1A Project is currently planned for April to July 2023 and therefore overlap with the piling programme for the Proposed Development is unlikely (Seagreen Wind Energy Ltd, 2020).

485. The original EIA for Inch Cape Offshore Wind Farm was submitted in 2014 (Inch Cape Offshore Ltd, 2014). However, as advised in the latest MS-LOT scoping opinion (February 2022), the revised EIA Report (Inch Cape Offshore Ltd, 2018) has been used to inform this CEA assessment.

486. Each project screened into cumulative assessment has a slightly different approach to assessing behavioural disturbance of cetaceans and pinnipeds. For many years since it was published, Southall *et al*. (2007), along with Lucke *et al*. (2009), has been the source of the most widely used criteria to assess the effects of noise on marine mammals, and was the main criteria used in the assessment of disturbance for Dogger Bank Creyke Beck A, Dogger Bank Creyke Beck B (Forewind, 2013). This represents a fixed threshold value approach, where it is assumed that all animals within the predicted impact area are to display a behavioural reaction, while none of the animals outside this area will react. Since then a dose-response curve derived using received noise level and harbour porpoise presence data (Graham *et al*., 2017) was used to determine the proportion of animals present likely to be displaced in assessments for projects such as Inch Cape (Inch Cape, 2018), Moray West (Moray West, 2018), Hornsea Project Three (GoBe, 2018a), Hornsea Project Four (SMRU Consulting, 2021) and Proposed Development (cetaceans only, see paragraph 96 *et seq.*). Given that respective projects used different criteria and noise thresholds modelled for marine mammal receptors in their assessments, it is necessary to exercise considerable caution if attempting any comparison between results of these appraisals. There are also variations between projects in the way results are presented. Using harbour porpoise as an example, some projects, such as Dogger Bank Teesside A and Sofia Offshore Wind Farms provided the range or area from which animals are expected to be excluded along with number of animals potentially disturbed, whilst other projects, such as Inch Cape, provide only number of animals predicted to be displaced due to underwater noise from pile driving. Various densities were used to assess these numbers (e.g. data from the integrated cetacean analysis (Mackenzie *et al.,* 2012) and combined site-specific density surface and SCANS III block data at Hornsea Project Three). As these values come from different sources, density details may reflect various densities of respective species throughout the year (i.e. seasonal versus average across the year). Respective projects also used different reference populations (i.e. Dogger Bank Teesside A used the SCANS III harbour porpoise population, while others such as Inch Cape and Hornsea Project Three used NS MU harbour porpoise population). Furthermore, some projects presented number of animals predicted to be disturbed during concurrent piling events (Hornsea Project Three), while for others only an assessment for single piling was available (i.e. Dogger Bank Teesside A, updated EIA does not indicate whether concurrent piling is considered). Therefore, assessment of the potential effects on marine mammals predicted by other wind farms is not always directly comparable to those presented for Proposed Development due to different approaches to assessment taken by other offshore developers, different noise criteria and thresholds used, and differing levels of detail presented in associated EIAs.

487. Each of the projects screened in for the cumulative assessment also have different construction timeline (i.e. there will be just a year of overlap in the construction phases of the Proposed Development and Seagreen 1A Project and Inch Cape but two or more years of overlap with projects such as Dogger Bank Teesside A/Sofia, Hornsea Project Three and Hornsea Project Four Offshore Wind Farms). However, these timelines are indicative and subject to change. Piling at each of these projects will occur as a discrete element within the overall construction phase and therefore the periods of piling may not coincide.

Magnitude of impact

Harbour porpoise

488. The number of harbour porpoise individuals predicted to be exposed to noise levels that could result in behavioural disturbance at any one time during piling at Seagreen 1A Project (Table 10.56) was based on a SCANS III Block R densities (0.599 animals/km^2). The North Sea (ICES Assessment Unit) reference population was used for this assessment (345,373 individuals; Seagreen Wind Energy Ltd, 2020). The original EIA (Seagreen Wind Energy Ltd, 2012) indicated that there is no evidence to show that the impacted area for this species represents important breeding or foraging habitat that would not be available elsewhere within the species home range over the North Sea. An updated assessment provided in the 2020 PS represents no change in impact significance compared to the 2012 EIA assessment. The residual effect of disturbance of harbour porpoise from piling at Seagreen 1A Project was predicted to be of minor adverse significance.

489. The number of harbour porpoise individuals predicted to be exposed to noise levels that could result in a behavioural disturbance at any one time during piling at Inch Cape (Table 10.56) was assessed using densities from SCANS III Block R data. The NS MU harbour porpoise population was taken forward as the reference population to inform the assessment (227,298 individuals: Inch Cape, 2018). The residual effect of behavioural disturbance on harbour porpoise from piling was predicted to be of minor adverse significance due to a medium-term duration and low magnitude (0.1% of NS MU population disturbed) effect.

490. Moray West assessed the number of harbour porpoise predicted to be affected by disturbance based on grid specific surface from MORL (2012) (Moray West, 2018; Table 10.56). The NS MU harbour porpoise population has been taken forward as reference population to inform the assessment (345,373 individuals; Moray West, 2018). It has been concluded that due to high mobility of this species and the availability of alternative foraging areas at the scale of the wider management unit, the survival of individuals is unlikely to be affected. However, a maximum of 0.4% of the population is expected to fail to breed over duration of piling (44 days). The residual effect of behavioural disturbance on harbour porpoise from piling was predicted to be of minor adverse significance.

491. The number of harbour porpoise individuals predicted to be exposed to a behavioural disturbance from concurrent piling events at Dogger Bank Creyke Beck A and B (Table 10.56) was assessed using precautionary approach based on densities estimated from site specific surveys and harbour porpoise and potential harbour porpoise sightings combined (Forewind, 2013). The NS MU harbour porpoise population has been taken forward as reference population to inform the assessment (232,450 individuals; Forewind, 2013). The assessment for both, Dogger Bank Creyke Beck A and B, predicted that it is unlikely that a significant effect would occur at the population level. The residual effect of behavioural disturbance on harbour porpoise as a result of piling was predicted to be of minor adverse significance.

492. The number of harbour porpoise individuals predicted to be exposed to a behavioural disturbance at any one time during piling during the construction of Dogger bank Teesside A (Table 10.56) was based on SCANS III Block N harbour porpoise densities. The SCANS III harbour porpoise reference population was used for this assessment (345,373 individuals; Royal Haskoning DHV, 2020). At any one time during piling, harbour porpoise is expected to be disturbed within approximately 34 km from the source. The residual effect of disturbance of harbour porpoise from piling was predicted to be of negligible adverse significance.

493. The revised environmental appraisal for Sofia Offshore Wind Farm (Innogy, 2020) used site-specific survey data to predict the number of harbour porpoise individuals with the potential to be exposed to noise levels that could result in a behavioural disturbance at any one time during piling (Table 10.56). The NS MU harbour porpoise reference population was used for this assessment (227,298 individuals: Innogy, 2020). At any one-time during piling, harbour porpoise was expected to be disturbed within approximately 3,160 km^2 from the source. The residual effect of disturbance of harbour porpoise from piling was predicted to be of negligible adverse significance.

494. The assessment for Hornsea Project Three predicted 7,330 porpoises to be exposed to behavioural disturbance during concurrent piling events, by combining the site-specific density surface estimates and the SCANS III density data (where impact areas extended beyond the mapped survey area)). The NS MU harbour porpoise reference population was used for this assessment (227,298 individuals: GoBe, 2018a). The effect of disturbance of harbour porpoise from piling was predicted to be of minor adverse significance. A cumulative assessment on the North Sea harbour porpoise population as a result of a number of scenarios of offshore wind farm construction in the North Sea has been carried out by Booth *et al*. (2017) and presented in Hornsea Project Three EIA (GoBe, 2018a). Based on current best evidence and expert judgement on how disturbance will affect individual porpoises, the assessment found that even with 15% of the population potentially disturbed, there was only a small (6%) increase in the risk of an annual population decline of 1% per year and that overall, impacted population trajectories were not significantly different from baseline population trajectories.

495. Hornsea Project Four assessed the number of minke whales predicted to be affected by disturbance based on SCANS III block O[9] (0.888 animals/km^2; SMRU Consulting, 2021; Table 10.56). The NS MU harbour porpoise population has been taken forward as reference population to inform the assessment (345,373 individuals). Based on findings of Benhemma-Le Gall *et al*. (2021), it was concluded that harbour porpoise can compensate for any resulting loss in energy intake by increasing foraging activities beyond impact zone and therefore the EIA considered it unlikely that there would be any significant effect on survival and reproductive rates, and thus no long-term effect on population trajectory (SMRU Consulting, 2021). The residual effect of behavioural disturbance on harbour porpoise from piling was predicted to be slight, which is not significant in EIA terms.

Table 10.56: Harbour Porpoise Cumulative Assessment – Numbers Predicted to be Disturbed as a Result of Underwater Noise During Piling for Tier 2 Projects

Project	Reference	Max No of Wind Turbine	Max No of Piles	Scenario	Piling Duration (Hours)	No Animals Disturbed	% Reference Population	Residual Impact
Seagreen Project 1A	Seagreen Wind Energy Ltd (2020)	36	144	Single (pile, 2,300 kJ)	432	1,882	0.55	Minor
Inch Cape	Inch Cape Offshore Ltd (2018)	72	74 monopiles	Concurrent (monopile, 5,000 kJ)	444	302	0.1	Minor
Moray West	Moray West (2018)	85	85 monopiles or 340 pin piles	Concurrent Piling (monopiles, 5,000 kJ)	1,056	1,609	0.49	Negligible
Dogger Bank Creyke Beck A	Forewind (2013)	300	1,388 pin piles	Concurrent, possible avoidance (maximum design, 3,000 kJ)	4,858	3,119	1.3	Minor adverse
Dogger Bank Creyke Beck B	Forewind (2013)	300	1,388 pin piles	Concurrent, possible avoidance (maximum design, 3,000 kJ)	4,858	4,394	1.89	Minor adverse
Dogger Bank Teesside A	Royal HaskoningDHV (2020)	120	120 monopoles	Single piling (monopole, 4,000 kJ)	420	2,148	0.95	Negligible
Sofia	Innogy (2020)	200	200 monopoles	Single piling (monopole, 4,000 kJ)	1,100	2,263	0.995	Negligible
Hornsea Project Three	GoBe (2018a)	300	319 monopiles	Concurrent (monopile, 5,000 kJ)	1,276	7,330	2.12	Minor
Hornsea Project Four	SMRU Consulting (2021)	180	180 monopiles	Concurrent (monopile, 4,000 kJ)	792	9,686	2,8	Slight (not significant)

[9] The Hornsea Project Four EIA (SMRU Consulting, 2021) concluded that since site-specific surveys did not extend far enough to cover the entire potential behavioural impact zones for the noise assessment of effects, the broader scale density estimates from SCANS III were more appropriate to be incorporated into the assessment.

496. Most projects refer to the North Sea reference population, which, as presented in the original Seagreen EIA (Seagreen Wind Energy Ltd, 2012), stretches across an area of 750,000 km^2. The number of harbour porpoise potentially disturbed has been considered for projects located more than 300 km from the Proposed Development array area (Table 10.54). Delineating the spatial extent of cumulative effects is commonly acknowledged as a challenge. Although harbour porpoise is generally rare in waters >200 m depth, the fact that this species utilises such a vast area further complicates a choice of appropriate spatial scale (Murray *et al.,* 2014). Given the vast extent of available habitat, the fact that harbour porpoise is a wide ranging species and the low percentage of the NS MU population disturbed as a result of piling at respective projects (Table 10.57), the likelihood of cumulative effects with projects located at large distances (e.g. >100 km) from the Proposed Development is considered to be low.

497. Due to the short-term, intermittent occurrence of piling within the wider construction phases (paragraph 487) and the conservative nature of each assessment, a cumulative assessment of the potential effects on marine mammals has been carried out by combining numbers of animals potentially disturbed across regional marine mammal study area. This is likely to represent an over precautionary assessment. Nevertheless, population modelling was carried out to explore the potential for cumulative effects as a result of disturbance during piling to affect the population trajectory over time (discussed with consultees during the Road Map meetings; Table 10.9). Population modelling considered all projects listed in Table 10.56 and respective numbers of animals potentially impacted against the MU population (see volume 3, appendix 10.4 for methods applied in the model). Results of the cumulative iPCoD modelling for harbour porpoise showed that the median ratio of size of the impacted to unimpacted population at a time point of 25 years after commencement of piling at cumulative projects was 99.2%. Small differences in the population size over time (e.g. 345,311 for the impacted population vs 349,064 for the unimpacted population at 25 years) fall within the natural variance of the population trajectory as can be seen in Figure 10.28. Therefore, it was considered that there is no potential for a long-term effect on this species

as a result of cumulative piling at the Proposed Development and respective projects (see volume 3, appendix 10.4 for more details).

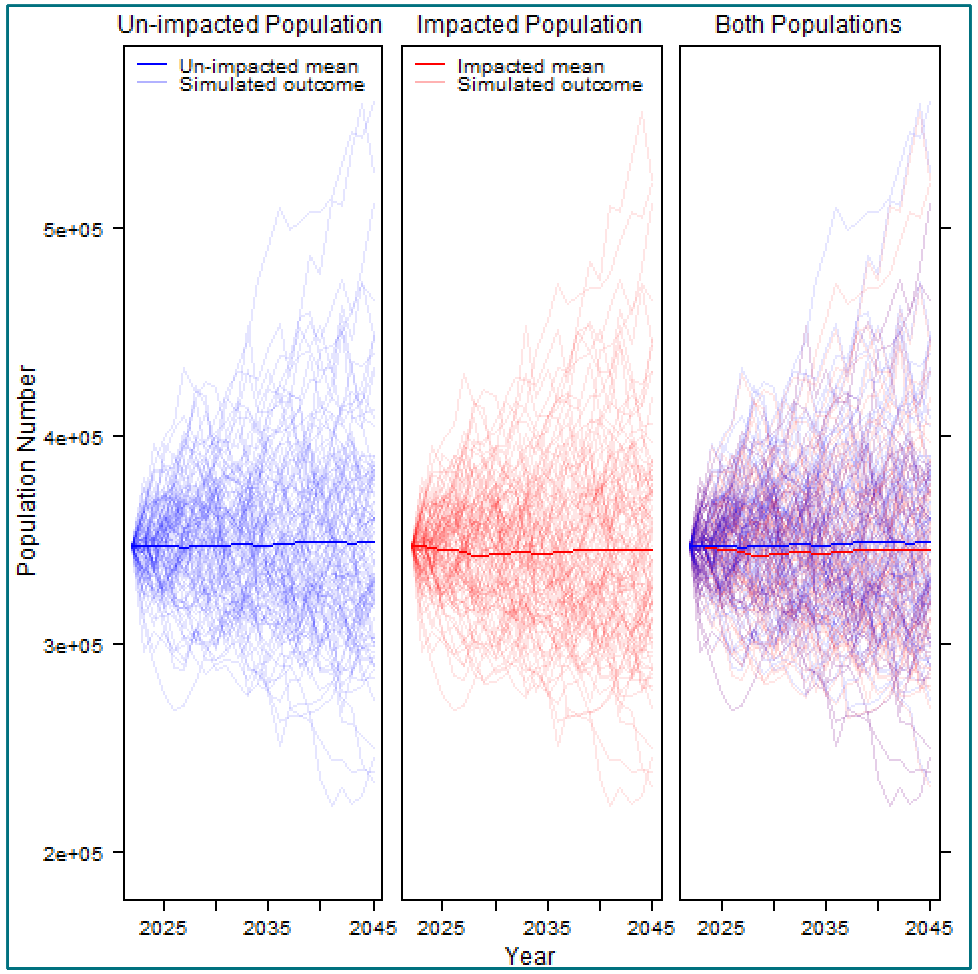


Figure 10.28: Simulated Harbour Porpoise Population Sizes for Both the Baseline and the Impacted Populations Under the Cumulative Scenario and no Vulnerable Subpopulation.

498. The cumulative impact of behavioural disturbance with respect to harbour porpoise 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.

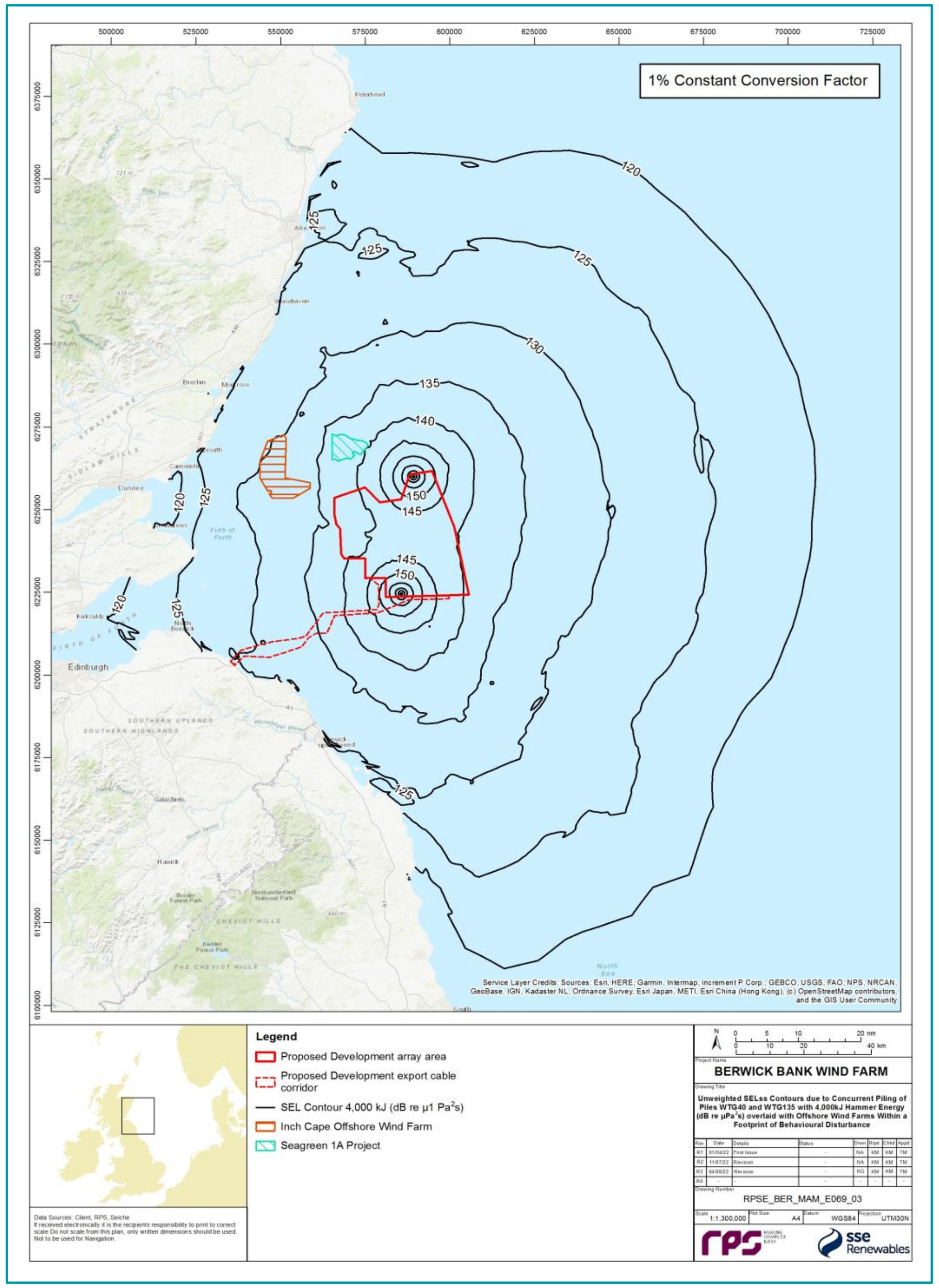


Figure 10.29: Unweighted Single Pulse SEL Contours Due to Concurrent Impact Piling of Piles at Wind Turbines at Maximum Hammer Energy (4,000 kJ) Overlaid with Projects within a Footprint of Behavioural Disturbance.

Bottlenose dolphin

499. The number of bottlenose dolphin individuals predicted to be exposed to noise levels that could result in a behavioural disturbance at any one time during piling in Seagreen Project 1A (Table 10.57) was based on a precautionary scenario. Densities were calculated on the assumption that half of the total MU population (98) is spread evenly across the area inside the 20 m depth contour between Aberdeen and south of Firth of Forth. The CES MU population was taken forward as reference population to inform the assessment (195 individuals, Seagreen Wind Energy Ltd, 2020). The residual effects of disturbance of bottlenose dolphin from piling at Seagreen 1A Project were predicted to be of minor adverse significance. To provide context for this assessment it is worth noting that the revised EIA used iPCoD population modelling to investigate effects of disturbance from the construction of 150 wind turbines when built sequentially (Seagreen Wind Energy Ltd, 2018). The results of iPCoD model predicted that the mean impacted baseline population would experience an initial slight decline in the growth rate. However, the population would continue to increase at the same rate as the baseline population for the remainder of the stimulations. There was no significant difference between the predicted baseline (unimpacted) and impacted population sizes as a result of predicted levels of disturbance.

500. The number of bottlenose dolphin individuals predicted to be exposed to noise levels that could result in behavioural disturbance at any one time during piling at Inch Cape (Table 10.57) was assessed using densities calculated based on the assumption that half of the total CES MU population (98) is spread evenly across the area inside the 20 m depth contour from Rattray Head south. The CES MU bottlenose dolphin population was taken forward as the reference population to inform the assessment (195 individuals; Inch Cape, 2018). Population level modelling predicted that displacement from pile driving at Inch Cape is unlikely to affect the size or growth of the bottlenose dolphin population off the east coast of Scotland. The residual effect of behavioural disturbance of bottlenose dolphin from piling was predicted to be of minor adverse significance due to a medium term duration and low magnitude (< 10% of CES MU population disturbed).

501. Moray West assessed the number of bottlenose dolphin predicted to be affected by disturbance based on grid specific surface densities from revised MORL (2012) (Moray West, 2018). The CES MU bottlenose dolphin population was taken forward as reference population to inform the assessment (195 individuals; Moray West, 2018). It was concluded that the highest bottlenose dolphin abundance areas were relatively distant from the piling locations and due to the high mobility of bottlenose dolphins and the availability of alternative known foraging areas and other areas of high usage within the Moray Firth, short-term displacement was unlikely to result in any effect on the survival of individuals. Population modelling results indicated that none of the bottlenose impact scenarios discussed in the EIA resulted in a significant long term population effects (Moray West, 2018). The residual effects of behavioural disturbance of bottlenose dolphin from piling was predicted to be of minor adverse significance.

Table 10.57: Bottlenose Dolphin Cumulative Assessment – Numbers Predicted to be Disturbed as a Result of Underwater Noise During Piling for Tier 2 Projects

Project	Reference	No of Wind Turbines	No of piles	Scenario	Piling Duration (Hours)	Max No Animals Disturbed	% Reference Population	Residual Impact
Sequential								
Seagreen 1A Project	Seagreen Wind Energy Ltd (2020)	36	144	Single (pile, 2,300 kJ)	432	4.0	2.1	Minor
Inch Cape	Inch Cape Offshore Ltd (2018)	72	74 monopiles	Concurrent (monopile, 5,000 kJ)	444	8.0	4.1	Minor
Moray West	Moray West (2018)	85	85 monopiles or 340 pin piles	Concurrent Piling (monopiles, 5,000 kJ)	1,056	15	7.5	Minor

502. All projects screened in for the cumulative assessment for bottlenose dolphin (Table 10.57) are located within the main distributional range of the population, restricted to the Moray Firth and coastal waters of the eastern Scotland (Figure 10.31).

503. Population modelling considered all projects listed in Table 10.57Table 10.56 and respective numbers of animals potentially impacted against the MU population (see volume 3, appendix 10.4 for methods applied in the model). Results of the cumulative iPCoD modelling for bottlenose dolphin showed that the median ratio in population size between the impacted and unimpacted population was 100% at a time point 25 after commencement of piling at cumulative projects. Very small differences in population size (i.e. 513 for the impacted population and 532 for the unimpacted population at 25 years) fall within the natural variance of the population (Figure 10.30). Therefore, it was considered that there is no potential for a long-term effect on this species as a result of cumulative piling at the Proposed Development and respective projects (see volume 3, appendix 10.4 for more details).

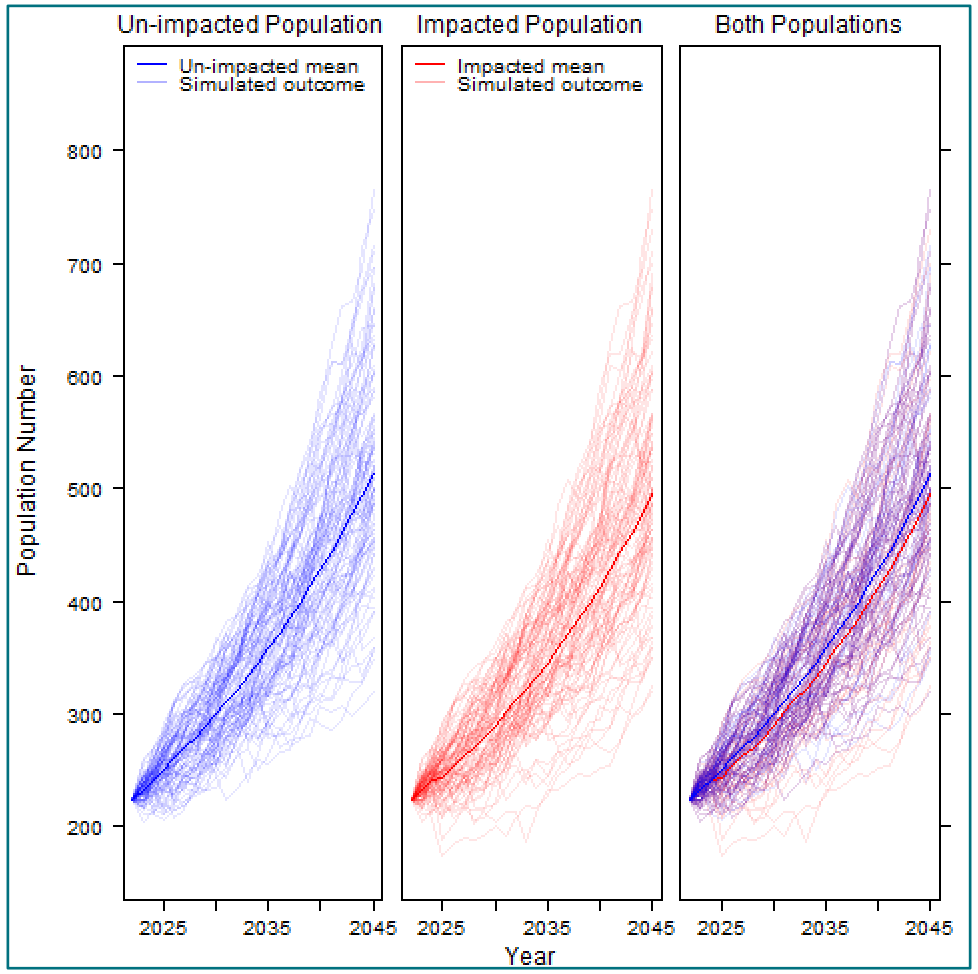


Figure 10.30: Simulated Bottlenose Dolphin Population Sizes for Both the Baseline and the Impacted Populations Under the Cumulative Scenario and no Vulnerable Subpopulation.

504. The cumulative impact of behavioural disturbance with respect to bottlenose dolphin 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.

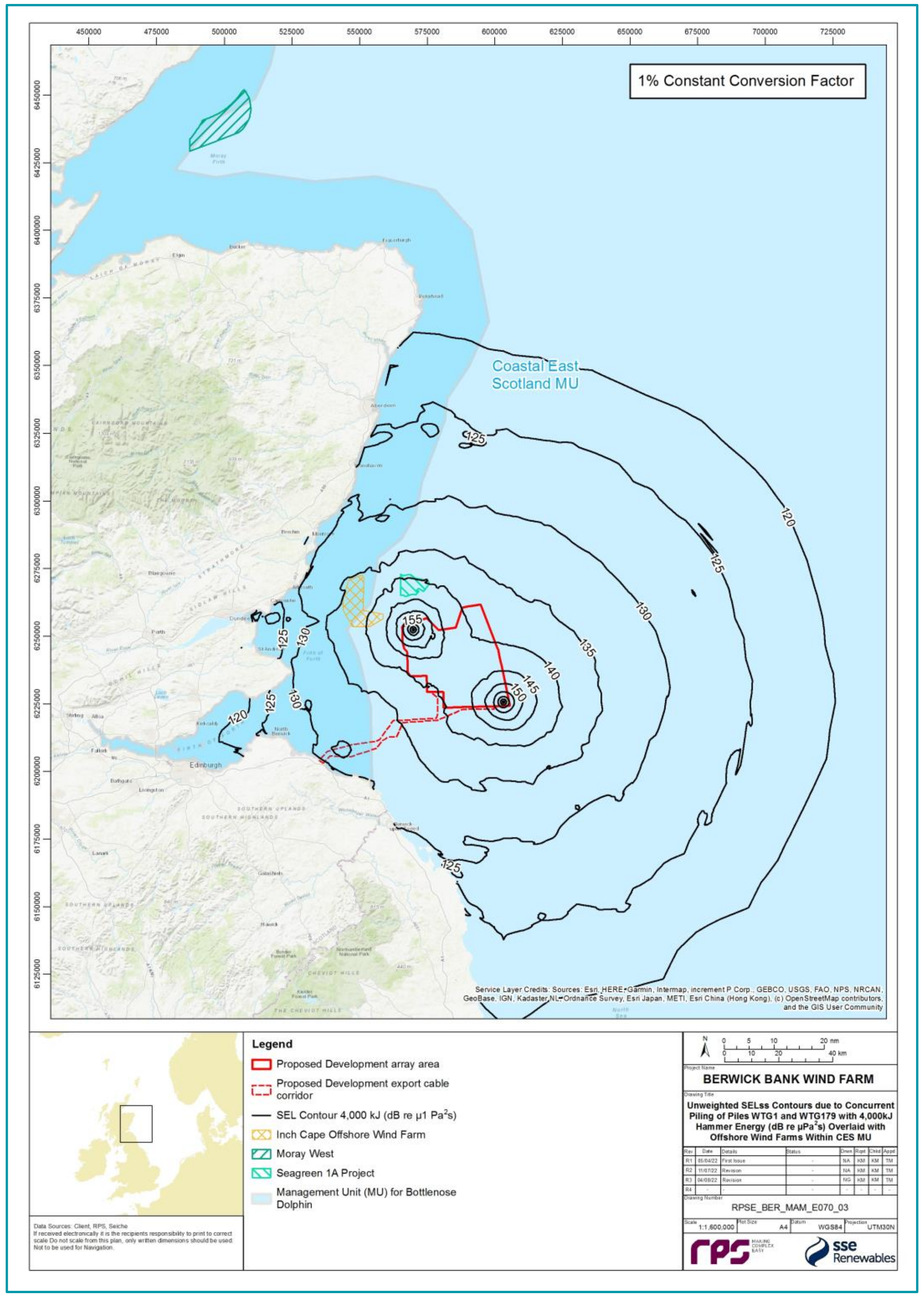


Figure 10.31: Unweighted Single Pulse SEL Contours Due to Concurrent Impact Piling at Maximum Hammer Energy (4,000 kJ) Overlaid with Projects within a Distributional Range of Bottlenose Dolphin Population

White-beaked dolphin

505. The number of white-beaked dolphin individuals predicted to be exposed to noise levels that could result in behavioural disturbance at any one time during piling at Seagreen Project 1A (Table 10.58) was based on a precautionary scenario using densities from SCANS III Block R (0.243 dolphins/km^2). The CGNS MU white-beaked dolphin abundance estimate was taken forward as a reference population to inform the assessment (36,287 individuals; Seagreen Wind Energy Ltd, 2020). The residual effect of disturbance of white-beaked dolphin from piling at Seagreen 1A Project, was predicted to be of minor adverse significance

506. The number of white-beaked dolphin individuals predicted to be exposed to noise levels that could result in a behavioural disturbance at any one time during piling at Inch Cape (Table 10.58) was assessed using densities from SCANS III Block R data. The CGNS MU white-beaked dolphin population has been taken forward as the reference population to inform the assessment (15,895 individuals: Inch Cape, 2018). The residual effect of behavioural disturbance of white-beaked dolphin from piling was predicted to be of minor adverse significance due to a medium-term duration and low magnitude of effect (0.3% of CGNS MU population disturbed).

507. The number of white-beaked dolphin individuals predicted to be exposed to noise levels that could result in behavioural disturbance from concurrent piling events at Dogger Bank Creyke Beck A and B (Table 10.58) was assessed using average densities estimated from site-specific surveys (Forewind, 2013). Updated analysis of the SCANS-II white-beaked dolphin population has been taken forward as the European reference population to inform the assessment (16,536 individuals; Forewind, 2013). The assessment for both Dogger Bank Creyke Beck A and B predicted that it is unlikely that a significant effect would occur at the population level. The residual effect of behavioural disturbance of white-beaked dolphin a result of piling was predicted to be of minor adverse significance.

508. The number of white-beaked dolphin individuals predicted to be exposed to a behavioural disturbance at any one time during piling at Dogger bank Teesside A (Table 10.58) was based on SCANS-III Block O white-beaked dolphin densities. The CGNS MU white-beaked dolphin reference population was used for this assessment (15,895 individuals: Royal Haskoning DHV, 2020). At any one time during piling, white-beaked dolphin was expected to be disturbed within approximately 11 km from the source. The residual effect of disturbance of white-beaked dolphin from piling was predicted to be of negligible adverse significance.

509. The revised environmental appraisal for Sofia Offshore Wind Farm (Innogy, 2020) predicted the number of white-beaked dolphin individuals with potential to be exposed to a behavioural disturbance at any one time during piling (Table 10.58) based on densities from site specific surveys. The British Irish MU white-beaked dolphin reference population (IAMMWG (2013) based on SCANS II) was used for this assessment (15,895 individuals: Innogy, 2020). At any one time during piling, white-beaked dolphin was expected to be disturbed within approximately 390 km^2 from the source. The residual effect of disturbance of white-beaked dolphin from piling was predicted to be of negligible adverse significance.

510. The assessment for Hornsea Project Three predicted 12 white-beaked dolphins to be exposed to behavioural disturbance during concurrent piling events, by combining the site-specific density surface and the SCANS-III density data (Table 10.58). The CGNS MU white-beaked dolphin reference population was used for this assessment (15,895 individuals: GoBe, 2018a). The residual effect of disturbance of white-beaked dolphin from piling was predicted to be of negligible adverse significance.

511. Hornsea Project Four assessed the number of white-beaked dolphins predicted to be disturbed based on SCANS III block O (0.002 animals/km^2; SMRU Consulting, 2021; Table 10.58). The CGNS MU white-beaked dolphin population has been taken forward as reference population to inform the assessment (43,951 individuals). The assessment for Hornsea Project Four EIA considered it unlikely for animals to remain in the impacted area on repeated days of impact, and thus unlikely that they would receive the repeated levels of disturbance that would result in changes to vital rates (SMRU Consulting, 2021). The residual effect of behavioural disturbance on white-beaked from piling was predicted to be slight, which is not significant in EIA terms.

Table 10.58: White-Beaked Dolphin Cumulative Assessment – Numbers Predicted to be Disturbed as a Result of Underwater Noise During Piling for Tier 2 Projects

Project	Reference	No of Wind Turbines	No of piles	Scenario	Piling Duration (Hours)	Max No Animals Disturbed	% Reference Population	Residual Impact
Sequential								
Seagreen 1A Project	Seagreen Wind Energy Ltd (2020)	36	144	Single (pile, 2,300 kJ)	432	764	2.1	Minor
Inch Cape	Inch Cape Offshore Ltd (2018)	72	74 monopiles	Concurrent (monopile, 5,000 kJ)	444	48	0.3	Minor
Dogger Bank Creyke Beck A	Forewind (2013)	300	1,388 pin piles	Concurrent, possible avoidance (maximum design, 3,000 kJ)	4,858	9	0.05	Minor adverse
Dogger Bank Creyke Beck B	Forewind (2013)	300	1,388 pin piles	Concurrent, possible avoidance (maximum design, 3,000 kJ)	4,858	10	0.06	Minor adverse
Concurrent								
Dogger Bank Teesside A	Royal HaskoningDHV (2020)	120	120 monopoles	Single piling (monopole, 4,000 kJ)	420	5	0.03	Negligible
Sofia	Innogy (2020)	200	200 monopoles	Single piling (monopole, 4,000 kJ)	1,100	5	0.03	Negligible
Hornsea Project Three	GoBe (2018a)	300	319 monopiles	Concurrent (monopile, 5,000 kJ)	1,276	12	0.08	Negligible
Hornsea Project Four	SMRU Consulting (2021)	180	180 monopiles	Concurrent (monopile, 5,000 kJ)	792	91	0.21	Not significant

512. The cumulative assessment of the potential effects on marine mammals carried out by combining numbers of animals potentially disturbed based on estimated by various wind farms is likely to be over precautionary due to the short-term, intermittent occurrence of piling within the wider construction phases (paragraph 487) and the conservative nature of each assessment. Since iPCoD did not facilitate modelling for white-beaked dolphin, as agreed with consultees (Table 10.9) no population modelling was carried out for this species.

513. Given the vast extent of available habitat, the fact that white-beaked dolphin is a wide ranging species and the low percentage of the CGNS MU population potentially disturbed as a result of piling at respective projects (Table 10.58), the likelihood of cumulative effects with projects located at very large distances (e.g. >100 km) from the Proposed Development is considered to be low.

514. There is, however, the potential for cumulative effects with projects within the behavioural disturbance footprint of the Proposed Development. Figure 10.10 displays unweighted noise contours with SEL_{ss} values decreasing in 5 dB steps from the source. The outermost contour of 120 dB represents the edge of the area within which white-beaked dolphins may experience noise levels which could result in behavioural disturbance during concurrent piling (at a 4,000 kJ hammer energy) at the Proposed Development.

515. Only Inch Cape and Seagreen Project 1A are located within these disturbance contours (Figure 10.29). The assessment presented in the Inch Cape EIA (Inch Cape Offshore Ltd, 2018) and Seagreen 1A Project PS (Seagreen Wind Energy Ltd, 2020) estimated that 48 and 764 white-beaked dolphins could experience disturbance during piling at respective projects (Table 10.58). The construction of Inch Cape and Seagreen 1A Project will be completed prior to commencement of piling at the Proposed Development so the potential for simultaneous piling, and therefore additive cumulative effects, with Proposed Development is highly unlikely. However, there is a potential that animals in the vicinity of the Firth of Forth will experience disturbance consecutively as piling at different projects progresses.

516. The cumulative impact of behavioural disturbance with respect to white-beaked dolphin 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.

Minke whale

517. The number of minke whale individuals predicted to be exposed to noise levels that could result in a behavioural disturbance at any one time during piling at Seagreen Project 1A (Table 10.59) was based on a precautionary scenario using integrated cetacean analysis. The European reference population was used for this assessment combining estimates from SCANS-II and CODA (25,379 individuals: Seagreen Wind Energy Ltd, 2012). The original EIA reported that as a result of piling, minke whale is expected to show a behavioural response to piling across an area of up to 18,195 km^2 in extent (Seagreen Wind Energy Ltd, 2012). The effects are considered in context of the North Sea as a minimum range for this species (approximately 750,000 km^2) and therefore the area of exclusion represents approximately 2.4% of the wider available habitat (Seagreen Wind Energy Ltd, 2012).

518. The number of minke whale individuals predicted to be exposed to noise levels that could result in behavioural disturbance at any one time during piling at Inch Cape (Table 10.59) was assessed using densities from SCANS III Block R data. The CGNS MU minke whale population has been taken forward as reference population to inform the assessment (23,528 individuals: Inch Cape, 2018). The residual effect of behavioural disturbance of minke whale from piling was predicted to be of minor adverse significance due to its medium-term duration and low magnitude (0.7% of the CGNS MU population disturbed).

519. Moray West assessed the number of minke whales predicted to be affected by disturbance based on grid specific densities from Paxton *et al.* (2014) (Moray West, 2018). The CGNS MU minke whale population has been taken forward as reference population to inform the assessment (23,528 individuals; Moray West, 2018). The residual effects of behavioural disturbance on minke whale from piling was predicted to be of minor adverse significance.

520. The number of minke whale individuals predicted to be exposed to noise levels that could result in behavioural disturbance from concurrent piling events at Dogger Bank Creyke Beck A and B (Table 10.58) is assessed using average densities estimated from site specific surveys (Forewind, 2013). The updated analysis of the SCANS II minke whale population has been taken forward as reference European population to inform the assessment (25,723 individuals; Forewind, 2013). The assessment for both, Dogger Bank Creyke Beck A and B, predicted that it is unlikely that a significant effect would occur at the population level. The residual effect of behavioural disturbance of minke whale as a result of piling was predicted to be of minor adverse significance.

521. The number of minke whale individuals predicted to be exposed to noise levels that could result in behavioural disturbance at any one time during piling at Dogger bank Teesside A (Table 10.59) was based on SCANS III block N minke whale densities. The CGNS MU minke whale reference population was used for this assessment (23,528; Royal Haskoning DHV, 2020). During piling, minke whale was expected to be disturbed within approximately 41 km from the source. The residual effect of disturbance of minke whale from piling was predicted to be of negligible adverse significance.

522. The revised environmental appraisal for Sofia Offshore Wind Farm (Innogy, 2020) predicted the number of minke whale individuals with potential to be exposed to noise levels that could result in behavioural disturbance at any one time during piling (Table 10.59) based on densities from site specific surveys. The British Irish Management Unit minke whale reference population (IAMMWG, 2013 based on SCANS II and CODA (Hammond *et al.* 2009)) was used for this assessment (23,528 individuals: Innogy, 2020). During piling, minke whale was expected to be disturbed within approximately 4,370 km^2 from the source. The residual effect of disturbance of minke whale from piling was predicted to be of negligible adverse significance.

523. The assessment for Hornsea Project Three predicted 51 minke whales could be exposed to noise levels that could result in behavioural disturbance during concurrent piling events, by using SCANS III density data (GoBe, 2018a; Table 10.59). The CGNS MU minke whale reference population was used for this assessment (23,528 individuals: GoBe, 2018a). The effect of disturbance on minke whale from piling was predicted to be of minor adverse significance.

524. Hornsea Project Four assessed the number of minke whales predicted to be affected by disturbance based on SCANS III block O (0.010 animals/km^2; SMRU Consulting, 2021; Table 10.59). The CGNS MU minke whale population has been taken forward as reference population to inform the assessment (20,118 individuals). Based on findings of expert elicitation and most conservating approach, individuals could be repeatedly disturbed and in the year of disturbance a small proportion of the MU could potentially fail to breed (SMRU Consulting, 2021). However, since animals are likely to move away from the area and therefore not be subject to repeated disturbance, this scenario was considered unlikely. The residual effect of behavioural disturbance on minke whale from piling was predicted to be slight, which is not significant in EIA terms.

Table 10.59: Minke Whale Cumulative Assessment – Numbers Predicted to be Disturbed as a Result of Underwater Noise During Piling for Tier 2 Projects

Project	Reference	No of Wind Turbines	No of piles	Scenario	Piling Duration (Hours)	Max No Animals Disturbed	% Reference Population	Residual Impact
Sequential								
Seagreen 1A Project[10]	Seagreen Wind Energy Ltd (2012)	75	324	Single (maximum design, pile)	297	313	1.20	Minor Adverse
Inch Cape	Inch Cape Offshore Ltd (2018)	72	74 monopiles	Concurrent (monopile, 5,000 kJ)	444	158	0.7	Minor
Moray West	Moray West (2018)	85	85 monopiles or 340 pin piles	Concurrent Piling (monopiles, 5,000 kJ)	1,056	30	0.13	Minor
Dogger Bank Creyke Beck A	Forewind (2013)	300	1,388 pin piles	Concurrent, possible avoidance (maximum design, 3,000 kJ)	4,858	14	0.05	Minor adverse
Dogger Bank Creyke Beck B	Forewind (2013)	300	1,388 pin piles	Concurrent, possible avoidance (maximum design, 3,000 kJ)	4,858	22	0.09	Minor adverse
Concurrent								
Dogger Bank Teesside A	Royal HaskoningDHV (2020)	120	120 monopoles	Single piling (monopole, 4,000 kJ)	420	35	0.15	Negligible
Sofia	Innogy (2020)	200	200 monopoles	Single piling (monopole, 4,000 kJ)	1,100	39	0.17	Negligible
Hornsea Project Three	GoBe (2018a)	300	319 monopiles	Concurrent (monopile, 5,000 kJ)	1,276	51	0.22	Minor
Hornsea Project Four	SMRU Consulting (2021)	180	180 monopiles	Concurrent (monopile, 5,000 kJ)	792	60	0.30	Not significant

525. Given the extent of available habitat, the fact that minke whale is a wide ranging species and low percentage of the CGNS MU population potentially disturbed as a result of piling at respective projects (Table 10.58), the likelihood of cumulative effects with projects located at very large distances (e.g. >100 km) from the Proposed Development is considered to be low.

526. Population modelling considered all projects listed in Table 10.59 and respective numbers of animals potentially impacted against the MU population (see volume 3, appendix 10.4 for methods applied in the model). Results of the cumulative iPCoD modelling for minke whale suggested a very slight decrease in the mean ratio size of the impacted population after the first two piling campaigns at Berwick Bank. However, the median of the ratio of impacted to unimpacted population size was predicted as 100% at all time points and growth rate remains constant suggesting that such declines would not be discernible in the context of natural population stochasticity, as can be seen in Figure 10.32.

[10] The assessment is based on impacts of piling at Seagreen Bravo presented in the original EIA (Seagreen Wind Energy Ltd, 2012), as it represents the maximum design scenario when compared with 2020 PS (Seagreen Wind Energy Ltd, 2020).

Figure 10.32: Simulated Minke Whale Population Sizes for Both the Baseline and the Impacted Populations Under the Cumulative Scenario and no Vulnerable Subpopulation

527. Therefore, it was considered that there is no potential for a long-term effects on this species as a result of cumulative piling at proposed Development and respective projects (see volume 3, appendix 10.4 for more details).

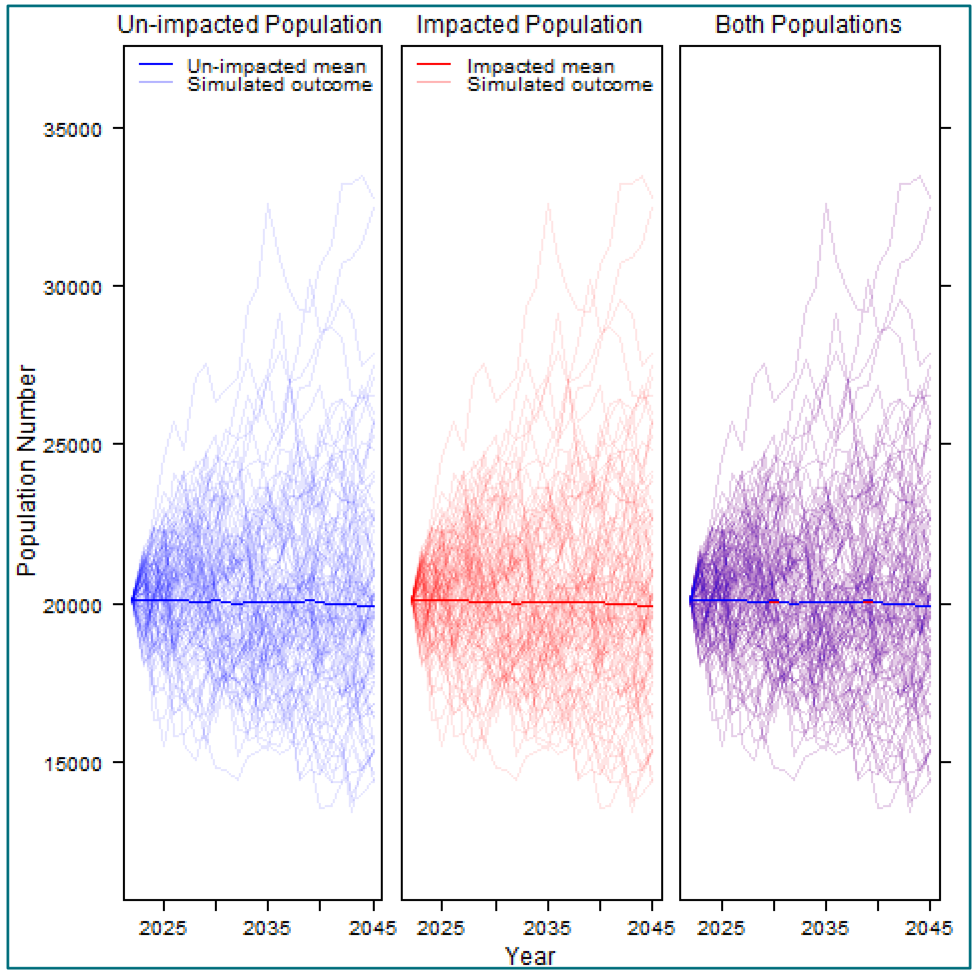


Figure 10.32: Simulated Minke Whale Population Sizes for Both the Baseline and the Impacted Populations Under the Cumulative Scenario and no Vulnerable Subpopulation

528. The cumulative impact of behavioural disturbance with respect to minke whale 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.

Harbour seal

529. The number of harbour seal individuals predicted to be exposed to noise levels that could result in behavioural disturbance at any one time during piling at Seagreen Project 1A (Table 10.60) was based on a precautionary scenario using regional density estimates (at-sea densities as presented in Sparling *et al.,* 2012). The East Coast Management Area (ECMA), which extends from Fraserburgh to the Scotland-England border was used as reference population for the assessment (540 individuals: Seagreen Wind Energy Ltd, 2012). The original EIA reported that as a result of piling, harbour seal is expected to show behavioural response to piling across an area of up to 885 km^2 in extent (Seagreen Wind Energy Ltd, 2012). Due to a high level of uncertainty regarding harbour seal behavioural response to piling as well as biological consequences of the disturbance, the 100% of reduction in fecundity for up to 9% of the population was conservatively assumed for the duration of piling (two years). However, it needs to be noted, that although the original EIA represents the maximum design scenario when compared to the 2020 PS in terms of numbers of harbour seals potentially affected, the revised project design envelope represents a 76% reduction in terms of the number of piled wind turbines compared to the maximum design scenario assessed in the original 2012 EIA. Additionally, 2020 PS assumes 36 days of piling and therefore, the duration of any disturbance will be relatively short in comparison to the duration of 300 days originally assessed (Seagreen Wind Energy Ltd, 2020).

530. The number of harbour seal individuals predicted to be exposed to noise levels that could result in behavioural disturbance at any one time during piling at Inch Cape (Table 10.60) was assessed using densities from seal usage maps produced by SMRU (Inch Cape, 2018). The ES MU harbour seal population was taken forward as reference population to inform the assessment (511 individuals: Inch Cape, 2018). The residual effect of behavioural disturbance of harbour seal from piling was predicted to be of minor adverse significance due to a medium-term duration and a low magnitude of effect (< 10% of the ES MU population disturbed).

Table 10.60: Harbour Seal Cumulative Assessment – Numbers Predicted to be Disturbed as a Result of Underwater Noise During Piling for Tier 2 Projects

Project	Reference	No of Wind Turbines	No of piles	Scenario	Piling Duration (Hours)	Max No Animals Disturbed	% Reference Population	Residual Impact
Sequential								
Seagreen 1A Project[11]	Seagreen Wind Energy Ltd (2012)	75	348	Single (maximum design, piles)	319	51	9.00	Moderate adverse
Inch Cape	Inch Cape Offshore Ltd (2018)	72	74 monopiles	Concurrent (maximum design, monopiles)	444	20	3.9	Minor

531. Population modelling considered all projects listed in Table 10.60 and respective numbers of animals potentially impacted against the MU population (see volume 3, appendix 10.4 for methods applied in the model). Results of the cumulative iPCoD modelling for harbour seal showed that no impacts are predicted on the population resulting from disturbance due to cumulative piling events, with the median of the ratio of impacted population to unimpacted population 100% at all modelled time points. Therefore, it was considered that there is no potential for a long-term effect on this species as a result of cumulative piling at the Proposed Development and respective projects (Figure 10.33; see volume 3, appendix 10.4 for more details).

[11] The assessment is based on impacts of piling at Seagreen Alpha presented in the original EIA (Seagreen Wind Energy Ltd, 2012), as it represents the maximum design scenario when compared with 2020 PS (Seagreen Wind Energy Ltd, 2020).

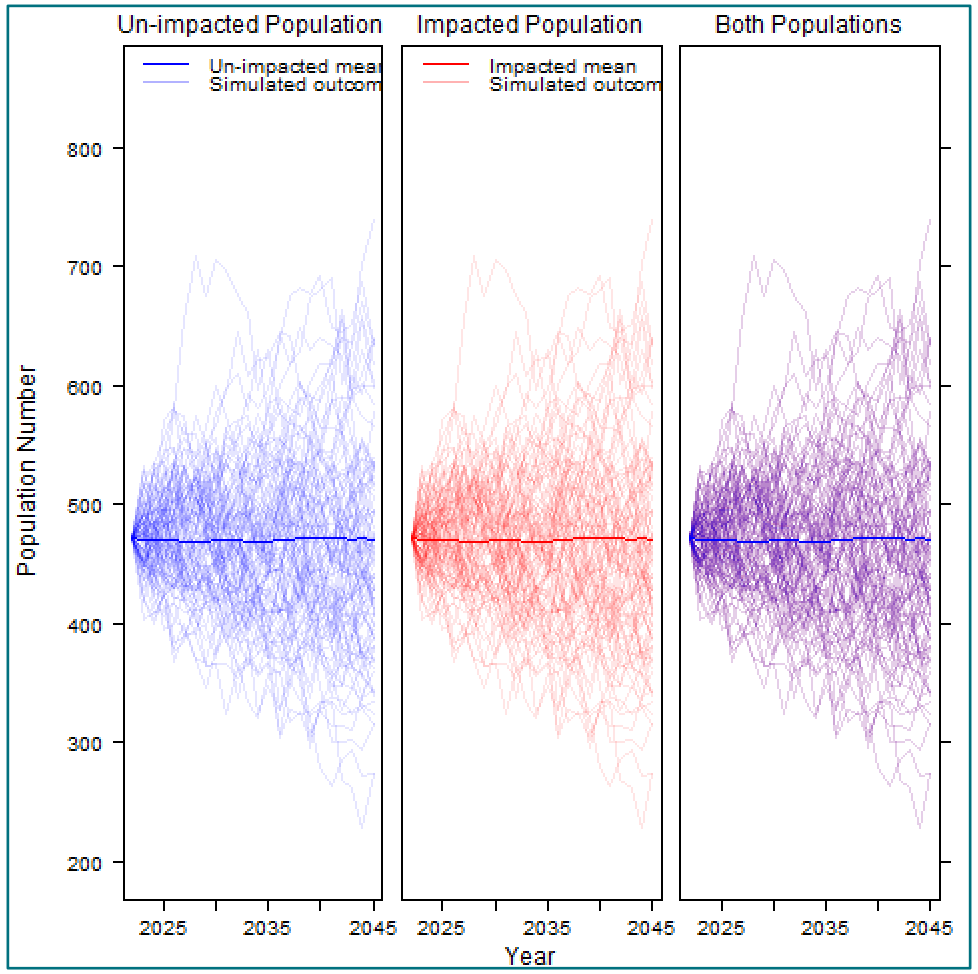


Figure 10.33: Simulated Harbour Seal Population Sizes for Both the Baseline and the Impacted Populations Under the Cumulative Scenario and no Vulnerable Subpopulation.

532. The cumulative impact of behavioural disturbance with respect to harbour seal 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.

Grey seal

533. The number of grey seal individuals predicted to be exposed to noise levels that could result in behavioural disturbance at any one time during piling at Seagreen Project 1A (Table 10.61) was based on a precautionary scenario using regional density estimates (at-sea densities as presented in Sparling *et al.,* 2012). The ECMA was used as reference population for the assessment (5,657 to 12,011 individuals; Seagreen Wind Energy Ltd, 2012). The original EIA reported that as a result of piling, grey seal is expected to show a behavioural response to piling across an area of up to 885 km² in extent (Seagreen Wind Energy Ltd, 2012). It was assumed that repeated exposure may lead to habituation or seals may be sufficiently motivated to carry on their normal behaviour despite the noise. As reported in the original Seagreen EIA and supported by most recent studies (SCOS,2020), the population of the east coast is increasing and therefore is likely to be robust to the degree of perturbation caused by behavioural response to pile driving. The residual effect of disturbance of grey seal from piling was predicted to be of minor adverse significance. Moreover, as previously presented for harbour seal in paragraph 529, although the original EIA represents the maximum design scenario when compared to the 2020 PS in terms of numbers of grey seals potentially affected, 2020 PS assumes 36 days of piling and therefore, the duration of any disturbance will be relatively short in comparison to the duration of 300 days originally assessed (Seagreen Wind Energy Ltd, 2020).

534. The number of grey seal individuals predicted to be exposed to a behavioural disturbance at any one time during piling at Inch Cape (Table 10.61) was assessed using densities from seal usage maps produced by SMRU (Inch Cape, 2018). The ES MU grey seal population has been taken forward as reference population to inform the assessment (15,950 individuals: Inch Cape, 2018). The residual effect of behavioural disturbance of grey seal from piling was predicted to be of minor adverse significance due to medium term duration and low in magnitude (< 10% of the ES population disturbed).

Table 10.61: Grey Seal Cumulative Assessment – Numbers Predicted to be Disturbed as a Result of Underwater Noise During Piling for Tier 2 Projects

Project	Reference	No of Wind Turbines	No of piles	Scenario	Piling Duration (Hours)	Max No Animals Disturbed	% Reference Population	Residual Impact
Sequential								
Seagreen 1A Project[12]	Seagreen Wind Energy Ltd (2012)	75	324	Single (maximum adverse, piles)	297	465	8%	Minor adverse
Inch Cape	Inch Cape Offshore Ltd (2018)	72	74 monopiles	Concurrent (maximum adverse, monopiles)	444	1,236	7.7	Minor

535. Population modelling considered all projects listed in Table 10.56 and respective numbers of animals potentially impacted against the MU population (see volume 3, appendix 10.4 for methods applied in the model). Results of the cumulative iPCoD modelling for grey seal showed that no impacts are predicted on the population resulting from disturbance due to cumulative piling events, with the median of the ratio of impacted population to unimpacted population 100% at all modelled time points. Therefore, it was considered that there is no potential for a long-term effect on this species as a result of cumulative piling at the Proposed Development and respective projects (Figure 10.34, see volume 3, appendix 10.4 for more details).

[12] The assessment is based on impacts of piling at Seagreen Bravo presented in the original EIA (Seagreen Wind Energy Ltd, 2012), as it represents the maximum design scenario when compared with 2020 PS (Seagreen Wind Energy Ltd, 2020).

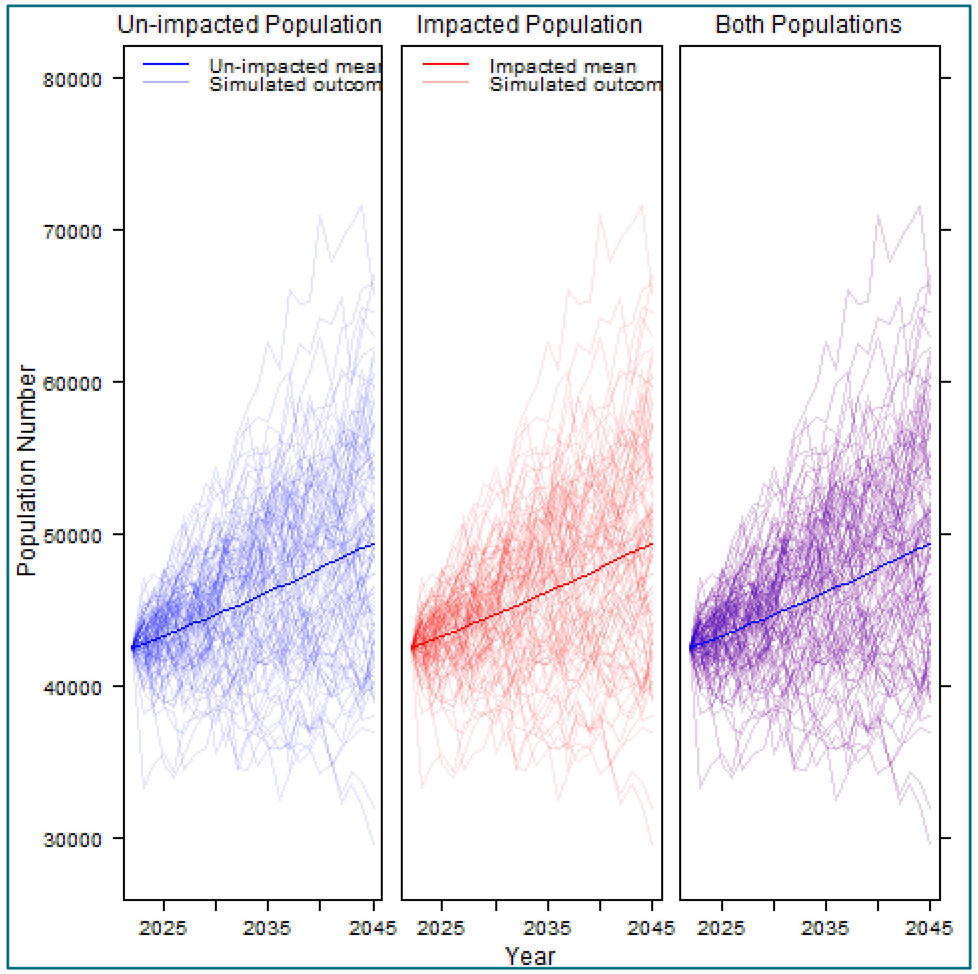


Figure 10.34: Simulated Grey Seal Population Sizes for Both the Baseline and the Impacted Populations Under the Cumulative Scenario and no Vulnerable Subpopulation

536. The cumulative impact of behavioural disturbance with respect to grey seal 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.

Sensitivity of receptor

537. The sensitivity of marine mammal IEFs to disturbance from elevated underwater noise due to piling activities is as described in section 10.11, paragraph 206 *et seq.* Behavioural disturbance may lead to the interruption of normal behaviours (such as feeding or breeding) and avoidance, leading to displacement from the area and exclusion from potentially critical habitats, making it difficult for an animal to perform its regular functions (Goold, 1996; Weller *et al*., 2002; Castellote *et al*., 2010, 2012). Some exposures may be loud enough to trigger stress responses, which in turn can lead to a depressed immune function and reduced reproductive success (Anderson *et al*., 2011; De Soto *et al*., 2013). The extent to which an animal will be behaviourally affected, however, is very much context-dependant and varies both inter- and intra-specifically.

538. All marine mammals, which are IEFs of international value, are deemed to be of medium vulnerability and high recoverability. The sensitivity of the receptors to behavioural disturbance is therefore considered to be medium.

Significance of effect

539. Overall, the magnitude of the cumulative effect 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.

Further mitigation and residual effect

540. No secondary marine mammal mitigation, other than that proposed for the Proposed Development alone (described in detail in paragraph 243 *et seq.*) is considered necessary because the predicted effect in the absence of mitigation is not significant in EIA terms.

Tier 3

<u>Construction phase</u>

541. The only Tier 3 project which has been identified in the CEA with the potential to result in cumulative effects as a result of injury and disturbance from elevated underwater noise during piling within the regional marine mammal study area is Green Volt Floating Offshore Wind Farm.

Magnitude of impact

542. The Green Volt scoping report has identified potential for auditory injury and disturbance as a result of underwater noise during piling as potential impacts during construction of the project (Royal Haskoning DHV, 2021). Floating wind turbine and OSPs/Offshore convertor station platform structures offer benefits over conventional fixed foundations in terms of reduced underwater noise as extensive piling operations are not required. Floating wind therefore also minimises potential noise impacts upon sea mammals during the construction phase of the project. If the floating structures for OSPs/Offshore convertor station platforms are not opted for, limited piling activities (installation of four substation foundations over an estimated period of 36 hours) may take place in offshore waters (approximately 75 km from the coast; Royal Haskoning DHV, 2021). However,

543. Given the distance from the Proposed Development, the overlap of disturbance range as a result of underwater noise due to piling is highly unlikely. No site-specific underwater noise modelling or assessment of impacts on marine mammals is currently available for the Green Volt Floating offshore Wind Farm, however, if required, piling at this project will be of short duration (36 hours) and negligible in comparison to piling periods at offshore wind farms listed in Tier 2 (see paragraph 477 *et seq.*).

544. The cumulative impact of behavioural disturbance with respect to marine mammal IEFs 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.

Sensitivity of receptor

545. The sensitivity of marine mammals to cumulative disturbance from elevated underwater noise due to piling is as described in paragraph 537 *et seq.* for the Tier 2 project.

546. All marine mammals, which are IEFs of international value, are deemed to be of medium vulnerability and high recoverability. The sensitivity of the receptors to behavioural disturbance is therefore considered to be medium.

Significance of effect

547. Overall, the magnitude of the cumulative effect 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.

Further mitigation and residual effect

548. No secondary marine mammal mitigation, other than that proposed for the Proposed Development alone (described in detail in paragraph 243 *et seq.*) is considered necessary because the predicted effect in the absence of mitigation is not significant in EIA terms. Therefore, the residual effect is considered to be of **minor** adverse significnce which is not significant in EIA terms.

INJURY AND DISTURBANCE TO MARINE MAMMALS FROM ELEVATED UNDERWATER NOISE DURING SITE INVESTIGATION SURVEYS

549. The risk of injury in terms of PTS to marine mammal receptors as a result of underwater due to site investigation surveys would be expected to be localised to within the boundaries of the respective projects. The assessment for the Proposed Development found that the numbers of animals impacted will be extremely low and the magnitude of the impact with respect to auditory injury occurring in marine mammals has been assessed as minor. Therefore, there is no potential for cumulative impacts for injury from elevated underwater noise due to site investigation surveys and the cumulative assessment provided in paragraph 550 *et seq.* focuses on disturbance only.

Tier 2

Construction phase

Magnitude of impact

550. The construction of the Proposed Development, together with Tier 2 projects identified in Table 10.55 may lead to disturbance to marine mammals site investigation surveys. Projects screened into this assessment include the construction and operation and maintenance Eastern Link 1 and Eastern Link 2.

551. The construction as well as operation and maintenance phases of Eastern Link 1 and Eastern Link 2, located respectively 14 km and 28 km from the Proposed Development array area, will overlap with the construction phase of the Proposed Development. Based on the Environmental Appraisals for both projects, the only underwater sound noise sources that are within hearing range of marine mammals and have potential to have an effect, are the operation of the Ultra-short Baseline (USBL) and the SBP (AECOM, 2022a; 2022b). The disturbance ranges for marine mammals were estimated as 63 m for USBL and 4,642 m for SBP. The detailed assessment of underwater noise impacts for both projects was presented only for installation phase. However, the significance of the effect resulting from increased underwater noise due site investigation surveys was assessed for both phases – installation as well as operation and maintenance – as minor and therefore not significant[13]. There are no disturbance ranges presented for the USBL for the Proposed Development alone but the disturbance range for SBP has been assessed as 2,045 m. Nevertheless, the assessment presented in paragraph 256 *et seq.* is based on the maximum disturbance range estimated as 7,459 m for vibro-coring. Based on the distance from the Proposed Development to both projects, the overlap of disturbance ranges is highly unlikely. The potential for an overlap exists only for site-investigation surveys taking place in the northern part of the Eastern Link 1, close to the Proposed Development export cable corridor and landfall. However, it needs to be noted that site investigation survey equipment will not be operating continuously, it will be used when required for investigations of particular areas of the seabed where additional information is required to inform the construction. Surveys are anticipated to be short-term in nature (weeks to a few months) and occur intermittently over the construction phase.

552. The impact of site investigation surveys leading to behavioural effects is predicted to be of local 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 receptor directly. The magnitude is therefore considered to be low.

Sensitivity of receptor

553. The sensitivity of marine mammals to elevated underwater noise due to site investigation surveys is as described in section 10.11, paragraph 272 *et seq*.

554. Berwickshire and North Northumberland Coast SAC is designated for grey seal and located on the east coast of Scotland, within the close vicinity of the projects screened into this assessment. With foraging ranges of up to 100 km this species may be sensitive to a behavioural disturbance during the site-investigation surveys as they move between haul-outs and key foraging areas. As advised by NatureScot for HRA purposes (see SSER, 2022d), grey seal in Scotland tend to stay within 20 km of the breeding colony during the breeding season, therefore that further restrict the foraging grounds in the vicinity of haul outs. During the breeding or moulting season many seals tend to spend more time on land, unaffected by underwater sound. Nevertheless, males and females have different requirements and fattening patterns throughout the year and they rely heavily on fat as a metabolic fuel and for insulation (Bennett *et al.,* 2017). Females accumulate fat stores during seven months of foraging at sea between the moulting and breeding period, and the amount stored is roughly equivalent to the amount lost during breeding (Sparling *et al.,* 2006), therefore the availability of food is vital to offspring survival and female fitness. Animals may be deterred from foraging grounds during the operation of the survey equipment, however, given that alternative areas for foraging are widely available, the disturbance to seals foraging offshore is not considered likely to have a significant impact on food availability (see paragraph 429 *et seq.* for the cumulative assessment of impacts as a result of changes in prey availability) and therefore on fitness and survival of the grey seal population.

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

Significance of effect

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

Further mitigation and residual effect

557. No secondary marine mammal mitigation is considered necessary as the predicted effect in the absence of further mitigation (beyond the designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore, the residual effect is considered to be of **minor** adverse significance which is not significant in EIA terms.

[13] It is assumed that the estimate for the operation and maintenance has been informed by the assessment presented for the cable installation phase (AECOM, 2022a; 2022b)

Operation and maintenance phase

Magnitude of impact

558. The operation and maintenance activities of the Proposed Development will overlap with Tier 2 projects identified in Table 10.55 and may lead to disturbance to marine mammals from site investigation surveys. Projects screened into this assessment include disposal activities at the Eyemouth disposal site, the operation and maintenance of Eastern Link 1 and Eastern Link 2.

559. The maximum design scenario for Proposed Development alone comprises routine geophysical surveys estimated to occur every six months for first two years and annually thereafter. This equates to up to 37 surveys over the 35-year life cycle of Proposed Development (Table 10.16).

560. As presented in paragraph 551, the detailed assessment of impacts on marine mammals as a result of underwater noise during the maintenance and operation and maintenance phase of the Eastern Link 1 and Eastern Link 2 is unavailable. However, the significance of the effect for the operation and maintenance phase has been estimated as minor based on the assessment presented for the cable installation phase (AECOM, 2022a; 2022b).

561. An overview of potential impacts resulting from behavioural disturbance due to elevated underwater noise during geophysical site investigation surveys is described in paragraph 551 et seq. for the construction phase and has not been reiterated here for the operation and maintenance phase. The magnitude of the impact of underwater noise from geophysical surveys during operation and maintenance phase in combination with other projects considered in this cumulative assessment could result in a negligible alteration to the distribution of marine mammals and overlap of disturbance ranges is unlikely to occur. Surveys are anticipated to be short-term in nature (weeks to a few months) and occur intermittently over the operation and maintenance phase.

562. With designed-in measures implemented for the geophysical surveys, the impact is predicted to be of local to regional 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.

Sensitivity of receptor

563. The sensitivity of marine mammals to cumulative disturbance from elevated underwater noise due to vessel use and other activities is as described in paragraph 553 *et seq.* for the construction phase.

564. All marine mammals, which are IEFs of international value, are deemed to be of medium vulnerability and high recoverability. The sensitivity of the receptor is therefore considered to be medium.

Significance of effect

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

Further mitigation and residual effect

566. No secondary marine mammal mitigation is considered necessary as the predicted effect in the absence of further mitigation (beyond the designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore, the residual effect is considered to be **minor** which is not significant in EIA terms.

INJURY AND DISTURBANCE TO MARINE MAMMALS FROM ELEVATED UNDERWATER NOISE DURING UXO CLEARANCE

Tier 2

Construction phase

567. The construction of the Proposed Development, together with construction of Tier 2 projects identified in Table 10.55, may lead to injury and/or disturbance to marine mammals from underwater noise during UXO clearance. Other projects screened into the assessment within the regional marine mammal study area include construction of Inch Cape Offshore Wind Farm, Moray West, Blyth Demo 2 for bottlenose dolphin, grey seal and harbour seal and additional following projects Dogger Bank Creyke Beck A, Dogger Bank Creyke Beck B, Dogger Bank Teesside A, Sofia Offshore Wind Farm, Hornsea Project Three and Hornsea Project Four for harbour porpoise, white-beaked dolphin and minke whale.

568. Potential effects of underwater noise from UXO detonations on marine mammals include mortality, physical injury or auditory injury. The risk of injury in terms of PTS to marine mammal receptors as a result of underwater noise during UXO clearance would be expected to be localised to the vicinity around the boundaries of the respective projects. It is anticipated that standard offshore wind industry mitigation methods (which include visual and acoustic monitoring of marine mammals as standard and additional mitigation in form of ADDs and/or soft start charges) will be applied based on UXO specific risk assessment, thereby reducing the magnitude of the impact with respect to auditory injury occurring in marine mammals. However, the potential for a residual risk of injury was investigated based on the UXO clearance technique and mitigation proposed. As previously presented for the Proposed Development alone in paragraph 294 *et seq.,* the duration of effect for each UXO detonation is less than one second and behavioural effects are therefore considered to be negligible in this context. Potential cumulative effects from TTS are also investigated.

Magnitude of impact

569. Projects screened in for this cumulative assessment are expected to involve similar construction activities to those described for the Proposed Development alone, including UXO clearance activities. It is anticipated that, for all projects, impacts associated with these activities will require additional assessment under EPS licensing, however such applications are not yet available in the public domain. Hornsea Project Three provides a high-level assessment of the impacts of potential UXO clearance as a part of the EIA Report (GoBe, 2018a) with the maximum design scenario for the assessment based on the number of UXO cleared for Hornsea Project One. Similarly, for Hornsea Project Four separate Marine Licence application will be submitted pre-construction for the detonation of any UXO. However, since detonation of UXO is a source of underwater noise the assessment has been also provided as a part of the EIA chapter (SMRU Consulting, 2021). For all other projects, due to the lack of project information at this stage, it is not possible to undertake a full, quantitative assessment for this impact therefore a qualitative assessment has been provided.

570. For Hornsea Project Three, there was no site-specific modelling undertaken and therefore the assessment of potential impacts on marine mammals as a result of underwater noise during UXO clearance was based on noise modelling for Hornsea Project One (PTS ranges) and 26 km buffer (disturbance range; Table 10.62) (GoBe, 2018a). In addition, no noise modelling was conducted for UXO clearance for Hornsea Project Four (SMRU Consulting, 2021).

Table 10.62: UXO Clearance Parameters for Proposed Development and Hornsea Project Three

Project	UXO Clearance Method	Maximum UXO Size Assessed		Number of UXOs
		PTS	TTS/Disturbance	
Hornsea Project Three [14]	High order detonation	260 kg	Not Available	23
Hornsea Project Four	High order detonation	800 kg	800 kg	86
Proposed Development	High order detonation	300 kg	300 kg	14

Permanent threshold shift

571. For a given marine mammal hearing group, exceedance of the threshold for the onset of PTS may result in a permanent hearing loss which in turn could inhibit ecological functioning, such as communication, foraging, navigation and predator avoidance. The inability to continue with these important activities could eventually lead to a decline in vital rates of an individual, including growth, reproduction and subsequently survival.

572. For the Proposed Development alone, the maximum range across which animals have the potential to experience PTS due to high order detonation of 300 kg charge was assessed for harbour porpoise as approximately 10,630 m (see paragraph 299 *et seq.)*. Minke whale could potentially experience PTS within a maximum of approximately 4 km from the source. The PTS ranges for HF cetaceans (bottlenose dolphin and white-beaked dolphin) as well as seals are relatively smaller with a maximum range of approximately 615 m and 2,085 m, respectively. PTS onset ranges for Inch Cape Offshore Wind Farm, Moray West, Blyth Demo 2, Dogger Bank Creyke Beck A, Dogger Bank Creyke Beck B, Dogger Bank Teesside A and Sofia Offshore Wind Farm are unknown, but for the purpose of this assessment we can assume that the maximum adverse scenario is no greater than assessed for the Proposed Development alone (since 300 kg represents a typical large munition size for the northern North Sea; Seagreen Wind Energy, 2021). Depending on the type of detonation and size of UXO, UXO clearance activities may have residual effects in respect to marine mammals and PTS injury. In November 2021, the UK government published a joint interim statement advising to use low noise alternatives to high order detonations where possible and it is anticipated that future developments will follow this guidance. However, due to a small inherent risk with these clearance methods that the UXO will detonate or deflagrate violently, accidental high order detonation can be expected as a maximum adverse scenario. Taking into account high order detonation of 300 kg charge and secondary mitigation measures, only small proportion of the respective species MU population would be affected (for more details on the number of animals potentially injured and percentage of respective populations for Proposed Development see paragraph 304 *et seq.*).

573. For the Proposed Development alone, with secondary mitigation applied (described in detail in paragraph 337 *et seq.*), there was predicted to be a small residual effect of PTS based on accidental high order detonation of UXOs. The residual magnitude for all species, except for harbour porpoise, was determined to be negligible. For harbour porpoise, it is expected that small, nominal number of animals could be exposed to PTS threshold. Given that details about UXO clearance technique to be used and charge sizes will not be available until after the consent is granted, it is not possible to quantify the effects of UXO detonations and therefore the residual number of animals is not presented within this chapter. At a later stage, when details about UXO sizes and specific clearance techniques to be used become available, it will be possible to provide detailed assessment and tailor the secondary mitigation to specific UXO sizes and species in order to reduce the risk of injury. Therefore, prior to the commencement of UXO clearance works, a more detailed assessment will be produced as a part of the EPS licence supporting information. Additionally, appropriate secondary mitigation measures will be agreed as a part of a UXO specific MMMP. It is therefore anticipated that following the application of secondary mitigation measures, agreed as a part of the UXO specific MMMP, the residual magnitude of this effect will be reduced to low.

574. As previously stated, for Hornsea Project Three there was no site-specific modelling undertaken and therefore the assessment of potential impacts in terms of injury (PTS) on marine mammals as a result of underwater noise during UXO clearance used the NOAA modelling for Hornsea Project One (GoBe, 2018a). The PTS ranges were presented for harbour porpoise based on the 260 kg charge. The remainder of the Hornsea Project One noise modelling predicted impact ranges for white-beaked dolphin and minke whale based on 227 kg charge (Table 10.63). The sensitivity of cetaceans and seals was assessed as high and medium, respectively. Following the application of appropriate secondary mitigation measures (to be agreed as a part of a UXO specific MMMP) the residual risk of injury was expected to be negligible for all marine mammal species (GoBe, 2018a).

575. Due to lack of project specific UXO noise modelling, Hornsea Project Four used estimates of the source level and predicted PTS-onset impact ranges based on Hornsea Project Two, calculated for a range of expected UXO sizes (up to 800 kg; SMRU Consulting, 2021). It was highlighted in the assessment that PTS-onset impact ranges, and number of animals affected, are likely to be overestimated, especially for large charge sizes (Table 10.63). The assessment concluded that with mitigation measures, which will be agreed as a part of the UXO MMMP, the impact of the UXO clearance on marine mammals will not be significant.

Table 10.63: Number of Animals with the Potential to Experience PTS During UXO Clearance at Hornsea Project Three and Hornsea Project Four

Project	Species	Estimated Number in Impact Area	Residual Magnitude Assessed in EIA
Hornsea Project Three	Harbour porpoise	200	Negligible
	White-beaked dolphin	<1	
	Minke whale	<1	
Hornsea Project Four	Harbour porpoise	613	Negligible
	White-beaked dolphin	830	
	Minke whale	2,470	

576. The cumulative impact of PTS from elevated subsea noise during UXO clearance is predicted to be of local to regional spatial extent, very short-term duration, intermittent and the effect of injury is of low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

[14] The assessment of potential injury (PTS) on marine mammals as a result of underwater noise during UXO clearance for Hornsea Project Three was based on noise modelling for Hornsea One (the most common total weight of explosive found within Hornsea Project One was 260 kg). In order to determine impact area from UXO clearance with respect to disturbance, a 26 km buffer around source location was applied (based on guidance for harbour porpoise, however in the absence of agreed metrics for the use of other marine mammals it has been applied all species).

Temporary threshold shift

577. The resulting effect of TTS onset would be a potential temporary loss in hearing. Whilst some ecological functions could be inhibited in the short-term due to TTS, these are reversible on recovery of the animal's hearing and therefore not considered likely to lead to any long-term effects on the individual.

578. For the Proposed Development alone, the maximum range across which animals have the potential to experience TTS due to high order detonation of a 300 kg charge (maximum adverse scenario) was assessed for minke whale as approximately 54 km (see paragraph 309 *et seq.)*. Harbour porpoise could potentially experience TTS within a maximum of 19 km from the source. The TTS ranges for HF cetaceans (bottlenose dolphin and white-beaked dolphin) as well as seals are relatively smaller with a maximum of approximately 1 km and 6 km, respectively. TTS onset ranges for Inch Cape Offshore Wind Farm, Moray West, Blyth Demo 2, Dogger Bank Creyke Beck A, Dogger Bank Creyke Beck B, Dogger Bank Teesside A and Sofia Offshore Wind Farm are unknown, but for the purpose of this assessment we can assume that the maximum adverse scenario is no greater than assessed for the Proposed Development alone (since 300 kg represents a typical large munition size for the northern North Sea; Seagreen Wind Energy Ltd, 2021). A spatial maximum design scenario would occur where UXO clearance activities occur concurrently at the respective projects considered in the cumulative assessment. This is however highly unlikely, as due to safety reasons the UXO clearance activities takes place before other construction activities commence, and all projects considered in the CEA start their construction activities between three to one year/s before commencement of construction at Proposed Development. Temporally however, sequential UXO clearance at respective projects could lead to a longer duration of effect. Since each clearance event results in no more than a one second ensonification event and since TTS is a recoverable injury, the potential for cumulative effects with respect to TTS is considered to be very limited, even for projects within Firth of Forth and Tay (i.e. Inch Cape).

579. For the Proposed Development alone, harbour porpoise, minke whale and grey seal have the potential to be affected by TTS in relatively high numbers although these numbers will be reduced with additional secondary mitigation proposed (see paragraph 337; Table 10.49). As previously stated, for Hornsea Project Three there was no site-specific modelling undertaken and therefore the assessment of potential impacts on marine mammals as a result of underwater noise during UXO clearance compared results from two approaches: 1) using a buffer of 26 km around the source location to determine the behavioural impact area, and 2) TTS onset ranges modelled by the Beatrice Offshore Wind Farm from a 50 kg charge mass (GoBe, 2018a). Given that the former option is more precautionary, it has been carried forward to the assessment with disturbance area and number of animals presented in Table 10.64. For Hornsea Three the magnitude was assessed as low and sensitivity of marine mammal receptors as medium. Therefore, the overall significance of this effect for Hornsea Project Three was assessed as negligible to minor.

580. Hornsea Project Four presented the predicted ranges for the onset of TTS from UXO clearance, but since no assessment of the number of animals, magnitude, sensitivity or significance of effect was given, TTS with respect to this project could not be quantitatively assessed.

Table 10.64: Number of Animals with the Potential to Experience TTS Onset During UXO Clearance at Hornsea Project Three

Species	Disturbance Area	Estimated Number in Impact Area	Magnitude Assessed in EIA
Harbour porpoise	2,124 km^2	1,869	Low
White-beaked dolphin		43	
Minke whale		21	

581. Production of underwater sound during detonation of UXOs as a part of the cumulative projects as well as the Proposed Development have the potential to cause TTS (disturbance) in marine mammal receptors, however, this effect will be very short-lived (during detonation only) and reversible.

582. The cumulative impact of TTS from elevated subsea noise during UXO clearance is predicted to be of regional spatial extent, very short-term duration, intermittent and the effect is of high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low to medium.

Sensitivity of receptor

583. The sensitivity of marine mammals to disturbance from elevated underwater noise during UXO clearance is as described in section 10.11, paragraph 326 *et seq*.

Permanent threshold shift

584. Various studies proven that harbour porpoise is at risk of permanent hearing loss at distances of several kilometres (up to 6 km for 325 charge mass) (Von Benda-Beckmann *et al.,* 2015; Salomons *et al.,* 2021). There is much less known about the sensitivity of other species to PTS, however studies reported that even when dolphins experience inner ear damage as a result of explosives, their surface behaviour near blast areas is not altered (Ketten, 1993).

585. Cumulatively, harbour porpoise and grey seal are animals likely to be impacted in highest numbers. Harbour porpoises are widely distributed throughout the North Sea and throughout the regional marine mammal study area. Based on historic records, as well as DAS , harbour porpoise have been recorded in the Firth of Forth most often during summer months, however, the reasons for higher abundance during that period are unknown. Grey seals, which are designated feature of Isle of May SAC, may be more sensitive to PTS during their breeding period (September to December).

586. All marine mammals, which are IEFs of international value, are deemed to be of high vulnerability and low recoverability. The sensitivity of the receptor to PTS is therefore considered to be high.

Temporary threshold shift

587. The degree and speed of hearing recovery after experiencing TTS by an animal will depend on the characteristics of the sound the animal is exposed to, and on the degree of shift in hearing experienced. A study measuring recovery rates of harbour porpoise following exposure to sound source of 75 db re 1 μPa (SEL) over 120 minutes found that recovery to the pre-exposure threshold was estimated to be complete within 48 minutes following exposure (SEAMARCO, 2011) suggesting that recovery may be rapid. Whilst there are no available species-specific recovery rates for bottlenose dolphin, white-beaked dolphin and minke whale to TTS, there is no evidence to suggest that recovery will be significantly different to harbour porpoise recovery rates. Various studies measures recovery rates of harbour seal following exposure to a sound sources and found that recovery from TTS to the pre-exposure baseline was estimated to be complete within 30 to 72 minutes following exposure (Kastelein *et al*., 2018a; SEAMARCO, 2011).

588. Whilst TTS could affect many tens of animals (depending on the densities within the respective project areas) recovery to baseline conditions would be anticipated to occur within a short timeframe (hours) following cessation of the detonation. If UXO clearance activities were to occur over similar time periods, this could lead to a larger area of effect and larger cumulative number of animals that could experience TTS (noting that this is considered to be unlikely; paragraph 578). However, given the short-lived nature of the ensonification during UXO detonation and the reversibility of TTS animals are expected to recover quickly. The majority of the marine mammal receptors identified as IEFs in this assessment are wide

ranging species and therefore there is a potential that some individuals may be repeatedly exposed to TTS at different times regardless of the distance from the Proposed Development.

589. Based on historic records, as well as Proposed Development DAS, harbour porpoise and minke whale have been recorded in the Firth of Forth most often during summer months (Sparling, 2012; Grellier and Lacey, 2011; Seagreen Technical Report, 2018; Paxton *et al*., 2016). Minke whales are moving to inshore waters during summer due to increased abundance of sandeel (Robinson *et al*., 2009). Minke whale and harbour porpoises have a widespread distribution and individuals have been documented either switching to different prey species depending on the prey availability (Santos and Pierce, 2003; Haug *et al*., 2002) or moving relatively large distances on a daily basis (Nielsen *et al*., 2013). The availability of wider suitable habitat across the MU, feeding patterns of respective species and their mobility, suggest that individuals may move to alternative foraging grounds. However, as access to feeding grounds in the area may be restricted and individuals need to venture further in order to find appropriate feeding grounds, the displacement may result in a reduction in health and vital rates. Given that offshore wind farm developers are expected to follow the JNCC guidance to minimise the risk of disturbance (JNCC, 2010b) and that the temporal overlap of UXO detonation events at respective projects is unlikely, the UXO clearance events are not expected to result in a cumulative impact that would affect vital rates (e.g. reproduction) at a population level.

590. Based on the most conservative approach of high order detonation of 300 kg mass charge, there will be no spatial overlap of the predicted TTS range as a result of UXO detonation at Proposed Development with the Forth of Tay area, where the density of bottlenose dolphins is the highest. Inch Cape Offshore Wind Farm is located slightly closer to the Forth of Tay area, however it is anticipated that the UXO clearance works will be carried out before the UXO clearance at the Proposed Development (construction of Inch Cape commences in 2023). Additionally, because the number and size of the UXOs is unknown for this project, it is not possible to assess the impact quantitatively. If there is a requirement to detonate an explosive within the offshore cable route, some individuals within the coastal range, south from Firth of Forth, may be affected by TTS. As described in more detail in volume 3, appendix 10.2, C-PODs deployed at St Abbs as a part of the ECOMMAS study recorded very low occupancy rates in comparison to other sites (5%) and therefore even if some individuals have the potential to be affected by TTS, the numbers of animals affected will represent small percentage of the east coast population.

591. Seasonal sensitivities are difficult to determine. Grey seals, which are designated features of the Isle of May SAC and Berwickshire and North Northumberland Coast SAC, may be sensitive to TTS during their breeding period (September to December). In addition, as capital breeders, female grey seals spend more time during summer months foraging at-sea to build energy reserves prior to lactation when they may also be vulnerable to disturbance. Seals could experience TTS across relatively large ranges of up to 6,430 m as a result of a high order detonation of a charge size of 300 kg., The closest distance to Isle of May SAC (when measured from the Proposed Development cable corridor) equates to approximately 21 km. Therefore, direct overlap of noise impacts from the Proposed Development with areas in vicinity of this SAC is not expected.

592. Subsea noise leading to TTS onset could affect seals foraging in the vicinity or within the Proposed Development marine mammal study area, as the telemetry study demonstrated connectivity between Isle of May SAC and Proposed Development marine mammal study area (volume 3, appendix 10.2, Annex B). An even higher proportion of tagged individuals were tracked between the Proposed Development marine mammal study area and the Berwickshire and North Northumberland Coast SAC, which is located only 4.1 km from the Proposed Development export cable corridor. The expert elicitation carried out to inform the iPCoD modelling of population consequences found that experts considered that disturbance to grey seals could result in reduced foraging efficiency, which could in turn affect fertility and interfere with mating opportunities due to habitat displacement (Harwood *et al*., 2014). However, Russell *et al*. (2013) have shown that individual grey seals tagged at different Mus on the east coast may utilise different haul-outs around the UK. There are three grey seal breeding colonies in the vicinity of the Proposed Development, it is therefore anticipated that if individuals are deterred from one breeding site, they could move to alternative breeding grounds. Even if individual seals leave the MU to reach an alternative breeding site, as they can travel large distances, it is likely that changes in the size of the populations in affected Mus will have a negligible effect on the density of adult females on individual breeding colonies, and therefore negligible effect on the survival of pups born to females from those MU.

593. All marine mammals, which are IEFs of international value, are deemed to be of medium vulnerability and high recoverability. The sensitivity of the receptor is therefore, considered to be low.

Significance of effect

Permanent threshold shift

594. Overall, the magnitude of the cumulative impact is deemed to be negligible to low and the sensitivity of the receptor is considered to be high. Given that the risk of injury will be reduced by appropriate measures (including visual and acoustic monitoring) at respective projects and only a small proportion of respective populations could be potentially injured (PTS), the effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Temporary threshold shift

595. Overall, the magnitude of the cumulative impact is deemed to be low to medium and the sensitivity of the receptor is considered to be low. Given that the effect is reversible and will affect small proportion of populations only during the UXO clearance, which is unlikely to occur simultaneously at all sites, cumulatively, the effect will be of **minor** adverse significance, which is not significant in EIA terms.

Further mitigation and residual effect

596. Each project is expected to reduce the risk of injury (PTS and TTS) by project specific designed-in measures as well as secondary mitigation. Therefore, no secondary marine mammal mitigation, other than that proposed for Proposed Development alone (described in detail in paragraph 337 *et seq.*) is considered necessary. The residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

Tier 3

Construction phase

597. The only Tier 3 project which has been identified in the CEA with the potential to result in cumulative effects as a result of injury and disturbance from elevated underwater noise during UXO clearance within the regional marine mammal study area is Green Volt Floating Offshore Wind Farm.

Magnitude of impact

Permanent threshold shift and temporary threshold shift

598. The scoping report has identified potential for auditory injury and disturbance as a result of underwater noise during UXO clearance as potential impacts during construction of the project (Royal Haskoning DHV, 2021). As per the scoping report, the potential for UXO within the Green Volt site and the offshore export cable routes is limited due the significant amount of previous collected survey data over both the development site and export cable corridors (Royal Haskoning DHV, 2021). Since no UXO survey has as yet been undertaken to determine possible risk, the impacts on marine mammals were screened out from the considerations in the Green Volt EIA and will most likely be considered at a later stage.

599. Given the distance from the Proposed Development, the overlap of PTS/TTS ranges as a result of underwater noise due to UXO clearance is highly unlikely. As described above, the potential for UXO

within Green Volt site is limited and it is anticipated that the magnitude of impact will be negligible in comparison to numbers of UXOs requiring clearance at offshore wind farms listed in Tier 2 (see paragraph 567 *et seq*.).

Permanent threshold shift

600. The cumulative impact of PTS from elevated subsea noise during UXO clearance is predicted to be of local to regional spatial extent, very short-term duration, intermittent and the effect of injury is of low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Temporary threshold shift

601. The cumulative impact of TTS from elevated subsea noise during UXO clearance is predicted to be of regional spatial extent, very short-term duration, intermittent and the effect is of high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low to medium.

Sensitivity of receptor

602. The sensitivity of marine mammals to disturbance from elevated underwater noise during UXO clearance is as described in paragraph 583 *et seq*. for Tier 2 projects.

Permanent threshold shift

603. All marine mammals, which are IEFs of international value, are deemed to be of high vulnerability and low recoverability. The sensitivity of the receptor to PTS is therefore considered to be high.

Temporary threshold shift

604. All marine mammals, which are IEFs of international value, are deemed to be of medium vulnerability and high recoverability. The sensitivity of the receptor is therefore, considered to be low.

Significance of effect

Permanent threshold shift

605. Overall, the magnitude of the cumulative impact is deemed to be negligible to low and the sensitivity of the receptor is considered to be high. Given that the potential risk of injury at respective projects is reduced by appropriate designed-in measures, cumulatively, the effect will therefore be of **minor** adverse significance, which is not significant in EIA terms.

Temporary threshold shift

606. Overall, the magnitude of the cumulative impact is deemed to be low to medium and the sensitivity of the receptor is considered to be low. Given that the effect is reversible and will affect small proportion of populations only during the UXO clearance, which is unlikely to occur simultaneously at all sites, cumulatively, the effect will be of **minor** adverse significance, which is not significant in EIA terms.

Further mitigation and residual effect

607. Each project is expected to reduce the risk of injury (PTS and TTS) by project specific designed-in measures as well as secondary mitigation. Therefore, no secondary marine mammal mitigation, other than that proposed for Proposed Development alone (described in detail in paragraph 335 et seq.) is considered necessary. The residual effect is considered to be of minor adverse significance, which is not significant in EIA terms.

INJURY AND DISTURBANCE TO MARINE MAMMALS FROM ELEVATED UNDERWATER NOISE DUE TO VESSEL USE AND OTHER ACTIVITIES

608. The risk of injury in terms of PTS to marine mammal receptors as a result of underwater due to vessel use and other activities would be expected to be localised to within the boundaries of the respective projects. The assessment for the Proposed found that the numbers of animals impacted will be extremely low and the magnitude of the impact with respect to auditory injury occurring in marine mammals has been assessed as negligible. Therefore, there is no potential for cumulative impacts for injury from elevated underwater noise due to vessel use and the cumulative assessment provided in paragraph 609 *et seq.* focuses on disturbance only.

Tier 2

Construction phase

Magnitude of impact

609. The construction of the Proposed Development, together with Tier 2 projects identified in Table 10.55 may lead to disturbance to marine mammals from vessel use and other activities. Projects screened into this assessment include disposal activities at the Eyemouth disposal site, the construction and operation and maintenance of Inch Cape Offshore Wind Farm, Seagreen 1A Project, Eastern Link 1 and Eastern Link 2 and operation and maintenance of Neart na Gaoithe Offshore Wind Farm, Seagreen 1 and Blyth Demo 2.

610. The construction as well as operation and maintenance phases of Inch Cape Offshore Wind Farm, located 15 km from the Proposed Development array area, will overlap with the construction phase of the Proposed Development. Based on the revised design, the maximum design scenario for vessel movements predicted approximately 1,500 vessel movements over total construction period (2023 to 2025) and scheduled maintenance and inspection of each wind turbine is likely to occur every six to twelve months during the operation and maintenance phase (Inch Cape Offshore Ltd Scoping Report, 2017). Vessels involved in the construction phase are jack-up platforms, barges, dredgers, cable laying vessels and tugs. The impacts from increased underwater noise due to vessel traffic were assessed as minor (not significant) for the Original Development (Inch Cape Offshore Ltd, 2014). As the revised design includes a reduction in vessel movements during the construction phase (from 3,5000 vessel round trips in the Original Inch Cape EIA Report to 1,500 vessel round trips in the revised version), the Revised Inch Cape Offshore Wind Farm project was anticipated to have less of an impact compared to the original Inch Cape Offshore Wind Farm and therefore the impacts from increased underwater noise due to vessel traffic were scoped out of the revised EIA (Inch Cape Offshore Ltd, 2018). None of the assessments, either original (Inch Cape Offshore Ltd, 2014) nor the revised version (Inch Cape Offshore Ltd, 2018), assessed the impacts associated with disturbance of marine mammals from elevated underwater noise due to vessel use and other activities during the operation and maintenance phase.

611. The construction and operation and maintenance phases of Seagreen 1A Project as well as operation and maintenance of Seagreen 1, located 5 km from the Proposed Development array area, will overlap with the construction phase of the Proposed Development. The construction activities within Seagreen 1A Project will involve up to eight large installation vessels on site as well as a cable laying vessel, piling vessel, structure installation vessel and a rock dispoal vessel, however the approximate number of round trips was not specified (Seagreen Wind Energy Ltd, 2012). Operation and maintenance activities within both offshore wind farms will include biannual visits per wind turbine with two vessels on site at any one time (Seagreen Wind Energy, 2012). The significance of the effect resulting from increased underwater noise due to vessel traffic for both phases was assessed as negligible.

612. The operation and maintenance phase of Neart na Gaoithe Offshore Wind Farm, located 16 km from the Proposed Development array area, will overlap with the construction phase of the Proposed Development. It is predicted that during the operation and maintenance phase, vessels such as SOV (20 to 30 round trips annually), maintenance (10 to 20 two week campaigns annually), jack-up barge (average two events annually) and SOV or catamaran for visual inspections (400 to 600 events annually) will be used (Mainstream Renewable Power, 2019). The effects resulting from increased vessel traffic during operation and maintenance phase, such as masking, displacement or behavioural changes, have been assessed as not significant in the original EIA Report (Mainstream Renewable Power, 2012) and were scoped out from the further assessment in the revised EIA Report (Mainstream Renewable Power, 2019).

613. The operation and maintenance phase of Blyth Demo Phase 2, located 102 km from the Proposed Development array area, will overlap with the construction phase of the Proposed Development. The original Blyth Offshore Demonstration Project EIA Report assessed impacts such as lethality, physical injury and behavioural avoidance, due to increased anthropogenic noise from vessel use and other activities such as cable burying and/or trenching (NAREC, 2012). The potential magnitude of the impact of anthropogenic noise was concluded as low (NAREC, 2012). A review of the assessment of effects for marine mammals was undertaken as part of the 2013 SEI but it did not lead to any change in the conclusions of the original EIA Report (NAREC, 2013). The exact number of round vessel trips for operation and maintenance phase was not provided in the original EIA Report (NAREC, 2012), however, the potential for impacts as a result of increased anthropogenic noise from vessel traffic and other activities during operation of the Blyth Demo 2 are considered to be less or equivalent when compared to original consent where the magnitude was assessed as low (EDF, 2020).

614. The construction as well as operation and maintenance phases of Eastern Link 1 and Eastern Link 2 located 28 km and 14 km from the Proposed Development array area, will overlap with construction phase of the Proposed Development. Sound as a result of vessel movements, including cable lay vessels with dynamic positioning has been listed as potential impact on marine mammal during construction as well as operation and maintenance phases of both projects. The Environmental Appraisals for the Eastern Link 1 (AECOM, 2022a) and the Eastern Link 2 (AECOM, 2022b) predicted that the underwater sound from vessels involved in installation is not considered to be at a level that would have a significant impact on the ambient underwater soundscape. The initial assessment of underwater noise impacts for both projects was presented only for installation phase. This impact has been scoped out, based on the assumption that there is no evidence of injury caused by a constantly moving vessel. Subsequently, the disturbance effects as a result of vessel movements during construction as well as operation were not determined. For construction activities such as rock placement or ploughing, jet trenching and mechanical trenching during cable installation, it was assessed that underwater sounds will not be generated at a level where injury or disturbance could be expected.

615. The operation of Eyemouth disposal site located 35 km from the Proposed Development array area, will overlap with the construction phase of the Proposed Development. A proposed dredging programme assumed use of a hopper barge that may require approximately 30 vessel round trips over a period of approximately 16 days between 2020 to 2023 (Eyemouth Harbour Trust, 2020). There was no information about the duration and/or number of vessel round tips after that date. Only one vessel will be involved in disposal activities at the Eyemouth disposal site and therefore, even if temporal overlap with the construction phase of the Proposed Development will take place, the increase in traffic is negligible when compared to vessel movements at offshore wind farms considered above and therefore is not anticipated to lead to cumulative disturbance to marine mammals.

616. The maximum scenario for the construction phase of the Proposed Development is presented in Table 10.16 with up to 9,806 vessel round trips over the period of 6 years. Vessel use during the construction phase of the Proposed Development is described in more detail in paragraph 352 *et seq.* The impacts due to disturbance to marine mammals from vessel use and other activities for the Proposed Development alone during the construction phase were assessed as minor.

617. Whilst there is no quantitative information available for noise disturbance ranges for offshore wind farms included in this CEA, it is anticipated that there will be a similar scale of effects with respect to noise effects as those described for Proposed Development alone (paragraph 350 *et seq.*). Therefore, the risk of injury in terms of PTS to marine mammal receptors would be expected to be localised to within the boundaries of the respective projects. It is expected that all projects will adhere to project specific mitigation plans to reduce the potential risk of auditory injury. Disturbance could occur over larger ranges compared to PTS, subsea noise modelling predicted a range of 4 km disturbance range for construction activities such as cable laying as well as activity of rock placement vessels (described in detail in volume 3, appendix 10.1) and therefore, only disturbance effects (not PTS) are likely to occur cumulatively. Given that construction activities for the other offshore wind projects have commenced in 2020 and that this is an area of high vessel traffic (see paragraph 353 *et seq.* for more details), it can be anticipated that marine mammals present in the vicinity of Firth of Forth demonstrate some degree of habituation to ship noises.

618. The highest number of vessels movements was predicted during the construction phase of each offshore wind farm. There would potentially be a relatively small temporal overlap of the construction phases, with only one year of overlap with Inch Cape as well as Seagreen 1A Project and the Proposed Development. Therefore, the potential cumulative effect during construction phases of the respective projects and the proposed Development will be short-term (no more than one year).

619. Vessel movements will be confined to the array areas and/or offshore export cable corridor routes and will follow existing shipping routes to/from port. As presented in volume 2, chapter 13, the commercial vessel numbers in the vicinity of the Proposed Development are expected to remain reasonably consistent in the future. In the longer term, there may be increases in wind farm related traffic associated with the ScotWind developments north and east of the Proposed Development. However, given the low data confidence associated with these developments it was not possible to make any quantitative assumptions. It has been assumed that future case traffic growth is likely to fluctuate depending on seasonality and cargo and industry trends.

620. As described in more detail in volume 2, chapter 13, commercial vessels do not transit through arrays, which has been corroborated during consultation for the Proposed Development. Two areas of sea room (gaps) between the Proposed Development array area and other future offshore wind farm developments were established, namely between Seagreen 1 and Inch Cape. The cumulative effect is predicted to be of local spatial extent, medium term duration, intermittent and the effects of behavioural disturbance are of high reversibility. It is predicted that the impact will affect the receptor directly. Given the minor temporal overlap in construction activities and that the operation and maintenance activities associated with the relevant projects will not add substantially to the total number of vessel round trips associated with the Proposed Development, with only a proportion of the operation and maintenance operations occurring during the construction phase of the Proposed Development, the magnitude of the impact will not be greater than that assumed for the project alone. The magnitude is therefore, considered to be low.

Sensitivity of receptor

621. The sensitivity of marine mammals to elevated underwater noise due to vessel use and other activities is as described in section 10.11, paragraph 368 *et seq*.

622. There are interspecific differences in the potential sensitivity of cetaceans to vessel noise with some species actively avoiding vessels, whilst other are attracted towards them. Harbour porpoise was highlighted as being particularly sensitive to vessel noise and avoidance is likely (Heinänen and Skov, 2015). Similarly, bottlenose dolphins reduce their activity in response to the noise arising from vessel movements (Pirotta *et al*., 2015). However, the link between vessel noise and reduced marine mammal

activity is not straightforward to establish due to intrinsic factors that may also contribute to a variance in distribution and abundance (e.g. changes in prey distribution and natural seasonal fluctuations). Despite the known sensitivity of harbour porpoise to vessel noise (i.e. active avoidance of vessels; Hermannsen and Bedholm, 2014, Dyndo *et al*. 2015), there was no detectable decrease in the numbers of harbour porpoise associated with an increase in vessel activity during pipeline construction (Culloch *et al*., 2016).

623. The sensitivity of seals to vessel noise was described previously in paragraph 376 *et seq* and highlighted that the presence of boats near seal haul-outs could lead to disruption of foraging and potentially reduced pupping success. Key harbour and grey seal haul-outs nearest the Proposed Development were identified as Kinghorn Rocks and Inchmickery and Cow and Calves. There are also three grey seal breeding colony sites (Fast Castle, Inchkeith and Craigleith). Harbour and grey seals at sea within the vicinity of the haul-outs in the inner Firth of Forth are likely to be exposed to existing high levels of vessel activity to/from busy ports and harbours in the area (e.g. Rosyth, Braefoot Bay, Methill and North Berwick). Therefore, seals in the vicinity of haul-out sites are anticipated to demonstrate some degree of habituation to ship noises.

624. On the east coast of Scotland, and within the vicinity of the other projects screened into this assessment, there are two SACs designated to support breeding colonies of harbour seals, namely Firth of Tay and Eden Estuary SAC and Dornoch Firth and Morrich More SAC. With small foraging ranges, harbour seal may be sensitive to a cumulative increase in vessel activity near key haul-outs. The closest point of the Proposed Development is located approximately 4 km from Berwickshire and North Northumberland Coast SAC and 21 km from Isle of May SAC, designated for grey seals. Therefore, grey seals from these SACs may occur in the vicinity of the Proposed Development, which has been confirmed by the telemetry data (see more details in volume 3, appendix 10.2, Annex B), with individuals also likely to move within project areas. With greater foraging ranges, grey seal, in particular, may be sensitive to an uplift in vessel activity as they move between haul-outs and key foraging areas. As described previously, however, seals in these areas (near busy ports) are already exposed to existing levels of baseline vessel activity and therefore are likely to be tolerant to intermittent uplifts in vessel traffic and associated noise. Due to the small and localised nature of the uplift in vessel activity and associated noise compared to baseline levels, it is considered unlikely that marine mammals will be more sensitive to the cumulative effects of disturbance compared to the Proposed Development alone.

625. Bottlenose dolphin occurring in the main distributional range of the population (Moray Firth to Firth of Forth) and south to Farne Islands are also expected to demonstrate a degree of habituation to ship noise. It is because this range overlaps with majority of the largest and busiest Scottish ports, namely Cromarty, Peterhead, Aberdeen, Dundee and ports within Firth of Forth. Furthermore, ports in Dundee support large numbers of cargo vessels and offshore support vessels (described in more detail in volume 2, chapter 13) that pass through the Firth of Tay, the area supporting approximately 50% of east coast bottlenose dolphin population. Cromarty port is known as leading hub for offshore renewable energy projects, and a primary location for oil rig inspection, repair and maintenance as well as subsea work. It is located in the Cromarty Firth, which as an arm of the Moray Firth and overlaps with Moray Firth SAC, which supports the only known resident population of bottlenose dolphin in the North Sea. Given that bottlenose dolphins aggregate in areas characterised by high vessel activity, the uplift in vessel traffic associated with Proposed Development and projects screened in for cumulative assessment is unlikely to affect survival or reproduction rate of individuals.

626. All marine mammals, which are IEFs of international value, are deemed to be of low vulnerability and high recoverability. The sensitivity of the receptor is therefore considered to be medium.

Significance of effect

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

Further mitigation and residual effect

628. No secondary additional marine mammal mitigation is considered necessary as the predicted effect in the absence of further mitigation (beyond the designed-in measures outlined in section 10.10) is not significant in EIA terms. Therefore, the residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

<u>Operation and maintenance phase</u>

Magnitude of impact

629. The operation and maintenance activities of the Proposed Development will overlap with Tier 2 projects identified in Table 10.55 and may lead to disturbance to marine mammals from vessel use and other activities. Projects screened into this assessment include disposal activities at the Eyemouth disposal site, the operation and maintenance of Inch Cape Offshore Wind Farm, Seagreen 1, Seagreen 1A Project, Eastern Link 1, Eastern Link 2, Blyth Demo 2, and Neart na Gaoithe Offshore Wind Farm.

630. The construction of the Proposed Development overlaps with the operation and maintenance phase of the respective projects, and therefore, where available, the number and types of vessel associated with operation and maintenance of projects considered in the cumulative assessment along with assessment of significance are provided in paragraph 609 *et seq.*

631. The maximum design scenario for the operation and maintenance phase of the Proposed Development is presented in Table 10.16 with up to 2,323 vessel round trips per year over the operational lifetime of the Project. Vessel use during the operation phase of the Proposed Development is described in more detail in paragraph 382 *et seq.* The impacts due to disturbance to marine mammals from vessel use and other activities for the Proposed Development alone during the operation and maintenance phase were assessed as negligible to minor.

632. Vessels involved in the operation and maintenance of other wind farms will include a similar suite of vessels as those described for the Proposed Development alone (see paragraph 382 *et seq.*), such as vessels used during routine inspections, repairs and replacement of equipment, major component replacement, painting or other coatings, removal of marine growth and replacement of access ladders. Given that the number of vessel round trips and their frequency is much lower for the operation and maintenance phases compared to construction phases of the respective projects, the magnitude of the impact for disturbance as a result of elevated underwater noise due to vessel use and other activities, for all marine mammal receptors, is expected to be less than that assessed for the construction phase. However, the duration of the effect will be longer (over the 35-year operating lifetime of the Proposed Development) and therefore a precautionary approach has been taken in assessing the magnitude.

633. During the operation and maintenance phase of the Proposed Development, the other Tier 2 wind farms will reach their decommissioning age before the Proposed Development reaches its decommissioning age in 2066. The operational lifetime of Inch Cape is expected to be up to 35 years, with construction ending in 2025 and decommissioning expected in 2060 (Inch Cape Offshore Ltd, 2018). The operational lifetime of Neart na Gaoithe is expected to be 25 years, with construction ending in 2023 and decommissioning expected in 2048 (Mainstream Renewable Power, 2019). Seagreen 1 and Seagreen 1A Project have an operation and maintenance phase of 25 – 30 years which will lead to their decommissioning in 2048 – 2053 (Seagreen Wind Energy Ltd, 2012). The environmental statements for offshore wind farms listed in paragraph 629 predicted the number and type of vessels associated with decommissioning are expected to be, at worst, similar to construction. Therefore, the cumulative magnitude of the impact of the decommissioning phase as a result of elevated underwater noise due to vessel use, for all marine mammal receptors, are considered to be equivalent to and potentially lower than the maximum adverse scenario effects assessed for the construction phase.

634. Additionally, it can be expected that after more than ten years of construction activities taking place in the vicinity of Firth of Forth (i.e. Seagreen 1 construction activities commenced in 2021 and the operation and maintenance phase of Proposed Development is expected to start from 2033), marine mammals present in the area will demonstrate some degree of habituation to ship noises.

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

Sensitivity of receptor

636. The sensitivity of marine mammals to cumulative disturbance from elevated underwater noise due to vessel use and other activities is as described in paragraph 623 *et seq.* for the construction phase.

637. All marine mammals, which are IEFs of international value, are deemed to be of low vulnerability and high recoverability. The sensitivity of the receptor is therefore considered to be medium.

Significance of effect

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

Further mitigation and residual effect

639. No secondary marine mammal mitigation is considered necessary as the predicted effect in the absence of further mitigation (beyond the designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore, the residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

Tier 3

Construction phase

640. The construction of the Proposed Development, together with Tier 3 projects identified in Table 10.55 may lead to disturbance to marine mammals from vessel use and other activities. Projects screened into this assessment include the construction and operation of Cambois connection and operation of Forthwind Demonstration Project.

641. The scoping report for the Forthwind Offshore Wind Demonstration Project concluded, that due to the small scale of deployment, the industrial nature of the location and relatively low presence of marine mammals, operational effects such as increased vessel movements were scoped out from further assessment (Cierco, 2019).

642. There is currently no information on the impacts the Cambois connection will have on marine mammal IEFs, although the Scoping Report have listed the types of vessels to be used during construction, including cable lay vessels, pre-lay survey vessels, rock protection vessels, support vessels, guard vessels, and possible use of jack-up vessels (SSER, 2022e). There are no details about number of vessel round trips during the construction phase of Cambois connection.

643. Due to lack of project information at this stage, it is not possible to undertake full, quantitative assessment for this impact and therefore a qualitative assessment is provided in paragraph 644 *et seq.*

Magnitude of impact

644. Behavioural effects on marine mammal may extend beyond the boundaries of the projects listed in paragraph 640, although the extent to which this occurs will depend on the design parameters. The maximum range over which potential disturbance may occur for the Proposed Development alone as a result of drilled piling and jet trenching, is predicted out to 1,900 m and 2,580 m, respectively. Cable installation activities assessed for the Proposed Development alone have the potential to disturb marine mammals out to 4,389 m. Although the range of effects for each respective project is predicted to be localised, given the distances from the Proposed Development (see Table 10.54 for distances) there is a potential for overlap in the behavioural ZoI. And cumulatively, construction activities could lead to a larger area of disturbance and larger number of animals disturbed across the regional marine mammal study area compared to the Proposed Development alone if projects were to conduct construction activities over similar time periods. However, the scale of the disturbance effects is considered to be small in the context of the wider habitat available.

645. The cumulative impact is predicted to be of local spatial extent, short term duration, intermittent and behavioural effects are of high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Sensitivity of receptor

646. The sensitivity of marine mammals to cumulative disturbance from elevated underwater noise due to vessel use and other activities is as described in paragraph 623 *et seq.* for the construction phase.

647. All marine mammals, which are IEFs of international value, are deemed to be of low vulnerability and high recoverability. The sensitivity of the receptor is therefore considered to be medium.

Significance of effect

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

Further mitigation and residual effect

649. No secondary marine mammal mitigation is considered necessary as the predicted effect in the absence of further mitigation (beyond the designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore, the residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

Operation and maintenance phase

650. The operation of the Proposed Development, together with Tier 3 projects identified in Table 10.55 may lead to disturbance to marine mammals from vessel use and other activities. Projects screened into this assessment include the operation of Cambois connection and Forthwind Demonstration Project.

651. The scoping report for the Forthwind Offshore Wind Demonstration Project concluded, that due to the small scale of deployment, the industrial nature of the location and relatively low presence of marine mammals, operational effects such as increased vessel movements were scoped out from further assessment (Cierco, 2019).

652. As presented in paragraph 642, there were no details about the number of vessel round trips or type of vessels that will be used during operation and maintenance phase of Cambois connection (SSER, 2022e).

653. Due to lack of detailed project information at this stage, it was not possible to undertake full, quantitative assessment for this impact.

Magnitude of impact

654. An overview of potential impacts for behavioural disturbance to marine mammals from elevated underwater noise due to vessel use and other activities is described in paragraph 644 *et seq.* for the construction phase and have not been reiterated here for the operation and maintenance phase.

655. The cumulative impact is predicted to be of local spatial extent, short term duration, intermittent and behavioural effects are of high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of receptor

656. The sensitivity of marine mammals to cumulative disturbance from elevated underwater noise due to vessel use and other activities is as described in paragraph 623 *et seq.* for the construction phase.

657. All marine mammals, which are IEFs of international value, are deemed to be of low vulnerability and high recoverability. The sensitivity of the receptor is therefore, considered to be medium.

Significance of effect

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

Further mitigation and residual effect

659. No secondary marine mammal mitigation is considered necessary as the predicted effect in the absence of further mitigation (beyond the designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore, the residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

INJURY OF MARINE MAMMALS DUE TO COLLISION WITH VESSELS

Tier 2

Construction phase

Magnitude of impact

660. The construction of the Proposed Development, together with Tier 2 projects and plans identified in Table 10.55, may lead to increased risk of collision with vessels. Projects screened into this assessment include the construction and operation and maintenance of Inch Cape Offshore Wind Farm, Seagreen 1A Project, Blyth Demo 2, Eastern Link 1 and Easter Link 2 and operation and maintenance of Neart na Gaoithe Offshore Wind Farm and Seagreen 1.

661. The number and types of vessel associated with construction of Proposed Development as well as construction and/or operation and maintenance of projects considered in the cumulative assessment is provided in paragraph 609 *et seq.* Collision risk and barrier effect from increased vessel movements were assessed as minor (not significant) in the original Inch Cape Offshore Wind Farm EIA for both, the construction as well as operation and maintenance phases (Inch Cape Offshore Ltd, 2014). Given that the revised version of the project predicted smaller number of vessel movements during operation and maintenance phase, it is anticipated to have less of an impact and therefore it has been scoped out from the revised Inch Cape Offshore Wind Farm EIA (Inch Cape Offshore Ltd Scoping Report, 2017). The risk of collision during the construction as well as operation and maintenance phase has been assessed as negligible for Seagreen 1A Project and Seagreen 1 (Seagreen Wind Energy Ltd, 2012). The Neart na Gaoithe EIA assessed a potential for injury as a result of collision with vessels as not significant during operation and maintenance (Mainstream Renewable Power, 2012). The Environmental Appraisal Reports for Eastern Link 1 and Eastern Link 2 assessed the likelihood of vessel collision with marine mammals during installation as unlikely and, therefore, the effect of this impact has been assessed as minor (AECOM, 2022a; AECOM, 2022b). The assessment of impacts on marine mammals as collision during the maintenance and operation and maintenance phase of the Eastern Link 1 and Eastern Link 2 is unavailable.

662. The original Blyth Offshore Demonstration Project EIA Report assessed a potential for injury as a result of collision during installation 15 monopiles (NAREC, 2012). Potential effects of collision risk impacts were concluded as low magnitude (NAREC, 2012). A review of the assessment of effects for marine mammals was undertaken as part of the 2013 SEI but it did not lead to any change in the conclusions of the original EIA (NAREC, 2013). Blyth Demo 2 will include construction of floating platforms, that will be built at the quayside and towed to site. Therefore, construction can be achieved more quickly than traditional offshore wind turbine construction assessed in original EIA Report (NERC, 2012) and does not rely on as many vessels or specialised vessels. The exact number of round vessel trips was not provided in the original EIA Report (NAREC, 2012); however, the potential for collision with vessels during construction and operation of the Blyth Demo 2 are considered to be less or equivalent when compared to existing consent where it was assessed as low (EDF, 2020).

663. The impacts to marine mammals due to collision risk for the Proposed Development alone during the construction phase were assessed as minor.

664. Given that vessel movements will be confined to the array areas and/or offshore export cable corridor routes and will follow existing shipping routes to/from port, the risk of collision to marine mammals is expected to be localised to within the boundaries of the respective projects. As presented in more detail in volume 2, chapter 13, commercial vessels associated with other projects and maritime activities will not transit through Proposed Development array area. The types of vessels involved in construction activities at the other offshore wind farms will be similar to those identified for construction of the Proposed Development, such as jack-up vessels, tug/anchor handers, cable installation vessels, scour/cable protection installation vessel, guard vessels, survey vessels and CTVs. As previously described for the Proposed Development alone (see paragraph 403 *et seq.*), vessels travelling at 7 m/s or faster are those most likely to cause death or serious injury to marine mammals (Laist *et al*., 2001). Vessels involved in the construction phase of Proposed Development and respective projects are likely to be travelling considerably slower than this. There is also a potential that the noise emissions from vessels will deter animals from the potential zone of impact.

665. The Proposed Development and respective projects are located in the area of relatively high vessel traffic (see paragraph 353 *et seq*.) and therefore it can be expected that marine mammals present in the vicinity of Firth of Forth will demonstrate some degree of habituation to the presence of high number of vessels. As previously stated in paragraph 619 *et seq*, the commercial vessel numbers in the vicinity of Proposed Development are expected to remain reasonably consistent in the future. In the longer term, there may be increases in wind farm related traffic associated with the ScotWind developments north and east of the Proposed Development. However, given the low data confidence associated with these developments it was not possible to make any quantitative assumptions. It is anticipated that the risk of collision at other offshore wind farm projects would be minimised through the adoption of factored-in measures such as vessel codes of conduct as standard good practice for offshore wind developments. Therefore, even with a cumulative increase in vessel traffic, the type of vessels involved and transit routes is unlikely to impose a greater risk to marine mammals.

666. The cumulative impact of collision risk is predicted to be of local spatial extent, medium term duration, intermittent and low reversibility. It is predicted that the impact will affect the receptor directly. Given the minor temporal overlap in construction activities and that the operation and maintenance activities

associated with the relevant projects will not add substantially to the total number of vessel round trips associated with the Proposed Development, with only a proportion of the operation and maintenance operations occurring during the construction phase of the Proposed Development, the magnitude of the impact will not be greater than that assumed for the project alone. The magnitude is therefore, considered to be low.

Sensitivity of receptor

667. The sensitivity of marine mammals to collision risk is as described in section 10.11, paragraph 399 *et seq.*

668. As presented above for vessel noise and other activities sensitivity section (paragraph 621 *et seq.*) the link between vessel movements and reduced marine mammal activity is not straightforward to establish due to intrinsic factors that may also contribute to a variance in distribution and abundance (e.g. changes in prey distribution and natural seasonal fluctuations). Harbour and grey seals at sea within the vicinity of the haul-outs in the inner Firth of Forth are likely to be exposed to existing high levels of vessel activity to/from busy ports and harbours in the area (e.g. Rosyth, Braefoot Bay, Methill and North Berwick). Therefore, seals in the vicinity of haul-out sites are anticipated to demonstrate some degree of habituation to presence of ships. Nevertheless, collision risk is anticipated to be higher in the vicinity of haul-out sites, particularly for young seals that have no previous experience of vessel traffic. Vessels associated with the Proposed Development would follow a Code of Conduct, included as a part of the NSPVMP (volume 4, appendix 25), which would include, for example, limiting the speed of vessels near haul-outs, avoiding sudden changes in direction, and refraining from approaching animals in the water (Table 10.21).

669. It is assumed that vessels will follow a Code of Conduct for vessel operators, therefore reducing the risk. However, although the potential to experience injury from construction traffic is relatively low, the consequences of collision risk, could be fatal. All marine mammals would have limited tolerance to a collision risk, and the effect of the impact could cause a change in both reproduction and survival of individuals, and receptors would have limited ability for the animal to recover from the effect.

670. All marine mammals, which are IEFs of international value, are deemed to be of medium vulnerability and medium recoverability. The sensitivity of the receptor is therefore considered to be medium.

Significance of effect

671. 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.

Further mitigation and residual effect

672. No secondary marine mammal mitigation is considered necessary as the predicted effect in the absence of further mitigation (beyond the designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore, the residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

<u>Operation and maintenance phase</u>

Magnitude of impact

673. The operation and maintenance activities of the Proposed Development will overlap with the operation and maintenance phase of the projects identified in Table 10.55 and may lead to increased risk of collision with vessels. Other projects screened into this assessment include the operation and maintenance of Inch Cape Offshore Wind Farm, Seagreen 1A Project, Seagreen 1, Eastern Link 1, Eastern Link 2, Blyth Demo 2 and Neart na Gaoithe Offshore Wind Farm.

674. Given that the construction of the Proposed Development overlaps with the operation and maintenance phase of the respective projects, the number and types of vessel associated with operation and maintenance of projects considered for operation and maintenance phase are provided in paragraph 609 *et seq.* An overview of potential effects due to collision with vessels along with assessment of significance for the operation and maintenance phase for Inch Cape, Seagreen 1A Project, Seagreen 1 and Neart na Gaoithe Offshore Wind Farm is presented in paragraph 660 *et seq*. An overview of potential effects due to collision with vessels during construction and operation of the Blyth Demo 2 is presented and paragraph 662, where it was assessed as low.

675. The maximum scenario for the operation and maintenance phase of the Proposed Development is presented in Table 10.16 with up to 2,323 vessel round trips per year over the operational lifetime of the Project. Vessel use during the operation phase of the Proposed Development is described in more detail in paragraph 382 *et seq.* The impacts due to injury of marine mammals due to collision risk for the Proposed Development alone during the operation and maintenance phase were assessed as minor.

676. Given that vessel movements will be confined to the array areas and/or offshore export cable corridor routes and will follow existing shipping routes to/from port, the risk of collision to marine mammals is expected to be localised to within the boundaries of the respective projects.

677. The types of vessels involved in operation and maintenance activities at the other offshore wind farms will be similar to those identified for the Proposed Development, such as vessels used during routine inspections, repairs and replacement of equipment, major component replacement, painting or other coatings, removal of marine growth and replacement of access ladders. The number of vessel movements during the operation and maintenance phase represents a slight increase in the risk of collision for marine mammals over the existing levels of vessel traffic. There is also a potential that the noise emissions from vessels will deter animals from the potential zone of impact.

678. Additionally, it can be expected that after more than ten years of construction activities taking place in the vicinity of Firth of Forth (i.e. Seagreen 1 construction activities commenced in 2021 and the operation and maintenance phase of Proposed Development is expected to start from 2033), marine mammals present in the area will demonstrate some degree of habituation to the presence of high number of vessels. It is anticipated that the risk of collision at other offshore wind farm projects would be minimised through the adoption of factored in measures such as vessel codes of conduct as standard good practice for offshore wind developments. Therefore, even with a cumulative increase in vessel traffic, the type of vessels involved and transit routes is unlikely to impose a greater risk to marine mammals.

679. During the operation and maintenance phase of the Proposed Development, the other Tier 2 wind farms will reach their decommissioning age before the Proposed Development reaches its decommissioning age in 2066. The operational lifetime of Inch Cape is expected to be up to 35 years, with construction ending in 2025 and decommissioning expected in 2060 (Inch Cape Offshore Ltd, 2018). The operational lifetime of Neart na Gaoithe is expected to be 25 years, with construction ending in 2023 and decommissioning expected in 2048 (Mainstream Renewable Power, 2019). Seagreen 1 and Seagreen 1A Project have an operation and maintenance phase of 25 – 30 years which will lead to its decommissioning in 2048 – 2053 (Seagreen Wind Energy Ltd, 2012). The environmental statements for offshore wind farms listed above predicted the number and type of vessels associated with decommissioning are expected to be, at worst, similar to construction. Therefore, the cumulative magnitude of the impact of the decommissioning phase as a result of collision with vessels, for all marine mammal receptors, are considered to be equivalent to and potentially lower than the maximum adverse effects assessed for the construction phase.

680. The cumulative impact is predicted to be of local spatial extent, long term duration, intermittent and effects are of low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Sensitivity of receptor

681. The sensitivity of marine mammals to cumulative collision risk is as described for construction phase above in paragraph 667 *et seq.*

682. All marine mammals, which are IEFs of international value, are deemed to be of medium vulnerability and medium recoverability. The sensitivity of the receptor is therefore considered to be medium.

Significance of effect

683. Overall, the magnitude of the cumulative effect 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.

Further mitigation and residual effect

684. No secondary marine mammal mitigation is considered necessary as the predicted effect in the absence of further mitigation (beyond the designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore, the residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

Tier 3

Construction phase

685. The construction of the Proposed Development, together with Tier 3 projects identified in Table 10.55 may lead to cumulative effects as a result of collision risk. Projects screened into this assessment include the construction and operation Cambois connection and operation of Forthwind Demonstration Project.

686. The scoping report for the Forthwind Offshore Wind Demonstration Project concluded, that due to the small scale of deployment, the industrial nature of the location and relatively low presence of marine mammals, impacts associated with vessel presence during the operation and maintenance phase (i.e. collision risk) were scoped out from further assessment (Cierco, 2019).

687. There is currently no information on the impacts the Cambois connection will have on marine mammal IEFs, although the Scoping Report have listed the types of vessels to be used during construction, including cable lay vessels, pre-lay survey vessels, rock protection vessels, support vessels, guard vessels, and possible use of jack-up vessels (SSER, 2022e). No details about the number of vessel round trips or type of vessels that will be used during operation and maintenance phase of were provided. However, risk of collision with vessels during the construction as well operation and maintenance phase cannot be discounted.

688. Due to lack of project information at this stage, it is not possible to undertake full, quantitative assessment for this impact and therefore a qualitative assessment is provided in paragraph 663 *et seq.*

Magnitude of impact

689. Vessel traffic associated with construction of the Proposed Development and construction as well as operation and maintenance of respective projects has the potential to lead to an increase in vessel movements, which could lead to an increase in interactions between marine mammals and vessels during offshore construction. However, vessel movements will be confined to the array areas and/or offshore cable routes and will follow existing shipping routes to/from port. As a result, the risk of collision to marine mammals is expected to be localised to within the boundaries of the respective projects. The types of vessels involved in construction activities at the other projects are expected to be similar to those identified for construction of the Proposed Development export cable corridor, such as jack-up vessels, tug/anchor handers, cable installation vessels, scour/cable protection installation vessel, guard vessels, survey vessels and CTVs. As previously described for the Proposed Development alone (see paragraph 403 et seq.), vessels travelling at 7 m/s or faster are those most likely to cause death or serious injury to marine mammals (Laist et al., 2001). Vessels involved in the construction phase of Proposed Development and respective projects are likely to be travelling considerably slower than this. There is also a potential that the noise emissions from vessels will deter animals from the potential zone of impact.

690. The cumulative impact of collision risk is predicted to be of local spatial extent, medium term duration, intermittent and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of receptor

691. The sensitivity of marine mammals to cumulative effects as a result of collision risk is as described in paragraph 667 *et seq*. for Tier 2 projects.

692. All marine mammals, which are IEFs of international value, are deemed to be of medium vulnerability and medium recoverability. The sensitivity of the receptor is therefore, considered to be medium.

Significance of effect

693. 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.

Further mitigation and residual effect

694. No secondary marine mammal mitigation is considered necessary as the predicted effect in the absence of further mitigation (beyond the designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore, the residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

Operation and maintenance phase

695. The operation of the Proposed Development, together with Tier 3 projects identified in Table 10.55 may lead to cumulative effects as a result of collision risk. Projects screened into this assessment include the operation of Cambois connection and Forthwind Demonstration Project.

696. The scoping report for the Forthwind Offshore Wind Demonstration Project concluded, that due location, scale and nature of the development, operational effects such as collision risk were scoped out from further assessment (Cierco, 2019).

697. As presented in paragraph 642, there were no details about the number of vessel round trips or type of vessels that will be used during operation and maintenance phase of Cambois connection (SSER, 2022e). However, although currently there is no information on the impacts the Cambois connection will have on marine mammal IEFs, risk of collision with vessels during the operation and maintenance phase cannot be discounted.

698. Due to lack of detailed project information at this stage, it was not possible to undertake full, quantitative assessment for this impact and therefore a qualitative assessment is provided in paragraph 699 *et seq.*

Magnitude of impact

699. Given that vessel movements will be confined to the array areas and/or cable routes and will follow existing shipping routes to/from port, the risk of collision to marine mammals is expected to be largely localised to within the boundaries of the respective projects.

700. It is anticipated that the types of vessels involved in operation and maintenance activities at the other projects will be similar to those identified for the Proposed Development, such as vessels used during routine inspections, repairs and replacement of equipment, major component replacement, painting or other coatings, removal of marine growth and replacement of access ladders. The number of vessel movements during the operation and maintenance phase is likely to represent a slight increase in the risk of collision for marine mammals over the existing levels of vessel traffic. There is also a potential that the noise emissions from vessels will deter animals from the potential zone of impact.

701. Additionally, as presented in paragraph 678 it can be expected that after more than ten years of construction activities taking place in the vicinity of Firth of Forth, marine mammals present in the area will demonstrate some degree of habituation to the presence of high number of vessels. It is anticipated that the risk of collision at respective projects would be minimised through the adoption of factored in measures such as vessel codes of conduct as standard good practice for offshore wind developments. Therefore, even with a cumulative increase in vessel traffic, the type of vessels involved and transit routes is unlikely to impose a greater risk to marine mammals.

702. The cumulative impact is predicted to be of local spatial extent, long term duration, intermittent and effects are of low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of receptor

703. The sensitivity of marine mammals to cumulative collision risk is as described for construction phase above in paragraph 691 *et seq.*

704. All marine mammals, which are IEFs of international value, are deemed to be of medium vulnerability and medium recoverability. The sensitivity of the receptor is therefore considered to be medium.

Significance of effect

705. Overall, the magnitude of the cumulative effect 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.

Further mitigation and residual effect

706. No secondary marine mammal mitigation is considered necessary as the predicted effect in the absence of further mitigation (beyond the designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore, the residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

CHANGES IN FISH AND SHELLFISH COMMUNITIES AFFECTING PREY AVAILABILITY

Tier 2

Construction phase

Magnitude of impact

707. The construction of the Proposed Development, together with the projects and plans identified in Table 10.54, may lead to changes in the prey resources available for marine mammals as a result of changes to the fish and shellfish community. Potential cumulative impacts on marine mammal prey species during the construction phase have been assessed in volume 2, chapter 9 using the appropriate maximum design scenarios for these receptors. These impacts include temporary subtidal habitat loss/disturbance, long-term subtidal habitat loss, injury and/or disturbance to fish and shellfish from underwater noise and vibration and increased SSC and associated sediment deposition.

708. The construction phases and/or operation and maintenance phases of Inch Cape Offshore Wind Farm, Neart na Gaoithe Offshore Wind Farm, Seagreen 1, Seagreen 1A Project, Seagreen 1A Export Cable Corridor, Eyemouth disposal site, Eastern Link 1 and Eastern Link 2 may lead to cumulative temporary subtidal habitat loss/disturbance. The total cumulative temporary subtidal habitat loss is 142,813,855 m^2 (=142.8 km^2), however this number is highly conservative as the temporal overlap in construction activities between projects will be small and habitat loss associated operation and maintenance will be spread over the entirety of the phase, and therefore there will only be a small area of temporary habitat loss happening at any one time. As such, the magnitude of the impact has been assessed as low. Most fish and shellfish receptors found within the fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and local to international importance and therefore sensitivity of the receptors was considered to be low to medium. Consequently, the cumulative effect of temporary habitat loss/disturbance was assessed as being of negligible to minor adverse significance.

709. The magnitude of long-term habitat loss caused by the presence of all structures on the seabed has been considered for the construction as well as operation and maintenance phases. The impacts have been assessed cumulatively with Inch Cape Offshore Wind Farm, Neart na Gaoithe Offshore Wind Farm, and Seagreen 1, Seagreen 1A Project, Seagreen 1A Export Cable Corridor and Eyemouth disposal site and may lead to long term subtidal habitat loss of up to 15,014,156 m^2 (=15.0 km^2). As the cumulative effect was predicted to be of local spatial extent, the magnitude has been assessed as low. Sensitivity of the fish and shellfish receptors was considered low to medium and the overall, cumulative effects were assessed as being of negligible to minor adverse significance.

710. The magnitude of impact on fish and shellfish receptors caused by the increase in SSC and associated deposition arising from the installation of wind turbines and OSPs/Offshore convertor station platform foundations, inter-array cables and offshore export cables during the construction phase has been assessed cumulatively with sea disposal of dredge material at the Eyemouth disposal site and installation of Inch Cape Offshore Wind Farm, Seagreen 1A Project, Eastern Link 1 and Eastern Link 2. Given that the magnitude of the cumulative effect has been determined ad low and sensitivity as low to medium, the cumulative effect of increased SSC and associated deposition was considered to be of negligible to minor adverse significance (see volume 2, chapter 9).

711. The potential for underwater noise and vibration during construction pile driving to result in injury and/or disturbance to fish and shellfish communities has been assessed cumulatively with Inch Cape Offshore Wind Farm and Seagreen 1A Project. Due to the application of soft start measures and small effect ranges, none of the projects predicted significant effects on fish and shellfish receptors. Given the limited duration of overlap in construction phases of the Proposed Development and aforementioned projects,

the magnitude of effect has been considered as low. As sensitivity of the fish and shellfish IEF is low to minor, the overall cumulative effects were considered to be of negligible to minor adverse significance. With respect to indirect effects on marine mammals, no additional cumulative effects other than those assessed for injury and disturbance to marine mammals as a result of elevated underwater noise during piling (see paragraph 115 *et seq.*) are predicted. This is because if prey are disturbed from an area as a result of underwater noise, it is assumed that marine mammals are likely to be disturbed from the same or greater area, and so any changes to the distribution of prey resources would not affect marine mammals as they would already be disturbed from the same (or larger) area.

712. The cumulative 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 indirectly. The magnitude is therefore considered to be low.

Sensitivity of receptor

713. The sensitivity of marine mammals to changes in fish and shellfish communities affecting prey availability is as described in section 10.11, paragraph 439 *et seq*.

714. In the outer Firth of Forth area, sandeels are key prey items for harbour porpoise (Santos *et al.,* 2004), minke whale (Robinson *et al.,* 2007) and grey seal (Sparling, 2012). The cumulative assessment in volume 2, chapter 9 predicted that with respect to sandeel, given the minor temporal overlap in construction activities, impacts associated with temporal subtidal habitat disturbance will not add substantially to the total footprint associated with the Proposed Development. Subsequently, with wider sandeel habitat available within the regional marine mammal study area, projects considered in the cumulative assessment are not anticipated to affect foraging opportunities for sensitive marine mammal receptors.

715. The assessment for fish and shellfish IEFs concluded that significant cumulative effects on fish and shellfish communities are not anticipated (see volume 2, chapter 9). Marine mammals are known to forage over wide areas and exploit a range of prey species and whilst there may be some potential for cumulative effects to fish and shellfish communities due to multiple activities from relevant projects these effects will, for the most part, be highly localised and short term and therefore marine mammals are likely to be able to compensate and move to alternative foraging grounds.

716. All marine mammals, which are IEFs of international value, are deemed to be of low vulnerability and high recoverability. The sensitivity of the receptor is therefore considered to be low.

Significance of effect

717. Overall, the magnitude of the cumulative effect is deemed to be low and the sensitivity of the receptor is considered to be low. Given the extent of available foraging area in the regional marine mammal study area, the cumulative effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Further mitigation and residual effect

718. No secondary marine mammal mitigation is considered necessary as the predicted effect in the absence of further mitigation (beyond the designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore, the residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

<u>Operation and maintenance phase</u>

Magnitude of impact

719. The operation and maintenance activities of the cumulative projects (Inch Cape Offshore Wind Farm, Neart na Gaoithe Offshore Wind Farm, Seagreen 1, Seagreen 1A Project, Seagreen 1A Export Cable Corridor, Eastern Link 1, Eastern Link 2 and Eyemouth disposal site) will overlap with the operation and maintenance phase of the Proposed Development and may lead to temporary subtidal habitat loss/disturbance of up to 32,277,197 m^2. Additionally, Offshore Wind Farms listed above will reach their decommissioning age during Proposed Development operation and maintenance phase. However, it is important to note that the maximum design scenario for habitat loss from the cumulative projects is precautionary, as operation and maintenance activities will occur intermittently throughout the lifetime of the Proposed Development and the temporal overlap with activities at other projects is unlikely. The magnitude of the effect on fish and shellfish IEFs was assessed as low and the sensitivity of the receptors ranged from low to medium with the majority of fish receptors deemed to be of low vulnerability and high recoverability. Consequently, the cumulative effects of temporary habitat loss/disturbance on fish and shellfish IEFs during the operation and maintenance phase was assessed as being of negligible to minor adverse significance.

720. Cumulative impacts could arise from EMFs due to the presence of subsea cabling during the operation and maintenance phases of the Proposed Development as well as Inch Cape Offshore Wind Farm, Neart na Gaoithe Offshore Wind Farm, Seagreen 1, Seagreen 1A Project, Seagreen 1A Export Cable Corridor, Eastern Link 1 and Eastern Link 2. A total length of up to 6,170 km of subsea cabling was estimated for all projects. As the effect of EMF was predicted to be of local spatial extent, cumulatively, the magnitude was assessed as low. Sensitivity of the fish and shellfish receptors was considered to be low to medium and the overall, cumulative effects will be of negligible to minor adverse significance.

721. Artificial structures introduced into areas of predominantly soft sediments has the potential to alter community composition and biodiversity. There is a potential for cumulative effects arising from colonisation due to the presence of Inch Cape Offshore Wind Farm, Neart na Gaoithe Offshore Wind Farm, Seagreen 1, Seagreen 1A Project, Seagreen 1A Export Cable Corridor, Eastern Link 1 and Eastern Link 2 with a maximum scenario of up to 17,513,271 m^2 of hard structures from wind turbines, OSPs/Offshore convertor station platforms, meteorological masts, of cable protection, and cable crossings. Given that the cumulative effect was predicted to be of local spatial extent, the magnitude was assessed as low. Sensitivity of the fish and shellfish receptors was considered to be low and the overall, cumulative effects will be of negligible to minor adverse significance. This is likely to be a conservative prediction as there is some evidence (although with uncertainties) that marine mammal populations are likely to benefit from introduction of hard substrates and associated fauna.

722. The cumulative impact is predicted to be of local spatial extent, long term duration, intermittent/continuous and the effect is of high reversibility. It is predicted that the impact will affect the receptor indirectly. The magnitude is therefore considered to be low.

Sensitivity of receptor

723. The sensitivity of marine mammals to cumulative changes in fish and shellfish communities affecting prey availability is as described in section 10.11, paragraph 713 *et seq.*

724. All marine mammals, which are IEFs of international value, are deemed to be of low vulnerability and high recoverability. The sensitivity of the receptor is therefore considered to be low.

Significance of effect

725. Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. Given the extent of available foraging area in the regional marine mammal study

area, the cumulative effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Further mitigation and residual effect

726. No secondary marine mammal mitigation is considered necessary as the predicted effect in the absence of further mitigation (beyond the designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore, the residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

Tier 3

Construction phase

Magnitude of impact

727. The construction of the Proposed Development, together with the projects and plans identified in Table 10.54, may lead to changes in the prey resources available for marine mammals as a result of changes to the fish and shellfish community. Potential cumulative impacts on marine mammal prey species during the construction phase have been assessed in volume 2, chapter 9 using the appropriate maximum design scenarios for these receptors.

728. The only Tier 3 project which has been identified in the CEA with the potential to result in cumulative temporary habitat loss with the Proposed Development is the Cambois connection. There is, however, currently no detailed information on the impact that these projects will have on fish and shellfish ecology IEFs and therefore it is not possible to undertake full, quantitative assessment for this impact.

729. The temporary subtidal habitat loss associated with Cambois connection assumes that 680 km of offshore export cables will be installed in trenches with a width of temporary ZoI of 25 m. The majority of this disturbance will not spatially overlap with the Proposed Development. Consequently, the cumulative effect of temporary habitat loss/disturbance for Tier 3 projects in volume 2, chapter 9 was assessed as being of minor adverse significance.

730. The predicted extent of long term habitat loss associated with this the Cambois connection Scoping Report (SSER, 2022e) is assumed to come from the installation of 102 km (15% of the total cable length) of cable protection with a width of 3 m in the form of rock/mattress protection.

731. The magnitude of impact on fish and shellfish receptors caused by the increase in SSC and associated deposition arising from the Cambois connection cable installation has been assessed as low (volume 2, chapter 9). The cumulative effect of increased SSC and associated deposition for Proposed Development and Tier 3 projects was considered to be of negligible to minor adverse significance.

732. The cumulative 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 indirectly. The magnitude is therefore considered to be low.

Sensitivity of receptor

733. The sensitivity of marine mammals to changes in fish and shellfish communities affecting prey availability is as described for Tier 2 projects in paragraph 713 *et seq*.

734. All marine mammals, which are IEFs of international value, are deemed to be of low vulnerability and high recoverability. The sensitivity of the receptor is therefore considered to be low.

Significance of effect

735. Overall, the magnitude of the cumulative effect is deemed to be low and the sensitivity of the receptor is considered to be low. Given the extent of available foraging area in the regional marine mammal study area, the cumulative effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Further mitigation and residual effect

736. No secondary marine mammal mitigation is considered necessary as the predicted effect in the absence of further mitigation (beyond the designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore, the residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

Operation and maintenance phase

Magnitude of impact

737. Cumulative impacts could arise from EMFs due to the presence of subsea cabling during the operation and maintenance phases of the Cambois connection. This project includes up to 680 km of cable therefore combining this with tier 2 projects and the Proposed Development would lead to a cumulative length of 5,568 km. The cumulative effect on fish and shellfish IEFs was predicted to be of negligible to minor adverse significance (volume 2, chapter 9).

738. Artificial structures introduced into areas of predominantly soft sediments has the potential to alter community composition and biodiversity. The Cambois connection has the potential to create 306,000 m^2 of new hard habitat associated with rock/mattress cable protection which represents protection covering 15% the total length the four offshore export cables (volume 2, chapter 9). The cable protection represents a change in seabed type, however as the cable protection does not extend into the water column, the opportunity for colonisation by some species is reduced.

739. The cumulative impact is predicted to be of local spatial extent, long term duration, intermittent/continuous and the effect is of high reversibility. It is predicted that the impact will affect the receptor indirectly. The magnitude is therefore, considered to be low.

Sensitivity of receptor

740. The sensitivity of marine mammals to cumulative changes in fish and shellfish communities affecting prey availability is as described in section 10.11, paragraph 713 *et seq.*

741. All marine mammals, which are IEFs of international value, are deemed to be of low vulnerability and high recoverability. The sensitivity of the receptor is therefore considered to be low.

Significance of effect

742. Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. Given the extent of available foraging area in the regional marine mammal study area, the cumulative effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Further mitigation and residual effect

743. No secondary marine mammal mitigation is considered necessary as the predicted effect in the absence of further mitigation (beyond the designed in measures outlined in section 10.10) is not significant in EIA terms. Therefore, the residual effect is considered to be of **minor** adverse significance, which is not significant in EIA terms.

10.12.3. PROPOSED MONITORING

744. No residual significant effect on marine mammals has been identified in the cumulative assessment provided above (paragraph 476 *et seq.)*. No monitoring as a result of the CEA is proposed.

10.13. TRANSBOUNDARY EFFECTS

745. A screening of transboundary impacts has been carried out and has identified that there were no likely significant transboundary effects with regard to marine mammals from the Proposed Development upon the interests of European Economic Area (EEA) States. This was due to the relatively limited scale of effects (regional) and appropriately assessed secondary mitigation which would prevent effects occurring in other countries.

10.14. INTER-RELATED EFFECTS (AND ECOSYSTEM ASSESSMENT)

746. A description of the likely inter-related effects arising from the Proposed Development on marine mammals is provided in volume 3, appendix 18.1 of the Offshore EIA Report.

747. For marine mammals, the following potential impacts have been considered within the inter-related assessment:

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

748. Table 10.65 lists the inter-related effects that are predicted to arise during the construction, operation and maintenance, and decommissioning phases of the Proposed Development (project lifetime effects). Table 10.65 also lists the inter-related effects where stressors may combine to lead to greater effects on marine mammal receptors (receptor-led effects).

Table 10.65: Summary of Likely Significant Inter-Related Effects for Marine Mammals from Individual Effects Occurring Across the Construction, Operation and Maintenance and Decommissioning Phases of the Proposed Development and from Multiple Effects Interacting Across all Phases (Receptor-led Effects)

Description of Impact	Phase[15] C	O	D	Maximum Design Scenario
Injury and disturbance from elevated underwater noise during piling (fixed foundations).	✓	×	×	Elevated subsea noise during piling (construction phase only) could interact with other sources of subsea noise associated with the Proposed Development. This could contribute to an increase in the soundscape which in turn could affect marine mammals. However, the subsea noise from piling is likely to reach over a greater extent compared to other noise-producing activities and therefore during this time it is unlikely that it would act additively with other noise-producing activities occurring at the same time as piling noise is likely mask other noise sources. Piling noise, although occurring during construction phase only, would contribute to the overall duration of noise impacts throughout all phases of the Proposed Development.
Injury and disturbance to marine mammals from elevated underwater noise during site investigation surveys.	✓	✓	×	Elevated subsea noise during site investigation surveys could interact with other sources of subsea noise over the construction and operation and maintenance phases of the Proposed Development and contribute to an increase in the soundscape which in turn would affect marine mammals. This impact will occur during short term events. Additive effects are possible as more animals may be affected at any one time and/or the duration of elevated subsea noise from all activities could be extended.
Injury and disturbance to marine mammals from elevated underwater noise during UXO clearance.	✓	×	×	Elevated subsea noise during UXO clearance (pre-construction phase) could interact with other sources of subsea noise. This could contribute to an increase in the soundscape which in turn could affect marine mammals. The proposed approach to UXO clearance is clearance using low order techniques which would result in localised disturbance (TTS fleeing) out to ~3 km. Additional disturbance is possible due to use of ADDs and soft start charges as part of the secondary mitigation approach to reduce the risk of injury. Additive effects are possible as more animals may be affected at any one time, although noting that for each UXO clearance the duration – including secondary mitigation - will be very short (approximately 1.5 hour). However, temporally UXO clearance could add to the overall duration of elevated subsea noise from all other activities during pre-construction and will contribution to the overall duration of noise impacts throughout all phases of the Proposed Development.
Injury and disturbance to marine mammals from elevated underwater noise due to vessel use and other activities.	✓	✓	✓	Elevated subsea noise during vessel use and other non-piling construction activities could interact with other impacts that produce subsea noise and contribute to an increase in the soundscape which in turn would affect marine mammals. Vessels will be used throughout all stages of the Proposed Development and could cause additional disturbance to marine mammals. Other construction activities include drilling (foundation installation) and cable trenching/laying and could also lead to disturbance effects. Effects are likely to be localised for non-piling construction activities and during vessel movements (e.g. out to maximum of 4.3 km), however, temporally these effects could occur over all phases of the Proposed Development.
Increased risk of injury of marine mammals due to collision with vessels.	✓	✓	✓	Over the lifetime of the Proposed Development there will be an ongoing risk of collision associated with vessel activity throughout all phases. If injury to marine mammals from collisions did occur this could lead to losses of individuals and potentially have an effect at the population-level, particularly for species with smaller populations (i.e. MUs), such as bottlenose dolphin and harbour seal. However, with designed-in measures the risk of collisions will be reduced through adopting good practice code of conduct for vessel operators (Table 10.21) and therefore the risks will be reduced. In addition, to some extent the noise 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.
Changes in fish and shellfish communities affecting prey availability.	✓	✓	✓	Fish and shellfish communities may be affected variously through all phases of the Proposed Development 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. For all potential impacts and at all phases of the Proposed Development the effects were, however, predicted to be very localised and 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.

Receptor led effects

A number of the impacts identified could potentially interact to cause an additive/synergistic/antagonistic effects on marine mammal receptors. There are three key stressors identified for marine mammals:

- stressor 1: injury or disturbance from elevated subsea noise;
- stressor 2: injury due to collisions with vessels; and
- stressor 3: changes in prey communities.

Various activities described from the impacts considered above could interact to contribute to each of these stressors (i.e. there are a number of activities that lead to elevations in subsea noise) and in additional each stressor could interact to contribute to a different, or greater effect on marine mammal receptors than when the effects are considered in isolation.

[15] C = Construction, O = Operation and maintenance, D = Decommissioning

Stressor 1. Injury or disturbance from elevated subsea noise:

749. During the pre-construction phase activities resulting in elevated subsea noise include UXO clearance, site investigation surveys and vessel movements. These activities are likely 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 each activity. For example, UXO clearance would result in no more than 14 single events with disturbance occurring mainly during secondary 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 (due to an accidental a high order detonation). Site investigation surveys are likely to occur over a total duration of up to three months whilst disturbance during vessel activity will occur intermittently throughout this phase with timings linked to the pre-construction activities.

750. During the construction phase, activities resulting in elevated subsea noise include pile-driving, other construction activities and vessel movements. Since injury to marine mammals will be mitigated through an MMMP, the key focus is on disturbance effects. Disturbance could occur intermittently on a total of 372 days (within a 52-month piling period) during the construction phase of 96 months. Other construction activities (e.g. drilling and cable laying) and vessel movements would occur intermittently within the 96 months construction phase. When piling occurs the disturbance effects are likely to be greater than for any of the other activities contributing to elevated subsea noise so there is less likely to be an additive or synergistic effect during piling. There may, however, be an additive effect spatially where two or more noise-producing activities occur in different parts of the Proposed Development area, or temporally due to ongoing disturbance from activities throughout the construction phase (e.g. if they occur consecutively).

751. Activities resulting in elevated subsea noise during the operation and maintenance phase include vessel activity and geophysical surveys. These activities are likely 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 each activity and there may be an additive effect spatially where two or more noise-producing activities occur in different parts of the Proposed Development area, or temporally due to ongoing disturbance from activities throughout the operation and maintenance phase (e.g. if they occur consecutively).

752. Vessel movements associated with decommissioning activities will result in elevated subsea noise 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 of the Proposed Development area, or temporally due to ongoing disturbance throughout the decommissioning phase.

753. Marine mammal receptors will experience ongoing disturbance due to elevations in subsea noise from different sources at all phases of the Proposed Development. The sensitivity of key species will be linked to their ability to tolerate the stressor such that their ability to function normally (forage, reproduce, communicate, avoid predators, etc) is not impeded. The assessment – which adopted a highly precautionary approach - has demonstrated that for all impacts, considered in isolation, the residual effects will not be significant (after implementation of secondary mitigation) as either the spatial scale is very localised or where larger scale effects do occur (i.e. during piling) these will be highly reversible with animals returning to baseline levels rapidly. After implementation of secondary mitigation there is, however, potentially a small residual number of harbour porpoise that could experience auditory injury during UXO clearance activities and would represent only a very small proportion of the NS MU population. There are, however, uncertainties as to how all activities interact to contribute to an additive effect from subsea noise as a stressor. In a Before-After-Control-Impact design (BACI) study looking at foraging activity of harbour porpoise between baseline periods and different construction phases of the Beatrice and Moray East Offshore Wind Farms, Benhemma-Le-Gall *et al.*, (2021) found an eight to 17% decline in porpoise occurrence in the impacted area during pile-driving and other construction activities with probability of detection negatively related to levels of vessel intensity and background noise.

754. To some extent it is anticipated that animals will acclimatise to or compensate for such increases in subsea noise. For example, Graham *et al*. (2019) demonstrated acclimatisation by showing that the proportional response of harbour porpoise to piling noise decreased over the piling phase; from the first pile to the last pile the proportion of animals disturbed at a received level of 160 dB re 1 µPa decreased from 91.5% to 49.2%. Kastelein *et al.* (2019b) 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 within out any detriment to their health. In the Moray Firth, harbour porpoises displaced during wind farm construction of Beatrice and Moray East Offshore Wind Farms increased their buzzing activity, potentially compensating for lost foraging opportunities (although there may be an additional energetic cost from the fleeing and distance travelled to compensate for) (Benhemma-Le Gall *et al.,* 2021).

Stressor 2. Injury due to collisions with vessels:

755. This stressor is associated with vessel movement, the impact of which was assessed from different types of vessels and at different phases of the Proposed Development. As described in paragraph 403 *et seq.*, over the lifetime of the Proposed Development there will be a longer term risk to marine mammal receptors however, with designed-in measures in place the potential of experiencing injury is likely to be reduced and therefore it is not anticipated that an additive effect will occur. In addition, as mentioned in Table 10.65 to some extent the noise 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. Furthermore, marine mammals in this area are already accustomed to high level of vessel activity. Buckstaff (2004) demonstrated that bottlenose dolphins increased their rate of whistle production at the onset of a vessel approach and then decreased production during and after it had passed. Increased whistle production may be a tactic to reduce signal degradation to ensure that information is being communicated in noisy environment, but it also demonstrates that animals are aware of approaching vessel from a distance. Findings of this study also corroborated previous research of Nowacek *et al*. (2001) who found that bottlenose dolphins swim in tighter groups during vessel approaches and that if the vessel is loud enough to be detected by an animal, the likelihood of collision decreases.

Stressor 3: Changes in prey communities:

756. The assessment considers overall effect on fish and shellfish communities from multiple stressors (i.e. habitat loss, SSC, subsea noise, EMF etc) and therefore, in this respect, has taken an ecosystem-based approach. For some, stressors (e.g. subsea noise the effects on fish and shellfish) will be over the same timescales as marine mammals whilst for others, such as temporary habitat loss, timescales may be different (e.g. low mobility or sessile species may recover slowly). The assessment of effects, however, demonstrated that due to high mobility of marine mammals and ability to exploit different prey species, and small scale of potential changes in context of wider available habitat, the changes to fish and shellfish communities are unlikely to have an effect even from multiple stressors.

Multiple stressors: inter-related effect of all stressors

757. Arrigo *et al*. (2020) studied synergistic interactions among growing stressors to an Arctic ecosystem and found that synergistic interactions amplify adverse stressor effects and the impact of synergy is predicted

to increase with the magnitude of stressors. Findings of this study suggest that although large organisms at higher trophic levels, such as marine mammals, tend to be generally negatively impacted by increasing stressor interaction strength, the variability in the response to stressor is small and therefore reduces the probability of population collapse.

758. For stressor 1 (increase in subsea noise), the potential for marine mammals to forage in different habitats and to compensate for reduced foraging time was discussed. The ability of displaced animals will therefore 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). Namely, due to the importance of the areas for survival, (i.e. high resource availability), animals may be highly motivated to remain in an area despite adverse impacts (Rolland *et al.,* 2012). Thus, the inter-related effects of subsea noise and changes in fish and shellfish prey resources needs to be considered. Impacts on fish and shellfish prey resources (stressor 2) 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 the Proposed Development area. Within the boundaries of the Proposed Development there may, however, be short term inter-related effects of noise disturbance and reduced fish and shellfish prey resources. For example, for animals remaining in proximity to the Proposed Development a disruption in foraging may not be easy to compensate for where there are shifts in the species composition or localised reductions of fish and shellfish communities. Gordon *et al.* (2013) suggested that it might be possible that damaged or disoriented prey could attract marine mammals to an area of impact, providing short term feeding opportunities but increasing levels of exposure, however, there have as yet been no attempts to investigate such indirect effects on marine mammals.

759. The assessment has described only potential adverse effects but there is also potential for some benefitial effects on marine mammal receptors. The introduction of hard substrates in offshore wind farms can lead to the establishment of new species and new fauna communities which 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) 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. Lindeboom *et al*. (2011) studied the ecological effects of the Offshore Wind Farm Egmond aan Zee and reported that even though the fish community was highly dynamic in time and space and only minor effects upon fish assemblages were observed during the operation and maintenance phase, some fish species, such as cod, positively benefited from the 'shelter' within the wind farm due to reduced fishing activity and the new hard substratum with associated fauna. Increased echolocation activity of harbour porpoise within the wind farm may be correlated with presence of additional food sources, suggesting that more harbour porpoises were found within the wind farm area compared to the reference areas due to increased food availability (Lindeboom *et al.,* 2011).

760. Inter-related effects between subsea noise and collision risk have been discussed previously 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 noise) while the vessels are approaching (Muto *et al.* 2018) and/or become habituated to vessel noise, not moving away from the vessel (McWhinnie *et al.,* 2018), which would result in a synergistic interaction (Weilgart, 2011). Subsequently, the outcome will depend on the degree of habituation and a number of acoustical properties that allow an approaching vessel to be detected by a marine mammal species (Gerstein *et al.,* 2005). However, with designed-in measures in place it is likely that any risk of injury from collision with vessels will be negligible.

761. Evidence for the potential long-term effects of wind farms on marine mammals, related to all potential stressors, comes from monitoring programmes comparing baseline levels of abundance to construction and post-construction (operation and maintenance) phases. It is not common to prescribe impact monitoring studies with regard to marine mammals as a part of licence conditions in the UK and therefore data is sparse. A synopsis of the available evidence is provided in paragraph 762 *et seq*.

762. At Scroby Sands Offshore Wind Farm, off the coast of Norfolk, aerial survey haul-out counts were conducted before, during and after the construction phases in order to monitor harbour and grey seal counts at haul-out site, located less than two kilometres away from the offshore wind farm array (Skeate and Perrow 2008; Skeate *et al.,* 2012). Studies reported a decline in harbour seal numbers 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). Regional changes in patterns of haul-out use by harbour seals in the Wash coincided with the construction of the Scroby Sands Offshore Wind Farm, however, such changes in harbour seal number could have been part of wider regional dynamics (Verfuss *et al*., 2016).

763. As a part of marine mammal monitoring at Robin Rigg Offshore Wind Farm, boat-based surveys for cetaceans were conducted before, during, and after construction (Walls *et al*., 2013). Data suggested that harbour porpoise were displaced from the wind farm site during the construction period 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 (Verfuss *et al*., 2016).

764. With the expansion of offshore wind farms, post-construction monitoring programmes are being executed at various developments in Europe. A study on short-term effects of the construction of wind turbines on harbour porpoises at Horns Rev Offshore Wind Farm showed a decrease in porpoise acoustic activity within the wind farm at the onset of piling operations and subsequent recovery to higher levels a few hours after each piling operation was completed (Tougaard, *et al.,* 2003). Another study at Horns Rev has shown that over the entire construction phase there was no significant change in the abundance of harbour porpoise in the wind farm area compared to reference areas (Teilmann *et al*., 2008). 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. At Nysted Offshore Wind Farm, initially during construction and the first two years of operation there were lower acoustic detections of harbour porpoises in the wind farm area with recovery starting to occur within two years after the end of construction suggesting that animals were gradually habituating and returning to the wind farm area (Teilman *et al.,* 2008).

765. Simulations of the response of harbour porpoise to wind farm construction undertaken by Nabe-Nielsen *et al*. (2011) suggested that wind farms already existing off Danish coast do not have impact on 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. Similarly, various studies investigated possible interactions between seals and Danish offshore wind farms (Nysted Wind Farm, 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 (Edren *et al*., 2010; McConnell *et al*., 2012).

766. These examples of monitoring studies suggest that, despite the potential effects from multiple stressors associated with offshore wind farms, marine mammals can quickly recover and return to the impacted area.

10.15. SUMMARY OF IMPACTS, MITIGATION MEASURES, LIKELY SIGNIFICANT EFFECTS AND MONITORING

767. Information on marine mammals within the regional marine mammal study area and the Proposed Development marine mammal study area was collected through desktop review, site-specific surveys, and consultation. This information is summarised in Table 10.9 to Table 10.11. The baseline characterisation used to inform the assessment of the marine mammal IEFs present within the vicinity of the Proposed Development marine mammal study area is presented in volume 3, appendix 10.2 and summarised in Table 10.12.

768. Table 10.66 presents a summary of the potential impacts, secondary mitigation measures and the conclusion of likely significant effects on marine mammals in EIA terms. The impacts assessed include: injury and disturbance from elevated underwater noise during piling (fixed foundations), injury and disturbance to marine mammals from elevated underwater noise during site investigation surveys, injury and disturbance to marine mammals from elevated underwater noise during UXO clearance, injury and disturbance to marine mammals from elevated underwater noise due to vessel use and other activities, increased risk of injury of marine mammals due to collision with vessels and changes in fish and shellfish communities affecting prey availability. Overall, it is concluded that for all impacts, considered in isolation, the residual effects will not be any greater than minor (after implementation of secondary mitigation) during the construction, operation and maintenance or decommissioning phases and are not significant in EIA terms.

769. Table 10.67 presents a summary of the potential cumulative effects, secondary mitigation measures and the assessment of likely significant effects on marine mammals in EIA terms. The cumulative effects assessed include: injury and disturbance from elevated underwater noise during piling (fixed foundations), injury and disturbance to marine mammals from elevated underwater noise during site investigation surveys, injury and disturbance to marine mammals from elevated underwater noise during UXO clearance, injury and disturbance to marine mammals from elevated underwater noise due to vessel use and other activities, increased risk of injury of marine mammals due to collision with vessels and changes in fish and shellfish communities affecting prey availability. Overall, it is concluded that there will be minor significant cumulative effects from the Proposed Development alongside other projects/plans.

770. As noted in section 10.7.2, an assessment of the likely significant effects in EIA terms on the relevant features of sites that comprise part of the UK National Site Network or Natura 2000 network (i.e. European Sites) has been made in this chapter. The assessment of the potential impacts on the site itself are deferred to the RIAA (SSER, 2022d) for the Proposed Development. The RIAA concluded that no adverse effect on integrity was predicted to occur on any European sites designated for marine mammals, specifically:

- Berwickshire and North Northumberland Coast SAC
- Isle of May SAC
- Firth of Tay and Eden Estuary SAC
- Moray Firth SAC
- Southern North Sea SAC

771. An assessment on the individual qualifying interest features of the sites relevant to marine mammals has also been undertaken in this chapter.

772. No likely significant transboundary effects have been identified in regard to effects of the Proposed Development.

773. As per the Scoping opinion for 2020 Berwick Bank (Table 10.9), given the distance of seal haul-out sites from construction works at landfall or activities associated with cable installation, these works are unlikely to affect any individuals hauled out on land. Therefore, the effects on intertidal ecology have been screened out from marine mammal assessment. No likely significant transboundary effects have been identified in regard to effects of the Proposed Development.

Table 10.66: Summary of Likely Significant Environmental Effects, Secondary Mitigation and Monitoring

Description of Impact	Phase C	Phase O	Phase D	Species	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Secondary Mitigation	Residual Effect	Proposed Monitoring
Injury and disturbance from elevated underwater noise during piling (fixed foundations).	✓			Harbour porpoise	Low (injury/disturbance)	High (Injury)/medium (disturbance)	Minor (injury/disturbance)	ADD deployment	Minor (injury/disturbance)	Noise monitoring to be agreed post-consent
				Bottlenose dolphin	Low (injury/disturbance)	High (Injury)/medium (disturbance)	Minor (injury/disturbance)		Minor (injury/disturbance)	
				White-beaked dolphin	Low (injury/disturbance)	High (Injury)/medium (disturbance)	Minor (injury/disturbance)		Minor (injury/disturbance)	
				Minke whale	Medium (injury)/low (disturbance)	High (Injury)/medium (disturbance)	Moderate (injury)/minor (disturbance)		Minor (injury/disturbance)	
				Harbour seal	Low (injury)/low (disturbance)	High (Injury)/medium (disturbance)	Minor (injury/disturbance)		Minor (injury/disturbance)	
				Grey Seal	Low (injury)/low (disturbance)	High (Injury)/medium (disturbance)	Minor (injury/disturbance)		Minor (injury/disturbance)	
		✗		N/A	N/A	N/A	N/A	N/A	N/A	N/A
			✗	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Injury and disturbance to marine mammals from elevated underwater noise during site investigation surveys.	✓			All receptors	Low (injury/disturbance)	High (injury)/medium (disturbance)	Minor (injury/disturbance)	None	Minor	N/A
		✓		All receptors	Low (injury/disturbance)	High (injury)/medium (disturbance)	Minor (injury/disturbance)	None	Minor	N/A
			✗	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Injury and disturbance to marine mammals from elevated underwater noise during UXO clearance.	✓			Harbour porpoise	Medium (injury)/low (TTS)	High (Injury)/low (TTS)	Moderate (injury)/minor (TTS)	Implementation of soft start charges and ADD deployment	Minor (injury/TTS)	Noise monitoring to be agreed post-consent
				Bottlenose dolphin	Low (injury/TTS)	High (Injury)/low (TTS)	Minor (injury/TTS)		Minor (injury/TTS)	
				White-beaked dolphin	Low (injury/TTS)	High (Injury)/low (TTS)	Minor (injury/TTS)		Minor (injury/TTS)	
				Minke whale	Low (injury/TTS)	High (Injury)/low (TTS)	Minor (injury/TTS)		Minor (injury/TTS)	
				Harbour seal	Low (injury/TTS)	High (Injury)/low (TTS)	Minor (injury/TTS)		Minor (injury/TTS)	
				Grey Seal	Medium (injury)/low (TTS)	High (Injury)/low (TTS)	Moderate (injury)/minor (TTS)		Minor (injury/TTS)	
		✗			N/A	N/A	N/A	N/A	N/A	N/A
			✗		N/A	N/A	N/A	N/A	N/A	N/A
Injury and disturbance to marine mammals from elevated underwater noise due to vessel use and other activities.	✓			All receptors	Low (injury/disturbance)	High (injury)/medium (disturbance)	Minor (injury/disturbance)	None	Minor (injury/disturbance)	N/A
		✓		All receptors	Low (injury/disturbance)	High (injury)/medium (disturbance)	Minor (injury/disturbance)	None	Minor (injury/disturbance)	N/A
			✓	All receptors	Low (injury/disturbance)	High (injury)/medium (disturbance)	Minor (injury/disturbance)	None	Minor (injury/disturbance)	N/A
Increased risk of injury of marine mammals due to collision with	✓			All receptors	Low	Medium	Minor	None	Minor	N/A
		✓		All receptors	Low	Medium	Minor	None	Minor	N/A
			✓	All receptors	Low	Medium	Minor	None	Minor	N/A

Description of Impact	Phase C	Phase O	Phase D	Species	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Secondary Mitigation	Residual Effect	Proposed Monitoring
vessels.										
Changes in fish and shellfish communities affecting prey availability.	✓			All receptors	Low	Low	Minor	None	N/A	N/A
		✓		All receptors	Low	Low	Minor	None	N/A	N/A
			✓	All receptors	Low	Low	Minor	None	N/A	N/A

Table 10.67: Summary of Likely Significant Cumulative Environment Effects, Secondary Mitigation and Monitoring

Description of Impact	Phase C	Phase O	Phase D	Species	Cumulative Effects Assessment Tier	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Secondary Mitigation	Residual Effect	Proposed Monitoring
Injury and disturbance from elevated underwater noise during piling (fixed foundations).	✓			Harbour porpoise	Tier 2	Low (disturbance)	Medium (disturbance)	Minor (disturbance)	As for Proposed Development alone – use of ADD	Minor	N/A
				Bottlenose dolphin		Low (disturbance)	Medium (disturbance)	Minor (disturbance)		Minor	
				White-beaked dolphin		Low (disturbance)	Medium (disturbance)	Minor (disturbance)		Minor	
				Minke whale		Low (disturbance)	Medium (disturbance)	Minor (disturbance)		Minor	
				Harbour seal		Low (disturbance)	Medium (disturbance)	Minor (disturbance)		Minor	
				Grey Seal		Low (disturbance)	Medium (disturbance)	Minor (disturbance)		Minor	
		✗		N/A		N/A	N/A	N/A	N/A	N/A	N/A
			✗	N/A		N/A	N/A	N/A	N/A	N/A	N/A
Injury and disturbance to marine mammals from elevated underwater noise during site investigation surveys.	✓			All receptors	Tier 2	Low (disturbance)	Medium (disturbance)	Minor (disturbance)	None	Minor	N/A
		✓		All receptors		Low (disturbance)	Medium (disturbance)	Minor (disturbance)	None	Minor	N/A
			✗	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Injury and disturbance to marine mammals from elevated underwater noise during UXO clearance.	✓			All receptors	Tier 2	Low (injury)/medium (TTS)	High (Injury)/low (TTS)	Minor (injury/TTS)	As for Proposed Development alone – soft start charges and use of ADD	Minor (injury/TTS)	N/A
		✗		N/A		N/A	N/A	N/A	N/A	N/A	N/A
			✗	N/A		N/A	N/A	N/A	N/A	N/A	N/A
Injury and disturbance to marine mammals from elevated underwater noise due to vessel use and other activities.	✓			All receptors	Tier 2	Low	Medium	Minor	None	Minor	N/A
		✓		All receptors		Low	Medium	Minor	None	Minor	
			✓	All receptors		N/A	N/A	N/A	N/A	N/A	N/A
Injury and disturbance to marine mammals from elevated underwater noise due to vessel use and other activities.	✓			All receptors	Tier 3	Low	Medium	Minor	None	Minor	N/A
		✓		All receptors		Low	Medium	Minor	None	Minor	
			✓	All receptors		N/A	N/A	N/A	N/A	N/A	N/A
Increased risk of injury of marine mammals due to collision with vessels.	✓			All receptors	Tier 2	Low	Medium	Minor	None	Minor	N/A
		✓		All receptors		Low	Medium	Minor	None	Minor	
			✓	All receptors		N/A	N/A	N/A	N/A	N/A	N/A
Changes in fish and shellfish communities affecting prey availability.	✓			All receptors	Tier 2	Low	Low	Minor	None	Minor	N/A
		✓		All receptors		Low	Low	Minor	None	Minor	
			✓	All receptors		N/A	N/A	N/A	N/A	N/A	N/A

10.16. REFERENCES

Aarts, G., Brasseur, S. and Kirkwood, R. (2018). *Behavioural response of grey seals to pile-driving*. (No. C006/18). Wageningen Marine Research.

AECOM. (2022a). Scotland England Green Link 1 / Eastern Link 1 - Marine Scheme. Environmental Appraisal Report. Volume 2. Chapter 10 - Marine Mammals.

AECOM. (2022b). Eastern Green Link 2 - Marine Scheme. Environmental Appraisal Report. Volume 2. Chapter 10 - Marine Mammals.

Albouy, C., Delattre, V., Donati, G., Frolicher, T. L., Albouy-Boyer, S., Rufino, M., Pellissier, L., Mouillot, D. and Leprieur, F. (2020). *Global vulnerability of marine mammals to global warming*. Sci Rep 10, 548.

Andersson, M. H., Berggren, B., Wilhelmsson, D., and Öhman, M. C. (2009). *Epibenthic Colonization of Concrete and Steel Pilings in a Cold-Temperate Embayment: A Field Experiment.* Helgoland Marine Research, 63, pp. 249–260.

Anderson, P.A., Berzins, I.K., Fogarty, F., Hamlin, H.J. and Guillette, L.J. (2011). *Sound, stress, and seahorses: the consequences of a noisy environment to animal health.* Aquaculture, 311, 129–138. Anderwald, P., Brandecker, A., Coleman, M., Collins, C., Denniston, H., Haberlin, M.D., O'Donovan, M., Pinfield, R., Visser, F. and Walshe, L. (2013). *Displacement responses of a mysticete, an odontocete, and a phocid seal to construction-related vessel traffic.* Endang Species Res. ol. 21, 231–240.

Anderwald, P., Evans, P.G., Dyer, R., Dale, A.C., Wright, P.J., and Hoelzel, A.R. (2012). *Spatial scale and environmental determinants in minke whale habitat use and foraging*. Marine Ecology Progress Series, 450, 259-274.

Anderwald, P., Brandecker, A., Coleman, M., Collins, C., Denniston, H., Haberlin, M.D., O'Donovan, M., Pinfield, R., Visser, F. and Walshe, L. (2013). *Displacement responses of a mysticete, an odontocete, and a phocid seal to construction-related vessel traffic.* Endang Species Res. ol. 21: 231–240, 2013.

Arrigo, K.R., van Dijken, G.L., Cameron, M.A., van der Griend, J., Wedding, L. M., Hazen, L., Leape, J., Leonard, G., Merkl, A., Micheli, F., Millis, M. M., Monismith, S., Ouellette, N. T., Zivian, A., Levi, M. and Bailey, R. M. (2020). *Synergistic interactions among growing stressors increase risk to an Arctic ecosystem*. Nat Commun 11, 6255.

Arso Civil, M., Quick, N. J., Cheney, B., Pirotta, E., Thompson, P. M. and Hammond, P. S. (2019). *Changing distribution of the east coast of Scotland bottlenose dolphin population and the challenges of area-based management.* Aquatic Conservation: Marine and Freshwater Ecosystems, 29(S1), 178–196. Available at: https://doi.org/10.1002/aqc.3102. Accessed on: 2 March 2022.

Arso Civil, M., Quick, N., Mews, S., Hague, E. Cheney, B.J., Thompson, P.M. and Hammond, P.S. (2021). *Improving understanding of bottlenose dolphin movements along the east coast of Scotland.* Final report. Report number SMRUC-VAT-2020-10 provided to European Offshore Wind Deployment Centre (EOWDC), March 2021 (unpublished).

Au, W.W.L., Floyd, R.W., Penner, R.H., and Murchison, A.E. (1974). *Measurement of echolocation signals of the Atlantic bottlenose dolphin,* Tursiops truncatus *Montagu, in open waters*. Journal of the Acoustical Society of America, 56, 1280– 1290.

Authier, M., Peltier, H., Dore´mus, G., Dabin, W., Van Canneyt, O. and Ridoux, V. (2014). *How much are stranding records affected by variation in reporting rates? A case study of small delphinids in the Bay of Biscay*, Biodiversity Conservation, 23, 2591–2612.

Avila, I. C., Kaschner, K. and Dormann, C. F. (2018). *Current global risks to marine mammals: Taking stock of the threats*, Biological Conservation 221: 44-58.

Bailey, H. and Thompson, P. (2010). *Effect of oceanographic features on fine-scale foraging movements of bottlenose dolphins*. Marine Ecology Progress Series, 418, pp.223-233.

Bailey, H., Senior, B., Simmons, D., Rusin, J., Picken, G. and Thompson, P. M. (2010). *Assessing underwater noise levels during pile-driving at an offshore windfarm and its potential effects on marine mammals*. Marine pollution bulletin, 60(6), 888-897.

Beatrice. (2018). Piling Strategy Implementation Report.

Bejder, L., Samuels, A.M.Y., Whitehead, H.A.L., Gales, N., Mann, J., Connor, R., Heithaus, M., Watson-Capps, J.A., Flaherty, C. and Krützen, M. (2006). *Decline in relative abundance of bottlenose dolphins exposed to long-term disturbance*. Conservation Biology, 20(6), pp.1791-1798.

Benhemma-Le-Gall, A., Graham, I. M., Merchant, N. D. and Thompson, P. M. (2021). *Broad-Scale Responses of Harbor Porpoises to Pile-Driving and Vessel Activities During Offshore Windfarm Construction*. Front. Mar. Sci.

Bennett, K.A., Robinson, K.J., Moss, S.E.W (2017). *Using blubber explants to investigate adipose function in grey seals: glycolytic, lipolytic and gene expression responses to glucose and hydrocortisone*. Sci Rep 7, 7731 .https://doi.org/10.1038/s41598-017-06037-x

Birchenough, S. N. R. and Degraer, S. (2020). *Science in support of ecologically sound decommissioning strategies for offshore man-made structures: taking stock of current knowledge and considering future challenges*, ICES Journal of Marine Science, Volume 77, Issue 3, Pages 1075–1078, https://doi.org/10.1093/icesjms/fsaa039.

Boisseau, O., McGarry, T., Stephenson, S., Compton, R., Cucknell, A. C., Ryan, C., McLanaghan, R. and Moscrop, A. (2021). *Minke whales Balaenoptera acutorostrata avoid a 15 kHz acoustic deterrent device (ADD).* Marine Ecology Progress Series, 667, 191-206.

Bonner W. (1982*). Seals and man: a study of interactions*. Seattle, WA (USA). University of Washington Press.

Booth, C., Harwood, J., Plunkett, R., Mendes, S. and Walker, R. (2017). *Using The Interim PCoD Framework To Assess The Potential Effects Of Planned Offshore Wind Developments In Eastern English Waters On Harbour Porpoises In The North Sea.* Final Report. SMRUC-NEN-2017-007.

Brandt, M. J., Diederichs, A., Betke, K. and Nehls, G. (2011). *Responses of harbour porpoises to pile driving at the Horns Rev II offshore wind farm in the Danish North Sea.* Marine Ecology Progress Series, 421, 205-216.

Brandt, M. J., Dragon, A. C., Diederichs, A., Bellmann, M. A., Wahl, V., Piper, W., & Nehls, G. (2018). *Disturbance of harbour porpoises during construction of the first seven offshore wind farms in Germany.* Marine Ecology Progress Series, 596, 213–232. https://doi.org/10.3354/ meps12560

Brasseur, S., Aarts, G., Meesters, E., T. van Polanen Petel, Dijkman, E., Cremer, J. and Reijnders, P. (2012). *Habitat preference of harbour seals in the Dutch coastal area: analysis and estimate of effects of offshore wind farms*.

Buckstaff, K.C. (2004). *Effects of watercraft noise on the acoustic behaviour of bottlenose dolphins, Tursiops truncatus, in Sarasota Bay, Florida*. Mar. Mamm. Sci., 20 (2004), pp. 709-725

Calderan, S. and Leaper, R. (2019). *Review of harbour porpoise bycatch in UK waters and recommendations for management*.

Carrillo M.A and Ritter F.A. (2010). *Increasing numbers of ship strikes in the Canary Islands: proposals for immediate action to reduce risk of vessel-whale collisions*. Journal of cetacean research and management, 11(2),131-8.

Carter, M. I. D., Boehme, L., Duck, C. D., Grecian, W. J., Hastie, G. D., McConnell, B. J., Miller, D. L., Morris, C. D., Moss, S. E. W., Thompson, D., Thompson, P. M. & Russell, D. J. F. (2020). *Habitat-based predictions of at-sea distribution for grey and harbour seals in the British Isles.* Sea Mammal Research Unit, University of St Andrews, Report to BEIS, OESEA-16-76/OESEA-17-78

Castellote, M., Clark, C. and Lammers, M. (2010). *Potential negative effects in the reproduction and survival on fin whales (Balaenoptera physalus) by shipping and airgun noise*. Int. Whal. Comm. (SC/62/E3).

Castellote, M., Clark, C. W., and Lammers, M. O. (2012). *Acoustic and behavioural changes by fin whales (Balaenoptera physalus) in response to shipping and airgun noise*. Biological Conservation, 147(1), 115-122.

Cates, K., DeMaster, D.P., Brownell Jr, R.L., Silber, G., Gende, S., Leaper, R., Ritter, F. and Panigada, S. (2017). *Strategic Plan to Mitigate the Impacts of Ship Strikes on Cetacean Populations*: *2017-2020*. IWC.

CEFAS (2010). *Strategic review of offshore wind farm monitoring data associated with FEPA licence conditions – annex 4: underwater noise*. Cefas report ME1117.

Cheney, B., Thompson, P. M., Ingram, S. N., Hammond, P. S., Stevick, P. T., Durban, J. W., Culloch, R. M., Elwen, S. H., Mandleberg, L., Janik, V. M., Quick, N. J., Islas-Villanueva, V., Robinson, K. P., Costa, M., Eisfeld, S. M., Walters, A., Phillips, C., Weir, C. R., Evans, P. G., Anderwald, P., Reid, R. J., Reid, J. B. and Wilson, B. (2013). *Integrating multiple data sources to assess the distribution and abundance of bottlenose dolphins Tursiops truncatus in Scottish waters*. Mammal Review 43:71-88.

Cheney, B., Graham, I. M., Barton, T., Hammond, P. S. and Thompson, P. M. (2018). *Site Condition Monitoring of bottlenose dolphins within the Moray Firth Special Area 288 of Conservation*: 2014-2016. Scottish National Heritage Research Report No 1021.

Christiansen, F. and Lusseau, D. (2015). *Linking behavior to vital rates to measure the effects of non-lethal disturbance on wildlife*. Conservation Letters, 8(6), pp.424-431.

Christiansen, F., Víkingsson, G. A., Rasmussen, M. H. and Lusseau, D. (2013a). *Minke whales maximise energy storage on their feeding grounds*. Journal of Experimental Biology, *216*(3), 427-436.

Christiansen, F., Rasmussen, M. and Lusseau, D. (2013b). *Whale watching disrupts feeding activities of minke whales on a feeding ground.* Marine Ecology Progress Series, *478*, 239-251.CIEEM. (2019). G*uidelines for ecological impact assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine*. September 2018 Version 1.1 - updated September 2019. Chartered Institute of Ecology and Environmental Management, Winchester.Cierco. (2019). *Forthwind Offshore Wind Demonstration Project Environmental Scoping Request* Available at: Forthwind Offshore Demonstration Array (marine.gov.scot). Accessed on: 2 March 2022.

CIEEM (2018) *Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater,*

Coastal and Marine. Version 1.2. Chartered Institute of Ecology and Environmental Management, Winchester.

Copping, A. (2018). *The State of Knowledge for Environmental Effects Driving Consenting/Permitting for the Marine Renewable Energy Industry*. Prepared for Ocean Energy Systems On behalf of the Annex IV Member Nations, January 2018.

Costa, D. P. (2012). *A bioenergetics approach to developing the PCAD model.* In A. N. Popper & A. Hawkins (Eds.), The Effects of Noise on Aquatic Life, New York: Springer-Verlag, 23–426.

Cranford, T. W. and Krysl, P. (2015). *Fin whale sound reception mechanisms: skull vibration enables low-frequency hearing*. PloS one, 10(1), e0116222.

CSA (2019). *Evaluation of Potential EMF Effects on Fish Species of Commercial or Recreational Fishing Importance in Southern New England*. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Headquarters, Sterling, VA. OCS Study BOEM 2019-049. 59 pp.

CSIP (2015). *UK Cetacean Strandings Investigation Programme Report. Annual Report for the period 1st January – 31st December 2015 (Contract number MB0111)*. Available at :http://ukstrandings.org/csip-reports/. Accessed on: 2 March 2022.

Culik, B. (2010). *Odontocetes. The toothed whales*. UNEP/CMS Secretariat, Bonn, Germany. https://www.cms.int/reports/small_cetaceans/index.htm

Culloch, R.M., Anderwald, P., Brandecker, A. and Haberlin, D. (2016). *Effect of construction-related activities and vessel traffic on marine mammals*. Mar Ecol Prog Ser 549:231-242.

Culloch, R.M. and Robinson, K.P. (2008). *Bottlenose dolphins using coastal regions adjacent to a Special Area of Conservation (SAC) in NE Scotland*. Journal of the Marine Biological Association UK 88: 1237–1243.

Damseaux, F., Siebert, U., Pomeroy, P., Lepoint, G. and Das, K. (2021). *Habitat and resource segregation of two sympatric seals in the North Sea*. Science of The Total Environment, Volume 764, 142842, ISSN 0048-9697. Available at: https://doi.org/10.1016/j.scitotenv.2020.142842. Accessed on: 3 March 2022

de Boer, M.N. (2010). *Spring distribution and density of minke whale Balaenoptera acutorostrata along an offshore bank in the central North Sea*. Mar Ecol Prog Ser 408:265-274.

Deecke, V. B., Slater, P. J., and Ford, J. K. (2002). *Selective habituation shapes acoustic predator recognition in harbour seals*. Nature, 420(6912), 171-173.

Degraer, S., Carey, D. A., Coolen, J. W. P., Hutchison, Z. L., Kerckhof, F., Rumes, B., and Vanaverbeke, J. (2020). *Offshore wind farm artificial reefs affect ecosystem structure and functioning: A Synthesis*. Oceanography, 33(4), 48–57.

Dahl, P.H. and Reinhall, P.H. (2013). *Beam Forming of the Underwater Sound Field from Impact Pile Driving*. The Journal of the Acoustical Society of America 134 (1): EL1–6.

Delefosse, M., Rahbek, M., Roesen, L., and Clausen, K. (2018). *Marine mammal sightings around oil and gas installations in the central North Sea*. Journal of the Marine Biological Association of the United Kingdom, 98(5).

De Soto, N. A., Delorme, N., Atkins, J., Howard, S., Williams, J., and Johnson, M. (2013). *Anthropogenic noise causes body malformations and delays development in marine larvae.* Scientific reports, *3*(1), 1-5.

Diederichs, A., Hennig, V. and Niels, G. (2008). *Investigation of the bird collision risk and the responses of harbour porpoises in the offshore wind farms Horns Rev, North Sea and Nysted, Baltic Sea, in Denmark Part II: Harbour porpoises*. Universit¨at Hamburg and BioConsult SH, p 99.

Douglas, A. B., Calambokidis, J., Raverty, S., Jeffries, S. J., Lambourn, D. M. and Norman, S. A. (2008). *Incidence of ship strikes of large Whales in Washington state.* J. Mar. Biol. Assoc. 88, 1121–1132. doi: 10.1017/S0025315408000295.

Dukas, R. (2002). *Behavioural and ecological consequences of limited attention.* Philos. T. R. Soc. B. 357, 1539–1547. doi: 10.1098/rstb.2002.10063.

Dyndo, M., Wiśniewska, D. M., Rojano-Doñate, L. and Madsen, P. T. (2015). *Harbour porpoises react to low levels of high frequency vessel noise*. Sci. Rep. 5:11083.EDF. (2020). Blyth Offshore Demonstration Project Phase 2 – Supporting Environmental Information, document reference: 1233849.

Elliott, M. and Birchenough, S. N. R. (2022). *Man-made marine structures – Agents of marine environmental change or just other bits of the hard stuff?* Marine Pollution Bulletin, Volume 176. https://doi.org/10.1016/j.marpolbul.2022.113468.

Ellison, W. T., Southall, B. L., Clark, C. W. and Frankel, A. S. (2012). *A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds.* Conservation Biology, 26(1), 21-28.

Embling, C.B., Gillibrand, P.A., Gordon, J., Shrimpton, J., Stevick, P.T. and Hammond, P.S. (2010). *Using habitat models to identify suitable sites for marine protected areas for harbour porpoises (Phocoena phocoena)*. Biological Conservation 143: 267 – 279

Erbe, C., Dunlop, R. and Dolman, S. (2018). *Effects of Noise on Marine Mammals.* Chapter 10 in: Effects of Anthropogenic Noise on Animals, Slabberkoorn, H., Dooling, R.J., Popper, Ar.N., and Fay, R.R (Eds). Springer Handbook of Auditory Research. Volume 66. Series Editors Richard R. Fay and Arthur N. Popper. Springer and ASA Press.

Erbe, C. and McPherson, C. (2017). Underwater noise from geotechnical drilling and standard penetration testing. J Acoust Soc Am. 142(3):281. doi: 10.1121/1.5003328.

Edren, S.M.C., Andersen, S.M., Teilmann, J., Carstensen, J., Harders, P.B., Dietz, R. and Miller, L.A. (2010) *The effect of a large Danish offshore wind farm on harbor and gray seal haul-out behavior*. Marine Mammal Science, 26, 614-634.

Fernandez-Betelu, O., Graham, I. M., Brookes, K. L., Cheney, B. J., Barton, T. R. and Thompson, P. M. (2021). *Far-field effects of impulsive noise on coastal bottlenose dolphins*. Frontiers in Marine Science, 837

Finneran, J. J. (2015). *Noise-induced hearing loss in marine mammals: A review of temporary threshold shift studies from 1996 to 2015*. The Journal of the Acoustical Society of America, 138(3), 1702-1726.

Finneran, J. J., and Schlundt, C. E. (2013). *Effects of fatiguing tone frequency on temporary threshold shift in bottlenose dolphins (Tursiops truncatus).* The Journal of the Acoustical Society of America, 133(3), 1819-1826.

Finneran, J.J., Schlundt, C.E., Carder, D.A., Clark, J.A., Young, J.A., Gaspin, J.B. and Ridgway, S.H. (2000). *Auditory and behavioral responses of bottlenose dolphins (Tursiops truncatus) and a beluga whale (Delphinapterus leucas) to impulsive sounds resembling distant signatures of underwater explosions*. Journal of the Acoustical Society of America, 108, 417–431.

Fisher, H.D. and Harrison, R.J. (1970). *Reproduction in the Common porpoise (Phocoena phocoena) of the North Atlantic*. Journal of Zoology London 1970. 161: 471–486.

Forewind. (2013). *Environmental Statement Chapter 14 - Marine Mammals. Dogger Bank Creyke Beck, Application Reference 6.14.*

Forney, K.A., Southall, B.L., Slooten, E., Dawson, S., Read, A.J., Baird, R.W. and Brownell, R.L. Jr. (2017). *Nowhere to go: noise impact assessments for marine mammal populations with high site fidelity.* Endang Species Res 32:391-413. https://doi.org/10.3354/esr00820

Fowler, A.M., Jørgensen, A.M., Svendsen, J.C., Macreadie, P.I., Jones, D.O., Boon, A.R., Booth, D.J., Brabant, R., Callahan, E., Claisse, J.T. and Dahlgren, T.G. (2018). *Environmental benefits of leaving offshore infrastructure in the ocean*. Frontiers in Ecology and the Environment, 16(10), pp.571-578.

Gall, B. L., Graham, I. M., Merchant, N. D. and Thompson, P. M. (2021). *Broad-Scale Responses of Harbor Porpoises to Pile-Driving and Vessel Activities During Offshore Windfarm Construction*. Frontiers in Marine Science, 8, 735

Gerstein, E. R., Blue, J. E. and Forysthe, S. E. (2005). *The acoustics of vessel collisions with marine mammals*. In Proceedings of OCEANS 2005 MTS/IEEE (pp. 1190-1197). IEEE.

Gill, A., Reid, R.J. and Fairburns, B.R. (2000). *Photographic and strandings data highlighting the problem of marine debris and creel rope entanglement to minke whales (Balaenoptera acutorostrata)*. Eur Res Cetaceans 14:173–178.

Gill, A. B., Gloyne-Phillips, I., Neal, K. J. and Kimber, J. A. (2005). *The Potential Effects of Electromagnetic Fields Generated by Sub-Sea Power Cables Associated with Offshore Wind Farm Developments on Electrically and Magnetically Sensitive Marine Organisms – A Review*. COWRIE 1.5 Electromagnetic Fields Review.

GoBe. (2018a*). Hornsea Project Three Offshore Wind Farm Environmental Statement: Volume 2, Chapter 4 – Marine Mammals*. PINS Document Reference: A6.2.4 APFP Regulation 5(2)(a).

GoBe. (2018b). *Appendix 15 to Deadline I submission – In-Principle Southern North Sea SCI Site Integrity Plan*.

Goldstein, T., Johnson, S. P., Phillips, A. V., Hanni, K. D., Fauguier, D. A., and Gulland, F. M. D. (1999). *Human-related injuries observed in live stranded pinnipeds along the central California coast 1986-1998.* Aquat. Mamm. 25, 43–51.

Goold, J. C. (1996). *Acoustic assessment of populations of common dolphin Delphinus delphis in conjunction with seismic surveying*. Journal of the Marine Biological Association of the United Kingdom, 76(3), 811-820.

Gordon, J., Gillespie, D., Potter, J., Frantzis, A., Simmonds, M. P., Swift, R., & Thompson, D. (2003). *A review of the effects of seismic surveys on marine mammals. Marine Technology Society Journal*, *37*(4), 16-34.

Graham, I. M., Pirotta, E., Merchant, N. D., Farcas, A., Barton, T. R., Cheney, B. and Thompson, P. M. (2017). *Responses of bottlenose dolphins and harbor porpoises to impact and vibration piling noise during harbor construction*. Ecosphere, 8(5), e01793.

Graham, I. M., Merchant, N. D., Farcas, A., Barton, T. R., Cheney, B., Bono, S. and Thompson, P. M. (2019). *Harbour porpoise responses to pile-driving diminish over time*. Royal Society open science, 6(6), 190335

Grellier, K. and Lacey, C. (2011). *Analysis of The Crown Estate aerial survey data for marine mammals for the FTOWDG*. SMRU Report dated 12/12/2011.

Hague, E. L., Sinclair, R.R. and Sparling, E. (2020). R*egional baselines for marine mammal knowledge across the North Sea and Atlantic areas of Scottish waters*. Scottish Marine and Freshwater Science Vol 11 No 12. Published by Marine Scotland Science. Available from: MSS Reports Template (marine.gov.scot) Accessed August 2021.

Hall, A.J., McConnell, B.J. and Barker, R.J. (2001). *Factors affecting first-year survival in grey seals and their implications for life history strategy*. J Anim Ecol 70:138–149.

Hammond, P., K. McLeod, and M. Scheidat. (2006). *Small Cetaceans in the European Atlantic and North Sea (SCANS-II).* Final Report. Saint Andrews.

Hammond, P.S., MacLeod, K., Gillespie, D., Swift, R., and Winship, A. (2009). CODA Final Report Feb 2009.

Hammond, P. S., K. MacLeod, P. Berggren, D. L. Borchers, L. Burt, A. Cañadas, G. Desportes, G. P. Donovan, A. Gilles, D. Gillespie, J. Gordon, L. Hiby, I. Kuklik, R. Leaper, K. Lehnert, M. Leopold, P. Lovell, N. Øien, C. G. M. Paxton, V. Ridoux, E. Rogan, F. Samarra, M. Scheidat, M. Sequeira, U. Siebert, H. Skov, R. Swift, M. L. Tasker, J. Teilmann, O. Van Canneyt, and J. A. Vázquez. (2013). *Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management.* Biological Conservation 164:107-122

Hammond, P. S., C. Lacey, A. Gilles, S. Viquerat, P. Börjesson, H. Herr, K. Macleod, V. Ridoux, M. Santos, M. Scheidat, J. Teilmann, J. Vingada, and N. Øien. (2017). *Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys.* Wageningen University. 40p.

Hammond, P. S., Lacey, C., Gilles, A., Viquerat, S., Börjesson P., H. Herr, K., Macleod, V. Ridoux, M.B. Santos, M. Scheidat, J. Teilmann, Vingada, J. and Øien, N. (2021) *Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys.*

Hanson, N., Thompson., D., Duck, C., Baxter, J. and Lonergan, M. (2017). *Harbour seal (Phoca vitulina) abundance within the Firth of Tay and Eden Estuary, Scotland* : recent trends and extrapolation to extinction ' , Aquatic Conservation: Marine and Freshwater Ecosystems 27: 268-281.

Harris, C.M., Thomas, L., Falcone, E.A., Hildebrand, J., Houser, D., Kvadsheim, P.H., Lam, F.P.A., Miller, P.J., Moretti, D.J., Read, A.J. and Slabbekoorn, H. (2018). *Marine mammals and sonar: Dose‐response studies, the risk‐disturbance hypothesis and the role of exposure context*. Journal of applied ecology, 55(1), pp.396-404.

Harwood, J., King, S., Schick, R., Donovan, C. and Booth, C. (2014). *A Protocol for Implementing the Interim Population Consequences of Disturbance (PCOD) Approach: Quantifying and assessing the Effects of UK Offshore Renewable Energy Developments on Marine Mammal Populations: Report SMRUL-TCE-2013-014*. Scottish Marine and Freshwater Science, 5(2), 1-90.

Hastie, G.D., Donovan, C., Götz, T. and Janik, V.M. (2014). *Behavioral responses by grey seals (Halichoerus grypus) to high frequency sonar.* Marine pollution bulletin, *79*(1-2), 205-210.

Hastie, G.D., Russell, D.J.F., McConnell, B., Moss, S., Thompson, D. and Janik. V.M. (2015). *Sound exposure in harbour seals during the installation of an offshore wind farm: predictions of auditory damage*. Journal of Applied Ecology 52:631-640.

Hastie, G. D., Russell, D. J., Benjamins, S., Moss, S., Wilson, B. and Thompson, D. (2016). *Dynamic habitat corridors for marine predators; intensive use of a coastal channel by harbour seals is modulated by tidal currents*. Behavioral Ecology and Sociobiology:1-14.

Hastie, G., Merchant, N. D., Götz, T., Russell, D. J., Thompson, P. and Janik, V. M. (2019). *Effects of impulsive noise on marine mammals: investigating range-dependent risk*. Ecological Applications, 29(5), e01906.

Hayes, M. P. and Gough, P. T. (1992). *Broad-band synthetic aperture sonar.* IEEE Journal of Oceanic engineering, 17(1), 80-94.

Hastie, G. D., Lepper, P., McKnight, J. C., Milne, R., Russell, D. J. and Thompson, D. (2021). *Acoustic risk balancing by marine mammals: anthropogenic noise can influence the foraging decisions by seals.* Journal of Applied Ecology, 58(9), 1854-1863.

Haug, T., Lindstrøm, U. and Nilssen, K. T. (2002). *Variations in Minke Whale (Balaenoptera acutorostrata) Diet and Body Condition in Response to Ecosystem Changes in the Barents Sea*. Sarsia, 87:6, 409-422.

Heinänen, S., and H. Skov. (2015). *The identification of discrete and persistent areas of relatively high harbour porpoise density in the wider UK marine area*. JNCC Report No. 544, JNCC, Peterborough.

Helker, V. T., M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K.Wilkinson, and J. Jannot (2017). *Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2011-2015.* U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-354,112 pp.

Henderson, D. and Hamernik, R. P. (1986). *Impulse noise: Critical review*. Journal of the Acoustical Society of America, 80, 569-584

Hermannsen, L. and Beedholm, K. (2014). *High frequency components of ship noise in shallow water with a discussion of implications for harbor porpoises (Phocoena phocoena)*. The Journal of the Acoustical Society of America 136, 1640.

Hoelzel, A. R., Potter, C. W. and Best, P.B. (1998). *Genetic differentiation between parapatric 'nearshore' and 'offshore' populations of the bottlenose dolphin*. Proceedings of the Royal Society of London. Series B. Biological Sciences 265: 1177–1183.

IAMMWG. 2013. Management Units for marine mammals in UK waters (June 2013).

IAMMWG. (2015). *Management Units for cetaceans in UK waters*. JNCC Report 547, ISSN 0963-8091.

IAMMWG. (2021). *Updated abundance estimates for cetacean Management Units in UK waters.* JNCC Report No. 680, JNCC Peterborough, ISSN 0963-8091.

IAMMWG, Camphuysen, C.J. and Siemensma, M.L. (2015). *A Conservation Literature Review for the Harbour Porpoise (Phocoena phocoena).* JNCC Report No. 566, Peterborough. 96pp.

IJsseldijk, L., Brownlow, A., Davison, N., Deaville, R., Haelters, J., Keijl, G., Siebert, U. and Ten Doeschate, M. (2018). *Spatiotemporal trends in white-beaked dolphin strandings along the North Sea coast from 1991–2017.* 61: 153-163.

Inch Cape Offshore Limited. (2014). *Offshore Environmental Statement.*

Inch Cape Offshore Limited Scoping Report. (2017). *Inch Cape Offshore Windfarm (Revised Design) - Scoping Report*.

Inch Cape Offshore Limited. (2018). *Offshore Environmental Statement Revised.*

Inger, R., Attrill, M.J., Bearhop, S., Broderick, A.C., James Grecian, W., Hodgson, D.J., Mills, C., Sheehan, E., Votier, S.C., Witt, M.J. and Godley, B.J. (2009). *Marine renewable energy: potential benefits to biodiversity? An urgent call for research*. Journal of Applied Ecology, 46: 1145-1153.

Innogy. (2020). *Sofia Offshore Wind Farm Environmental Appraisal of Increased Hammer Energy: Main Report*. Document Ref: 003230484-02. Available at: EN010051-002445-Innogy Renewables UK Limited Hammer Energy Increase 4000kJ Environmental Appraisal Main Report 2020.pdf (planninginspectorate.gov.uk). Accessed on: 25 March 2022.

IWC (2006). *58th Annual Meeting of the International Whaling Commission*. Ship strikes working group. First progress report to the conservation committee. Report No. IWC/58CC3.

Jensen, A. S., and Silber, G. K. (2003). *Large Whale Ship Strike Database. NOAA Technical Memorandum NMFS-OPR.* Silver Spring, MD: US Department of Commerce.

Jensen, A. S., and Silber, G. K. (2004). *Large Whale Ship Strike Database. NOAA Technical Memorandum NMFS-OPR.* Silver Spring, MD: US Department of Commerce

Jensen, S.K., Lacaze, J.P., Hermann, G., Kershaw, J., Brownlow, A., Turner, A. and Hall, A. (2015) *Detection and effects of harmful algal toxins in Scottish harbour seals and potential links to population decline*. Toxicon. (97): 1 -14.

JNCC. (2019a). *Article 17 Habitats Directive Report 2019: Species Conservation Status Assessments 2019. Conservation status assessment for the species: S1351 - Harbour porpoise (Phocoena phocoena).*

JNCC. (2019b). *Article 17 Habitats Directive Report 2019: Species Conservation Status Assessments 2019. Conservation status assessment for the species: S1349 - Bottlenose dolphin (Tursiops truncatus).*

JNCC. (2019c). *Article 17 Habitats Directive Report 2019: Species Conservation Status Assessments 2019. Conservation status assessment for the species: S2032 - White-beaked dolphin (Lagenorhynchus albirostris).*

JNCC. (2019d). *Article 17 Habitats Directive Report 2019: Species Conservation Status Assessments 2019. Conservation status assessment for the species: S2618 - Minke whale (Balaenoptera acutorostrata).*

JNCC. (2019e). *Article 17 Habitats Directive Report 2019: Species Conservation Status Assessments 2019. Conservation status assessment for the species: S1365 - Common seal (Phoca vitulina).*

JNCC. (2019f). *Article 17 Habitats Directive Report 2019: Species Conservation Status Assessments 2019. Conservation status assessment for the species: S1365 S1364 - Grey seal (Halichoerus grypus).*

JNCC (2010a). *Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise*. August 2010. Available at: Statutory nature conservation agency protocol for minimising the ris of injury to marine mammals from piling noise (jncc.gov.uk). Accessed on 02 March 2022.

JNCC (2010b). *JNCC guidelines for minimising the risk of injury to marine mammals from using explosives*. Joint Nature Conservation Committee, Aberdeen, UK.

JNCC (2017). *JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys*.

Johnson, A., and Acevedo-Gutiérrez, A. (2007). *Regulation compliance by vessels and disturbance of harbor seals*. Canadian Journal of Zoology, 85, 290-294.

Kastelein, R. A., Hardeman, J., and Boer, H. (1997). *Food consumption and body weight of harbour porpoises (Phocoena phocoena)*. The biology of the harbour porpoise, 217-233.

Kastelein, R. A., van Heerden, D., Gransier, R., and Hoek, L. (2013). *Behavioral responses of a harbor porpoise (Phocoena phocoena) to playbacks of broadband pile driving sounds.* Marine environmental research, 92, 206-214.

Kastelein, R. A., Hoek, L., Gransier, R., Rambags, M., and Claeys, N. (2014). *Effect of level, duration, and inter-pulse interval of 1-2 kHz sonar signal exposures on harbor porpoise hearing.* The Journal of the Acoustical Society of America, 136(1), 412–422.

Kastelein, R. A., Helder-Hoek, L., Covi, J., and Gransier, R. (2016). Pile driving playback sounds and temporary threshold shift in harbor porpoises (Phocoena phocoena): Effect of exposure duration. The Journal of the Acoustical Society of America, 139(5), 2842-2851.

Kastelein, R.A., Helder-Hoek, L. and Van de Voorde, S. (2017). *Hearing thresholds of a male and a female harbor porpoise (Phocoena phocoena).* The Journal of the Acoustical Society of America, 142(2), 1006-1010.

Kastelein, R. A., Helder-Hoek, L., Kommeren, A., Covi, J., and Gransier, R. (2018a). *Effect of pile-driving sounds on harbor seal (Phoca vitulina) hearing.* The Journal of the Acoustical Society of America, 143(6), 3583-3594.

Kastelein, R. A., Helder-Hoek, L., and Terhune, J. M. (2018b). *Hearing thresholds, for underwater sounds, of harbor seals (Phoca vitulina) at the water surface.* The Journal of the Acoustical Society of America, 143(4), 2554-2563.

Kastelein, R.A., Helder-Hoek, L., Cornelisse, S., Huijser, L.A. and Terhune, J.M. (2019a). *Temporary hearing threshold shift in harbor seals (Phoca vitulina) due to a one-sixth-octave noise band centered at 16 kHz*. The Journal of the Acoustical Society of America, 146(5), 3113-3122.

Kastelein, R. A., Helder-Hoek, L., Booth, C., Jennings, N. and Leopold, M. (2019b). *High levels of food intake in harbor porpoises (Phocoena phocoena): Insight into recovery from disturbance*. Aquatic Mammals, 45(4), 380-388.

Kastelein, R.A., Helder-Hoek, L., Cornelisse, S.A., von Benda-Beckmann, A. M., Lam, F.A., de Jong, C.A.F and Ketten, D.R. (2020). Lack of reproducibility of temporary hearing threshold shifts in a harbor porpoise after exposure to repeated airgun sounds. The Journal of the Acoustical Society of America 148, 556-565.

Kastelein, R.A., Helder-Hoek, L., Cornelisse, S.A., Defillet, L.N., Huijser, L.A. and Gransier, R. (2021). *Temporary Hearing Threshold Shift in a Harbor Porpoise (Phocoena phocoena) Due to Exposure to a Continuous One-Sixth-Octave Noise Band Centered at 0.5 kHz.* Aquatic Mammals, 47(2), 135-145.

Ketten, D. R. (1993). *Blast injury in humpback whale ears: Evidence and implications*. The Journal of the Acoustical Society of America 94, 1849-1850 (1993)

Ketten, D. R. and Mountain, D. C. (2009). *Modelling minke whale hearing*. Presentation to the Joint Industry Programme, United Kingdom.

King, S. and Sparling, C. (2012). *FTOWDG Cetacean Density Modelling –Non Technical summary*. Report number SMRUL-SGW-029.

Lacy, R.C., Williams, R., Ashe, E., Balcomb III, K.C., Brent, L.J., Clark, C.W., Croft, D.P., Giles, D.A., MacDuffee, M. and Paquet, P.C. (2017). *Evaluating anthropogenic threats to endangered killer whales to inform effective recovery plans.* Scientific reports, 7(1), pp.1-12.

Laist, D.W., Knowlton, A.R., Mead, J.G., Collet, A.S. and Podesta, M. (2001). *Collisions between ships and whales.* Marine Mammal Science. 17, 35 - 75.

Langton, R., Boulcott, P. and Wright, P.J. (2021*). A verified distribution model for the lesser sandeel Ammodytes marinus*. Mar Ecol Prog Ser 667:145-159. Available at: https://doi.org/10.3354/meps13693. Accessed on: 3 March 2022.

Leaper, R., Calderan, S. and Cooke, J. (2015). *A Simulation Framework to Evaluate the Efficiency of Using Visual Observers to Reduce the Risk of Injury from Loud Sound Sources.* Aquatic Mammals, 41(4).

Leatherwood, S., Reeves, R. R., Perrin, W. F., & Evans, W. E. (1988). *Whales, dolphins, and porpoises of the eastern North Pacific and adjacent Arctic waters: A guide to their identification*. New York: Dover Publications.

Lee, P. H. and Weis, J. S. (1980). *Effects of magnetic fields on regeneration in fiddler crabs*. Biol. Bull. 159, 681–691.

Lindeboom, H. J., H. J. Kouwenhoven, M. J. N. Bergman, S. Bouma, S. Brasseur, R. Daan, R. C. Fijn, D. de Haan, S. Dirksen, R. van Hal, R. Hille Ris Lambers, R. ter Hofstede, K. L. Krijgsveld, M. Leopold, and M. Scheidat. (2011). *Short-term ecological effects of an offshore wind farm in the Dutch coastal zone; a compilation*. Environmental Research Letters 6:1-13.

Lippert, S., Huisman, M., Ruhnau, M., Estorff, O.V. and van Zandwijk, K. (2017). *Prognosis of Underwater Pile Driving Noise for Submerged Skirt Piles of Jacket Structures*. In 4th Underwater Acoustics Conference and Exhibition (UACE 2017), Skiathos, Greece.

Lucke, K., Siebert, U., Lepper, P. A. and Blanchet, M-A. (2009). *Temporary shift in masked hearing thresholds in a harbor porpoise (Phocoena phocoena) after exposure to seismic airgun stimuli.* The Journal of the Acoustical Society of America, 125(6), 4060-4070.

Luksenburg. (2014). *Prevalence of External Injuries in Small Cetaceans in Aruban Waters, Southern Caribbean*. PLoS One, 9 (1) doi: 10.1371/journal.pone.0088988.

Lusseau, D., Williams, R., Wilson, B., Grellier, K., Barton, T.R., Hammond, P.S. and Thompson, P.M. (2004). *Parallel influence of climate on the behaviour of Pacific killer whales and Atlantic bottlenose dolphins.* Ecology Letters, 7: 1068-1076.

Lusseau, D., New, L., Donovan, C., Cheney, B., Thompson, P.M., Hastie, G. and Harwood, J (2011). *The development of a framework to understand and predict the population consequences of disturbances for the Moray Firth bottlenose dolphin population*. Scottish Natural Heritage Commissioned Report No. 468.

MacLeod, C.D., S.M. Bannon, G.J. Pierce, C. Schweder, J.A. Learmonth, J.S. Herman and R.J. Reid (2005). *Climate change and the cetacean community of north-west Scotland*. Biological Conservation 124 (4): 477-483.

MacLeod, C.D., Weir, C.R., Santos, M.B. and Dunn, T.E. (2008). *Temperature-based summer habitat partitioning between white-beaked and common dolphins around the United Kingdom and Republic of Ireland*. Journal of the Marine Biological Association of the United Kingdom 88(6): 1193-1198.

Madsen, P. T., Wahlberg, M., Tougaard, J., Lucke, K. and Tyack, P. (2006). *Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs.* Marine Ecology Progress Series 309:279-295.

Mainstream Renewable Power (2019). *Neart Na Gaoithe Offshore Wind Farm Environmental Statement.*

Marine Scotland. (2022). Berwick Bank Wind Farm Scoping Opinion. Available at: Scoping Opinion – Berwick Bank Offshore Wind Farm | Marine Scotland Information. Accessed on 9 June 2022.

McGarry, T., Boisseau, O., Stephenson, S. and Compton, R. (2017). *Understanding the Effectiveness of Acoustic Deterrent Devices (ADDs) on Minke Whale (Balaenoptera acutorostrata), a Low Frequency Cetacean*. ORJIP Project 4, Phase 2. RPS Report EOR0692. Prepared on behalf of The Carbon Trust. November 2017.

McGarry, T., De Silva, R., Canning, S., Mendes, S., Prior, A., Stephenson, S. & Wilson, J. (2020). Evidence base for application of acoustic deterrent devices (ADDs) as marine mammal mitigation (Version 2.0). JNCC Report No. 615, JNCC, Peterborough. ISSN 0963-8091.

Marubini, F., Gimona, A., Evans, P. G., Wright, P. J. and Pierce, G. J. (2009). *Habitat preferences and interannual variability in occurrence of the harbour porpoise Phocoena phocoena off northwest Scotland*. Marine Ecology Progress Series 381:297-310.

McConnell, B., Lonergan, M. and Dietz, R. (2012). *Interactions between seals and offshore wind farms*.' The Crown Estate, 41 pages. ISBN: 978-1-906410-34-6.

Mclean, D., Cerqueira, F., Luciana, B., Jessica, M., Karen, S., Marie-Lise, S., Matthew, B., Oliver, B., Silvana, B., Todd, B., Fabio, B., Ann, C., Jeremy, C., Scott, C., Pierpaolo, C., Joop, J., Michael, F., Irene, F., Ashley, G., Bronwyn, T. M. (2022). *Influence of offshore oil and gas structures on seascape ecological connectivity*. Global Change Biology. 32. 10.1111/gcb.16134.

McWhinnie, L. H., Halliday, W. D., Insley, S. J., Hilliard, C. and Canessa, R. R. (2018). *Vessel traffic in the Canadian Arctic: management solutions for minimizing impacts on whales in a changing northern region.* Ocean Coast Manage 160: 1-17.

Mellish, J.E., Iverson, S.J. and Bowen, D.W. (1999). *Individual variation in maternal energy allocation and milk production in grey seals and consequences for pup growth and weaning characteristics*. Physiol Biochem Zool 72:677–690

Mikkelsen, L., Johnson, M., Wisniewska, D.M., van Neer, A., Siebert, U., Madsen, P.T. and Teilmann, J. (2019). *Long‐term sound and movement recording tags to study natural behavior and reaction to ship noise of seals.* Ecology and evolution, 9(5), pp.2588-2601.

Miller, L. J., Solangi, M., and Kuczaj, S. A. (2008). *Immediate response of Atlantic bottlenose dolphins to high-speed personal watercraft in the Mississippi Sound.* Journal of the Marine Biological Association of the United Kingdom, 88(6), 1139-1143.

MMO (2014). *Review of Post-Consent Offshore Wind Farm Monitoring Data Associated with Marine Licence Conditions.* A report produced for the Marine Management Organisation, pp 194. MMO Project No: 1031. ISBN: 978-1-909452-24-4.

Moray Offshore Renewables Ltd. (2012). *Moray Offshore Renewables Limited Environmental Statement Technical Appendix 7.3 A - Marine Mammals Environmental Impact Assessment*. Produced by Natural Power on behalf of Moray Offshore Renewables Ltd.

Moray West. (2018). *Offshore EIA Report, Moray Offshore Windfarm (West) Limited.*

Morell, M., IJsseldijk, L.L., Berends, A.J., Gröne, A., Siebert, U., Raverty, S.A., Shadwick, R.E. and Kik, M.J. (2021). *Evidence of Hearing Loss and Unrelated Toxoplasmosis in a Free-Ranging Harbour Porpoise (Phocoena phocoena).* Animals, 11(11), 3058.

Murray, C., Mach, C. Megan, E. and Martone, R. G. (2014). *Cumulative effects in marine ecosystems: scientific perspectives on its challenges and solutions*. WWF-Canada and Center For Ocean Solutions. 60 pp.

Muto, M. M., V. T. Helker, R. P. Angliss, B. A. Allen, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, R. G. Towell, P. R. Wade, J. M. Waite, and Zerbini, A. N. (2018). *Alaska marine mammal stock assessments, 2017*. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-378, 382 p.

Nabe-Nielsen, J., Tougaard, J., Teilmann, J. and Sveegaard, S. (2011). *Effects of wind farms on harbour porpoise behavior and population dynamics.* Report commissioned by the Environmental Group under the Danish Environmental Monitoring Programme. Danish Centre for Environment and Energy, Aarhus University.

NAREC (2012). *Blyth Offshore Demonstration Project Environmental Statement*.

NAREC (2013). *Blyth Offshore Demonstration Project Supplementary Environmental Information*.

National Grid (2021a). *Scotland to England Green Link (SEGL) ~ Eastern Link 1 Marine Scheme Scoping Report*. March 2021.

National Grid (2021b). *Scotland to England Green Link (SEGL) ~ Eastern Link 2 Marine Scheme Scoping Report*. July 2021.

National Marine Fisheries Service (NMFS) (2005). *Scoping Report for NMFS EIS for the National Acoustic Guidelines on Marine Mammals*. National Marine Fisheries Service.

NatureScot. (2020). Southern Trench Marine Protected Area. Available at: Accessed on 12 May 2022.

Nielsen, N. H, Hansen, R. G., Teilmann, J. and Heide-Jorgensen, M. P. (2013). *Extensive offshore movements of harbour porpoises (Phocoena phocoena).* NAMMCO SC/20/HP/08. Harbour porpoise working group.

NMFS (2012). *National Marine Fisheries Service Policy Directive 02-238. Process for Distinguishing Serious from Non-Serious Injury of Marine Mammals*. Available at: http://www.nmfs.noaa.gov/op/pds/documents/02/02-238.pdf. Accessed on: 3 March 2022.

NMFS. (2018). *2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts*. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-59, 167 p

NMPi (2021). *Webmap Service. National Marine Plan Interactive*. Available at: Marine Scotland - National Marine Plan Interactive (atkinsgeospatial.com). Accessed August 2021.

Normandeau, E., Tricas, T. and Gill, E. (2011). *Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species.* U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Pacific OCS Region, Camarillo, CA. OCS Study BOEMRE 2011-09.

Northridge, S., Cargill, A., and Coram, A. (2010). *Entanglement of Minke Whales in Scottish Waters; An Investigation into Occurrence, Causes and Mitigation.* Final Report to Scottish Government, CR/2007/49. St Andrews: University of St Andrews, 57

Northridge, S., Kingston, A. and Thomas, L. (2018). *Annual report on the implementation of Council Regulation (EC) No 812/2004 during 2018*.

Northridge, S., Kingston, A. and Thomas, L. (2019). *Annual report on the implementation of Council Regulation (EC) No 812/2004 during 2018*.

Nowacek, D. P., Thorne, L. H., Johnston, D. W. and Tyack, P. L. (2007). *Responses of cetaceans to anthropogenic noise*. Mammal Rev. 2007, Volume 37, No. 2, 81–115.

Nowacek, S. M., Wells, R.S. and Solow, A. R. (2001). Short-term effects of boat traffic on bottlenose dolphins, Tursiops truncatuJ, in Sarasota Bay, Florida. Marine Mammal Science 17:673-688

Onoufriou, J., Jones, E., Hastie, G., and Thompson, D. (2016). *Investigations into the interactions between harbour seals (Phoca vitulina) and vessels in the inner Moray Firth*. Marine Scotland Science.

Ordtek. 2017. Unexploded Ordnance (UXO) Hazard and Risk Assessment with Risk Mitigation Strategy: Seagreen Alpha and Bravo Offshore Wind Farms, October 2017., Report reference JM5383_RA-RMS_V2.0, Ordtek Limited.

Ordtek. 2019. Unexploded Ordnance (UXO) Risk Assessment with Risk Mitigation Strategy: Seagreen Alpha and Bravo Offshore Wind Farms, June 2019, Report reference JM5602_RARMS_V2.1, Ordtek Limited.

OSPAR IA (2017). *Abundance and distribution of cetaceans*. Available from: https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/. Accessed on 04 August 2022.

Otani, S., Naito, Y., Kato, A. and Kawamura, A. (2000). *Diving behaviour and swimming speed of a freeranging harbour porpoise* Phocoena phocoena. Marine Mammal Science 16, 811-814

Parsons, E.C.M., Dolman, S.J., Wright, A.J., Rose, N.A., Burns, W.C.G. (2008). *Navy sonar and cetaceans: Just how much does the gun need to smoke before we act?* Marine Pollution Bulletin 56, 1248–1257.

Parsons, E.C.M., Dolman, S.J., Jasny, M., Rose, N.A., Simmonds, M.P., Wright, A.J. (2009). A critique of the UK's JNCC seismic survey guidelines for minimising acoustic disturbance to marine mammals: Best Practice? Marine Pollution Bulletin 58: 643 – 651.

Paxton, C., Scott-Hayward, L. and Rexstad, E. (2014). *Statistical approaches to aid the identification of Marine Protected Areas for minke whale, Risso's dolphin, white-beaked dolphin and basking shark*. Scottish Natural Heritage Commissioned Report No. 594., Scottish Natural Heritage Commissioned Report No. 594.

Paxton, C.G.M., Scott-Hayward, L., Mackenzie, M., Rexstad, E. and Thomas L. (2016). *Revised Phase III Data Analysis of Joint Cetacean Protocol Data Resource*. JNCC Report No.517

Pelagica Environmental Consultancy Ltd. (2018). Chapter 8 Marine Mammals, Neart na Gaoithe Offshore Wind Farm Environmental Impact Assessment Report. Available at: https://marine.gov.scot/sites/default/files/combined_document_-_revised.pdf . Accessed on 02 March 2022.

Peltier, H., Beaufils, A., Cesarini, C., Dabin W., Dars, C., Demaret, F., Dhermain, F., Doremus, G., Labach H., Van Canneyt, O. and Spitz, J. (2019). *Monitoring of Marine Mammal Strandings Along French Coasts Reveals the Importance of Ship Strikes on Large Cetaceans: A Challenge for the European Marine Strategy Framework Directive*. Frontiers in Marine Science, 6, pp. 486.

Petersen, J. K and Malm, T. (2006). *Offshore Windmill Farms: Threats to or Possibilities for the Marine Environment*. Ambio, 35(2), 75–80.

Pierpoint, C. (2008). *Harbour porpoise (Phocoena phocoena) foraging strategy at a high energy, near-shore site in south-west Wales, UK*. Journal of the Marine Biological Association of the UK 88:1167-1173.

Pirotta, E., Merchant, D., Thompson M., Barton R., and Lusseau, D. (2015). *Quantifying the effect of boat disturbance on bottlenose dolphin foraging activity.* Biological Conservation, 181, 82-89*.*

Prideaux, G. (2016). CMS Family *Guidelines on Environmental Impact Assessment for Marine Noise-generating Activites*, Convention on Migratory Species of Wild Animals, Bonn.

Quick, N. J., M. Arso Civil, B. Cheney, V. Islas, V. Janik, P. M. Thompson, and Hammond, P. S. (2014). *The east coast of Scotland bottlenose dolphin population: Improving understanding of ecology outside the Moray Firth SAC*. This document was produced as part of the UK Department of Energy and Climate Change's offshore energy Strategic Environmental Assessment programme.

Quick, N. and Cheney, B. (2011). *Cetacean Baseline Characterisation for the Firth of Tay based on existing data: Bottlenose dolphins*. SMRU Limited.

Raoux, A., Tecchio, S., Pezy, J.P., Lassalle, G., Degraer, S., Wilhelmsson, D., Cachera, M., Ernande, B., Le Guen, C., Haraldsson, M. and Grangeré, K. (2017). *Benthic and fish aggregation inside an offshore wind farm: which effects on the trophic web functioning?*. Ecological Indicators, 72, pp.33-46.

Reichmuth, C., Sills, J. M., Mulsow, J., and Ghoul, A. (2019). *Long-term evidence of noise-induced permanent threshold shift in a harbor seal (Phoca vitulina).* The Journal of the Acoustical Society of America, 146(4), 2552-2561.

Reid, J., Evans, P.G.H. and Northridge, S.P. (2003). *Cetacean Distribution Atlas*. Joint Nature Conservation Committee, Peterborough. 68pp.

Reiser, C., Funk, D., Rodrigues, R. and Hannay, D. (2011). *Marine Mammal Monitoring and Mitigation During Marine Geophysical Surveys by Shell Offshore, Inc. in the Alaskan Chukchi and Beaufort Seas, July-October 2010: 90-Day Report.* LGL Alaska Research Associates.

Richardson, W.J., Greene, C.R. Jr., Malme, C.I., and Thomson, D.H. (1995*). Marine Mammals and Noise.* Academic Press, San Diego, CA, USA. 576p

Richardson, H. (2012) *The effect of boat disturbance on the bottlenose dolphin (Tursiops truncatus) of Cardigan Bay in Wales.* Thesis submitted for the degree of MSc Conservation, Dept of Geography, UCL (University College London). August 2012.

Risch, D., Wilson, S.C. and Hoogerwerf, M. (2019). *Seasonal and diel acoustic presence of North Atlantic minke whales in the North Sea*. Sci Rep 9, 3571

Robards, M. D., Silber, G. K., Adams, J. D., Arroyo, J., Lorenzini, D., Schwehr, K., and Amos, J. (2016). *Conservation science and policy applications of the marine vessel Automatic Identification System (AIS)—A review.* Bulletin of Marine Science, 92(1), 75-113.Robinson, K.J., Hall, A.J., Scholl, G., Debier, C., Thome, J., Eppe, G., Adam, C. and Bennet, K.A. (2019) *Investigating decadal changes in persistent organic pollutants in Scottish grey seal pups.* Aquatic Conserv: Mar Freshw Ecosyst. 29(S1): 86– 100.

Robinson, K.P. and Tetley, M.J., (2005). *Environmental factors affecting the fine-scale distribution of minke whales (Balaenoptera acutorostrata) in a dynamic coastal ecosystem*. ICES Annual Science Conference, Aberdeen, Scotland, 20–24 September 2005, CM 2005 R:20.

Robinson, K.P., Stevick, P.T. and MacLeod, C.D. (2007). *An Integrated Approach to Non-lethal Research on Minke Whales in European Waters*. European Cetacean Society Spec. Public. Series 47: 8-13.

Robinson, K. P., Tetley, M. and Mitchelson-Jacob, E. (2009). *The distribution and habitat preference of coastally occurring Minke whales (Balaenoptera acutorostrata) in the outer southern Moray firth, Northeast Scotland*. Journal of Coastal Conservation. 13. 39-48. 10.1007/s11852-009-0050-2.

Robinson, S. P., Wang, L., Cheong, S., Lepper, P.A., Marubini, F. and Hartley, J. P. (2020). *Underwater acoustic characterisation of unexploded ordnance disposal using deflagration*. Marine Pollution Bulletin, Volume 160, 111646, ISSN 0025-326X.

Rojano-Doñate, L., Mcdonald, B., Wisniewska, D., Johnson, M., Teilmann, J.,Wahlberg, M., Kristensen, J. and Madsen, P. (2018). *High field metabolic rates of wild harbour porpoises*. The Journal of Experimental Biology. 221.

Rolland, R.M., Parks, S.E., Hunt, K.E. and Castellote, M. (2012). *Evidence that ship noise increases stress in right whales*. Proc Biol Sci 279: 2363−2368.

Rouse, S., Porter, J.S., Wilding, T.A. (2020*). Artificial reef design affects benthic secondary productivity and provision of functional habitat.* Ecol Evol. 10: 2122– 2130. https://doi.org/10.1002/ece3.6047

Royal Haskoning DHV. (2020). *NMC Application: Environmental Report RE-PM763-RHDHV-00002*.

Royal Haskoning DHV. (2021). *Green Volt Offshore windfarm - Offshore Environmental Impact Assessment Offshore Scoping Report. Reference: PC2483-RHD-ZZ-XX-RP-Z-0001.*

Russell, D. J. F., McConnell, B., Thompson, D., Duck, C., Morris, C., Harwood, J., and Matthiopoulos, J. (2013). *Uncovering the links between foraging and breeding regions in a highly mobile mammal*. Journal of Applied Ecology, 50(2), 499–509. doi:10.1111/1365-2664.12048.

Russell, D. J., Brasseur, S. M., Thompson, D., Hastie, G. D., Janik, V. M., Aarts, G., McClintock, B. T., Matthiopoulos, J., Moss, S. E. and McConnell, B. (2014*). Marine mammals trace anthropogenic structures at sea*. Current Biology 24:R638-R639

Russell, D.J., Hastie, G.D., Thompson, D., Janik, V.M., Hammond, P.S., Scott-Hayward, L.A., Matthiopoulos, J., Jones, E.L. and McConnell, B.J., (2016). *Avoidance of wind farms by harbour seals is limited to pile driving activities.* Journal of Applied Ecology, 53(6), pp.1642-1652.

Russell, D. J. R., Jones, E. L. and Morris, C. D. (2017). *Updated Seal Usage Maps: The Estimated at-sea Distribution of Grey and Harbour Seals.* Scottish Marine and Freshwater Science Report Vol 8 No 25. Published by Marine Scotland Science ISSN: 2043-7722 DOI: 10.7489/2027-1

Salomons, E. M., Binnerts, B., Betke, K. and von Benda-Beckmann, A. M. (2021). *Noise of underwater explosions in the North Sea. A comparison of experimental data and model predictions*. The Journal of the Acoustical Society of America 149, 1878-1888 (2021) https://doi.org/10.1121/10.0003754

Santos, M.B., and Pierce, G.J. (2003). *The diet of harbour porpoise (Phocoena phocoena) in the Northeast Atlantic.* Oceanography and Marine Biology: an Annual Review 2003, 41, 355–390.

Santos, M.B., Pierce, G.J., Learmonth, J.A., Reid, R.J., Ross, H.M., Patterson, I.A.P., Reid, D.G. and Beare, D. (2004). *Variability in the diet of harbour porpoises (Phocoena phocoena) in Scottish waters 1992-2003*. Marine Mammal Science, 20(1), 1-27.

Santos, M. E., Couchinho, M. N. and Luis, A. R. (2010). *Monitoring underwater explosions in the habitat of resident bottlenose dolphins*. The Journal of the Acoustical Society of America 128, 3805

Sarnocińska, J., Teilmann, J., Balle, J. D., van Beest, F. M., Delefosse, M., and Tougaard, J. (2020). *Harbor porpoise (Phocoena phocoena) reaction to a 3D seismic airgun survey in the North Sea.* Frontiers in Marine Science, *6*, 824.

Scheidat, M., Tougaard, J., Brasseur, S., Carstensen, J., T. van Polanen Petel, Teilmann, J. and Reijnders, P. (2011). *Harbour porpoises (Phocoena phocoena) and wind farms: a case study in the Dutch North Sea.* Environmental Research Letters 6:1-10.

Schoeman, R.P., Patterson-Abrolat, C. and Plön, S. (2020). *A Global Review of Vessel Collisions With Marine Animals*. Front. Mar. Sci. 7:292.

Schulte-Pelkum, N., Wieskotten, S., Hanke, W., Dehnhardt, G., and Mauck, B. (2007). *Tracking of biogenic hydrodynamic trails in harbour seals (Phoca vitulina*). Journal of Experimental Biology, 210(5), 781-787.SCOS (2020). *Scientific Advice on Matters Related to the Management of Seal Populations: 2020.* Sea Mammal Research Unit. Available at: SCOS Reports | SMRU (st-andrews.ac.uk). Accessed on: 25 November 2021.

Seagreen Technical Report. (2018). *Appendix F1 Baseline Technical Report Round 3 Zone 2 Firth of Forth Offshore Wind Farm Development*.

Seagreen Wind Energy Ltd. (2020). *Offshore Wind Farm Piling Strategy.* LF000009-CST-OF-PLN-0022. Available at: https://marine.gov.scot/sites/default/files/owf_piling_strategy.pdf. Accessed on 08 July 2022.

Seagreen Wind Energy Ltd (2021) Seagreen Alpha and Bravo Site UXO clearance – European Protected Species Risk Assessment and Marine Mammal Mitigation Plan. Available at https://marine.gov.scot/sites/default/files/eps_risk_assessment_3.pdf. Accessed on 08 July 2022

Seagreen Wind Energy Ltd. (2022a). Seagreen S36C Application Environmental Appraisal Report. LF-000009-CST-OF-LIC-REP-0011. Available at: https://marine.gov.scot/sites/default/files/seagreen_s36c_environmental_appraisal_report.pdf. Accessed on 08 July 2022.

Seagreen Wind Energy Ltd. (2022b). Seagreen S36C Application Screening Report. LF000012-CST-EV-REP-0001. Available at: https://marine.gov.scot/sites/default/files/appendix_a_-_seagreen_s36c_application_screening_report.pdf. Accessed on 08 July 2022

Seagreen Wind Energy Ltd. (2021). *Seagreen Alpha and Bravo Site UXO clearance – European Protected Species Risk Assessment and Marine Mammal Mitigation Plan*.

Seagreen Wind Farm Energy Ltd. (2021). *Project Overview - December 2021*. Available at: https://www.seagreenwindenergy.com/. Accessed on 01 April 2022.

Seagreen Wind Energy Ltd (2012). *Environmental Statement - Volume 1 - Main Text - Seagreen Alpha and Bravo Offshore Wind Farms*.

Seagreen Wind Energy Ltd (2018). *Marine Mammals.* Volume 1 Chapter 10 in Seagreen Phase I Environmental Impact Assessment Report. LF009-ENV-MA-RPT-0002. September 2018.

SEAMARCO (2011). *Temporary hearing threshold shifts and recovery in a harbor porpoise and two harbor seals after exposure to continuous noise and playbacks of pile driving sounds*. Part of the Shortlist Masterplan Wind 'Monitoring the Ecological Impact of Offshore Wind Farms on the Dutch Continental Shelf'. SEAMARCO Ref: 2011/01.

Senior, B., Bailey, H., Lusseau, D., Foote A., and Thompson, P.M. (2008). *Anthropogenic noise in the Moray Firth SAC; potential sources and impacts on bottlenose dolphins.* Scottish Natural Heritage Commissioned Report No.265 (ROAME No. F05LE02).

Sills, J. M., Ruscher, B., Nichols, R., Southall, B. L., & Reichmuth, C. (2020). Evaluating temporary threshold shift onset levels for impulsive noise in seals. The Journal of the Acoustical Society of America, 148(5), 2973-2986.

Siebert, U., Stürznickel, J., Schaffeld, T., Oheim, R., Rolvien, T., Prenger-Berninghoff, E., Wohlsein, P., Lakemeyer, J., Rohner, S., Schick, L. A., Gross, S., Nachtsheim, D., Ewers, C., Becher, P., Amling, M. and Morell, M. (2022). *Blast injury on harbour porpoises (Phocoena phocoena) from the Baltic Sea after explosions of deposits of World War II ammunition*. Environment International, Volume 159.

Sinclair, R. R., Sparling, C. E. and Harwood, J. (2020). *Review Of Demographic Parameters And Sensitivity Analysis To Inform Inputs And Outputs Of Population Consequences Of Disturbance Assessments For Marine Mammals.* Scottish Marine and Freshwater Science Vol 11 No 14, 74pp. DOI: 10.7489/12331-1

Sinclair, R. R. (2022). *Seal haul-out and telemetry data in relation to the Berwick Bank Offshore Wind Farm.* SMRU consulting report number SMRUC - RPS-2021-005, provided to RPS, January 2022.

Skeate, E.R. and Perrow, M.R. (2008). *Scroby Sands offshore wind farm: Seal monitoring. Analysis of the 2006 post-construction aerial surveys and summary of the monitoring programme results from 2002–2006.* Final report to E.ON UK Renewables Offshore Wind Limited prepared by ECON Ecological Consultancy, Norwich, UK.

Skeate, E.R., Perrow, M.R. and Gilroy, J.J. (2012). *Likely effects of construction of Scroby sands offshore wind farm on a mixed population of harbour Phoca vitulina and grey Halichoerus grypus seals*. Mar. Pollut. Bull. 64:872–881.

SMRU Consulting. (2021). *Hornsea Project Four: Environmental Statement (ES) PINS Document Reference: A2.4 APFP Regulation: 5(2)(a) Volume A2, Chapter 4: Marine Mammals*. Available at: Test (planninginspectorate.gov.uk). Accessed on 8 July 2022.

Soloway, A. G., and Dahl, P. H. (2014). *Peak Sound Pressure and Sound Exposure Level from Underwater Explosions in Shallow Water*. The Journal of the Acoustical Society of America 136 (3): EL218–23.

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene Jr, C.R., Kastak, D Miller, J.H., Nachtigall, P.E. and Richardson, W.J. (2007). *Marine Mammal Noise-Exposure Criteria: Initial Scientific Recommendations.* Aquatic Mammals 33 (4): 411–521.

Southall, B. L., Finneran, J. J., Reichmuth, C., Nachtigall, P. E., Ketten, D. R., Bowles, A. E., Ellison, W.T., Nowacek, D.P and Tyack, P. L. (2019). *Marine mammal noise exposure criteria: updated scientific recommendations for residual hearing effect*s. Aquatic Mammals, 45(2).

Southall, B.L., Nowacek, D.P., Bowles, A.E., Senigaglia, V., Bejder, L. and Tyack, P.L., (2021). *Marine Mammal Noise Exposure Criteria: Assessing the Severity of Marine Mammal Behavioral Responses to Human Noise*. Aquatic Mammals, 47(5), pp.421-464.

Sparling, C.E. (2012). *Seagreen Firth of Forth Round 3 Zone Marine Mammal Surveys*. Report number SMRUL-ROY-2012-006 to Royal Haskoning and Seagreen Wind Energy Ltd.

Sparling, C.E., Speakman, J.R. and Fedak, M.A. (2006). *Seasonal variation in the metabolic rate and body composition of female grey seals: fat conservation prior to high-cost reproduction in a capital breeder?*. J Comp Physiol B 176, 505–512.

Special Committee on Seals (SCOS) (2017). *Scientific Advice on Matters Related to the Management of Seal Populations: 2016.* Sea Mammal Research Unit. Available from: httpp://www.smru.st-andrews.ac.uk/documents. Accessed on: 16 December 2021.

SSER (2021a). *Berwick Bank Wind Farm Offshore Scoping Report*.

SSER (2022a). *Berwick Bank Wind Farm Onshore EIA Report*.

SSER (2022b). *Berwick Bank Wind Farm Marine Protected Area Assessment Report.*

SSER (2022d). *Berwick Bank Wind Farm Report to Inform the Appropriate Assessment.*

SSER (2022e) *The Cambois connection Scoping Report*

Stone, C. J., and Tasker, M. L. (2006). *The effects of seismic airguns on cetaceans in UK waters.* Journal of Cetacean Research and Management, 8(3), 255.

Sveegaard, S., J. Teilmann, P. Berggren, K. N. Mouritsen, D. Gillespie, and J. Tougaard. (2011). *Acoustic surveys confirm the high-density areas of harbour porpoises found by satellite tracking*. ICES Journal of Marine Science 68:929-936.

Swails, K. (2005). *Patterns of seal strandings and human interactions in Cape Cod, MA.* Master of Environmental Management Thesis, Nicholas School of the Environment and Earth Sciences of Duke University.

Teilmann, J., Tougaard, J. and Carstensen, J. (2006a). *Summary on harbour porpoise monitoring 1999-2006 around Nysted and Horns Rev Offshore Wind Farms*.

Teilmann, J., Tougaard, J., Cartensen, J., Dietz, R. and Tougaard, S. (2006b*). Summary on seal monitoring 1999-2005 around Nysted and Horns Rev Offshore Wind Farms.*

Teilmann J.O, Larsen F.I and Desportes G.E. (2007). *Time allocation and diving behaviour of harbour porpoises (Phocoena phocoena) in Danish and adjacent waters*. J Cetacean Res Manag. 9, 201-10.

Teilmann, J., Tougaard, J. and Carsensen, J. (2008). *Effects from offshore wind farms on harbour porpoises in Denmark. In: Evans, P. G. (Ed). Offshore wind farms and marine mammals: impacts & methodologies for assessing impacts. In Proceedings of the ASCOBANS/ECS Workshop*. ECS Special Publication Series (Vol. 49).

Terhune, J. M. and Almon, M. (1983). *Variability of harbour seal numbers on haul-out sites*. Aquatic Mammals 10(3), 71-78.

Tetley, M. J., Mitchelson-Jacob, E. G. and Robinson, K. P. (2008). *The summer distribution of coastal minke whales (Balaenoptera acutorostrata) in the southern outer Moray Firth, NE Scotland, in relation to co-occurring mesoscale oceanographic features. Remote Sensing of Environment*, 112(8), 3449–3454. https://doi.org/10.1016/J.RSE.2007.10.015

Thompson, D. (2015). *Parameters for collision risk models*. Report by Sea Mammal Research Unit, University of St Andrews, for Scottish Natural Heritage.

Thompson, P.M., Lusseau, D., Barton, T., Simmons, D., Rusin, J., and H. Bailey. (2010). *Assessing the Responses of Coastal Cetaceans to the Construction of Offshore Wind Turbines.* Marine Pollution Bulletin 60 (8): 1200–1208.

Thompson, P. M., Brookes, K. L., Graham, I. M., Barton, T. R., Needham, K., Bradbury, G., and Merchant, N. D. (2013). *Short-term disturbance by a commercial two-dimensional seismic survey does not lead to long-term displacement of harbour porpoises*. Proceedings of the Royal Society B: Biological Sciences, 280(1771), 20132001.

Thompson, P.M., Graham, I.M., Cheney, B., Barton, T.R., Farcas, A. and Merchant, N.D. (2020). *Balancing risks of injury and disturbance to marine mammals when pile driving at offshore windfarms*. Ecol Solut Evidence. 1:e12034. https://doi.org/10.1002/2688-8319.12034

Todd, V.L.G., Warley, J.C. and Todd, I.B. (2016). *Meals on wheels? A decade of megafaunal visual and acoustic observations from offshore oil & gas rigs and platforms in the North and Irish seas*. PLoS ONE 11, e0153320.CrossRefGoogle ScholarPubMed

Tougaard, J., Carstensen, J., Damsgaard Henriksen, O., and Teilmann, J. (2003*). Short-term effects of the construction of wind turbines on harbour porpoises at Horns Reef*. Denmark: N. p., 2003. Web.

Tougaard, J., Wright, A. J. and Madsen, P. T. (2015). *Cetacean noise criteria revisited in the light of proposed exposure limits for harbour porpoises*. Mar. Pollut. Bull. 90, 196–208.

Van Beest, F.M., Teilmann, J., Hermannsen, L., Galatius, .A, Mikkelsen, L., Sveegaard, S., Balle, J.D., Dietz, R. and Nabe-Nielsen, J. (2018). *Fine-scale movement responses of free-ranging harbour porpoises to capture, tagging and short-term noise pulses from a single airgun.* R. Soc. open sci.5: 170110.

Vanderlaan, A. S. M. and Taggart. C. T. (2007). *Vessel collisions with whales: the probability of lethal injury based on vessel speed.* Marine Mammal Science, 23(1), 144-156.

Van Waerebeek K., Baker A., Felix F., Gedamke J., Iniguez M., Sanino G., Secchi E., Sutaria E., Sutaria D., Helden A and Wang Y. (2007). *Vessel collisions with small cetaceans worldwide and with large whales in the Southern Hemisphere, an initial assessment.* Latin American Journal of Aquatic Mammals, 6.

Verfuss, U.K., Sparling, C.E., Arnot, C., Judd, A. and Coyle, M. (2016). *Review of Offshore Wind Farm Impact Monitoring and Mitigation with Regard to Marine Mammals*. In: Popper, A., Hawkins, A. (eds) The Effects of Noise on Aquatic Life II. Advances in Experimental Medicine and Biology, vol 875. Springer, New York, NY.

Víkingsson, G.A., Elvarsson, B., Ólafsdóttir, D., Sigurjónsson, J., Chosson, V. and Galan, A. (2014). *Recent changes in the diet composition of common minke whales (Balaenoptera acutorostrata) in Icelandic waters*. A consequence of climate change?, Marine Biology Research, 10:2, 138-152, DOI: 10.1080/17451000.2013.793812

Víkingsson, G, A., Pike, D. G., Valdimarsson, H., Schleimer, A., Thorvaldur, G., Teresa, S., Elvarsson, B., Mikkelsen, B., Øien, N., Desportes, G., Valur, B. and Hammond, P. S. (2015). *Distribution, abundance, and feeding ecology of baleen whales in Icelandic waters: have recent environmental changes had an effect?* Frontiers in Ecology and Evolution. (3) : 1-6.

Von Benda-Beckmann, A.M., Aarts, G., Sertlek, H.Ö., Lucke, K., Verboom, W.C., Kastelein, R.A., Ketten, D.R., van Bemmelen, R., Lam, F.P.A., Kirkwood, R.J. and Ainslie, M.A. (2015). *Assessing the impact of underwater clearance of unexploded ordnance on harbour porpoises (Phocoena phocoena) in the Southern North Sea.* Aquatic Mammals, 41(4), p.503.

Waggitt, J. J., P. G. H. Evans, J. Andrade, A. N. Banks, O. Boisseau, M. Bolton, G. Bradbury, T. Brereton, C. J. Camphuysen, J. Durinck, T. Felce, R. C. Fijn, I. Garcia-Baron, S. Garthe, S. C. V. Geelhoed, A. Gilles, M. Goodall, J. Haelters, S. Hamilton, L. Hartny-Mills, N. Hodgins, K. James, M. Jessopp, A. S. Kavanagh, M. Leopold, K. Lohrengel, M. Louzao, N. Markones, J. Martinez-Cediera, O. O'Cadhla, S. L. Perry, G. J. Pierce, V. Ridoux, K. P. Robinson, M. B. Santos, C. Saavedra, H. Skov, E. W. M. Stienen, S. Sveegaard, P. Thompson, N. Vanermen, D. Wall, A. Webb, J. Wilson, S. Wanless, and J. G. Hiddink. (2020). D*istribution maps of cetacean and seabird populations in the North-East Atlantic*. Journal of Applied Ecology 57:253-269.

Walls, R., Canning, S., Lye, G., Givens, L., Garrett, C. and Lancaster, J. (2013). *Analysis of marine environmental monitoring plan data from the Robin Rigg offshore wind farm, Scotland (Operational Year 1).* Technical report to E.ON Climate & Renewables UK prepared by Natural Power Consultants Ltd., Dumfries and Galloway

Watkins, W. A. (1986)*. Whale reactions to human activities in Cape Cod waters.* Marine mammal science, 2(4), 251-262.

Weilgart, L. (2011). *Underwater Noise: Death Knell of our Oceans?* Available at: http://www.raincoast.org/library/wp-content/uploads/2011/05/weilgart_underwater-noise-death-knell.pdf. Accessed on 08 April 2022.

Weir, C. (2001). *Sightings of marine mammals and other animals recorded offshore installations in the North Sea.*

Weir, C. R. (2008). *Overt responses of humpback whales, sperm whales and Atlantic spotted dolphins to seismic exploration off Angola*. Aquatic Mammals, 34.

Weir, C., Stockin, K. and Pierce, G. (2007). *Spatial and temporal trends in the distribution of harbour porpoises, white-beaked dolphins and minke whales off Aberdeenshire (UK), north-western North Sea.* Journal of the Marine Biological Association of the United Kingdom. 87. 327 - 338. 10.1017/S0025315407052721.

Weller, D., Ivashchenko, Y. and Tsidulko, G. (2002). *Influence of seismic surveys on western gray whales off Sakhalin Island, Russia in 2001.* Publ. Agencies Staff U.S. Dep. Commer. Paper 73.

Wells, R. S., Allen, J. B., Hofmann, S., Fauquier, D, A., Barros, N. B., DeLynn, R. E., Sutton, G., Socha, V. and Scott, M. D. (2008). *Consequences of injuries on survival and reproduction of common bottlenose dolphins (Tursiops truncatus) along the west coast of Florida*, Marine Mammal Science, 24 (4).

Weston, D. E. 1976. "Propagation in Water with Uniform Sound Velocity but Variable-Depth Lossy Bottom." Journal of Sound and Vibration 47 (4): 473–83.

Weston. 1980a. "Acoustic Flux Formulas for Range-Dependent Ocean Ducts." The Journal of the Acoustical Society of America 68 (1): 269–81.

Weston. 1980b. “Acoustic Flux Methods for Oceanic Guided Waves.” The Journal of the Acoustical Society of America 68 (1): 287–96.

Wilson, B., Batty, R. S., Daunt, F. and Carter, C. (2007). *Collision risks between marine renewable energy devices and mammals, fish and diving birds.* Report to the Scottish Executive. Scottish Association for Marine Science, Oban.

Wisniewska, D. M., Johnson, M., Teilmann, J., Rojano-Doñate, L., Shearer, J., Sveegaard, S. and Madsen, P. T. (2016). *Ultra-high foraging rates of harbor porpoises make them vulnerable to anthropogenic disturbance*. Current Biology, 26(11), 1441-1446.

Wisniewska, D. M., Johnson, M., Teilmann, J., Siebert, U., Galatius, A., Dietz, R., and Madsen, P. T. (2018). *High rates of vessel noise disrupt foraging in wild harbour porpoises (Phocoena phocoena).* Proceedings of the Royal Society B: Biological Sciences, *285*(1872), 20172314.

Wright, A.J., and Cosentino, A.M. (2015). *JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys: We can do better.* Marine Pollution Bulletin

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