Chapter 10: Marine Mammals

Array EIA Report

2024

Revision	Comments	Author	Checker	Approver
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Approval for Issue		
For and on behalf of Ossian OWFL	Rich Morris	28 June 2024

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10. MARINE MAMMALS

10.1. INTRODUCTION

1. This chapter of the Array Environmental Impact Assessment (EIA) Report presents the assessment of the likely significant effects (as per the EIA Regulations) on marine mammals as a result of the Ossian Array which is the subject of this application (hereafter referred to as “the Array”). Specifically, this chapter assesses the likely significant effects of the Array on marine mammals during the construction, operation and maintenance, and decommissioning phases.

2. Likely significant effect is a term used in both the EIA Regulations and the Habitat Regulations. Reference to likely significant effect in this Array EIA Report refers to likely significant effect (LSE[1]) as used by the EIA Regulations. This Array EIA Report is accompanied by a Report to Inform Appropriate Assessment (RIAA) (Ossian OWFL, 2024) which uses the term as defined by the Habitats Regulations.

3. The following technical chapters also inform the assessment presented in this chapter:

- 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 also 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 Array 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 volume 3, appendix 10.1 which models the predicted underwater noise emissions associated with the construction and installation of the Array.

10.2. PURPOSE OF THE CHAPTER

5. The Array EIA Report provides the Scottish Ministers, statutory and non-statutory stakeholders with adequate information to determine the LSE[1] of the Array on the receiving environment. This is further outlined in volume 1, chapter 3.

6. The purpose of this marine mammals Array EIA Report chapter is to:

- summarise the existing environmental baseline established from desk studies, site-specific surveys and telemetry data as well as consultation with stakeholders;
- identify any assumptions and limitations encountered in compiling the environmental information;
- present results of underwater noise modelling;
- present the environmental impacts on marine mammals arising from the Array and reach a conclusion on the significance of effects on marine mammals, based on the information gathered and the analysis and assessments undertaken; and
- highlight any necessary monitoring and/or mitigation measures which are recommended to prevent, minimise, reduce or offset the likely significant adverse environmental effects of the Array on marine mammals.

10.3. STUDY AREA

7. For the purpose of this chapter, two study areas have been defined. Figure 10.1 illustrates the marine mammal study areas for the Array as follows:

- Array marine mammal study area: an area encompassing the site boundary (within which the Array will be located) plus 8 km buffer (Figure 10.1). This area also corresponds with the site-specific survey area, in which 24 months of Digital Aerial Surveys (DAS) were conducted; and
- Regional marine mammal study area: an area encompassing the wider northern North Sea to account for the highly mobile nature of marine mammals which encompasses the zone of influence (ZoI) for all impacts. The boundaries of the northern North Sea are closely aligned with those of Marine Protected Areas (MPAs) (Wildlife Trusts, 2023), and encompasses multiple SCANS IV blocks (Gilles *et al.*, 2023) and overlaps with relevant species-specific MUs (summarised in Table 10.13, with detail presented in volume 3, appendix 10.2) . The regional marine mammal study area has informed the screening of internationally designated sites (section 10.9.3) and has been used to identify projects included in the Cumulative Effects Assessment (CEA) (section 10.12).

8. These study areas are as described in the Array EIA Scoping Report (Ossian OWFL, 2023), and the use of the two marine mammal study areas has been agreed with MD-LOT via the Scoping Opinion in June 2023 (see Table 10.10).

10.4. POLICY AND LEGISLATIVE CONTEXT

9. Volume 1, chapter 2 presents the policy and legislation of relevance to renewable energy infrastructure. Policy and legislation specifically in relation to marine mammals is contained in the Marine and Coastal Access Act 2009, the Habitats Regulations[1] (see volume 1, chapter 2 for more details on this collective term), 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.

10. A summary of the legislative provisions and policy frameworks relevant to marine mammals is provided in Table 10.1 to Table 10.9. Further detail is presented in volume 1, chapter 2.

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[1] The Conservation of Offshore Marine Habitats and Species Regulations 2017 and the Conservation of Habitats and Species Regulations 2017 transpose the provisions of the Habitats Directive in offshore waters, beyond 12 nm and in relation to applications made under the Electricity Act 1989.

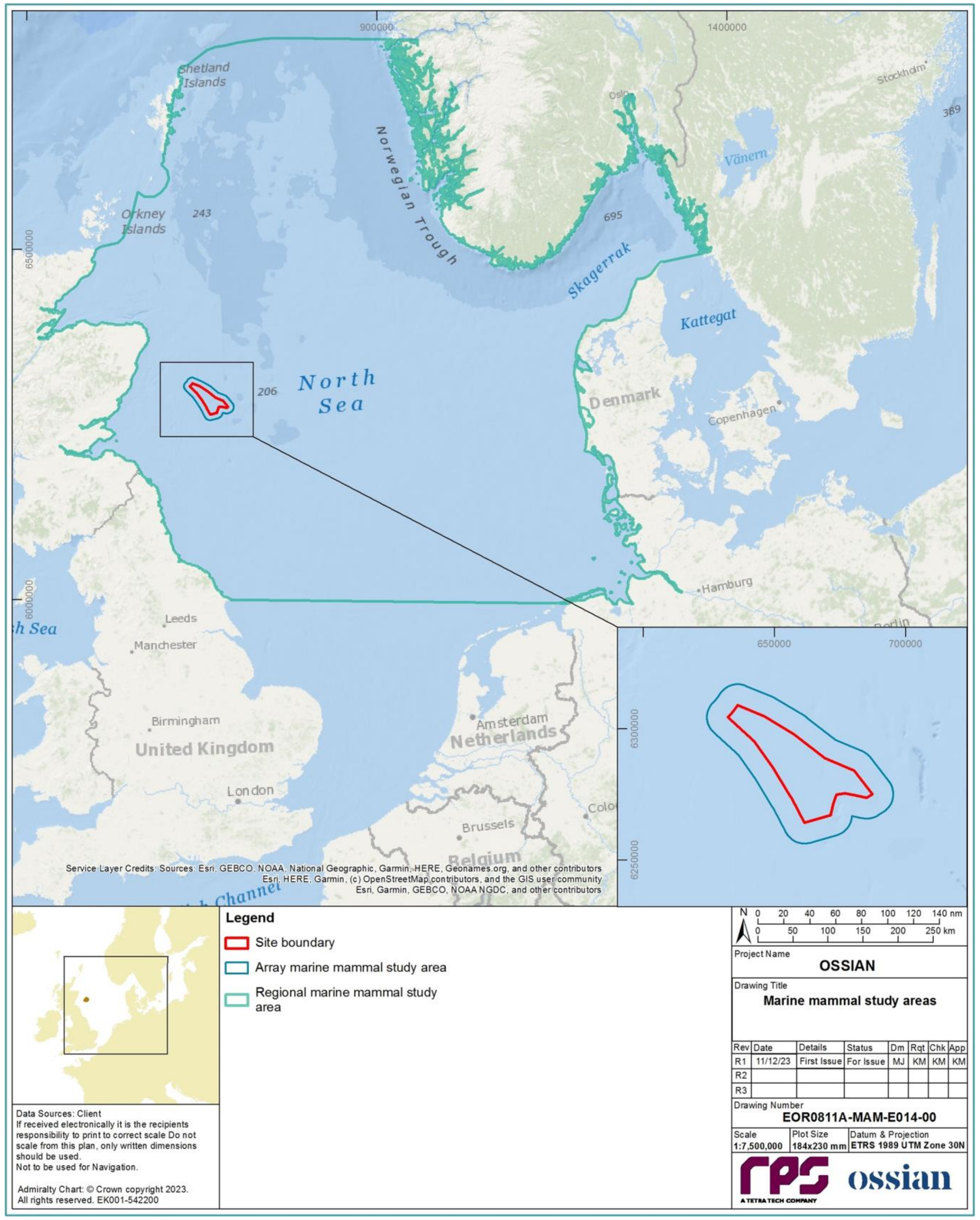

Figure 10.1: Marine Mammal Study Areas

Table 10.1: Summary of Marine and Coastal Access (MCAA) Act 2009 Relevant to Marine Mammals

Summary of Relevant Legislation	How and Where Considered in the Array EIA Report
MPAs/Marine Conservation Zones (MCZs)	
MPAs existing beyond the 12 nm limit in Scottish Waters and MCZs in English waters are designated under the MCAA 2009. These sites (MPAs and MCZs) are areas that have been designated for the purpose of conserving – marine flora and fauna; marine habitat or types of marine habitat; or features of geological or geomorphological interest. The Nature Conservation Marine Protected Area (ncMPA) network, designated under the above legislation, includes several NCMPAs which protect marine features such as Risso’s dolphin *Grampus griseus* and minke whale *Balaenoptera acutorostrata*.	All relevant MPAs in Scottish offshore waters (beyond 12 nm) are listed in section 10.7.2 and further described in volume 3, appendix .1 and potential effects on these are considered in section 10.11. The Southern Trench ncMPA is identified in the regional marine mammal study area.

Table 10.2: Summary of Marine (Scotland) Act 2010 Relevant to Marine Mammals

Summary of Relevant Legislation	How and Where Considered in the Array EIA Report
Habitat Health	
The Scottish Ministers, and public authorities must act in the way best calculated to further the achievement of sustainable development, including the protection and, where appropriate, enhancement of the health of that area.	The assessment of the environmental impacts of the Array on the marine mammals is presented 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.	The designated haul-out sites located in vicinity to the Array are 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 any phase of the Array.
Nature Conservation Marine Protected Areas	
The Marine (Scotland) Act 2010 provides for the development of a marine spatial planning system, creating a framework for marine developments and enables the creation of ncMPA.	In line with the agreement during the pre-Scoping workshop held on 17 November 2022, the Southern Trench ncMPA is considered in section 10.11 due to the overlap of noise contours with the boundaries of this site.

Table 10.3: Summary of the Habitats Regulations Relevant to Marine Mammals

Summary of Relevant Legislation	How and Where Considered in the Array 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, a competent authority must make an appropriate assessment of the implications of the plan or project for that site in view of that site's conservation objectives. If the competent authority is satisfied that, there being no alternative solutions, the plan or project must be carried out for imperative reasons of over-riding public interest it may agree to the plan or project notwithstanding a negative assessment of the implications for the European site and if compensatory measures can be secured.	All European sites with marine mammals as protected features, located in vicinity of the Array are listed in section 10.7.2 and effects on these are considered in section 10.11. A consideration of impacts on the relevant European sites from the Array cumulatively with other plans and projects is provided in section 10.12. European sites are further assessed in accordance with the HRA is presented in the RIAA (Ossian OWFL, 2024).
Species Protection	
A person is guilty of an offence if they deliberately capture, injure, or kill any wild animal of a European Protected Species (EPS). In Scottish inshore waters (within 12 nm of the coast), offences relating to the protection of marine EPS are provided for under the Habitats Regulations.	All the relevant protected species have been identified in section 10.7.1. The environmental assessments of impacts of the Array on marine mammals provided in section 10.11 consider the conservation status of marine mammals when determining 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 an offence and this application would be informed by the assessments presented in section 10.11.

Table 10.4: Summary of Scotland's National Marine Plan (2015) Relevant to Marine Mammals

Summary of Relevant Policy Framework	How and Where Considered in the Array EIA Report
General Policies	
GEN 9 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.*"	Marine mammal protected species and PMFs are identified in section 10.7.1. Section 10.11 presents an assessment of the significance of the effects of the Array on marine mammals along with mitigation measures adopted to prevent, minimise, reduce or offset potential impacts.
Paragraph 4.47 *et seq.* of the Plan refers to ncMPAs 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 a ncMPA 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 as a result of the construction, operation and maintenance and decommissioning phases of the Array on marine mammal receptors with respect to the designated sites, including the Southern Trench ncMPA.
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.*" (4.53)	Marine mammal protected species and PMFs are identified in section 10.7.1. Section 10.11 presents an assessment of the significance of the effects of the Array on marine mammals 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 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 Array in the context of climate change in volume 2, chapter 17.

Table 10.5: Summary of PMFs in Scotland's Seas – Habitats Relevant to Marine Mammals (NatureScot, 2020)

Summary of Relevant Policy Framework	How and Where Considered in the Array 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.	Marine mammal PMFs are identified in section 10.7.1. Section 10.11 presents an assessment of the significance of the effects of the Array on marine mammal receptors along with mitigation measures adopted to prevent, minimise, reduce or offset potential impacts.

Table 10.6: Summary of The Sectoral Marine Plan for Offshore Wind Energy 2020[2] Relevant to Marine Mammals

Summary of Relevant Policy Framework	How and Where Considered in the Array 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.(2.1)	Section 10.11 presents assessments of the significance of the effects as a result of the construction, operation and maintenance and decommissioning phases of the Array on marine mammal receptors. A consideration of impacts on the relevant European sites from the Array cumulatively with other plans and projects is provided in section 10.12.
Offshore Wind and Marine Renewable Energy Policies	
Regional cumulative effects include the potential for negative effects on bird populations, benthic habitats, cetaceans, navigational safety, seascape/landscape and commercial fisheries. The Sectoral Marine Plan includes measures to mitigate potential impacts at various scales. (4.1)	A consideration of impacts on the relevant European sites from the Array cumulatively with other plans and projects is provided in section 10.12 alongside relevant mitigation measures.

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[2] At the time of writing, the SMP is subject to an iterative review process, therefore, the information provided within this chapter is based upon the SMP published by the Scottish Government in 2020.

Table 10.7: Summary of the UK Marine Policy Statement Relevant to Marine Mammals

Summary of Relevant Policy Framework	How and Where Considered in the Array EIA Report
General Policies	
Ensure a sustainable marine environment which promotes healthy, functioning marine ecosystems and protects marine habitats, species and our heritage assets. (Introduction)	The magnitude of impacts and the sensitivity of marine mammal receptors are assessed in section 10.11 to determine if the impacts as a result of the construction, operation and maintenance and decommissioning phases of the Array may result in a significant effect on the marine mammal receptors.
The marine environment plays an important role in mitigating climate change. (2.2)	The impact of climate change on the baseline environment and how this may influence the assessment of effects is considered as part of the future baseline in section 10.7.4. A climate change assessment has been undertaken that considers the Array in the context of climate change in volume 2, chapter 17.
Biodiversity is protected, conserved and where appropriate recovered and loss has been halted. (2.2)	Marine mammal PMFs are identified in section 10.7.1. Section 10.11 presents an assessment of the significance of the effects of the Array 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. (2.2)	Section 10.11 presents an assessment of the significance of the effects of the Array on marine mammal receptors along with mitigation measures adopted to prevent, minimise, reduce or offset potential impacts.

Table 10.8: Summary of the Nature Conservation (Scotland) Act 2004 Relevant to Marine Mammals

Summary of Relevant Legislation	How and Where Considered in the Array EIA Report
General Principles	
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. (4A)	Section 10.11 presents an assessment of the significance of the effects of the Array on marine mammal receptors along with mitigation measures adopted to prevent, minimise, reduce or offset potential impacts. An application for an EPS licence will be made for any activity which has potential to result in an offence and this application would be informed by assessment presented in section 10.11.

Table 10.9: Summary of The Scottish Biodiversity Strategy (Scottish Government 2023) Relevant to Marine Mammals

Summary of Relevant Policy Framework	How and Where Considered in the Array EIA Report
General Principles	
Sets out a vision for 2045 explaining how the government will conserve biodiversity for the people of Scotland now and in the future with the objective to halt the loss of biodiversity.	Section 10.11 presents an assessment of the significance of the effects of the Array on marine mammal receptors along with mitigation measures adopted to prevent, minimise, reduce or offset potential impacts.

10.5. CONSULTATION

11. Table 10.10 presents a summary of the key issues raised during consultation activities undertaken to date specific to marine mammals for the Array and in the Ossian Array Scoping Opinion (Marine Directorate – Licensing Operations Team (MD-LOT, 2023) along with how these have these have been considered in the development of this marine mammal EIA Report chapter. Further detail is presented within volume 1, chapter 5. To date, consultation activity has included the pre-Scoping workshop with MD-LOT, NatureScot and Marine Scotland Science (November 2022), the Scoping Opinion from MD-LOT (June 2023) and post-scoping consultation with NatureScot (via email) for further key areas of agreement (Marine Mammal Consultation Notes 1 and 2; volume 3, appendix 5.1, annexes D and E, respectively).

Table 10.10: Summary of Issues Raised During Consultation and Scoping Opinion Representations Relevant to Marine Mammals

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
Pre-Scoping Workshop			
November 2022	MD-LOT, NatureScot, Marine Directorate Science, Evidence, Data and Digital (MD-SEDD) (previously Marine Scotland Science, hereafter referred to as "MD-SEDD")	NatureScot queried inclusion of an assessment of impacts as a result of operational noise from cables.	The assessment of impacts as a result of operational underwater noise from cables and mooring lines is presented in section 10.11.
		Marine Scotland Science advised that primary and secondary entanglement should be scoped in for the operation and maintenance phase.	The assessment of impacts as a result of primary and secondary entanglement is presented in section 10.11
		NatureScot queried inclusion of an assessment of impacts as a result of electromagnetic fields (EMFs) from the floating array.	The assessment of impacts as a result of EMFs from dynamic cables is presented in section 10.11.
		NatureScot advised that scoping in the Southern Trench ncMPA should be reconsidered when noise contours are available.	Given the overlap of the modelled noise contours with the Southern Trench ncMPA, it is considered in the assessment in section 10.11.
		NatureScot advised that in relation to foraging distances, 20 km distance should be used for grey seals *Halichoerus grypus* for Special Areas of Conservation (SACs) because these are classed as breeding sites.	The foraging distance of 20 km has been considered in the assessment of impacts for grey seal with relation to the Berwickshire and North Northumberland Coast SAC in section 10.11.
		NatureScot advised that a dual metric approach is used in underwater noise modelling but also that the unweighted peak sound pressure level (SPL_{pk}) metric is used to inform the Permanent Threshold Shift (PTS) assessment and appropriate mitigation range.	Both SPL_{pk} and cumulative sound exposure level (SEL_{cum}) are considered, with the assessment of significance with regards to PTS presented in section 10.11 is based on SPL_{pk}.
Scoping Opinion			
June 2023	MD-LOT Scoping Opinion (June 2023)	*"The Scottish Ministers are broadly content with the study areas as described in section 6.3.2 of the Scoping Report and support the baseline data sources as listed in Appendix 9, Table 9.1."*	The assessment of effects on marine mammal receptors is carried out with respect to the study areas presented in section 10.3. These study areas are as described in the Array EIA Scoping Report. In addition, baseline data sources as listed in the Array EIA Scoping Report have been used to inform both this chapter (chapter 10) and appendix 10.2.
		"With regards to baseline characterisation, in line with the NatureScot representation, the Scottish Ministers advise against apportioning unidentified marine mammal sightings during Digital Aerial Surveys ("DAS") to the most abundant identified species and/or groups, to prevent introducing bias to the DAS results. The highest density estimate for each species should be used from site-specific surveys and publicly available density estimates and the advice from NatureScot in this regard must be fully addressed in the EIA Report."	Apportioning of unidentified marine mammal sightings was not included during the analysis of the DAS data in volume 3, appendix 10.2, annex A. The Array EIA Scoping Report detailed 46 unidentified marine mammals in the interim DAS data at the time, and following advice from MD-LOT., these were not included in the analysis of DAS data in volume 3, appendix 10.2, annex A. Reference populations are as described in the Array EIA Scoping Report for harbour porpoise *Phocoena phocoena*, minke whale and white-beaked dolphin *Lagenorhynchus albirostris*, and uses the two seal management units (SMU) presented in the Array EIA Scoping Report (East Scotland SMU and Northeast England SMU). Publicly available density estimates and site-specific survey densities were presented in detail in volume 3, appendix 10.2, which includes those sources presented in the Array EIA Scoping Report, with the final density estimates agreed by NatureScot following post-scoping consultation (Marine Mammal Consultation Notes 1 and 2; volume 3, appendix 5.1, annexes D and E, respectively).
		"Table 6.13 of the Scoping Report summarises the potential impacts to marine mammals identified during different phases of the Proposed Development. In addition to the impact pathways identified to be scoped into the EIA Report, the Scottish Ministers advise that underwater noise from floating turbines and dynamic cables during the operational phase must be scoped into the EIA Report. Additionally due to the limited information regarding marine mammal interaction with buried cables, the impacts of EMF from subsea electrical cabling should also be scoped into the EIA Report during the operation and maintenance phase. This view is supported by the NatureScot representation which should be fully addressed by the Developer in the EIA Report."	A qualitative assessment of effects on marine mammal receptors as a result of operational noise from underwater floating wind turbines and dynamic cables and the impacts of EMF from subsea electrical cabling during the operation and maintenance phase is presented in section 10.11. Whilst the effects of operational noise from floating turbines and dynamic cables and EMF were originally scoped out in the Array EIA Scoping Report, they are included in the assessment of effects in section 10.11 in the Array EIA Report following advice from MD-LOT and NatureScot.
		"Additionally, the Scottish Minister currently advise in relation to UXO clearance that, until the outcomes of the deflagration campaign in Scottish waters are available, both high order and low order clearance should be modelled to ensure that the worst case scenario is assessed. The Scottish Ministers direct the Developer to the joint interim position statement outlined in the NatureScot representation in this regard."	Low order techniques are used as preferred unexploded ordnance (UXO) clearance technique for the Array (which aligns with the recommendation in the joint interim position statement (UK Government *et al.*, 2022)), with this approach presented in the Array EIA Scoping Report. However, the assessment of effects on marine mammal receptors presented in section 10.11 is based on both low and high order detonation. The joint interim position statement (UK Government *et al.*, 2022) has been considered in the assessment of UXO clearance in section 10.11.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
		"In relation to subsea noise generated during piling, the Scottish Ministers advise that bottlenose dolphin and harbour seal are scoped in for assessment until noise modelling for piling indicates that they can be ruled out. Humpback whale should also be scoped in but this assessment may be qualitative in nature. This view is supported by the NatureScot representation."	As presented in section 10.7, bottlenose dolphin *Tursiops truncatus* (quantitatively) and humpback whale *Megaptera novaeangliae* (qualitatively) are scoped into the assessment following advice from MD-LOT on the Array EIA Scoping Report (which had excluded these two species as key marine mammal receptors for assessment) and subsequent consultation post scoping. Following a thorough review of harbour seal *Phoca vitulina* connectivity with the Array marine mammal study area presented in the Marine Mammal Consultation Note 1 (volume 3, appendix 5.1, annex D), it has been concluded that significant effects on harbour seal populations on the east coast of Scotland are highly unlikely. Furthermore, NatureScot confirmed in their response to the Marine Mammal Consultation Note 1 that there is sufficient evidence that the likelihood of significant effects on harbour seal are low, and so can be excluded from the Array EIA Report. As such, the Applicant included the detailed assessment of harbour seal ecology and distribution within the regional marine mammal study area in volume 3, appendix 10.2 and its annex A and annex B as well as volume 3, appendix 10.3, but excluded this species from further analysis in this chapter (which aligns with the target species presented in the Array EIA Scoping Report).
		"The Scottish Minister are broadly content with the approach to assessment in section 6.3.8 of the Scoping Report however advise that the additional guidance identified by NatureScot should be incorporated."	The assessment of effects on marine mammal receptors is carried out in line with the EIA methodology presented in section 10.11 and in, addition to the approach presented in the Array EIA Scoping Report, additional guidance (Joint Nature Conservation Committee (JNCC) (2017), JNCC (2021c)) identified by NatureScot has been considered in the relevant impact assessment for UXO and geophysical surveys (section 10.11.2).
		"*In regards to mitigation and monitoring, the Scottish Ministers are content with the measures detailed in section 6.3.5 of the Scoping Report and advise that, where impact pathways have been identified, the full range of mitigation measures and published guidance must be included in the EIA Report. In line with the NatureScot representation, the Scottish Ministers advise that noise monitoring through all stages of the Proposed Development must be considered in the EIA Report."*	The designed in measures will evolve over the development process as the EIA progresses, but includes the measures set out in the Array EIA Scoping Report. The marine mammal assessment presented in section 10.11 considers the potential for residual risk of injury after implementation of primary and tertiary mitigation (designed in measures) The Applicant will seek to work with the other offshore wind projects and stakeholders in Scotland to develop a robust approach to regional and strategic monitoring as appropriate, including for any noise monitoring taking account of the final project design. They will seek to support strategic monitoring taking account of the evidence maps and ongoing work being progressed as part of the Scottish Marine Energy Research (ScotMER) programme to address data gaps.
		"The Scottish Ministers are broadly content with the approach to the cumulative assessment as described in section 6.3.9 of the Scoping Report. The Developer is encouraged to use the Cumulative Effects Framework and collaborate with neighbouring offshore wind developers to reduce the potential cumulative impacts from subsea noise."	The assessment of cumulative effects on marine mammals is carried out in line with the methodology presented in section 10.12, and is as described in the Array EIA Scoping Report. The Cumulative Effects Framework (CEF) tool has not been published at the time of writing this assessment and therefore interim Population Consequences of Disturbance Model (iPCoD) modelling has been undertaken in line with the methodology presented in the Marine Mammal Methodology Note (volume 3, appendix 5.1, annex B).
June 2023	MD-LOT Scoping Opinion (June 2023)	*"Transboundary effects will need to be considered within the EIA Report for cetacean species but not for seal species. The Developer should seek further advice from NatureScot in regard to transboundary effects when initial impact assessments have be concluded."*	The Array EIA Scoping Report proposed to scope out transboundary effects, but following advice from MD-LOT and NatureScot, has been considered within the Array EIA Report. Further advice on transboundary effects was sought through Marine Mammal Consultation Note 2 (volume 3, appendix 5.1, annex E), which detailed including projects in other European Economic Areas (EEAs) in the CEA (section 10.12) in a qualitative approach and was confirmed as appropriate by NatureScot. Transboundary effects have been assessed in section 10.14.
June 2023	NatureScot Scoping Representation (May 2023)	*"In regard to the HRA Screening, in line with the NatureScot representation, the Scottish Ministers advise the Moray Firth SAC should remain screened into the assessment in respect of bottlenose dolphin until noise modelling is completed, after which the Developer should engage with NatureScot to agree an approach to assessment. The Berwickshire and North Northumberland Coast SAC for grey seal and Southern North Sea SAC for harbour porpoise should also remain screened in for further assessment in line with the Natural England advice dated 05 June 2023 (unless later agreed with Natural England that these can be screened out). The remaining UK protected sites and associated marine mammal qualifying features should be scoped out of the assessment."*	The Moray Firth SAC, Berwickshire and North Northumberland Coast SAC and Southern North Sea SAC are taken forward to consideration in sections 10.11 and 10.12 of this report as well as in the RIAA (Ossian OWFL, 2024). The Firth of Tay and Eden Estuary and Dornoch and Morrich More SAC, both designated for harbour seal, were both presented in the Array EIA Scoping Report, but have been excluded from assessment when harbour seal was scoped out as a key species (following confirmation from NatureScot in Marine Mammal Consultation Note 1; volume 3, appendix 5.1, annex D).
		"We support the proposed approach of carrying out a desk-based review of existing marine mammal data, focusing on sourcing data that has been collected within or near to the study area. We support the list of existing datasets as described in Appendix 9, Apx Table 9.1. This has been supplemented by site-specific monthly digital aerial surveys (DAS), and note that interim DAS results have been included in this baseline characterisation."	A summary of data sources, historic surveys within the wider Firth of Forth and Tay as well as the site-specific DAS used to inform the marine mammal baseline is provided in section 10.6 of this report (see volume 3, appendix 10.2 for more details) and includes baseline sources listed in the Array EIA Scoping Report.
		"Approximately 5% of all DAS marine mammal sightings were recorded as unidentified marine mammals. We advise against apportioning these to the most abundant identified species / groups, as this introduces bias in the DAS results."	Apportioning of unidentified marine mammal sightings was not included during the analysis of the DAS data in volume 3, appendix 10.2, annex A. The Array EIA Scoping Report detailed 46 unidentified marine mammals in the interim DAS data at the time, and following advice from MD-LOT., these were not included in the analysis of DAS data in volume 3, appendix 10.2, annex A.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
June 2023		*“Consideration is needed as to whether density estimates from site-specific surveys, or those derived from publicly available density estimates (e.g. SCANS/ Waggitt 2020) are used in the assessment. Our position is to use whichever is the highest density estimate for each species.”*	A range of densities from publicly available data sources and site-specific surveys, along with the justification for densities taken forward to the assessment is provided for each species in volume 3, appendix 10.2. A summary of densities for use in the impact assessment is presented in Table 10.14. Consultation with NatureScot has been undertaken post Scoping Opinion on the most appropriate and robust densities for each species for the assessment. Justification for the densities were provided in the Marine Mammal Consultation Note 1 and all densities were agreed with NatureScot except for minke whale (for which further justification was requested) and harbour porpoise (for which additional clarification on DAS was requested) (volume 3, appendix 5.1, annex D). Marine Mammal Consultation Note 2 provided further justification on the density estimate used for minke whale and information on the correction factors used for calculating density estimates for harbour porpoise from DAS data. NatureScot confirmed agreement of the density for minke whale and use of the correction factor for harbour porpoise in their response to Marine Mammal Consultation Note 2 (volume 3, appendix 5.1, annex E).
		“Table 6.13 summarises the impacts to be scoped into the marine mammal assessment, and Table 6.14 the impacts proposed to be scoped out of assessment. We broadly support the proposed approach, however we do not support scoping out of EMF from subsea electrical cabling during the operation and maintenance phase and we advise that it is scoped into assessment.”	The assessment of effects on marine mammal receptors as a result of EMF from subsea electric cabling in the water column during the operation and maintenance phase is presented in section 10.11 for the project alone and section 10.12 for the CEA. Whilst the effect of EMF on marine mammal receptors were originally scoped out in the Array EIA Scoping Report, they are included in the assessment of effects in section 10.11 in the Array EIA Report following advice from MD-LOT and NatureScot.
		“We appreciate there is limited information available around the potential interaction between marine mammal prey species and EMF from buried cables, however there is an absence of information on the potential interactions between EMF from ‘exposed’ dynamic cables. Given the novel nature of floating wind technology, together with the scale of this and other ScotWind proposals, we consider there is an urgent need to better understand EMF effects from dynamic cables, as well as the potential risk of entanglement. This is likely to be best addressed through strategic monitoring and we welcome the ScotMER project “A Targeted Approach to Defining EMF from Subsea Cables and Understanding Potential Impacts on Fish and Benthic Species”.”	The recommended ScotMER project has been considered in the assessment of effects on benthic and fish receptors in volume 2, chapter 8 and volume 2, chapter 6. The effects of altered prey availability, from impacts including EMF, have been assessed in section 10.11 and section 10.12 for the CEA. The effects of both potential EMF and potential risk of entanglement from dynamic cables in the water column on marine mammal receptors have been assessed in section 10.11 for the project alone and section 10.12 for the CEA. The effect of EMF on marine mammals was originally scoped out in the Array EIA Scoping Report but is included in the Array EIA Report in section 10.11 and section 10.12 following advice and consultation post-scoping. The Applicant will seek to engage with other offshore wind developers and strategically, through initiatives such as ScotMER to address evidence gaps in understanding for key areas of uncertainty in relation to floating offshore wind (FOW).
		“At this stage, we also advise that operational noise from turbines should be scoped in as well as operational noise from dynamic cables, due to the scale of the development and the limited understanding of underwater noise from floating wind projects.”	The assessment of operational noise from turbines and from dynamic cables have been assessed in section 10.11 for the project alone and section 10.12 for the CEA. Whilst the effect of operational noise on marine mammal receptors were originally scoped out in the Array EIA Scoping Report, they are included in the assessment of effects in section 10.11 in the Array EIA Report following advice from MD-LOT and NatureScot.
		“In considering UXO, we advise the applicants to refer to the 2022 Joint Interim Position Statement. Our preference is to see the use of deflagration as a removal technique and there is currently a deflagration campaign ongoing in Scottish waters. However, in the absence of the outcomes of this campaign, we advise that currently, both high order and low order clearance should be modelled to ensure the worst case scenario is assessed.”	Low order techniques are used as preferred UXO clearance technique (which aligns with the recommendation in the joint interim position statement (UK Government *et al.*, 2022), with this approach presented in the Array EIA Scoping Report, however, the assessment of effects on marine mammals presented in section 10.11 is based on low and high order detonation. The joint interim position statement (UK Government *et al.*, 2022) has been considered in the assessment of UXO clearance in section 10.11.
		“We recognise that the construction methods for floating OWF technology are expected to produce less subsea noise than that of fixed foundation OWFs. However, the scale of Ossian comprises up to 270 WTGs each with potentially 9 piled anchors, along with 6 OSPs with 16 piles per platform with a construction period of up to 9 years. While we appreciate non-piling mooring techniques will be explored for the WTGs, we understand that there could still be a significant scale of anchor piling needed for this project.”	Injury and disturbance from underwater noise generated during piling of floating foundations, including anchor piling, is assessed in section 10.11 for the project alone and section 10.12 for the CEA.
		“*We also note that bottlenose dolphin (Appendix 9, paragraph 242) and harbour seal (Appendix 9, paragraph 241) have been scoped out for further assessment and while we acknowledge that they both tend to be more coastal species, we advise they are scoped in for further assessment until the noise modelling results for piling provides evidence that they can be ruled out of requiring further assessment. Similarly, due to a recent increase in sightings of humpback whale on the east coast of Scotland, we advise that this species is also included in the marine mammal assessment (this may be qualitative).*”	As presented in section 10.7, bottlenose dolphin (quantitively) and humpback whale (qualitatively) are scoped into the assessment following advice from MD-LOT and NatureScot (these species were initially scoped out in the Array EIA Scoping Report). Following a thorough review of harbour seal connectivity with the Array marine mammal study area presented in the Marine Mammal Consultation Note 1 (volume 3, appendix 5.1, annex D), it has been concluded that the significant effects on harbour seal populations on the east coast of Scotland are highly unlikely. Furthermore, NatureScot confirmed in their response to the Marine Mammal Consultation Note 1 that there is sufficient evidence that the likelihood of significant effects on harbour seal are low, and so can be excluded from the Array EIA Report. As such, the Applicant included the detailed assessment of harbour seal ecology and distribution within the regional marine mammal study area in volume 3, appendix 10.2 and its annex A and annex B as well as volume 3, appendix 10.3, but excluded this species from further analysis in this chapter, aligning with the Array EIA Scoping Report which initially scoped harbour seal out as a key species.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
June 2023	NatureScot Scoping Representation (May 2023)	*"We encourage the applicant to work collaboratively to understand cumulative impacts from underwater noise, making use of the Cumulative Effects Framework and working with neighbouring developers to reduce and better understand cumulative subsea noise."*	The CEF tool has not been published at the time of writing this assessment and therefore iPCoD modelling has been undertaken in line with the methodology presented in the Marine Mammal Methodology Note (volume 3, appendix 5.1, annex B), and aligns with the approach presented in the Array EIA Scoping Report.
June 2023	NatureScot Scoping Representation (May 2023)	*"We welcome the inclusion of these impact pathways into assessment and have no specific comments to offer. We broadly support the approach to assessment set out in section 6.3.8. Most of the relevant technical guidance has been identified in paragraph 406, however we advise that JNCC guidance on explosives and seismic activities should be added."*	JNCC guidance on explosives and seismic activities (JNCC, 2017, JNCC, 2021c) has been considered in the relevant assessment of effects for UXO and geophysical surveys (section 10.11.2) in addition to the guidance documents presented in the Array EIA Scoping Report.
June 2023	NatureScot Scoping Representation (May 2023)	*"We are broadly content with the proposed approach to cumulative assessment described in section 6.3.9."*	The approach proposed in the Scoping Opinion and accepted by NatureScot has been adopted for the CEA in section 10.12.
June 2023	NatureScot Scoping Representation (May 2023)	*"We welcome the designed in measures described in section 6.3.5. We note the content of the Mitigation and Monitoring Commitments Register in the EIA Scoping Report (Appendix 2), which includes a Marine Mammal Mitigation Plan (MMMP). We specifically welcome the proposed use of PAM, ADDs and MMOs in the MMMP. We advise that the full range of mitigation measures and published guidance is considered and discussed in the EIA Report."*	The designed in measures, which include those presented in the Array EIA Scoping Report, will evolve over the development process as the EIA progresses. The marine mammal assessment presented in section 10.11 considers the potential for residual risk of injury after implementation of primary and tertiary mitigation (designed in measures). The outline MMMP (volume 4, appendix 22) includes use of Passive Acoustic Monitoring (PAM), Acoustic Deterrent Devices (ADDs) and Marine Mammal Observers (MMOs[2]).
June 2023	NatureScot Scoping Representation (May 2023)	*"There do not appear to be any specific marine mammal monitoring measures in Appendix 2, and further information on proposed marine mammal monitoring should be discussed in the EIA Report."*	Proposed marine mammal monitoring is detailed in section 10.13.
June 2023	NatureScot Scoping Representation (May 2023)	*"Consideration may need to be given to transboundary effects for certain cetacean species, but not for seal species due to existing marine mammal management units. Once initial impact assessment has been carried out we can provide further advice on this aspect."*	The Array EIA Scoping Report proposed to scope out transboundary effects, but following advice from MD-LOT and NatureScot, has been considered within the Array EIA Report. Further advice on transboundary effects was sought through Marine Mammal Consultation Note 2, which detailed including projects in other EEAs in the CEA (section 10.12) in a qualitative approach and was confirmed as appropriate by NatureScot (volume 3, appendix 5.1, annex E). Transboundary effects have been considered in section 10.14.
June 2023	NatureScot Scoping Representation (May 2023)	*"We note that HRA Stage 1 LSE Screening Report paragraph 157 lists 5 UK European sites designated for Annex II marine mammals. However, due to the distance between the proposal and these designated sites, alongside the foraging ranges of the relevant species, we do not support this list of UK European sites. We advise that Moray Firth SAC should remain scoped into assessment, and all other marine mammal sites should be scoped out.".*	The Moray Firth SAC is taken forward to consideration in section 10.7.2 of this report as well as in the RIAA (Ossian OWFL, 2024) (it was initially screened out in the Habitats Regulations Appraisal (HRA) Stage 1 LSE Screening Report but has been included following consultation with NatureScot) Additionally, in line with the advice from Natural England and Scottish Ministers, Berwickshire and North Northumberland Coast SAC and Southern North Sea SAC are taken forward to consideration in section 10.7.2 of this report as well as in the RIAA (Ossian OWFL, 2024) with both SACs included in the Array EIA Scoping Report and the HRA Stage 1 LSE Screening Report.
June 2023	Natural England Scoping Representation (April 2023)	*"Natural England cannot agree with the advice provided by NatureScot with regard to scoping the BNNC SAC and the SNS SAC out of the Habitats Regulations Appraisal (HRA) Stage 1 LSE Screening Report.* *It is therefore our advice that the BNNC SAC* [Berwickshire and North Northumberland SAC] *and SNS SAC* [Southern North Sea SAC] *are retained at the screening stage and taken forward to Appropriate Assessment (AA)."*	The Berwickshire and North Northumberland Coast SAC and Southern North Sea SAC are taken forward to consideration in section 10.7.2 of this report as well as in the RIAA (Ossian OWFL, 2024) following advice from Natural England on the HRA Stage 1 LSE Screening Report.
Post-Scoping Consultation			
September 2023	NatureScot response on the Underwater Sound from Piling: Modelling Methodology Note (volume 3, appendix 5.1, annex C)	NatureScot was content with the underwater noise report approach and stated it provided good clear explanation of modelling and why approaches were chosen, noting the modelling follows the von Pein approach, which seems to be an improvement on the conversion factors approach.	The underwater noise methodology is described in detail in volume 3, appendix 10.1, and uses the von Pein modelling approach as agreed by NatureScot. This informs the assessment of effects from underwater noise on marine mammals in this chapter.
September 2023	NatureScot, response on the Marine Mammal Methodology Note (volume 3, appendix 5.1, annex B)	NatureScot was content with the proposed approach to the analysis of aerial data (proposed approaches to data collection, data analysis, availability bias and modelling). These approaches all align with good practice.	A summary of the approach to the analysis of DAS data used to inform the marine mammal baseline is provided in section 10.6.3 (see volume 3, appendix 10.2, annex A for more details).
		NatureScot was content with the proposed criteria and metrics for the assessment of injury and disturbance to marine mammals (using Southall *et al.* (2019) criteria for auditory injury and National Marine Fisheries Service (NMFS (2018) criteria for disturbance, alongside a fleeing animal model using conservative swim speeds).	The assessment of potential injury and disturbance to marine mammal receptors is carried out in line with the methodology presented in section 10.11.1 and with the methodology presented in the Array EIA Scoping Report.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
		NatureScot was partially content with the marine mammal densities presented and advised to consider available sources with density data, including DAS, Small Cetaceans in European Atlantic waters and the North Sea (SCANS) (Gilles *et al.*, 2023, Hammond *et al.*, 2021, Lacey *et al.*, 2022) and Waggitt *et al.* (2020). The advice was to use the most precautionary densities or provide a justification why other preferred option is taken forward.	A range of densities from publicly available data sources and site-specific surveys, along with the justification for densities taken forward to the assessment is provided for each species in volume 3, appendix 10.2, and includes those presented in the Array EIA Scoping Report. Justification for the densities were provided in Marine Mammal Consultation Note 1 and all densities were agreed with NatureScot except for minke whale (for which further justification was requested) and harbour porpoise (for which additional clarification on correction factors used in deriving densities from DAS data was requested) (volume 3, appendix 5.1, annex D). Marine Mammal Consultation Note 2 provided further justification on the density estimate used for minke whale and information on the correction factors used for calculating density estimates for harbour porpoise from DAS data and was agreed by NatureScot (volume 3, appendix 5.1, annex E).
		NatureScot was content with the proposed approach to the iPCoD modelling (for the Array alone as well as cumulatively with other plans and projects). This approach aligns with good practice.	As presented in the Array EIA Scoping Report, iPCoD was used to model population level effects from elevated underwater noise from piling. A summary of the approach to iPCoD modelling for the Array alone as well as cumulatively with other plans and projects is presented in section 10.11.1, with full detail presented in volume 3, appendix 10.3.
		NatureScot was content with a qualitative approach to the assessment of operational noise.	The potential impacts on marine mammals due to operational noise are presented in section 10.11 and uses a qualitative approach to assessment. Whilst the effect of operational noise on marine mammal receptors were originally scoped out in the Array EIA Scoping Report, they are included in the impact assessment in section 10.11 in the Array EIA Report following advice from MD-LOT and NatureScot.
		NatureScot was content with a qualitative approach to the assessment of entanglement to marine mammals (using a range of biological and physical parameters).	The LSE[1] on marine mammals due to entanglement, as presented Array EIA Scoping Report, are assessed in section 10.11 and uses a qualitative approach to assessment.
January 2024	NatureScot, response on Marine Mammal Consultation Note 1 (volume 3, appendix 5.1, annex D)	Marine Mammal Consultation Note 1 summarised the updated underwater noise modelling methodology for piling and the use of a linear model. NatureScot were content that the updated methodology appears to be broadly in line with the JASCO recommendations, however, were unable to confirm whether the proposed methodology is robust. As such, NatureScot advised that further advice is sought from MD-SEDD, via MD-LOT.	Underwater noise modelling is presented in detail in volume 3, appendix 10.1, with a summary of marine mammal and underwater noise presented in section 10.11.1. Advice was sought from MD-SEDD, no confirmation of approach was received, however, the approach applied is considered appropriate on the basis of the following: The recommended ScotMER Report was considered by Ossian underwater noise specialists, and, following potential highlighted issues with representing piling as a point source, a line source model was used for the Ossian project. The updated noise modelling methodology was presented to NatureScot, and confirmed the line source model was the correct approach to use. The ScotMER report also identified that noise modelling based on ECFs is prone to significant errors. Therefore the methodology for the assessment of underwater noise for the Array does not include the use of conversion factors and uses the von Pein *et al*. (2022) methodology, and NatureScot response to the Ossian Underwater Sound Modelling methodology stated “seems to be an improvement on the conversion factors approach”.
January 2024	NatureScot, response on Marine Mammal Consultation Note 1 (volume 3, appendix 5.1, annex D)	NatureScot were content that the note summarised findings of the site-specific DAS and telemetry study and the presentation of species taken forward to assessment, with density and abundance estimates. NatureScot were content with the species-specific density estimates for harbour porpoise (calculated based on DAS data), white-beaked dolphin (based on Lacey *et al.* (2022)) and grey seal (derived from Carter *et al.* (2022) maps).	For harbour porpoise, a site-specific DAS density estimate has been taken forward to the assessment, with the justification for densities taken forward to the assessment provided for each species in volume 3, appendix 10. Justification for densities taken forward to the assessment is provided in detail for each species in volume 3, appendix 10.2, which includes the baseline data sources presented in the Array EIA Scoping Report, and a summary of the species-specific densities used in the assessment is presented in Table 10.14.
January 2024	NatureScot, response on Marine Mammal Consultation Note 1 (volume 3, appendix 5.1, annex D)	NatureScot requested justification for a less precautionary estimate selected for minke whale.	Further justification was provided in Marine Mammal Consultation Note 2, and the density estimate from Lacey *et al.* (2022) was agreed with NatureScot. Justification for densities taken forward to the assessment is provided in detail for each species in volume 3, appendix 10.2, which includes the baseline data sources presented in the Array EIA Scoping Report, and a summary of the species-specific densities used in the assessment is presented in Table 10.14.
January 2024	NatureScot, response on Marine Mammal Consultation Note 1 (volume 3, appendix 5.1, annex D)	NatureScot requested clear justification for the correction factors used in calculating density estimates for agreement prior to submission of the Array EIA Report.	Further justification was provided in Marine Mammal Consultation Note 2, which detailed the correction factors used in calculating density estimates for harbour porpoise from DAS data. NatureScot confirmed they were content with the approach for the Array following the further justification. Species-specific densities taken forward to the assessment are presented in Table 10.14, with a detailed baseline for each species given in volume 3, appendix 10.2, and includes baseline data sources presented in the Array EIA Scoping Report.
January 2024	NatureScot, response on Marine Mammal Consultation Note 1 (volume 3, appendix 5.1, annex D)	Marine Mammal Consultation Note 1 established the designated sites taken forward to the assessment in the EIA and Habitat Regulations Appraisal (HRA). NatureScot were content with the approach for the inclusion of Moray Firth SAC and deferred to advice from Natural England on Berwickshire and North Northumberland Coast SAC and Southern North Sea SAC.	SACs considered in the EIA are presented in Table 10.15 and are taken forward to the assessment in section 10.11. Moray Firth, Berwickshire and North Northumberland Coast SAC and Southern North Sea SAC were presented in the Array EIA Scoping Report for consideration in the EIA and HRA.
January 2024	NatureScot, response on Marine Mammal Consultation Note 1 (volume 3, appendix 5.1, annex D)	Marine Mammal Consultation Note 1 presented the impacts to be scoped in and the approach to the marine mammal assessment, in particular the approach to the assessment of underwater noise. NatureScot were content with the list of impacts scoped in and confirmed the approaches to UXO clearance, vessel noise, and geophysical surveys were as expected.	Effects scoped in are assessed in section 10.11, with impacts scoped out of the assessment detailed in section 10.8.2. The effect of operational noise, disturbance due to pre-construction and geophysical surveys and EMF were initially scoped out in the Array EIA Scoping Report, but have been included following the Scoping Opinion feedback from MD-LOT and NatureScot and are assessed in section 10.11.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
March 2023	NatureScot response on Marine Mammal Consultation Note 2 (volume 3, appendix 5.1, annex E)	NatureScot were content that assessment of noise impacts on the minke whale feature of the Southern Trench ncMPA is contained within the marine mammal chapter of the EIA Report and does not require a separate supporting MPA assessment document. The advice from NatureScot was based on the understanding of the distribution of minke whale within Southern Trench ncMPA, i.e. low densities in the eastern part of the site which is closest to the Ossian array and initial modelling work which suggests that noise levels within this part of the ncMPA are likely to only present a risk of mild, but not strong, disturbance as defined by NMFS (2005) and Southall *et al.* (2021).	The Southern Trench ncMPA was presented in the Array EIA Scoping Report for consideration in the EIA, and following consultation, the assessment of noise impacts on the minke whale feature of the Southern Trench ncMPA is contained within the impact assessment in section 10.11 in this report.
March 2023	NatureScot response on Marine Mammal Consultation Note 2 (volume 3, appendix 5.1, annex E)	NatureScot accepted the use of Lacey *et al.* (2022) density estimate for minke whale on the basis that environmental covariates used in the study are particularly relevant to determining minke whale distribution and the 10 km spatial resolution used with these environmental variables offers more fine-scale density mapping than the large-scale SCANS blocks.	The minke whale density estimate used in the assessment is presented in Table 10.14 and is derived from Lacey *et al.* (2022), which was included in the baseline sources in the assessment of the LSE[1] of the Array.
March 2023	NatureScot response on Marine Mammal Consultation Note 2 (volume 3, appendix 5.1, annex E)	NatureScot confirmed the CEA methodology approach presented in Marine Mammal Consultation Note 2 seemed reasonable but deferred to MD-LOT to confirm which plans and projects should be included in cumulative assessment and what cut-off timescale is acceptable.	The CEA assessment methodology, which was presented to NatureScot, is detailed in section 10.12.1 and aligns with the approach outlined in the Array EIA Scoping Report.
March 2023	NatureScot response on Marine Mammal Consultation Note 2 (volume 3, appendix 5.1, annex E)	NatureScot confirmed the approach to CEA with regards to inclusion of projects in other EEAs was appropriate, with a qualitative assessment carried out to assess transboundary impacts.	Projects within the regional marine mammal study area have been screened in for the CEA (section 10.12) including projects in other EEAs. Though initially scoped out in the Array EIA Scoping Report, transboundary effects have been assessed in section 10.14 following advice from MD-LOT and NatureScot.
March 2023	NatureScot response on Marine Mammal Consultation Note 2 (volume 3, appendix 5.1, annex E)	NatureScot confirmed the proposed approach to iPCoD modelling was as expected and confirmed that Coastal East Scotland (CES[2]) MU is the appropriate population for assessment of impacts on bottlenose dolphin.	Detailed iPCoD modelling is presented in volume 3, appendix 10.3, and has been used to inform the assessment of effects from piling (sections 10.11 and 10.12). The CES[2] MU has been used to assess effects on bottlenose dolphin (which has been scoped in as a key species since the Array EIA Scoping Report).
March 2023	NatureScot response on Marine Mammal Consultation Note 2 (volume 3, appendix 5.1, annex E)	NatureScot advised that pre-piling mitigation should be based on the instantaneous risk for PTS onset, but the impact assessment itself should use SEL_{cum} (acknowledging all the caveats around it being over-precautionary due to the assumptions made) as well as SPL_{pk} (i.e. the dual metric approach). If the SEL_{cum} predictions indicate that there may be auditory injury to marine mammals, then the figures for injury should be inputted to the iPCoD model.	Following more recent advice from NatureScot following Marine Mammal Consultation Note 2, the assessment of PTS from piling and UXO is based upon the dual metric approach, whereby the maximum injury range from either SPL_{pk} or SEL_{cum} is used in assessment and inputted into the iPCoD modelling for piling (see section 10.11.2). This dual metric approach aligns with the approach presented in the Array EIA Scoping Report.
March 2023	NatureScot response on Marine Mammal Consultation Note 2 (volume 3, appendix 5.1, annex E)	NatureScot confirmed the approach to base auditory injury assessment on the number of animals remaining present following 30 minutes of ADD usage is appropriate for population modelling (iPCoD). NatureScot stated they expected the use of ADDs to be secured via conditions of any relevant consents.	The assessment of auditory injury (PTS) for piling is based upon inclusion of 30 minute ADD duration and is presented in section 10.11.2. This is also applied to the population modelling which informs the assessment (use of iPCoD, as presented in the Array EIA Scoping Report), with a detailed iPCoD report presented in volume 3, appendix 10.3.

10.6. METHODOLOGY TO INFORM BASELINE

12. A range of existing studies and datasets (including historic surveys) have been reviewed and analysed to inform this marine mammal baseline. In addition, consultation with MD-LOT and NatureScot has been carried out to aid the collection of baseline information.

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 which are summarised in Table 10.11.

14. Both the literature review of the reports, and numerical modelling using the datasets available, were used to characterise the baseline. The marine mammals technical report (volume 3, appendix 10.2) includes full details of the analysis undertaken to develop the marine mammals baseline.

Table 10.11: Summary of Key Desktop Reports

Title	Source	Extent	Year	Author
Published literature				
Seal at-sea usage Global Positioning System (GPS) tracking dataset (114 grey and 239 harbour seals)	University of St Andrews data repository University of St Andrews data repository	2005 to 2019	2023	Carter *et al.*
Estimates of cetacean abundance in European Atlantic waters in summer 2022 from the SCANS IV aerial and shipboard surveys	SCANS data project publication	2022	2023	Giles *et al.*
Seal haul-out counts	Annex B to volume 3, appendix 10.2 Marine Mammals Technical Report	1996 to 2021	2023	Stevens
Seal haul-out counts	Annex to volume 3, appendix 10.2	1990 to 2018	2023	Stevens
Density surface modelling from SCANS III surveys	SCANS data project publication	2016	2022	Lacey *et al.*
Estimates of cetacean abundance in European Atlantic waters from the SCANS III aerial and shipboard surveys	SCANS data project publication	2016	Gilles *et al.* (2023) 2021	Hammond *et al.*
Regional Baselines for marine mammal knowledge across the North Sea and Atlantic areas of Scottish waters	Scottish Marine and Freshwater Science report	Mid-1960s to 2020	2020	Hague *et al.*
Marine Ecosystems Research Program cetacean density surfaces	Journal of Applied Ecology	1980 to 2018	2020	Waggitt *et al.*
Bottlenose dolphin photo-identification surveys and SAC site condition monitoring	The collation of sighting records from a wide variety of published and unpublished sources, please refer to literature cited	2009 to 2019	2013, 2014, 2018, 2019	Cheney *et al.*, Quick *et al.,* Arso Civil *et al.*
Joint Cetacean Protocol Phase III	JNCC Report 517	1994 to 2010	2016	Paxton *et al.*
JNCC Report 544: Harbour Porpoise Density	JNCC Report 544	1994 to 2011	2015	S. Heinänen and H. Skov
Forth and Tay Offshore Wind Developers Group (FTOWDG) cetacean survey data analysis report	Report produced by DMP Stats for Sea Mammal Research Unit (SMRU)	2009 to 2011	2012	Mackenzie *et al.*
Analysis of The Crown Estate (TCE) aerial survey data for marine mammals for the FTOWDG	TCE commissioned report by SMRU Ltd	2009 to 2010	2011	K. Grellier and K. Lacey
Cetacean Baseline Characterisation for the Firth of Tay: Bottlenose dolphins	FTOWDG commissioned report produced by SMRU Ltd	Photo-identification: 2009 and 2010 PAM: 2006 to 2009	2011	N. Quick and B. Cheney
Historic surveys of the Firth of Forth and Tay				
Berwick Bank Wind Farm Offshore EIA - Annex A: Marine mammal aerial survey data analysis	Berwick Bank Aerial Surveys	2019 to 2021	2022c	SSE Renewables
Seagreen Wind Energy - Appendix 10A: Marine Mammal Baseline Technical Report. Baseline characterisation update	Seagreen Ornithology Surveys	2017	2018	*Seagreen Wind Energy Limited*
Seagreen Firth of Forth Round 3 Zone Marine Mammal Surveys	Seagreen Boat-Based Surveys	2010 to 2011	2012	Sparling, C.
Analysis of TCE aerial survey data for marine mammals for the FTOWDG region	TCE Aerial Survey	2009 to 2010	2011	K. Grellier and K. Lacey
Assessment of TCE survey marine mammal data for the Firth of Forth development areas	TCE Aerial Survey	2009 to 2010	2011	C. D. MacLeod and C. E. Sparling

10.6.2. IDENTIFICATION OF DESIGNATED SITES

15. A three-step process was used to identify 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 Array. This process is described below:

- Step 1: All designated sites of international, national, and local importance within the regional marine mammal study area were identified using a number of sources, including JNCC (2023c), NatureScot (2023b), Natural Resources Wales (NRW) (2023a) and the Department of Agriculture, Environment and Rural Affairs (DAERA) (2023).
- Step 2: Information was compiled on the relevant marine mammal features for each of these sites using data in the public domain (e.g. JNCC (2023b)).
- Step 3: Using the above information and expert judgement, sites were included for further consideration if:
    - a designated site directly overlaps with the Array and therefore has the potential to be directly affected by the Array;
    - a designated site and associated features are located within the potential Zone of Influence (ZoI) for impacts associated with the Array (e.g. potential effect ranges of underwater noise as a result of piling activities during construction; see section 10.11); or
    - a designated site and associated features are located within the regional marine mammal study area and have a potential for connectivity with the Array (features are likely to regularly use the Array marine mammal study area).

16. Detailed consideration of designated sites located within the regional marine mammal study area and those taken forward to the assessment is provided in volume 3, appendix 10.2.

10.6.3. SITE-SPECIFIC SURVEYS

17. Site-specific surveys were undertaken to inform the marine mammal Array EIA Report chapter for the Array (see volume 3, appendix 10.2 for further details). A summary of the surveys undertaken used to inform the marine mammal assessment of effects is outlined in Table 10.12.

Table 10.12: Summary of Site-Specific Survey Data

Title	Extent of Survey	Overview of Survey	Survey Contractor	Date	Reference to Further Information
DAS	Site boundary plus 8 km buffer	Digital Aerial Survey	HiDef Ltd.	March 2021 to February 2023	Volume 3, appendix 10.2, annex A

10.7. BASELINE ENVIRONMENT

10.7.1. OVERVIEW OF BASELINE ENVIRONMENT

18. The following sections provide a summary of the marine mammal baseline environment. The marine mammal technical report, volume 3, appendix 10.2, includes full details of the analysis undertaken to develop the marine mammal baseline and information on species ecology, distribution, seasonality as well as density and abundance.

19. There are 11 species of cetaceans and two species of pinnipeds that are regularly encountered within the regional marine mammal study area (Gilles *et al.*, 2023, Hammond *et al.*, 2021, Hammond *et al.*, 2013, Weir *et al.*, 2001). The distribution and abundance of marine mammals is highly correlated with the distribution of prey. Certain areas along the east coast of Scotland, like the northern North Sea, adjacent deep Atlantic waters, continental shelf edge, and trench parallel to the Aberdeenshire coastline, consistently host higher numbers of marine mammals than other locations within the regional marine mammal study area, due to abundant prey (NatureScot, 2019, Weir *et al.*, 2001).

20. Although some species may occur within the regional marine mammal study area occasionally, e.g. killer whale *Orcinus orca*, these are unlikely to travel through or use the Array marine mammal study area as important foraging grounds (see volume 3, appendix 10.2 for more details). The DAS of marine mammals commenced in March 2021 and continued monthly up to and including February 2023. The 24 months of data collection allowed identification of the most common species likely to be encountered within the Array marine mammal study area. For more details on DAS data analysis please refer to volume 3, appendix 10.2, annex A.

21. There were four cetaceans observed that could not be assigned to species level, and sightings classified as ‘seal species’ (due to the difficulty of identifying pinnipeds to species level from aerial survey data) occurred in 16 of the 24 months surveyed. Following advice from NatureScot and MD-LOT (Table 10.10), unidentified marine mammal sightings were not apportioned to a species and were excluded from further analysis. As the unidentified marine mammals numbered only four individuals, the exclusion of these from quantitative analyses would not result in any material change to the outcomes of the assessment. Moreover, the suite of mitigation measures described in section 10.10 are expected to minimise the potential impacts of the Array to all marine mammal species in the area.

22. The summary of the marine mammal baseline within the Array marine mammal study area, in the context of the regional marine mammal study area, is presented in Table 10.13. Densities and reference populations taken forward to assessment for each species are presented in Table 10.14, and all densities and reference populations have been agreed with NatureScot (see Table 10.10). Further detail is given in volume 3, appendix 10.2. The relevant Management Units (MUs) are presented in Figure 10.2.

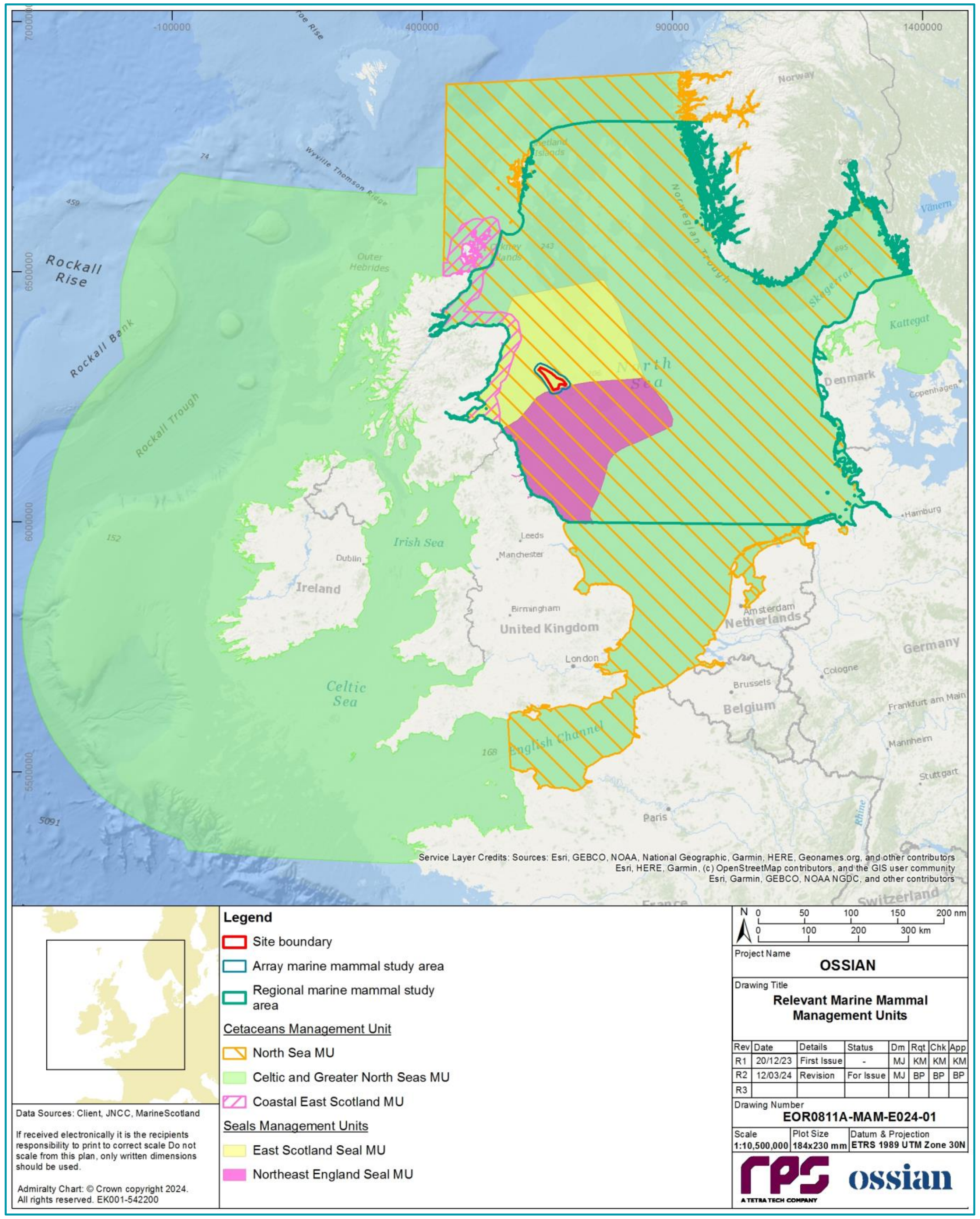

Figure 10.2: Relevant Marine Mammal Management Units and Study Areas

Table 10.13: Summary of Marine Mammal Baseline

Species	Baseline Summary	Conservation Importance
Harbour porpoise	Harbour porpoise is widespread throughout the cold and temperate seas of Europe, including the North Sea. Harbour porpoise accounted for the highest number of sightings identified to species level (based on raw count data) during DAS and was recorded in all but three survey months (volume 2, appendix 10.2). It was the most commonly identified cetacean during historic aerial surveys in the wider Firth of Forth and Tay region (Grellier and Lacey, 2011, Sparling, 2012, SSE Renewables, 2022d). Inter-Agency Marine Mammal Working Group (IAMMWG (2022) presented estimated abundance for the North Sea MU as 346,601 individuals. SCANS IV data estimated the density in block NS-D, where the Array is located, as 0.5985 harbour porpoise per km^2 and presented an abundance of 38,577 individuals Gilles *et al.* (2023). Site-specific modelled estimates from the DAS provided a mean encounter rate of 0.041 animals per km with a monthly peak of 0.154 animals per km in July 2021. The annual mean model-based density (corrected for availability bias) was estimated as 0.355 animals per km^2 with summer density being higher at 0.648 animals per km^2. Design-based absolute density estimates using DAS sightings data are considered the most appropriate to use to reflect densities of harbour porpoise within the Array marine mammal study area and therefore a peak seasonal density (summer bio-season) of 0.651 animals per km^2 will be taken forward to the assessment, as agreed with NatureScot following Marine Mammal Consultation Note 2 (see section 5.1.1 in volume 3, appendix 10.2 for more details regarding the most appropriate density value to be taken forward to the assessment).	• Least Concern on International Union for Conservation of Nature (IUCN) Red List; • Annex II species protected under Habitats Regulations; • Qualifying feature of European Marine Sites (EU) and SACs (UK); • Regional marine mammal study area overlaps with Southern North Sea SAC in UK; • EPS and PMF in Scotland; and • Priority Species under UK Post-2010 Biodiversity Framework.
Bottlenose dolphin	Bottlenose dolphins are present within the northern North Sea, however, only the coastal population, distributed within the 2 m to 20 m depth contour and approximately 2 km from the shore, is well studied (Geelhoed *et al.*, 2022a). The main distributional range of this CES^2 MU population is from Moray Firth to Firth of Forth, although ongoing citizen science projects suggest that some individuals of this population are relocating into waters off the coast of eastern England (as far as south of Scarborough) (Hackett, 2022). IAMMWG (2022) presented estimated abundance for the CES^2 MU as 224 individuals (based on Arso Civil *et al.* (2019)). No bottlenose dolphins were recorded during DAS of the Array marine mammal study area (volume 3, appendix 10.2). SCANS III estimated their offshore abundance for block R as 1,924 individuals (Hammond *et al.*, 2021). Given that there were no bottlenose dolphin sightings within block NS-D during SCANS IV survey, no density values were published (Gilles *et al.*, 2023). Density estimates reported by Lacey *et al.* (2022) are considered the most appropriate to use to reflect densities of bottlenose dolphins in offshore waters where the site boundary is located and a density of 0.00303 animals per km^2 will be taken forward to the assessment as agreed with NatureScot following Marine Mammal Consultation Note 1 (see section 5.1.2 in volume 3, appendix 10.2 for more details regarding the most appropriate density value to be taken forward to the assessment).	• Least Concern on IUCN Red List; • Annex II species protected under Habitats Regulations; • Qualifying feature of European Marine Sites (EU) and SACs (UK); • Regional marine mammal study area overlaps with Moray Firth SAC in UK; • EPS and PMF in Scotland; and • Priority Species under UK Post-2010 Biodiversity Framework.
White-beaked dolphin	White-beaked dolphin is considered the second most abundant cetacean in the North Sea, with the highest rates of sightings on the east coast of Scotland during summer months (Weir *et al.*, 2001). White-beaked dolphin accounted for the second highest number of sightings during DAS and was recorded in seven months over the 24-month survey period (volume 3, appendix 10.2). Site-specific modelled estimates from the DAS provided a mean encounter rate of 0.005 animals per km with a monthly peak of 0.013 animals per km in July 2021. The annual mean design-based density (corrected for availability bias) was estimated as 0.031 animals per km^2 with summer density being higher at 0.016 animals per km^2. However, a number of studies have suggested that the abundance of white-beaked dolphins in the UK waters is declining as a result of increases in local water temperature (Lambert *et al.*, 2014, MacLeod *et al.*, 2005, MacLeod *et al.*, 2007, MacLeod *et al.*, 2008, van Weelden *et al.*, 2021). Findings from SCANS IV surveys conducted in 2022 also suggest a decline in the number of white-beaked dolphins on the east coast of Scotland with an estimated density of 0.0799 animals per km^2 for block NS-D (Gilles *et al.*, 2023) compared to the density of 0.245 animals per km^2 for block R during SCANS III surveys carried out in 2016 (Hammond *et al.*, 2021). The white-beaked dolphin abundance reported by Gilles *et al.* (2023) for SCANS IV block NS-D is also smaller with 5,149 individuals compared to SCANS III Block R abundance of 15,694 animals (Hammond *et al.*, 2021). IAMMWG (2022) estimated white-beaked dolphin abundance for the Celtic and Greater North Seas (CGNS) MU as 43,951 animals (Coefficient of Variation (CV)=0.22). It is considered that density estimates based on Lacey *et al.* (2022) are the most appropriate to use and a density of 0.120 animals per km^2 will be taken forward to the assessment as agreed with NatureScot following Marine Mammal Consultation Note 1 (see section 5.1.3 in volume 3, appendix 10.2 for more details regarding the most appropriate density value to be taken forward to the assessment).	• Least Concern on IUCN Red List; • EPS and PMF in Scotland; and • Priority Species under UK Post-2010 Biodiversity Framework.
Minke whale	Minke whale is widely distributed in northern North Sea. In Scotland, minke whales display seasonal occurrence patterns with inshore movements during summer, as dictated by increased availability of key prey species (usually sandeel *Ammodytes marinus* during summer months) (Robinson *et al.*, 2021, Robinson *et al.*, 2009), returning to offshore waters in winter. The data from DAS as well as historic surveys within the wider Firth of Forth and Tay areas suggest that minke whale presence is highly seasonal with most encounters during summer months (Mainstream Renewable Power, 2019, Sparling, 2012, SSE Renewables, 2022a). IAMMWG (2022) presented estimated abundance for the CGNS MU of 20,118 individuals. Gilles *et al.* (2023) reported minke whale densities within the SCANS IV NS-D block as 0.0419 animals per km^2 compared to SCANS III estimated density of 0.0387 individuals per km^2 (Hammond *et al.*, 2021). Minke whales were recorded in four months only during DAS of the Array marine mammal study area (volume 3, appendix 10.2). Minke whale abundance within SCANS IV block NS-D was estimated as 2,702 individuals (Gilles *et al.*, 2023). It is considered that density estimates based on Lacey *et al.* (2022) are the most appropriate to use and a density of 0.0284 animals per km^2 will be taken forward to the assessment, as agreed by NatureScot following Marine Mammal Consultation Note 2 (see section 5.2.1 in volume 3, appendix 10.2 for more details regarding the most appropriate density value to be taken forward to the assessment).	• Least Concern on IUCN Red List; • EPS and PMF in Scotland; and • Priority Species under UK Post-2010 Biodiversity Framework.

Species	Baseline Summary	Conservation Importance
Humpback whale	Humpback whale travel long annual migration distances and individuals in Scottish waters have been matched with both recovering (western North Atlantic) and non-recovering (Cape Verde) breeding populations. There are limited abundance and density data for humpback whale in Scottish waters. However, there has been an increased recording of this species in Scotland in recent years (Hague, 2023, O'Neil *et al.*, 2019). Observations have been recorded mostly within the Firth of Forth during winter months (December to March), which may represent a migratory stopover, or a feeding or recovery opportunity en route of a longer migration between high and low latitude areas (O'Neil *et al.*, 2019, O'Neil *et al.*, 2019). No humpback whales were recorded during DAS of the Array marine mammal study area (volume 3, appendix 10.2). However, as four individuals have been sighted by citizen science projects (2017 to 2019) humpback whale is included qualitatively in the assessment, at the request of NatureScot.	• Least Concern on IUCN Red List; • EPS; and • Priority Species under UK Post-2010 Biodiversity Framework.
Grey seal	The east coasts of Scotland and northern England provide important breeding and haul-out habitats for grey seal. The UK total grey seal population size at the start of the 2022 breeding season was estimated to be 162,000 grey seals of which 129,100 (approximately 80%) were in Scotland (Stevens, 2023). The most recent August grey seal counts took place in 2021 in both the East Scotland Seal MU (SMU) and Northeast England SMU, resulting in scaled August population estimates of 10,783 and 25,913 grey seals, respectively (Special Committee on Seals (SCOS), 2023). The closest designated haul-out site is Fast Castle located approximately 113 km south west from the Array marine mammal study area. Based on Carter *et al.* (2022) maps, mean grey seal at-sea usage within the Array marine mammal study area is low, as the hotspots are located closer to the shore and in the vicinity of the Berwickshire and North Northumberland Coast SAC, Firth of Forth, Tay and Eden Estuary and north of Aberdeen (volume 3, appendix 10.2). Grey seal were the most recorded pinniped species during the monthly site-specific DAS, with 18 animals recorded over nine months. The annual mean design-based density (corrected for availability bias) was estimated as 0.021 animals per km^2, with a higher density during the non-breeding season (January to August) of 0.034 animals per km^2. Tagging data illustrated a high-level of connectivity between the Array marine mammal study area and Berwickshire and North Northumberland Coast SAC, with approximately 9% of tagged individuals being tracked within the Array marine mammal study and this SAC. Tagging data determined minimal connectivity (2%) between the Isle of May SAC and the Array and was omitted from assessment following consultation (Table 10.10). Given the uncertainty associated with identification of seals to species level based on DAS, density estimates reported by Carter *et al.* (2022) are considered the most appropriate to use and a density of 0.180 animals per km^2 will be taken forward to the assessment as agreed with NatureScot following Marine Mammal Consultation Note 1 (see section 5.3.2 in volume 3, appendix 10.2 for more details regarding the most appropriate density value to be taken forward to the assessment).	• Least Concern on IUCN Red List; • Annex II species protected under Habitats Regulations; • Qualifying feature of European Marine Sites (EU) and SACs (UK); • Regional marine mammal study area overlaps with Berwickshire and North Northumberland Coast SAC in UK; and • PMF in Scotland.

Table 10.14: Densities and Reference Populations for Each Species Taken Forward to the EIA

Species	Density (Animals per km^2)	Management Unit	Population in MU
Harbour porpoise	0.651	North Sea MU	346,601 (IAMMWG, 2022)
Bottlenose dolphin	0.003	Coastal East Scotland MU	224 (IAMMWG, 2022, Arso Civil *et al.*, 2021)
White-beaked dolphins	0.120	Celtic and Greater North Seas MU	43,951 (IAMMWG, 2022)
Minke whale	0.028	Celtic and Greater North Seas MU	20,118 (IAMMWG, 2022)
Humpback whale	Estimates are unavailable for this species due to low number and infrequency of sightings (see volume 3, appendix 10.2)		
Grey seal	0.180	East Scotland and Northeast England SMU	10,783 + 25,913 = 36,696 (Stevens, 2023)

10.7.2. DESIGNATED SITES

23. A screening of designated sites in the vicinity of the Array has been carried out and has identified that there were no designated sites relevant to marine mammals which fulfilled the screening criteria described in section 10.6.2.

24. Sites designated for the conservation of internationally important Annex II marine mammal species within the regional marine mammal study area include the Berwickshire and North Northumberland Coast SAC and Isle of May SAC both designated for grey seal, the Moray Firth SAC designated for bottlenose dolphin and the Southern North Sea SAC designated for harbour porpoise. Following a comprehensive assessment of potential connectivity as well as feedback from NatureScot, Natural England and MD-LOT provided as part of the Scoping Opinion (Table 10.10), only sites presented in Table 10.15 will be considered further in the EIA and HRA processes (see volume 3, appendix 10.2 for more details).

25. The Firth of Tay and Eden Estuary SAC designated for harbour seal also lies within the regional marine mammal study area. However following review of connectivity between the Array marine mammal study area and harbour seal populations of the east coast of Scotland it was concluded that the potential for significant effects was highly unlikely. Following consultation with NatureScot (Table 10.10) (whilst a detailed assessment of harbour seal ecology and distribution within the regional marine mammal study area has been included in volume 3, appendix 10.2) the species was therefore excluded as a key species in the EIA and therefore the Firth of Tay and Eden Estuary SAC is not considered in the EIA. The Dornoch Firth and Morrich More SAC is also designated for harbour seal but was scoped out early on following the Scoping Opinion (Table 10.10).

26. Marine Mammal Consultation Note 1 confirmed the designated sites taken forward to the assessment in the EIA and HRA (refer to volume 3, appendix 5.1, annex D). NatureScot were content with the approach for the inclusion of Moray Firth SAC, and deferred to advice from Natural England on Berwickshire and North Northumberland Coast SAC and Southern North Sea SAC. Natural England advised in the Scoping Opinion that both Berwickshire and North Northumberland Coast SAC and Southern North Sea SAC are to be included.

27. In line with advice received from stakeholders during the Scoping Workshop (see Table 10.10), given the overlap of the noise contours with the Southern Trench ncMPA (see section 10.11.2 for more details), the site is also considered further in the EIA (Table 10.15). NatureScot further confirmed agreement in their response to marine mammal Consultation Note 2 (see Table 10.10; volume 3, appendix 5.1, annex E) to the inclusion of the noise impacts on the minke whale feature of the Southern Trench ncMPA in the EIA, and a separate supporting MPA assessment document was not required.

28. Designated sites and relevant qualifying interest features identified for the marine mammals Array EIA Report chapter are described in Table 10.15 and presented in Figure 10.3.

Table 10.15: Designated Sites and Relevant Qualifying Interest Features for the Marine Mammal Array EIA Report Chapter

Designated Site	Closest Distance to Array (km)	Relevant Qualifying Interest Feature(s)
Southern Trench ncMPA	66.9	• Minke whale
Berwickshire and North Northumberland SAC	114.0	• Grey seal
Southern North Sea SAC	130.7	• Harbour porpoise
Moray Firth SAC	176.5	• Bottlenose dolphin

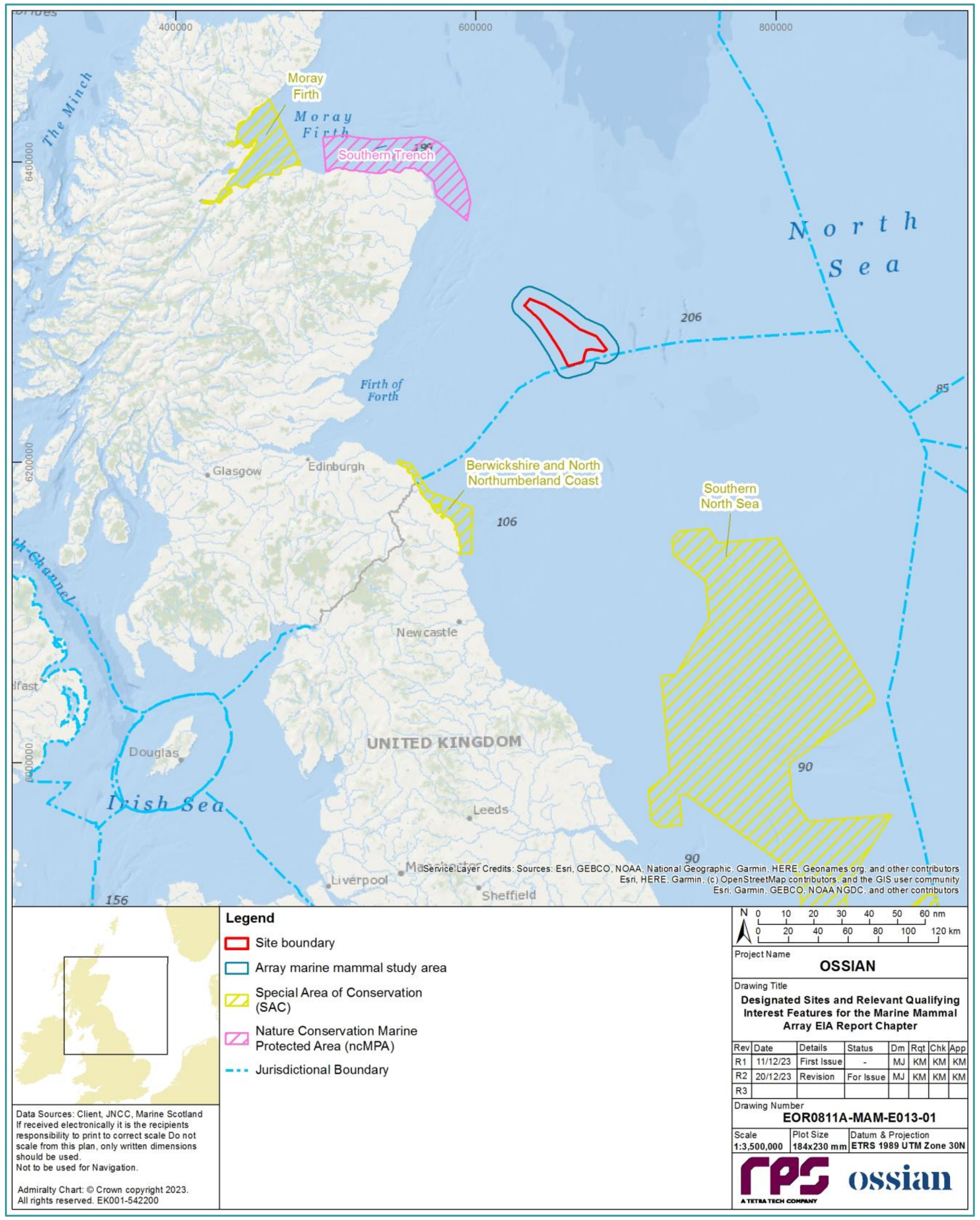

Figure 10.3: Marine Mammals Relevant Designated Sites

10.7.3. IMPORTANT ECOLOGICAL FEATURES

29. Important Ecological Features (IEFs) for the purposes of the marine mammal EIA have been identified using best practice guidelines (Chartered Institute of Ecology and Environmental Management (CIEEM, 2022). The potential impacts of the Array which have been scoped into the assessment (see section 10.8) have been considered in relation to the IEFs to determine whether or not they are important, therefore, the IEFs assessed are those that are considered to be important and potentially impacted by the Array. 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 Oslo and Paris Conventions (OSPAR); IUCN Red List species; UK Biodiversity Action Plan (BAP) priority species either alone or under a grouped action plan; and PMFs in Scotland.

30. Table 10.16 lists all of the IEFs within the Array marine mammal study area. All marine mammals with the potential to be affected by the Array 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.

31. Bottlenose dolphin (quantitatively) and humpback whale (qualitatively) have been scoped into the assessment following advice from MD-LOT and NatureScot on the Array EIA Scoping Report and subsequent consultation (see Table 10.10). Harbour seal has been included within volume 3, appendix 10.2 but has been excluded from the impact assessment due to low likelihood for significant effects based on DAS, telemetry, and low densities in the Array. This was agreed with NatureScot following Marine Mammal Consultation Note 1 (see Table 10.10; volume 3, appendix 5.1, annex D) on the basis that there was sufficient evidence provided that the likelihood of significant effects on harbour seal are low.

Table 10.16: IEFs within the Array Marine Mammal Study Area

IEF	Value	Justification
Odontocetes		
Harbour porpoise	International	• Annex II species that is a designated feature of Southern North Sea SAC; • EPS; • Scottish PMF; • OSPAR protected species; • IUCN Red List Least Concern; and • UK BAP priority species.
Bottlenose dolphin	International	• Annex II species that is a designated feature of Moray Firth SAC; • EPS; • Scottish PMF; • IUCN Red List Least Concern; and • UK BAP priority species.
White-beaked dolphin	International	• EPS; • Scottish PMF; • IUCN Red List Least Concern; and • UK BAP priority species.
Mysticetes		
Minke whale	International	• EPS; • Scottish PMF; • IUCN Red List Least Concern; and • UK BAP priority species.

IEF	Value	Justification
Humpback whale	International	- EPS; - IUCN Red List Least Concern; and - UK BAP priority species.
Pinnipeds		
Grey seal	International	- Annex II species that is a designated feature of Berwickshire and Northumberland Coast SAC; - IUCN Red List Least Concern; and - Scottish PMF.

10.7.4. FUTURE BASELINE SCENARIO

32. The EIA Regulations require that "*a description of the relevant aspects of the current state of the environment (baseline scenario) and an outline of the likely evolution thereof without implementation of the project as far as natural changes from the baseline scenario can be assessed with reasonable effort, on the basis of the availability of environmental information and scientific knowledge*" is included within the Array EIA Report.

33. If the Array does not come forward, the 'without development' future baseline conditions is described within this section.

34. Marine mammal species face direct adverse impacts from various anthropogenic activities (Avila *et al.*, 2018), encompassing offshore developments and associated underwater noise, fisheries and increased rates of vessel activity. According to Avila *et al.* (2018), almost all global marine mammal species (98%) were documented to be affected by at least one threat between 1991 and 2016. Bycatch in active fishing gear was the most prevalent threat for odontocetes and mysticetes, followed by pollution (solid waste), commercial hunting, and boat collisions. Pinnipeds were documented as primarily threatened by ghost-net entanglements, solid and liquid wastes, and infections (Avila *et al.*, 2018). As discussed in volume 2, chapter 9, fisheries management measures will affect marine mammal prey species, such as the recent closure of sandeel fisheries in Scottish waters (i.e. The Sandeel (Prohibition of Fishing) (Scotland) Order 2024) which will see a ban on the fishing for sandeel from March 2024 within the Scottish zone. It is anticipated that this closure will provide wider potential benefits to the marine ecosystem including direct benefits to sandeel populations (through reduction of pressures from fishing) and indirect benefits to marine mammal species through potential increased prey availability, as sandeel is an important prey species for many marine mammal species (detailed in volume 3, appendix 10.2).

35. Beyond the direct anthropogenic impacts detailed in paragraph 34 above, marine mammals are susceptible to non-direct effects from human activities (Avila *et al.*, 2018), such as climate change and global warming leading to rising sea temperatures. A common response of marine mammals to temperature changes is shifts in their spatial distribution, potentially modifying the ranges of certain species (e.g. white-beaked dolphin). Changes in water temperatures may also impact the life cycles of marine mammal prey species, creating discrepancies in prey abundance that affect migratory marine mammal species and those exhibiting site fidelity. Additionally, global warming could influence marine mammal survival rates by impacting reproductive success, increasing stress, and promoting pathogen infections (Albouy *et al.*, 2020).

36. Given that climatic changes now compound anthropogenic pressures, predicting future trajectories of marine mammal populations without comprehensive data is challenging. Monitoring is not consistently in place at relevant temporal or spatial scales for some species, especially minke whale. Therefore, information presented in this section provides a summary of current and anticipated pressures. Where data are available, information about population dynamics is presented.

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

Harbour porpoise

38. Harbour porpoise are severely vulnerable to incidental entanglements in fishing gear, known as bycatch (Moan *et al.*, 2020). Harbour porpoise are likely to die shortly after entanglement, as they cannot drag fishing gear to the surface to breathe, and this mortality can have large population-level effects, causing adverse population trajectories (IMR/NAMMCO, 2019). In the North Sea, harbour porpoise are considered vulnerable to bycatch in gillnets (Calderan and Leaper, 2019). Assuming that fishing vessels of 12 m or over follow the obligation to use pingers, Kindt-Larsen *et al.* (2019) estimated harbour porpoise bycatch in the UK 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 compared to the 2017 estimate of 1,098 animals. (IJsseldijk *et al.*, 2022) investigated the pathological findings related to anthropogenic and natural causes of death in harbour porpoises that stranded between 2008 and 2019. The largest anthropogenic category was bycatch (17%), with mainly juveniles affected and peak periods in March and September to October. Other, infrequently diagnosed anthropogenic causes of death were trauma (4%), largely most likely due to ship collisions, and marine debris ingestion and entanglement (0.3%).

39. Prey availability may also influence harbour porpoise abundance. Harbour porpoise have a high metabolic rate (Rojano-Doñate *et al.*, 2018) and therefore have to feed regularly. As a result of this, harbour porpoise are highly dependent on year-round proximity to food sources and their distribution and condition is considered likely to reflect the availability and energy density of prey (Lambert, 2020, Santos and Pierce, 2003). Any changes in the abundance and density of harbour porpoise prey species (e.g. sandeel, whiting, sprat and herring) (e.g. as result of closures of sandeel fisheries in Scotland) therefore have the potential to affect harbour porpoises foraging in an area.

40. Harbour porpoise have high parasitic exposure, with post-mortem examinations regularly revealing heavy parasitic worm burdens (Bull *et al.*, 2006). A causal immunotoxic relationship between polychlorinated biphenyl (PCB) exposure and infectious disease mortality has also been highlighted (Murphy *et al.*, 2015), with total PCB levels significantly higher in the infectious disease group compared to a physical trauma group (Bull *et al.*, 2006), suggesting that anthropogenic contaminants are having adverse effects on harbour porpoise. In a study conducted by (van den Heuvel-Greve *et al.*, 2021), it was found lower halogenated and more toxic contaminants were transferred to calves, exposing them to high levels of contaminants early in life. Of all animals included in the study, 38.5% had PCB concentrations exceeding a threshold level for adverse health effects (>9 mg/kg lipid weight (lw)). The study also stated that results provide further evidence for potential health effects of persistent organic pollutants (POPs) on harbour porpoises of the southern North Sea, which may consequently increase their susceptibility to other pressures (van den Heuvel-Greve *et al.*, 2021).

41. The impact of climate change on harbour porpoise remains poorly understood (Evans and Bjørge, 2013) with existing research limited and uneven in distribution. Potential impacts of climate change on marine mammals in general have included geographical range shifts ((Gilles *et al.*, 2011, Lambert *et al.*, 2011) (Nøttestad *et al.*, 2015, Silber *et al.*, 2017, Víkingsson *et al.*, 2015), food web changes (Nøttestad *et al.*, 2015, Víkingsson *et al.*, 2015), and increased susceptibility to disease and contaminants (Fire and Van Dolah, 2012, Jensen *et al.*, 2015, Mazzariol *et al.*, 2018, Twiner *et al.*, 2011).

42. Data from SCANS I to SCANS IV suggested that the abundance of harbour porpoise in the NS MU (for which there are enough data to assess trends) is stable between surveys (Gilles *et al.*, 2023, IAMMWG, 2021, IAMMWG. *et al.*, 2015). A study of the impact of climate change on the species range and distribution in van Weelden *et al.* (2021) suggested a northward shift and expansion of harbour porpoise range, similar to MacLeod *et al.* (2009), but no increase in maximum latitude. This shift may lead to range contraction

and present a risk for north-west European populations with their preference for sub-polar to temperate water temperature.

43. Climate change may impact on harbour porpoise prey distribution and abundance (see volume 2, chapter 9 for effects on prey species) (Evans and Bjørge, 2013). Evans and Bjørge (2013) predicted that rising sea temperatures may enhance stratification as discussed in volume 2, chapter 7, forcing earlier occurrence of the spring phytoplankton bloom and potential cascading effects through the food chain. A study by Sadykova *et al.* (2020) predicted a large future distribution shift in sandeel and harbour porpoise habitat overlap (164 km) but a small shift (16 km) in overlap between herring *Clupea harengus* and harbour porpoise.

44. The most recent UK assessment of favourable conservation status shows that the current range of harbour porpoise covers all of the UK's continental shelf and there appears to have been no change in range since 1994 (JNCC, 2019d, Paxton *et al.*, 2016).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, 2019d). As a result of 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 (which includes the Array marine mammal study area) should remain 'favourable' (JNCC, 2019d).

Bottlenose dolphin

45. The observed distribution of bottlenose dolphins in SCANS-IV was similar to SCANS-III in the southern areas but different in the north west, with more sightings in the northern Celtic Sea, Irish Sea and the Hebrides in 2022 (Gilles *et al.*, 2023). Gilles *et al.* (2023) states there is no information on abundance of bottlenose dolphin in the central North Atlantic, but the differences in distribution and abundance estimates between SCANS surveys (2005, 2016 and 2022) may reflect animals responding to interannual spatial variation in prey availability across the wider range. According to the recent OSPAR Quality Status Report (QSR) 2023, the population in the East Coast Scotland MU is showing signs of increase and range expansion in recent years (Geelhoed *et al.*, 2022a).

46. Over the last 20 years, the size of the population of bottlenose dolphins off the east coast of Scotland has increased (Arso Civil *et al.*, 2021, Cheney *et al.*, 2018, Cheney *et al.*, 2013) and their distribution has observed a southern range expansion, with the same identifiable individuals regularly occurring off eastern England (Arso Civil *et al.*, 2021, Arso Civil *et al.*, 2019). The boundaries of the Moray Firth SAC initially intended to include the main Scottish population's core range, following research conducted in the 1980s and early 1990s. However, Wilson *et al.* (2004) documented a range shift of the east coast of Scotland population outside of the designated Moray Firth SAC. This was evidenced by photo identification studies and bottlenose dolphin carcasses which were found in areas considered to be outside the original range of the species, raising questions about the efficacy of this area-based protection. Surveys over the past ten years have shown that around 50% of the population use the Tay Estuary and adjacent waters during summer months (Arso Civil *et al.*, 2019).

47. The movement of bottlenose dolphin individuals may 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 a study by Lusseau *et al.*(2004) which reported that bottlenose dolphin group sizes in the Moray Firth were significantly related to prey abundance and that changes in the abundance of fish prey would result in interannual variation in grouping patterns of bottlenose dolphin. 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 climate change are therefore likely to be a major factor driving changes in bottlenose dolphin distribution. A study on a Mediterranean population of bottlenose dolphin found that regardless of the sex and social unit to which the animals belong, from 2017 to 2020 individual home range size increased threefold (on average from 5 km^2 to 15 km^2) compared to 2013 to 2016, when sea surface temperature was on average 1.34 °C lower and marine heat waves shorter than 29 days/year (La Manna *et al.*, 2023). Demonstrating the influence of sea surface temperature and marine heatwaves on bottlenose dolphins spatial traits, these results are thought to be potentially useful in mitigating the effects of climate change on coastal dolphins in other regions (La Manna *et al.*, 2023).

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

49. The results of the most recent UK assessment of favourable conservation status showed that the future trend in the range of bottlenose dolphin is 'overall stable (good)' (JNCC, 2019a). However, although the pressures impacting bottlenose dolphin populations 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, 2019a). Therefore, the overall assessment of future prospects and conservation status for bottlenose dolphin is 'unknown' (JNCC, 2019a).

White-beaked dolphin

50. SCANS IV large scale population survey results revealed no significant change in abundance of white-beaked dolphins in the North Sea since the mid-1990s (Gilles *et al.*, 2023).

51. White-beaked dolphin is a species endemic to cold temperate waters of the North Sea and has an estimated population of around 36,000 individuals.(IJsseldijk *et al.*, 2018). Increasing water temperature may lead to reduced areas suitable for foraging and also habitat loss, both of which may result in decline in the population numbers in certain areas of the species range (IJsseldijk *et al.*, 2018). The study reported the first indication of a change in habitat-use and population distribution whereby changes in densities from southern to northern regions of the North Sea were evidenced from strandings data, and IJsseldijk *et al.* (2018) suggested this may result from changes in prey distribution and availability. 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 (IJsseldijk *et al.*, 2018). In study of white-beaked dolphin strandings between 1948 and 2003, MacLeod *et al.* (2005) reported 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.

52. 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, 2019b). Population estimates suggest that the population is relatively stable (JNCC, 2019b). While pressures on white-beaked dolphin populations and their habitat are not believed to be increasing, no threats have been identified that are likely to be impactful. However, due to insufficient data to establish a current trend for this species, the future trajectory of their population and habitat parameters remains 'unknown' (JNCC, 2019b).Therefore, the overall assessment of future prospects and conservation status for white-beaked dolphin is 'unknown' (JNCC, 2019b).

Minke whale

53. In coastal waters off east Scotland, *Ammodytes marinus* are the main constituent of minke whale diet, however fish species such as pelagic herring and *Sprattus sprattus* are equally important for foraging whales in offshore waters (NatureScot, 2023a, Robinson *et al.*, 2009, Santos and Pierce, 2003). (Robinson *et al.*, 2023) examined the distribution and feeding behaviours of adult and juvenile minke whales from long term studies in the Moray Firth; Geographical Information System (GIS) data revealed spatial separation/habitat partitioning by age-class, with juveniles preferring shallower, inshore waters with sandy-gravel sediments, and adults preferring deeper, offshore waters with greater bathymetric slope.

Generalised Additive Models (GAMs) suggested that the partitioning between age-classes was predominantly based on the differing proximity of animals to the shore, with juveniles showing a preference for the gentlest seabed slopes, and both adults and juveniles showing a similar preference for sandy-gravel sediment types. 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 Gadidae and herring may reflect responses of minke whales to a changed environment, possibly driven by increased sea surface and bottom temperatures (Víkingsson *et al.*, 2013). 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). There may be potential increases in prey availability in the area in the future due to sandeel closures in Scotland (see paragraph 34), though the effects of closure would be unlikely to present at higher trophic levels immediately.

54. Major threats affecting minke whale in UK waters include direct and indirect interactions with fisheries (Leaper *et al.*, 2022). In Scotland, for example, evidence of entanglement in static fishing gear (pots or creels) was present in as many as 50% of stranded minke whales examined from 1990 to 2010 (Leaper *et al.*, 2022), Northridge *et al.* (2010) also estimated 30 minke whales becoming entangled each year within Scottish creel fishing gear. Minke whale are also affected by shipping due to direct mortality caused by ship strikes. 7% of minke whales necropsied by the Cetacean Strandings Investigation Programme (CSIP) between 2000 and 2017 had a cause of death of physical trauma due to ship strike (CSIP, 2024). Other impacts include ingestion of contaminants and exposure to persistent noise disturbance which may interrupt key life-cycle activities such as feeding and breeding, causing them to avoid or even abandon critical habitat areas (Anderwald *et al.*, 2013, Gill *et al.*, 2000, Robinson *et al.*, 2009). Data from SCANS II, SCANS III and SCANS IV suggested that the abundance of minke whales in the CGNS MU is stable (IAMMWG, 2022).

55. The results of the most recent UK assessment of favourable conservation status showed 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, 2019c). The OSPAR Intermediate Assessment (OSPAR IA, 2017) concluded that there was no evidence of change in abundance in the North Sea over the period 1994 to 2016 (JNCC, 2019c). However, although the pressures impacting minke whale population and available habitat are not considered to be increasing (JNCC, 2019c), 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 minke whale is ‘unknown’ (JNCC, 2019c).

Humpback whale

56. Following a severe decline due to commercial whaling, humpback whale populations in the North Atlantic region have been undergoing steady recovery during the latter part of the twentieth century (Johnson and Wolman, 1984, O'Neil *et al.*, 2019). In the western North Atlantic, entanglement in static fishing gear, namely crab and lobster creels (pots), is currently considered to be the largest source of anthropogenic mortality and injury for this species (Leaper *et al.*, 2022, Ryan *et al.*, 2016). There are reported stranding records of humpback whales in the southern North Sea (Haelters *et al.*, 2010), however sightings of large mysticetes are infrequent. Specifically, no abundance estimate exists for humpback whales in Scottish waters and SCANS and Cetacean Offshore Distribution and Abundance visual surveys did not detect any between 1994 and 2017 (Hammond *et al.*, 2017). However, influxes of humpback whales into the Firth of Forth were reported in 2017 and 2018, during migration (O'Neil *et al.*, 2019).

57. The main impacts on humpback whale populations in the southern North Sea includes disturbance, ship collisions, entanglement and crucially, changes in food supply (Leopold *et al.*, 2018). Humpback whales occur close to shore and therefore coastal areas with high human activity. Fournet *et al.* (2018) showed that humpback whales in foraging grounds in the North Pacific and North Atlantic have increased the source levels of their calls as ambient noise levels increased, suggesting increasing ocean noise may lead to masking impacts on the species. Increased disturbance to humpback whale due to increasing marine tourism is also thought to be potentially significant, if not managed carefully (Schaffar *et al.*, 2010).

58. Another threat to humpback whales is entanglement in fishing gear, which is increasing in Northeast Atlantic and European waters (Basran *et al.*, 2019, Ryan *et al.*, 2016). At least 25% of 379 individual humpback whales photographed off Iceland showed evidence of non-lethal entanglements with fishing gear (Basran *et al.*, 2019).

59. Concentrations of POPs tend to be lower in mysticetes in comparison with odontocete species due to their foraging preferences for lower trophic levels and generally shorter life spans. In a study by (Ryan *et al.*, 2013), PCB and dichlorodiphenyltrichloroethane (DDT) concentrations in humpback whales sampled in the eastern North Atlantic were found to be lower than threshold toxicity levels for blubber in marine mammals. The relatively low POP concentrations of the Cape Verde humpback whales (as described in Table 10.12) suggested that POPs are unlikely to be a factor in the poor recovery rate of this small putative population (Ryan *et al.*, 2013). The non-selective foraging technique mysticete species such as humpback which involves ingesting material surrounding the intended prey in the water could result in exposure to microplastic (Besseling *et al.*, 2015), with Besseling *et al.* (2015) reporting the first case of microplastic in intestines of a mysticete from the North Sea. Kahane-Rapport *et al.* (2022) found that mysticetes (humpback whale, fin whale, blue whale) predominantly feed at depths of between 50 m and 250 m which coincides with the highest measured microplastic concentration in the studied pelagic California Current Ecosystem, predicting whales that feed on fish may be less exposed to microplastic ingestion than those that feed on krill.

Grey seal

60. Approximately 35% of the world’s grey seals breed in the UK and 80% of these breed Scotland (with highest concentrations in the Outer Hebrides and Orkney) (SCOS, 2023), with the fastest growing colonies located in the central and southern North Sea (SCOS, 2023). UK grey seal numbers are currently stable or increasing throughout their monitored range (SCOS, 2023), suggesting that their population status is not under threat. Population dynamics depend on a colony, however, pup production at colonies in the North Sea is increasing at a rate of approximately 7% per annum (p.a.) (SCOS, 2023), therefore continuing to increase rapidly and does not show any indications of density dependent restraint on growth (SCOS, 2022). SCOS (2023) stated the East Coast of Scotland SMU is continuing to increase rapidly (5.38% p.a.), but the two SACs in the SMU show different trends in abundance. Production at the Isle of May increased exponentially to 9.9% p.a. since surveys began in 1979 (SCOS, 2022), however is now stable or potentially declining (SCOS, 2023). Pup production at Fast Castle, in the Berwickshire and North Northumberland Coast SAC, shows a rapidly increasing pup production (SCOS, 2023) does not show any indication of reaching an asymptote (SCOS, 2022).

61. As top marine predators, grey seal are particularly vulnerable to biotoxins because they possess large fat stores that accumulate POPs. 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). Most previous research focused on the transfer of contaminants through the trophic levels. However, Wilman *et al.* (2023) noted that mercury and polycyclic aromatic hydrocarbons (PAHs) in the lungs of the seals, with results suggesting the airborne influx of mercury and PAHs into the lungs from marine mammals to be plausible. This is of particular importance in juveniles (pups) who at the initial stage of life spend time on land and do not obtain food independently. Other threats to grey seals include entanglement in marine and plastic debris, particularly discarded fishing gear, disturbance and climate change affecting availability of prey.

62. In the SCOS Interim 2023 advice (SCOS, 2024), SCOS advised it unlikely that observed high sea surface temperatures in 2023 (with particularly warm sea surface temperatures off the east of the UK from Durham to Aberdeen) will have significant direct impacts on either grey or harbour seals in terms of their physiology or energetics, but any potential medium or longer term impacts are likely to be due to marine heatwave

effects on grey seal prey species. SCOS (2024) highlighted that warmer temperatures are more likely to impact animals in terms of thermoregulation on land during breeding or haul out, rather than when swimming at sea (where a large thermal gradient between internal body temperature (37°C) and the cold sea water means seals remain in the thermoneutral zone).

63. The results of the most recent UK assessment of favourable conservation status showed that the future trend in the range of grey seal is 'overall stable (good)' (JNCC, 2019e). 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, 2019e). As the current conservation status for range and population is favourable for this species, the future prospects for both parameters are considered 'good' (JNCC, 2019e). The future trend of grey seal habitat has been assessed as 'overall stable' (good) (JNCC, 2019e).

10.7.5. DATA LIMITATIONS AND ASSUMPTIONS

64. The data assumptions and limitations summarised in this section (and presented in more detail in volume 3, appendix 10.2, annex A) are typical challenges that are encountered in conducting DAS for marine mammals in field settings. A number of measures agreed in consultation with stakeholders (such as a choice of appropriate correction factors, see Table 10.10) were applied in data analysis to ensure the most precise results.

65. Although DAS were designed to be carried out monthly, due to logistical issues and/or unsuitable weather conditions, surveys were not conducted in two months: May 2021 and February 2022. Additional surveys were executed in early June 2021 and early March 2022 to fill the potential data gaps and represent the surveys that were not flown. It is essential to acknowledge that the single survey day per month provides only a snapshot of marine mammal distribution, making it challenging to assess the impact of environmental conditions on sighting rates, with consideration given only to seasonal changes. Detection probability may also be constrained by weather conditions, impacting the ability to record marine mammals, particularly distinguishing between grey sea and harbour seal at-sea. In order to ensure that bias is not introduced to the site-specific survey modelling results (Table 10.10), data from broader non-species-specific classifications were not assigned to species categories. As such, sightings classed as 'cetacean species', 'dolphin species', 'seal/small cetacean species' and 'seal species' are not considered in species-specific analyses.

66. Availability bias, representing the time when an animal is detectable either at the sea surface or just below, can also be considered as a potential limiting factor. It can lead to under-estimation of the number of animals present, as not all animals in the area may detectable, rather than not being present (e.g. deeper beneath the water surface) (see volume 3, appendix 10.2, annex A for full detail on availability bias). Therefore, relative density calculations for harbour porpoise, white-beaked dolphin, minke whale and grey seal were corrected for availability bias using published correction factors based on the likelihood of individuals being near the surface and detectable as agreed in consultation with stakeholders (volume 3, appendix 5.1, annexes D and E) .

67. Despite the aforementioned limitations for DAS, the baseline assessment is supplemented with information reported in published literature and therefore offers a comprehensive account of marine mammals within the Array marine mammal study area and the regional marine mammal study area. The presented baseline provides a robust and suitable characterisation of the two study areas against which this assessment is conducted. Consequently, it is concluded that the identified data limitations are not anticipated to impact the assessment's conclusions.

10.8. KEY PARAMETERS FOR ASSESSMENT

10.8.1. MAXIMUM DESIGN SCENARIO

68. The maximum design scenarios identified in Table 10.17 are those expected to have 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. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the Project Description (e.g. different infrastructure layout), to that assessed here, be taken forward in the final design scheme (volume 1, chapter 3).

69. The maximum design scenario informing the assessment of potential impacts on marine mammals from 'effects on marine mammals due to altered prey availability' is based on the maximum design scenario embedded in volume 2, chapter 9.

Table 10.17: Maximum Design Scenario Considered for Each Potential Impact as Part of the Assessment of LSE[1] on Marine Mammals

Potential Impact	Phase[3]			Maximum Design Scenario	Justification
	C	O	D		
Injury and disturbance from underwater noise generated during piling	✓	×	×	**Construction Phase** Wind turbines: • up to 265 semi-submersible floating wind turbine foundations with up to 6 anchors per foundation and one 4.5 m diameter pile per anchor (1,590 piles); • absolute maximum scenario is for 100% of piles to be driven piles; • maximum hammer energy of up to 3,000 kJ; • up to 2 vessels piling concurrently at floating wind turbine anchors; • minimum 950 m and maximum 30 km distance (as based on the Maximum Design Scenario (MDS) presented in volume 3, appendix 10.1) between concurrent piling events; • up to 8 hours maximum piling per pile, therefore 3 piles installed over 24 hours; • total duration of piling of 12,720 hours/530 days; and • total piling phase at floating wind turbine anchors of 63 months (assuming no piling during Q1 due to high likelihood of unsuitable offshore conditions) over a period of 7 years (within the 8 years construction phase). Offshore Substation Platforms (OSPs): • up to 15 OSPs comprising up to 3 large and 12 small jacket foundations with up to 12 and 6 legs per foundation, respectively; 24 x 4.5 m (large jacket) and 12 x 3.0 m (small jacket) diameter piles per leg (216 piles); • maximum hammer energy of up to 4,400 kJ; • only 1 vessel piling at any one time at OSP locations although there may be concurrent piling with a wind turbine anchor; • up to 8 hours maximum piling per pile, therefore 3 piles installed over 24 hours; • total duration of piling of 1,728 hours/72 days; and • total piling phase at OSP foundations of 72 months (assuming reduced piling during the winter period due to greater risk of inclement weather) over a period of 8 years. There is a potential for 2 vessels piling concurrently at either 2 wind turbine anchor locations or 1 wind turbine anchor and 1 OSP foundation. Number of days when piling may occur within piling phase at floating wind turbine anchors and OSPs = 602 days.	For the maximum spatial scenario concurrent piling events would lead to the largest spatial extent of ensonification at any one time. Note that MDS assumes concurrent piling for wind turbine anchors, but it may occur as a combination of wind turbine anchor and OSP foundation. Concurrent piling at wind turbines would be more frequent due to the number of piles for wind turbines, compared to concurrent piling at OSP and wind turbines. The maximum temporal scenario was assessed on the greatest number of days on which piling could occur based on the maximum duration of piling per pile (8 hours) and a single vessel. In total, a maximum of 2 piling vessels will be piling at any one time (either at two wind turbine anchor locations or at wind turbine anchor and OSP). Minimum spacing between concurrent piling represents the highest risk of injury to animals as noise from adjacent foundations could combine to produce a greater radius of effect compared to a single piling event. Maximum spacing between concurrent piling represents the highest risk of behavioural effects to marine mammals as a larger area would be ensonified at any one time.

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

Potential Impact	Phase[3]			Maximum Design Scenario	Justification
	C	O	D		
Injury and disturbance from underwater noise generated during UXO clearance	✓	×	×	**Site Preparation Phase** • clearance of 15 UXOs within the site boundary; • maximum UXO size of up to 698 kg Net Explosive Quantity (NEQ), realistic maximum scenario 227 kg NEQ; • UXO clearance campaign will involve the use of up to 2 vessels on site at any one time with up to 4 return trips; • intention for clearance of all UXOs using low order techniques (subsonic combustion) with a single donor charge of up to 0.25 kg NEQ for each clearance event; • up to 0.5 kg NEQ clearance shot for neutralisation of residual explosive material at each location; • up to 2 detonations within 24 hours; • total duration of UXO clearance campaign 8 days excluding any time lost due to weather conditions; and • clearance during daylight hours only.	Maximum number and maximum size of UXOs encountered within the site boundary is based on the UXO Hazard Assessment undertaken for the Array (Ordtek, 2022). Donor charge is maximum required to initiate low order detonation. Assumption of a clearance shot of up to 0.5 kg at all locations although noting that this may not always be required.
Injury and disturbance due to site-investigation surveys (including geophysical surveys)	✓	✓	×	**Site Preparation and Construction Phases** Geophysical surveys will include: • Multibeam Echosounder (MBES); • Magnetometer (MAG); • Side-scan sonar (SSS); • Sub-bottom profiler (SBP); and • 2D Ultra High-Resolution Seismic (UHRS). Geotechnical surveys will include: • Cone Penetration Test (CPT); • vibrocore; • piston core; • box core; and • borehole. Geophysical and geotechnical surveys will involve the use of up to 4 vessels on site at any one time with up to 50 vessel movements in total and will take place for 5 months over 3 year period. **Operation and maintenance phase** Geophysical surveys will include: • MBES; and • SBP. Geophysical surveys will involve the use of up to 8 Unmanned Surface Vehicles with one return trip each or 1 manned vessel with up to 2 return trips. Routine geophysical surveys will take place: • once every 24 months for wind turbines and OSP foundations as well as wind turbines interior and exterior; and • annually for the first 3 years, then every 24 months for inter-array cables and interconnector cables. Duration of routine geophysical survey campaign up to 3 months.	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.

Potential Impact	Phase[3]			Maximum Design Scenario	Justification
	C	O	D		
Injury and disturbance from underwater noise generated during vessel use and other noise producing activities	✓	✓	✓	**Site Preparation and Construction Phases** A total of 97 vessels will be involved over the duration of site preparation and construction phases (72 months in total, due to limited activity in winter months) at any one time making a total of up to 7,902 return trips. Vessels will be associated with a range of construction activities, including site preparation, floating wind turbine installation, OSPs installation (topside and foundations), and inter-array cables and interconnectors. Other activities would include: • drilling of up to 10% of piles at wind turbine anchors (159 piles) over a maximum drilling duration of 442 days; and • drilling of up to 10% piles at OSPs foundations (216 piles) over a maximum duration of 1,275 days. **Operation and Maintenance Phase** A total of 31 vessels at any one time will be involved over the duration of operation and maintenance phase (35 years) at any one time making a total of up to 508 return trips. Vessels will be associated with a range operation and maintenance activities, including routine inspections, repairs and replacements, removal of marine growth, painting, and removal of fishing debris. **Decommissioning Phase** During this phase there will be a range of vessels used for 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.	Maximum numbers of vessels on site at any one time and largest numbers of round trips during each phase will result in the greatest potential impact. Range of other activities producing underwater noise, including maximum timescales were also included.
Injury due to collision with vessels	✓	✓	✓	**Construction Phase** As described for injury and disturbance due to vessel use above. **Operation and Maintenance Phase** As described for injury and disturbance due to vessel use above. **Decommissioning Phase** As described for injury and disturbance due to vessel use above.	Maximum numbers of vessels on site at any one time and largest numbers of round trips during each phase will result in the greatest potential impact.
Effects on marine mammals due to EMFs from subsea electrical cabling in the water column	×	✓	×	**Operation and Maintenance Phase** Presence of dynamic inter-array cables: • up to 1,261 km of 66 kV or 132 kV inter-array cables with maximum 116 km in the water column; • up to 20% of inter-array cables may require cable protection; • cables will also require cable protection at asset crossings (up to 12 crossings); and • up to 228 junction boxes will be required for inter-array cables. Operation and maintenance phase of up to 35 years.	The MDS is based on the greatest cable length in the water column.

Potential Impact	Phase[3]			Maximum Design Scenario	Justification
	C	O	D		
Injury and disturbance from underwater noise generated during the operation of floating wind turbines and anchor mooring lines	×	✓	×	**Operation and Maintenance Phase** Up to 265 semi-submersible floating wind turbine foundations with up to 224 m hub height, placed 25 m deep in the water column with up to 100 m excursion limit. Anchor mooring lines: • up to 1,590 catenary mooring lines; • maximum line length of up to 750 m (measured from the connection at the sea surface to the anchor located at the deepest water depth); • maximum mooring radius of up to 700 m (measured from the anchor to the floater when located at a neutral central point within the excursion limit); • 200 m per mooring line will be dynamic in water column during the operation and maintenance phase with potential increases to 700 m during storms; and • the mooring line attachment to the foundation will be between 15 m above surface to 20 m below sea level. Operation and maintenance phase of up to 35 years.	The maximum scale of the Array (based upon the maximum number of turbines) as well as the type and dimensions of the floating wind turbines and anchor mooring lines represent the maximum potential for impacts associated with underwater noise during the operational of floating wind turbines and anchor mooring lines.
Effects on marine mammals due to entanglement associated with the Array	×	✓	×	**Operation and Maintenance Phase** Up to 265 floating wind turbines; spatial extent of the site boundary of 858 km^2. Inter-array cables: • up to 1,261 km of inter-array cables with a minimum diameter of 100 mm and a maximum external diameter of 300 mm; and • up to 116 km of inter-array cables will be dynamic in the water column. Mooring lines: • up to 1,590 catenary mooring lines; • maximum line length of up to 750 m (measured from the connection at the sea surface to the anchor located at the deepest water depth); • maximum mooring radius of up to 700 m (measured from the anchor to the floater when located at a neutral central point within the excursion limit); • 200 m per mooring line will be dynamic in water column during the operation and maintenance phase with potential increases to 700 m during storms; and • the mooring line attachment to the foundation will be between 15 m above surface to 20 m below sea level. Operation and maintenance phase of up to 35 years. Routine inspections of the inter-array cables and mooring lines is anticipated to be more frequent initially (e.g. years 1 and 2), and likely to decline in frequency after this, following a risk based approach, with removal of marine debris as required.	The maximum scale, type and dimensions of the mooring lines and inter-array cables in the water column represent the maximum potential for entanglement. Note that the majority of inter-array cables will be buried, rather than occurring in the water column, and therefore would not increase the magnitude of this impact.

Potential Impact	Phase[3] C	O	D	Maximum Design Scenario	Justification
Effects on marine mammals due to altered prey availability	✓	✓	✓	**Construction Phase** • a total of up to 49,948,548 m^2 (40.95 km^2) of temporary habitat loss and/or disturbance due to boulder and sand wave clearance, installation of inter-array and interconnector cables and foundation anchors, temporary offshore wet storage, jack up vessel use for OSP installation and drag embedment anchors (DEA); and • effects on fish and shellfish receptors due to underwater noise from piling and UXO clearance. **Construction and Operation and Maintenance Phases** • up to 19,270,958 m^2 (19.27 km^2) of long term subtidal habitat loss due to infrastructure installed in the construction phase, which will persist into the operation and maintenance phase. In addition, up to 812,808 m^2 of long term seabed disturbance may occur due to dynamic cabling of the mooring lines, which is subject to frequent and intermittent movement. **Operation and Maintenance Phase** • a total of up to 51,411,500 m^2 (51.41 km^2) of temporary habitat loss and/or disturbance due to jack-up vessel usage and disturbance caused by reburial of inter-array and interconnector cables; • up to 19,270,958 m^2 (19.27 km^2) of hard substrate will be installed in the construction phase could be colonised by benthic species; • increased SSCs and associated deposition from movement along seabed of up to 9 catenary mooring lines per semi-submersible foundation, of which there are up to 130; and • effects on fish and shellfish ecology due to EMFs from subsea electrical cabling due to presence of up to 1,261 km of 66 kV or 132 kV inter-array cables with maximum 116 km in the water column (with the rest buried to a minimum target depth of 0.4 m (subject to a Cable Burial Risk Assessment)) and up to 236 km of 275 kV Alternating Current (AC) or 525 kV Direct Current (DC) interconnector cables with total length buried to a minimum depth target burial depth of 1.0 m. **Decommissioning Phase** • a total of up to 43,200 m^2 of temporary habitat loss and/or disturbance due to the footprint area of jack-up vessel use for decommissioning activities; • up to 6,786,162 m^2 (6.79 km^2) of long term subtidal habitat loss due to infrastructure *left in* situ during the decommissioning of the Array (all scour protection and cable protection).	MDSs described for fish and shellfish receptors (volume 2, chapter 9) will result in the greatest potential impact on prey availability.

10.8.2. IMPACTS SCOPED OUT OF THE ASSESSMENT

70. The marine mammal pre-Scoping workshop (see Table 10.10) was used to facilitate stakeholder engagement on topics to be scoped out of the assessment.

71. On the basis of the baseline environment and the Project Description outlined in volume 1, chapter 3 of the Array EIA Report, a number of impacts are proposed to be scoped out of the assessment for marine mammals. This was either agreed with key stakeholders through consultation as discussed in volume 1, chapter 5, or otherwise, the impact was proposed to be scoped out in the Array EIA Scoping Report (Ossian OWFL, 2023) and no concerns were raised by key consultees within the Scoping Opinion.

72. The impact of disturbance due to site-investigation surveys (including geophysical surveys), effect of EMFs on marine mammal receptors from subsea electrical cabling in the water column, and injury and disturbance from underwater noise generated during the operation of floating wind turbines and anchor mooring lines were initially suggested to be scoped out in the Array EIA Scoping Report (Ossian OWFL, 2023) however following consultation with key stakeholders (Table 10.10), they have been included in the assessment and included in the MDS (Table 10.17).

73. Each impact is outlined, together with a justification for scoping it out of the assessment, in Table 10.18.

Table 10.18: Impact Scoped Out of the Assessment for Marine Mammals (Tick Confirms the Impact is Scoped Out)

Potential Impact	Phase[4]			Justification
	C	O	D	
Effects on marine mammals due to accidental release of pollutants	✓	✓	✓	The impact of pollution released during accidental spills and contaminant releases could reduce species survival rates, either as a result of direct mortality of marine mammals or through effects on marine mammals due to altered prey availability (impact scoped in, see Table 10.17). Designed in measures for this impact are the development and adherence to an Environmental Management Plan (EMP) (volume 4, appendix 21) (including a Marine Pollution Contingency Plan (MPCP) and Invasive and Non-Native Species Management Plan (INNSMP)). With these measures in place, it is considered unlikely that a major incident affecting any species at population-level will occur. Therefore, it was proposed that this impact was scoped out of the EIA in the Array EIA Scoping Report and no concerns to that were raised by consultees in the Scoping Opinion (MD-LOT, 2023, Ossian OWFL, 2023).
Effects on marine mammals due to increased Suspended Sediment Concentrations (SSC) and associated deposition	✓	×	✓	Increased SSC and associated deposition can disrupt water quality, which could have direct and indirect effects on marine mammals. Indirect impacts would include adverse effects on prey species and subsequently, effects on marine mammals due to altered prey availability (impact scoped in, see Table 10.17). Direct impacts on marine mammals would include impaired visibility, thereby reducing foraging ability. However, marine mammals are known to forage in areas where water conditions are turbid and visibility is low. As harbour porpoises and harbour seals have been observed foraging in these conditions (Hastie *et al.*, 2016, Marubini *et al.*, 2009, Pierpoint, 2008), it is unlikely that low light levels, increased turbidity and murky water associated with increased SSC will adversely impact marine mammal foraging ability. Although these conditions may compromise visual ability, marine mammals are able to use other senses to navigate their surroundings. Therefore, it was proposed that this impact was scoped out of the EIA in the Array EIA Scoping Report and no concerns to that were raised by consultees in the Scoping Opinion (MD-LOT, 2023, Ossian OWFL, 2023).

10.9. METHODOLOGY FOR ASSESSMENT OF EFFECTS

10.9.1. OVERVIEW

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

- Guidance for Ecological Impact Assessment in the UK and Ireland (CIEEM, 2018);
- Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects (Judd, 2012);
- Guidelines on the information to be contained in Environmental Impact Assessment Reports, Environmental Protection Agency (EPA, 2022); and
- Good Practice Guide for Underwater Noise Measurement (National Measurement Office *et al.*, 2014).

75. In addition, the marine mammal assessment of effects has considered the legislative framework as set out in volume 1, chapter 2 of the Array EIA Report.

10.9.2. CRITERIA FOR ASSESSMENT OF EFFECTS

76. When determining the significance of effects, a two stage process is used which 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.

77. The criteria for defining magnitude in this chapter are outlined in Table 10.19. Each assessment considered the spatial extent with respect to the relevant MU and species ecology, duration in the context of species-specific lifespan and reproductive cycle, frequency and reversibility of impact as well as the potential for long term population consequences when determining magnitude which are outlined within the magnitude section of each impact assessment.

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

Table 10.19: Definition of Terms Relating to the Magnitude of an Impact Within a Defined Geographic Frame of Reference

Magnitude of Impact	Definition
High	The impact could lead to large scale changes to behaviour and distribution, that are extensive in the context of the relevant geographic frame of reference (area/proportion of MU). The duration and frequency of the impact overlaps with a sufficient number of reproductive cycles to have the potential to alter the population trajectory. The effect, which may be either reversible or irreversible in individuals, would be of sufficient severity to affect the long term viability of the relevant population over a generational scale. (Adverse)
	Long term benefits to many individuals within the population (e.g. long term improvement of key habitats) such that there is an increase in the relevant population trajectory over a generational scale. (Beneficial)
Medium	The impact could lead to large scale changes to behaviour and distribution, that are moderate in the context of the relevant geographic frame of reference (area/proportion of MU). The duration and frequency of the impact are sufficient to overlap with at least one reproductive cycle. The effect, which may be either reversible or irreversible in individuals, could result in some population-level effects, but not at a level that would alter the relevant population trajectory over a generational scale. (Adverse)
	Lifetime benefits to some individuals although not enough to affect the relevant population trajectory over a generational scale. (Beneficial)
Low	The impact could lead to changes to behaviour and distribution in individuals, but which are relatively small in the context of the relevant geographic frame of reference (area/proportion of MU). The duration and frequency of the impact are such that there would be minimal disruption to reproductive cycles. Whilst there may be effects at an individual level which may be either reversible or irreversible, these would not be at a scale that would lead to any population-level effects. (Adverse)
	Minor benefit, or positive addition to individuals over a localised scale. (Beneficial)
Negligible	The impact could lead to very minor changes in behaviour and distribution of individuals within the impacted area but not at a level that would be measurable in the context of the geographic frame of reference. Effects are likely to be reversible and highly unlikely to result in any population-level effects. (Adverse)
	Very minor benefit, or positive addition to individuals but not at a level that would be measurable. (Beneficial)

78. The criteria for defining sensitivity in this chapter are outlined in Table 10.20. The sensitivity of marine mammal IEFs has been defined by an assessment of the ability of a receptor to adapt to a given impact (resilience and adaptability), and its ability to recover back to pre-impact conditions (recoverability).

- Resilience is the ability to withstand a perturbation or disturbance by resisting damage.
- Adaptability is the ability of an individual to adapt its behaviour to sustain ecological functioning and allow survival.
- Recoverability is the ability of the same species to return to a state close to that which existed before the activity or event which caused change. Recoverability is dependent on the ability of the individuals to recover following cessation of the activity that causes the impact and is defined as the susceptibility of a species to disturbance, damage or death, from a specific external factor.

79. Information on these aspects of sensitivity of the marine mammal IEFs to given impacts has been informed by the best available robust evidence from scientific research and published literature on marine mammals (studies on captive animals as well as observations from field studies). In particular, evidence from field studies of marine mammals during the construction and operation of offshore wind farms (and analogous activities such oil and gas surveys) has been used to inform this assessment. The review of resilience and recoverability of marine mammal IEFs has been combined to provide an overall evaluation of the sensitivity of a receptor to an impact as outlined in Table 10.20.

Table 10.20: Definition of Terms Relating to the Sensitivity of Individuals to Effects

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

80. The magnitude of the impact and the sensitivity of the receptor are combined when determining the significance of the effect upon marine mammals. The particular method employed for this assessment is presented in Table 10.21.

81. Where a range is suggested for the significance of effect, for example, minor to moderate, it is possible that this may span the significance outcome (i.e. the range is given as minor to moderate). The technical specialist's professional judgement was applied to determine which outcome defines the most likely effect, which takes in to account the sensitivity of the receptor and the magnitude of impact. Where professional judgement is applied to quantify final significance from a range, the assessment has 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.

82. 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.

83. 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 10.21: Matrix Used for the Assessment of the Significance of the Effect

		Magnitude of Impact			
		Negligible	**Low**	**Medium**	**High**
Sensitivity of Receptor	**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

84. This marine mammal chapter assesses the LSE[1] on the qualifying interest feature(s) of Natura 2000 sites (i.e. nature conservation sites in Europe designated under the Habitats or Birds Directives[5]) and/or sites in the UK that comprise the National Site Network (collectively termed ‘European sites’) as described within section 10.7.2 of this chapter. The RIAA for the Array includes the assessment of the potential impacts on the site itself. A summary of the outcomes reported in the RIAA is provided in Ossian OWFL (2024).

85. Where locally designated sites and national designations (other than European sites) fall within the boundaries of a European site and where qualifying interest features are the same, only the European site has been taken forward for assessment. Potential impacts on the integrity and conservation status of the locally or nationally designated site are assumed to be inherent within the assessment of the European site so a separate assessment for the local or national site is not undertaken.

86. However, assessment of the LSE[1] on a local or nationally designated site which falls outside the boundaries of a European site, but within the regional marine mammal study area, has been undertaken within this chapter using the EIA methodology described in section 10.9.2.

10.10. MEASURES ADOPTED AS PART OF THE ARRAY

87. As part of the Array design process, a number of designed in measures have been proposed to reduce the potential for impacts on marine mammal receptors (see Table 10.22). They are considered inherently part of the design of the Array and, as there is a commitment to implementing these measures, these have 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 designed in measures are considered standard industry practice for this type of development.

Table 10.22: Designed In Measures Adopted as Part of the Array

Designed In Measures Adopted as Part of the Array	Justification
The development of, and adherence to, an EMP (volume 4, appendix 21).	To ensure adequate environmental controls are in place across the project to manage and mitigate any potential risk to the environment. Measures will cover all aspects of environmental management including environmental awareness training, auditing, environmental reporting and waste management. It is anticipated that the MPCP and INNSMP will be appendices to the overarching EMP.
The Development of, and adherence to, a MPCP (volume 4, appendix 21, annex A)	To reduce the potential for release of pollutants from construction, operation and maintenance and decommissioning plant is reduced so far as reasonably practicable. 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 containing hazardous substances, and storage of these substances in impenetrable bunds. All vessels associated with the Array will be required to comply with the standards set out by MARPOL.
The development of and adherence to Navigational Safety and Vessel Management Plan (NSVMP) (volume 4, appendix 24).	The NSVMP will include measures to reduce disturbance to marine mammal receptors from transiting vessels, requiring them to: • not deliberately approach marine mammals as a minimum; and • avoid abrupt changes in course or speed should marine mammals approach the vessel to bow-ride. The NSVMP will be implemented as far as practicable and where it does not compromise the safety of vessels.

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[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.

Designed In Measures Adopted as Part of the Array	Justification
The development of and adherence to a Piling Strategy (PS) (or equivalent) which will set out the following measures. Implementation of initiation stage and soft start during piling. This will involve the use of a low hammer energy with a low number of strikes used initially, followed by lower hammer energies at a higher strike rate at the beginning of the piling sequence before energy input is 'ramped up' (increased) over time to required higher levels: • For anchor piles, a 1 minute initiation phase will be used with hammer energy of 450 kJ at a strike rate of 10 strikes per minute and then soft start duration is 20 minutes with hammer energy of 450 kJ with strike rate of 30 strikes per minute. A ramp up procedure will then increase from 450 kJ to 3,000 kJ with strike rate of 30 strikes per minute for 30 minutes. • For OSP jacket piles, a 1 minute initiation phase will be used with hammer energy of 660 kJ at a strike rate of 10 strikes per minute and then soft start duration is 20 minutes with hammer energy of 660 kJ with strike rate of 30 per minute. A ramp up procedure will then increase from 660 kJ to 4,400 kJ with strike rate of 30 strikes per minute for 30 minutes.	These measures will reduce the likelihood of injury from elevated underwater noise to marine life in the immediate vicinity of piling operations as far as practicable, allowing individuals to move away from the area before sound levels reach a level at which injury may occur. These measures will reduce the likelihood of injury from elevated underwater noise to marine mammals in the immediate vicinity of piling/UXO clearance operations as far as practicable, allowing individuals to move away from the area before sound levels reach a level at which injury may occur. This is in line with the most up to date guidance for piling/UXO clearance operations (JNCC, 2010a, JNCC, 2010b) and, in most cases, compliance with this guidance reduce the likelihood of injury to marine mammal receptors to negligible levels.
UXO clearance using low order disposal techniques where technically feasible	Low order techniques will be adopted wherever practicable (e.g. deflagration and clearance shots) as mitigation to reduce noise levels and thereby injury and disturbance to sound-sensitive receptors during UXO clearance. There is a small risk that low order disposal could unintentionally arise in a high order detonation and therefore this scenario has also been considered in the assessment of likely significant effects.
Implementation of soft start measures for UXO clearance using a sequence of small explosive charges detonated over set time intervals.	These measures will reduce the likelihood of injury from elevated underwater noise to marine mammals in the immediate vicinity of piling/UXO clearance operations as far as practicable, allowing individuals to move away from the area before sound levels reach a level at which injury may occur. This is in line with the most up to date guidance for piling/UXO clearance operations (JNCC, 2010a; JNCC, 2010b) and, in most cases, compliance with this guidance reduce the likelihood of injury to marine mammal receptors to negligible levels.
The development of and adherence to a MMMP (volume 4, appendix 22), which will present appropriate mitigation for activities that could potentially lead to injurious effects on marine mammals (e.g. piling, UXO clearance and geophysical surveys). For piling, measures will include setting a mitigation zone based on the maximum predicted injury range using unweighted SPL$_{pk}$ metric for the maximum spatial scenario across all marine mammal species. The outline MMMP sets out measures to be applied in advance of and during piling activity, including: • ADDs to discourage marine mammals from approaching an area where injury may occur; • Visual monitoring carried out by MMOs^2, and • Acoustic monitoring by PAM Operators. A maximum of 30 minutes ADD duration is considered to be a designed in measure^6. For UXO clearance, measures will include setting a mitigation zone of at least 1 km in line with current guidance (JNCC, 2010b). The extent of the mitigation zone will be informed by the underwater noise modelling and the injury ranges as a result of high order detonation of the largest UXO size (698 kg NEQ*).* Standard industry measures including visual and acoustic monitoring by PAM and MMO^2 operatives so that animals are out with the injury zone, plus the use of an ADD to deter animals over the injury zone (up to a 30 minute period). For geophysical surveys, measures will include setting a mitigation zone of at least 500 m in line with current guidance (JNCC, 2017), with the extent of the mitigation zone informed by the largest injury range across all types of geophysical surveys*.* Mitigation during geophysical surveys will involve visual and acoustic monitoring using MMOs^2 and PAM so that the risk of injury over the defined mitigation zone is reduced in line with JNCC guidance (JNCC, 2017). Soft starts will be applied for electromagnetic equipment (such as SBP and SSS) as well as seismic sources (UHRS). As per the JNCC (2017) MBES surveys in shallow waters (<200 m) are not subject to the requirements of mitigation therefore no mitigation will be proposed to this type of survey.	An outline MMMP has been developed on the basis of the most recent published statutory guidance and in consultation with key stakeholders (JNCC, 2010a, JNCC, 2010b, JNCC, 2017). The implementation of the MMMP will mitigate for the risk of permanent auditory injury to marine mammals within a pre-defined 'mitigation zone' for each activity. The mitigation zone is determined considering the largest injury zone across all species for each relevant activity. The use of an will also reduce the potential for collision risk, or potential injury to, marine mammals and other marine megafauna (e.g. basking shark and sea turtles) as far as practicable. The outline MMMP includes visual and acoustic monitoring as a minimum over the defined mitigation zones so that animals are clear before the activity commences. Additional measures to deter animals from injury risk zones may be applied in some instances (e.g. ADDs or soft start charges).
Routine inspections of the inter-array cables and mooring lines.	Mooring lines and dynamic inter-array cables in the water column will undergo regular inspections during the operation and maintenance phase with inspection frequency more frequent initially for the first two years and then decreasing to an annual schedule. The removal of marine debris from mooring lines and inter-array cables will be undertaken as necessary following monitoring and further relevant action taken if required, based on findings from the inspections. The removal of debris from mooring lines and cables further reduces the likelihood of secondary entanglement.

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[6] Anything additional to 30 minutes ADD is considered secondary mitigation and therefore not a designed in measure.

Designed In Measures Adopted as Part of the Array	Justification
The development of, and adherence to, a Decommissioning Programme (DP^2).	The aim of this plan is to adhere to the existing UK and international legislation and guidance (at the time of writing) during the decommissioning phase. This will reduce the amount of long term disturbance to the environment as far as reasonably practicable. Whilst this measure has been committed to as part of the Array, the MDS for the decommissioning phase has been considered in each of the impact assessments presented in section 10.11.

10.11. ASSESSMENT OF SIGNIFICANCE

88. Table 10.17 summarises the potential impacts arising from the construction, operation and maintenance and decommissioning phases of the Array, as well as the MDS against which each impact has been assessed. An assessment of the likely significance of the effects of the Array on the marine mammal receptors as a result of each identified impact is provided within this section..

89. Given that many of the impacts identified for marine mammals relate to underwater noise (Table 10.17), the assessment has been informed by underwater noise modelling, the scope of which was agreed through consultation (see volume 2, chapter 5). An overview of the relevant thresholds for onset of significant effects alongside the evidence base used to derive them in provided in section 10.11.1. Further detail about noise modelling is provided in volume 3, appendix 10.1.

10.11.1. MARINE MAMMALS AND UNDERWATER NOISE

90. Marine mammals, in particular cetaceans, are capable of generating and detecting sound and are dependent on sound for many aspects of their life, including prey identification, predator avoidance, communication and navigation (Au *et al.*, 1974, Bailey *et al.*, 2010). Increases in anthropogenic sound may consequently lead to a potential effect within the marine environment (Bailey *et al.*, 2010, Parsons *et al.*, 2008). Underwater noise influence may then subsequently affect marine mammals in a number of ways and vary with the distance from the noise source (Marine Mammal Commission, 2007). It can compete with important signals (masking) and alter behaviour (by inducing changes in foraging or habitat-use patterns, separation of mother-calf pairs). Underwater noise can also cause temporary hearing loss or, if the exposure is prolonged or intense, permanent hearing loss. It can also cause damage to tissues other than the ear if noise is sufficiently intense (Marine Mammal Commission, 2007).

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

Injury

92. Auditory injury in marine mammals can be either temporary, also referred to as Temporary Threshold Shift (TTS), where an animal's auditory system recovers over time, or permanent, referred to as PTS, where there is no hearing recovery in the animal. The 'onset' of TTS is deemed to be where there is a 6 dB shift in a hearing threshold, defined by NMFS (2016) as a "*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*". The acoustic threshold that would result in the PTS-onset in marine mammals have not been directly measured, largely as it is considered unethical to conduct experiments measuring PTS in animals. Therefore PTS-onset must be extrapolated from available TTS-onset measurements, including early studies on TTS growth rates in chinchillas (Henderson, 1983). The PTS onset is therefore conservatively considered to occur where there is 40 dB of TTS (Southall *et al.*, 2007). TTS exceeding 40 dB requires a longer recovery time than smaller shifts (e.g. of 6 dB), suggesting a higher probability of irreversible damage or different underlying mechanisms (Kryter, 1994, Ward, 1970).

93. Whether such shifts in hearing would lead to loss of fitness will depend on several factors including the frequency range of the shift and the duty cycle of impulsive sounds. For example, if a shift occurs within a frequency band that lies 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. Potential auditory injury is assessed in terms of PTS given the irreversible nature of the effect, unlike TTS which is temporary and reversible.

94. Marine mammals exposed to sound levels that could induce TTS are likely to respond by moving away from (fleeing) the ensonified area and therefore avoiding potential injury. It is considered there is a behavioural response (disturbance) that overlaps with potential TTS ranges. Since derived thresholds for the onset of TTS are based on the smallest measurable shift in hearing, TTS thresholds are likely to be very precautionary and could result in overestimates of TTS ranges. In addition, the conservative assumptions applied in the underwater sound modelling (e.g. use of impulsive sound thresholds at large ranges; see paragraph 116 *et seq.*) may also result in the overestimation of ranges.

95. Hastie *et al.* (2019) found that during piling there were range dependent changes in signal characteristics with received sound losing its impulsive characteristics at ranges of several kilometres, especially beyond 10 km. Therefore, where TTS ranges exceed 10 km it is not considered a useful predictor of the effects of underwater sound on marine mammals. As such, although TTS ranges were modelled for completeness for all sound-related impacts and are presented in volume 3, appendix 10.1, these are not included in the assessment of significance of auditory injury presented in this section (aligning with the proposed approach in the Array EIA Scoping Report (Ossian OWFL, 2023)). Alternatively, the assessment of potential auditory injury is assessed in terms of PTS and accounts for the irreversible nature of the effect.

96. For marine mammals, auditory injury thresholds are based on both SPL_{pk} (i.e. unweighted) and marine mammal hearing-weighted SEL_{cum} as per the latest guidance (Southall *et al.*, 2019) (Table 10.23). NatureScot was content with the proposed criteria and metrics for the assessment of injury using Southall *et al.* (2019) criteria for auditory injury to marine mammals (see Table 10.10). The marine mammal hearing-weighted categories are based on the frequency characteristics (bandwidth and sound level) for each group within which acoustic signals can be perceived and therefore assumed to have auditory effects (Table 10.23). To calculate distances using the SEL_{cum} metric the sound modelling assessment made a simplistic assumption that an animal would be exposed over the duration of the piling activity and that there would be no breaks in activity during this time. It was assumed that an animal would swim away from the sound source at the onset of activity at a constant rate. The conservative species-specific swim speeds, as agreed with the NatureScot (see Table 10.10), were incorporated into the model (Table 10.24).

97. 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 mysticetes with an estimated functional hearing range between 7 Hz and 35 kHz); minke whale and humpback whale are 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.
- Phocid Carnivores In Water (PCW) (i.e. true seals with an estimated functional hearing range between 50 Hz and 86 kHz); grey seal is the marine mammal IEF in the PCW group.

Table 10.23: Summary of Acoustic Thresholds for PTS Onset in Relevant Hearing Groups (Southall *et al.*, 2019)

Hearing Group	Parameter	Impulsive	Non-impulsive
Low Frequency (LF) cetaceans	Peak, dB re 1μPa unweighted	219	-
	SEL, dB re 1μPa^{2}s LF weighted	183	199
High Frequency (HF) cetaceans	Peak, dB re 1μPa unweighted	230	-
	SEL, dB re 1μPa^{2}s HF weighted	185	198
Very High Frequency (VHF) cetaceans	Peak, dB re 1μPa unweighted	202	-
	SEL, dB re 1μPa^{2}s VHF weighted	155	173
Phocid Carnivores in Water (PCW)	Peak, dB re 1μPa unweighted	218	-
	SEL, dB re 1μPa^{2}s PCW weighted	185	201

Table 10.24: Swim Speeds Used in the Underwater Noise Modelling

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

Disturbance

98. As sound intensity decreases beyond the injury threshold zone, sound levels have the potential to disrupt the behavioural patterns of marine mammals. Behavioural reactions can vary in severity, from sustained vigilance, to interruptions in foraging, to active avoidance or displacement (NRW, 2023b). Responses may not necessarily directly scale with received sound level (Gomez *et al.*, 2016). The reaction of a marine mammal to disturbance is dependent upon individual factors and contextual considerations (Southall *et al.*, 2019), with prior experience and acclimatisation playing crucial roles in determining whether an individual will manifest an aversive response to sound (Ellison *et al.*, 2012, Popper *et al.*, 2014), especially in regions characterised by elevated underwater sound levels associated with human activities.

99. Brandt *et al.* (2018) for example investigated disturbance in harbour porpoise during construction of the seven offshore wind farms in the German Bight, and found there was a clear gradient in the decline of porpoise detections after piling, depending on both the noise level and distance to piling activity. Within the local vicinity of the construction site (up to 2 km), porpoise detections declined several hours before the start of piling and were reduced for about one to two days after cessation of piling. Declines in harbour porpoise detections were found up to 17 km from piling when no noise mitigation system was used, with detections declining strongly during unmitigated piling. When mitigation was used, the maximum distance of effect was 14 km and the decline in detections was not as marked. Other studies at other wind farms (e.g. Nysted Offshore Wind Farm, Horns Rev Offshore Wind Farm, eight wind farms in the German Bight) which investigated the distances over which harbour porpoise are disturbed found effects up to 15 to 20 km from the piling site (Brandt *et al.*, 2011, Carstensen *et al.*, 2006, Dähne *et al.*, 2013, Tougaard *et al.*, 2006), though methodologies are not directly comparable and some did not involve acoustic measurements of piling noise, introducing uncertainty in transmission loss of noise over distance. Several studies demonstrated pronounced effects on harbour porpoise behaviour during construction but complete recovery once piling ceased (in the operation and maintenance phase) (Tougaard *et al.*, 2009a).

100. However, some studies have reported positive effects. (Scheidat *et al.*, 2011) reported an overall increase in harbour porpoise activity from baseline to operation at Dutch wind farm Egmond aan Zee, with acoustic activity significantly higher inside the wind farm than in the surrounding reference areas, indicating that the occurrence of porpoises in this particular array area increased (potentially due to the reef effect or sheltering effect).

101. Furthermore, the way in which disturbance is assessed in EIAs can vary considerably (NRW, 2023b). Key methods include dose-response curves, fixed noise thresholds and area-based thresholds (termed effective deterrent ranges (EDRs)). A summary of the approaches applied to this assessment is given in Table 10.25, with further detail on dose-response and thresholds used below.

Table 10.25: Summary of Criteria Used in The Impact Assessment of Behavioural Disturbance for Different Marine Mammal Species

Sound source	Species	Approach	Source
Piling	Harbour porpoise	• Dose-response; and • Unweighted threshold 143 dB re 1 μPa^{2}s SELss (strong disturbance).	• Graham *et al.* (2019); and • (Tougaard, 2021).
	Minke whale, bottlenose dolphin, white-beaked dolphin	• Dose-response; • Unweighted threshold 160 dB re 1 μPa root mean square (rms) (strong disturbance); and • Unweighted threshold of 140 dB re 1 μPa (rms) (mild disturbance).	• Graham *et al.* (2019); and • NMFS (2005).

Sound source	Species	Approach	Source
	Grey seal	• Dose-response; • Unweighted threshold 160 dB re 1 µPa (rms) (strong disturbance); and • Unweighted threshold of 140 dB re 1 µPa (rms) (mild disturbance).	• Whyte *et al.* (2020) • NMFS (2005)
UXO	All marine mammal species	• Unweighted $\mathrm{SPL_{pk}}$ and hearing-weighted $\mathrm{SEL_{cum}}$ for TTS as a proxy for disturbance (‘fleeing’ response).	• (Southall *et al.*, 2019)
Site-investigation surveys (impulsive)	All marine mammals species	• Unweighted threshold of 160 dB re 1 µPa (rms) (strong disturbance); and • Unweighted threshold of 140 dB re 1 µPa (rms) (mild disturbance).	• NMFS (2005)
Site-investigation surveys (non-impulsive)	All marine mammals species	• Unweighted threshold of 120 dB re 1 µPa (rms) (no distinction between mild and strong disturbance).	• NMFS (2005)
Vessel sound	All marine mammal species	• Single unweighted threshold of 120 dB re 1 µPa (rms) (no distinction between mild and strong disturbance).	• NMFS (2005)

Thresholds

102. For impulsive sound sources other than piling (e.g. UXO clearance, some geotechnical and geophysical surveys), this assessment adopts the NMFS (2005) Level B harassment threshold of 160 dB re 1 µPa rms for impulsive sound, which is defined as: *“having the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioural patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild”.* This definition is similar to the JNCC (2010) description of non-trivial (significant) disturbance. The United States (US) NMFS (2005) guidelines also suggest a precautionary threshold 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, although this is not considered likely to lead to a ‘significant’ disturbance response and is therefore hereinafter referred to as “mild disturbance”.

103. The assessment of significance for behavioural disturbance during piling will be based on the dose-response approach described in more detail in paragraph 105 *et seq*. The unweighted noise threshold value of 143 dB re 1µPa^{2}s $\mathrm{SEL_{ss}}$ was recently recommended in the position statement on assessing behavioural disturbance of harbour porpoise from underwater sound published by (NRW, 2023b). Acoustic recordings of the piling noise were utilised alongside harbour porpoise monitoring to derive a threshold for harbour porpoise reactions to the noise from piling. Declines were found at sound levels exceeding an unweighted $\mathrm{SEL_{ss}}$ of 143 dB re 1 µPa^{2}s and up to 17 km from piling. This means that harbour porpoises may react with avoidance only when exposure exceeds a threshold value of 143 dB re 1 µPa^{2}s. It is worth noting that the noise threshold of 143 dB re 1 µPa^{2}s was derived from modelled average of six different studies of full-scale pile driving operation and thereby represents a large amount of empirical data (Tougaard, 2021). As such, this threshold is also referred to in this assessment to provide context. It is particularly relevant to the HRA as a designated area-based approach and has also been applied to the HRA in reference to harbour porpoise SAC only.

104. The NMFS (2005) guidance sets the marine mammal Level B harassment threshold (analogous to disturbance) for continuous sound at 120 dB re 1 µPa (rms). This threshold has therefore been adopted in the assessment of effects as a result of continuous noise, such as noise originating from drilling and vessels.

Dose-response

105. The data collected during monitoring at offshore wind farms during construction suggests that piling 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 piling source (Brandt *et al.*, 2011). During monitoring at Horns Rev Offshore Wind Farm, harbour porpoise demonstrated 100% avoidance at distances 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). Graham *et al.* (2019) analysed data 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. The study demonstrated that the response of harbour porpoise to piling diminished over the piling phase such that, for a given received sound level or at a given distance from the source, there were more detections of animals at the last piling location compared to the first piling location (Graham *et al.*, 2019) (Figure 10.5). For harbour porpoise, as a representative approach, the dose-response curve was applied from the first location modelled as shown by Graham *et al.* (2019) where the probability of response approaches zero at circa 120 dB $\mathrm{SEL_{ss}}$. In the absence of species-specific data for other cetacean species, the same dose-response curve was assumed to apply to all cetacean species in this assessment (Figure 10.5) and represents a precautionary approach to assessment as other cetacean species are likely to be less sensitive than harbour porpoise to behavioural disturbance as noted in the literature (Tougaard, 2021).

106. Whyte *et al.* (2020) used tracking data from 24 harbour seal to estimate the effects of pile driving sounds on this species. The study used predictions of seal density during pile driving made by Russell *et al.* (2016) compared to distance from the wind farm and predicted single-strike SEL ($\mathrm{SEL_{ss}}$) by multiple approaches. The study reported predictions of seal density, and changes in seal density during piling, averaged across all water depths and piling events (Whyte *et al.*, 2020). Predicted seal density significantly decreased within 25 km or above 145 dB re 1 µPa^2 $\mathrm{SEL_{ss}}$ (averaged across depths and pile installations). Other studies have reported similar avoidance reactions for both grey seal and harbour seal to the same sound source (Aarts *et al.*, 2018, Götz and Janik, 2010) and therefore harbour seal dose-response curve is considered as appropriate to be used as a proxy for grey seal. As such, the dose-response curve derived from Whyte *et al.* (2020) (Figure 10.24) was applied to the grey seal assessment to determine the number of animals that may potentially respond behaviourally to received sound levels during piling.

107. To obtain the numbers of animals disturbed during piling, $\mathrm{SEL_{ss}}$ contours from underwater noise modelling were plotted by 5 dB isopleths in GIS for all modelled locations. The areas within each 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 at any given time. The number of animals predicted to respond are based on species-specific densities derived from site-specific surveys and desktop data (Table 10.13), as agreed with NatureScot (Table 10.10). For each species the location taken forward for assessment was that which resulted in the greatest number of animals affected, thereby representing the MDS. For cetaceans (except bottlenose dolphin, where an average density to represent distribution within the CES^2 MU population was used to estimate the number of animals) this was represented by the location with the largest spatial extent of the noise contours, whilst for bottlenose dolphin and grey seal (where the numbers of animals were calculated from the mean density derived from the Lacey *et al.* (2022) and Carter *et al.* (2022) density maps, respectively) it was the modelled contour that coincided with higher density areas. A full account of the approach to estimating marine mammal density for assessment is presented in volume 2, appendix 10.1).

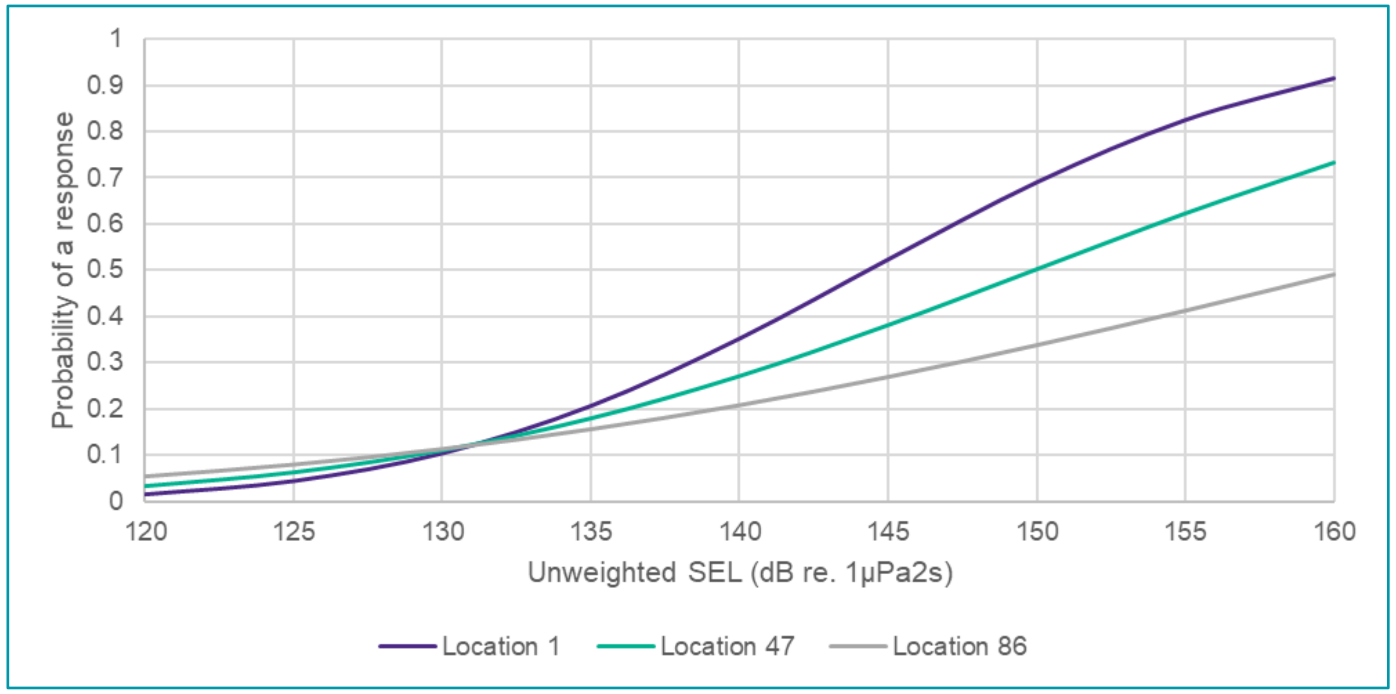


Figure 10.4: The Probability of a Harbour Porpoise Response (24 hrs) in Relation to the Partial Contribution of Unweighted Received SEL$_{ss}$ for the First Location Piled (Purple Line), the Middle Location (Green Line) and the Final Location Piled (Grey Line) (Graham *et al.*, 2019)

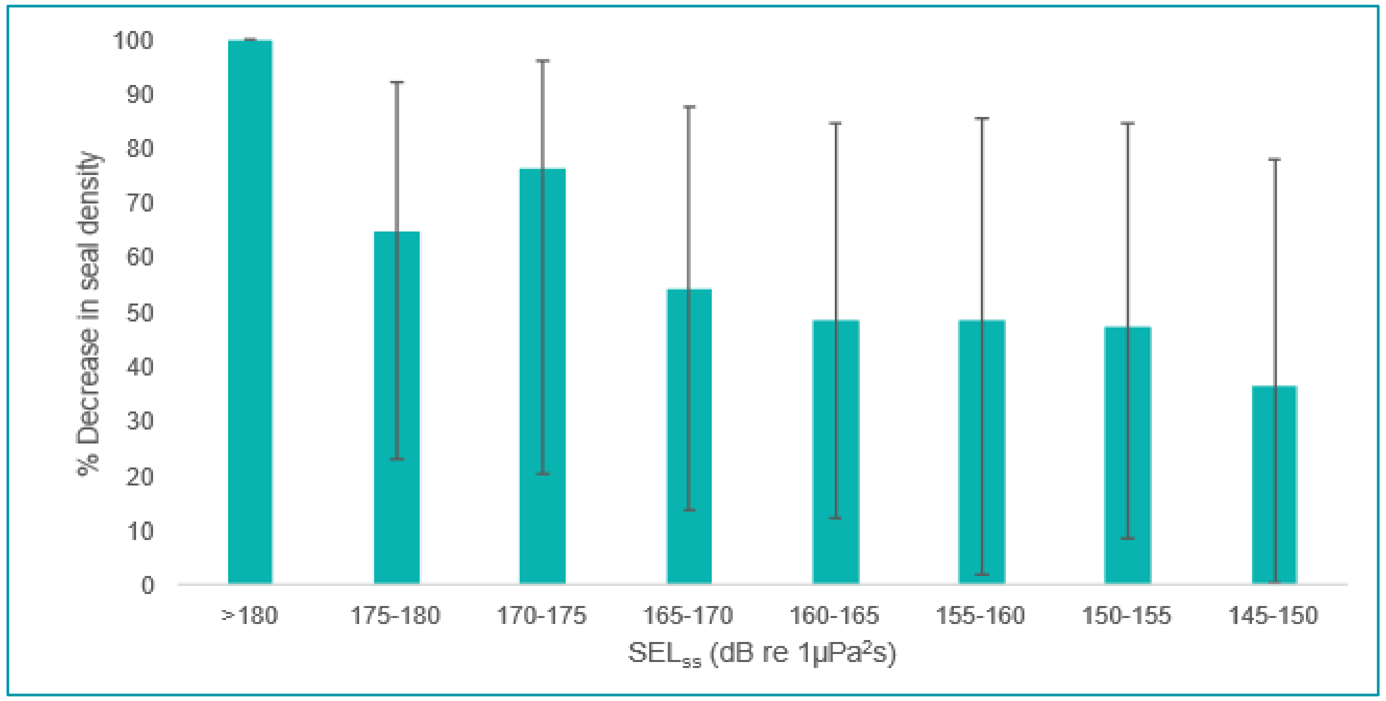


Figure 10.5: Predicted Decrease in Seal Density as a Function of Estimated Sound Exposure Level, Error Bars Show 95% Confidence Interval (CI) (Whyte *et al.*, 2020)

Assumptions and limitations

108. By applying the fixed-threshold based and dose-response criteria, the magnitude of impact can be quantified with respect to the spatial extent of disturbance, and subsequently the number of animals potentially disturbed based on available density information. However, Southall *et al.* (2021) noted that it is challenging to develop a comprehensive set of empirically derived criteria for such a diverse group of animals. The study identified data gaps, as for example, measurements of the effects of elevated sound on mysticetes have never been conducted and extrapolation from other species has been necessary. Since there are broad differences in hearing across the frequency spectrum for different marine mammal hearing groups, sounds that disturb one species may be irrelevant or inaudible to other species. Variance in responses even across individuals of the same species are well documented to be context and sound-type specific (Ellison *et al.*, 2012). In addition, the potential interacting and additive effects of multiple stressors (e.g. reduction in prey, sound and disturbance, contamination, etc.) is likely to influence the severity of responses (Lacy *et al.*, 2017).

109. As such, the recent recommendations by Southall *et al.* (2021) steer away from a single overarching approach. Instead, the study proposes a framework for developing probabilistic response functions for future studies (Southall *et al.*, 2021). The paper suggests different contexts for characterising marine mammal responses for both free-ranging and captive animals with distinctions made by sound sources (i.e. active sonar, seismic surveys, continuous/industrial sound and pile driving). Three parallel categories have been proposed within which a severity score from an acute (discrete) exposure can be allocated:

- survival – defence, resting, social interactions and navigation;
- reproduction – mating and parenting behaviours; and
- foraging – search, pursuit, capture and consumption.

110. Although some studies have been able to assign responses to these categories based on acute exposure, there is still limited understanding of how longer-term (chronic) exposure could translate into population-level effects. The potential for behavioural disturbance to lead to population consequences has been considered for this assessment using the iPCoD approach and is described in detail in paragraph 131 *et seq.* and in volume 3, appendix 10.3.

111. Southall *et al.* (2021) reported observations from long term whale-watching studies and suggested that there were differences in the ability of marine mammals to compensate for long term disturbance which related to their breeding strategy. For example, mysticetes as ‘capital breeders’ accumulate energy in their feeding grounds and transfer it to calves in their breeding ground, whilst other species such as harbour porpoise, bottlenose dolphin and harbour seal are ‘income breeders’ as they balance the costs of pregnancy and lactation by increased food intake, rather than depending on fat stores. Reproductive strategy can impact the energetic consequences of disturbance and cause variation in an individual’s vulnerability to disturbance based on both its reproductive strategy and stage (Harwood *et al.*, 2020).

112. Marine mammal ability to compensate for chronic exposure to sound will also depend on a range of ecological factors, including the relative importance of the disturbed area and prey availability within their wider home range, the distance to and quality of other suitable sites, the relative risk of predation or competition in other areas, individual exposure history, and the presence of concurrent disturbances in other areas of their range (Gill *et al.*, 2001). Animals may be able to compensate for short term disturbances by feeding in other areas, for example, which would reduce the likelihood of longer-term population consequences. Booth (2019) reported that although minimising the anthropogenic disturbance is an important factor to animal’s health, if animals can find suitable high-energy-density prey they may be capable of recovering from some lost foraging opportunities. Christiansen and Lusseau (2015) studied the effect of whale-watching on minke whale in Faxafloi Bay, Iceland and found no significant long term effects on vital rates, although years with low sandeel density led to increased exposure to whale-watching as whales were forced to move into disturbed areas to forage. Odontocetes may be more vulnerable to whale-watching compared to mysticetes due to their more localised, and often, coastal home ranges. Bejder *et al.* (2006) documented a decrease in local abundance of bottlenose dolphin which was associated with an increase in whale-watching in a tourist area compared to a control area. Studies of changes in abundance

as a result of disturbance should be considered in light of findings presented in Gill *et al.* (2001) who reported that if there is no suitable habitat nearby animals may be forced to remain in an area despite the disturbance, regardless of whether or not it could affect survival or reproductive success.

113. The marine mammal receptors considered in this assessment vary biologically and therefore have different ecological requirements that may affect their sensitivity to disturbance. This point is illustrated by the differences between marine mammals identified as key biological receptors in the baseline. Humpback whales and grey seals are capital breeders and store energy for reproduction and survival, while harbour porpoise (and other cetaceans whose ecology is well studied, e.g. bottlenose dolphin) are income breeders and they use energy that is acquired on a continual basis, including during the reproductive period (Stephens *et al.*, 2009).

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

- marine mammal baseline (e.g. use of seasonal density peaks for harbour porpoise densities);
- MDS for the project parameters (Table 10.17, e.g. use of high order UXO clearance as the MDS); and
- underwater noise modelling (see paragraph 116 et seq. for summary and volume 3, appendix 10.1 for more details).

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

Conservatism in the underwater noise modelling

116. In order to ensure that the assessment is precautionary, a number of conservative assumptions were adopted in the underwater noise model. These measures of conservatism are summarised in this section and highlight that both PTS (and TTS onset ranges) predicted using the SEL_{cum} threshold are likely to lead to overestimates in the ranges and therefore should be interpreted with caution. For more details refer to volume 3, appendix 10.1.

117. The underwater noise modelling assumed that the maximum hammer energy would be reached and maintained at all locations, whereas this is unlikely to be the case based on examples from other offshore wind farms, e.g. Beatrice Offshore Wind Farm, where the mean actual hammer energy averages were considerably lower than the maximum assessed in the Environmental Statement and only six out of 86 asset locations reached maximum hammer energy (Beatrice Offshore Wind Farm Ltd (BOWL), 2018).

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

119. The underwater noise modelling assessment also assumed that animals swim directly away from the sound source at constant and conservative average speeds based on published values. Whilst this buffers the uncertainty with respect to the directionality of their movement, it may lead to overestimates of the potential range of effect as animals are likely to exceed these speeds. For example, Otani *et al*. (2000) reported horizontal speed for harbour porpoise can be significantly faster than vertical speed and cite a maximum speed of 4.3 m/s (compared to 1.5 m/s used in the underwater noise model). Similarly, McGarry *et al*. (2017) reported minke whale speeds of up to 4.2 m/s during acoustic deterrent exposure experiments on free-ranging animals, compared to swim speed of 2.3 m/s used in the underwater noise model.

120. The underwater noise model accounts for the SEL_{cum} metric as an equal-energy rule, where exposures of equal-energy are assumed to produce the same sound-induced threshold shift regardless of how the energy is distributed over time. Since for intermittent sound (such as piling) the quiet periods between sound exposures will allow some recovery of hearing compared to continuous sound, the equal-energy rule is likely to overestimate the extent of impact. Additionally, modelling of concurrent piling assumed piling will occur at exactly the same time and strike piles simultaneously, whereas in reality this is highly unlikely and could lead to overestimates in the injury and/or disturbance ranges.

121. The impulsive sound is likely to undergo transition into non-impulsive sound at distance from the sound source due to a combination of factors (e.g. dispersion of the waveform, multiple reflections from sea surface and seafloor, and molecular absorption of high frequency energy). The empirical evidence suggest that such shifts in impulsivity could occur within 10 km from the sound source (Hastie *et al*., 2019). However, since the precise range at which this transition occurs is unknown, the underwater noise model adopted the impulsive thresholds at all ranges. This is likely to lead to an overly precautionary estimate of injury ranges at larger distances (tens of kilometres) from the noise source.

10.11.2. ASSESSMENT OF EFFECTS

INJURY AND DISTURBANCE FROM UNDERWATER NOISE GENERATED DURING PILING

Summary of piling scenarios

122. Piling during the construction phase of the Array has the potential to result in higher levels of underwater sound when compared to background levels and could result in auditory injury and/or potential behavioural effects on marine mammal receptors. A detailed underwater noise modelling assessment was carried out to investigate the potential for such effects to occur, using the latest assessment criteria as presented in paragraph 96 (and discussed in detail in volume 3, appendix 10.1).

123. As first recommended by stakeholders during the pre-Scoping workshop (see Table 10.10), only the SPL_{pk} is used to inform the appropriate mitigation zone. However, both metrics (SPL_{pk} and SEL_{cum}) are presented in the impact assessment of PTS for the Array. More recent advice from NatureScot (see Table 10.10) advised that pre-piling mitigation should be based on SPL_{pk} but the assessment of effects itself should use the dual metric approach (SPL_{pk} and SEL_{cum}). Therefore, the assessment of effects is based upon the dual metric approach following the latest advice from NatureScot.

124. The measures adopted to mitigate impacts within this mitigation zone, defined by SPL_{pk}, are detailed in the outline MMMP (volume 4, appendix 22). During piling, with respect to the SPL_{pk} metric, the soft start initiation is the most relevant period, as this is when animals may potentially experience injury from underwater sound emitted by the initial strike of the hammer, after which point it is assumed that they will move away from the noise source. However, to ensure a precautionary approach, the injury ranges for SPL_{pk} are based on the sound from the maximum hammer energy over the entire installation (which is highly conservative, as discussed in paragraph 117).

125. The scenarios modelled were based on the maximum hammer energies (of 3,000 kJ or 4,400 kJ, see Table 10.17) for the longest possible duration, noting that piling is unlikely to reach and maintain the absolute maximum hammer energy at all locations. The assessment of potential effects on marine mammal receptors from piling considered a maximum spatial and maximum temporal scenario (Table 10.17).

126. Maximum spatial scenarios assume concurrent piling of piles at OSPs and wind turbine (anchors), leading to the largest area of effect at any one time. Maximum temporal scenarios, leading to the greatest number of days of piling, is based on single piling of piles at wind turbines (anchors) and OSPs (jackets).

127. Underwater sound modelling modelled concurrent piling at:

- wind turbines (anchors) with a maximum hammer energy of 3,000 kJ; and
- wind turbines (anchors) and OSP with a maximum hammer energy of 3,000 kJ and 4,400 kJ, respectively.

128. For the concurrent piling scenarios modelled, the following assumptions were identified:

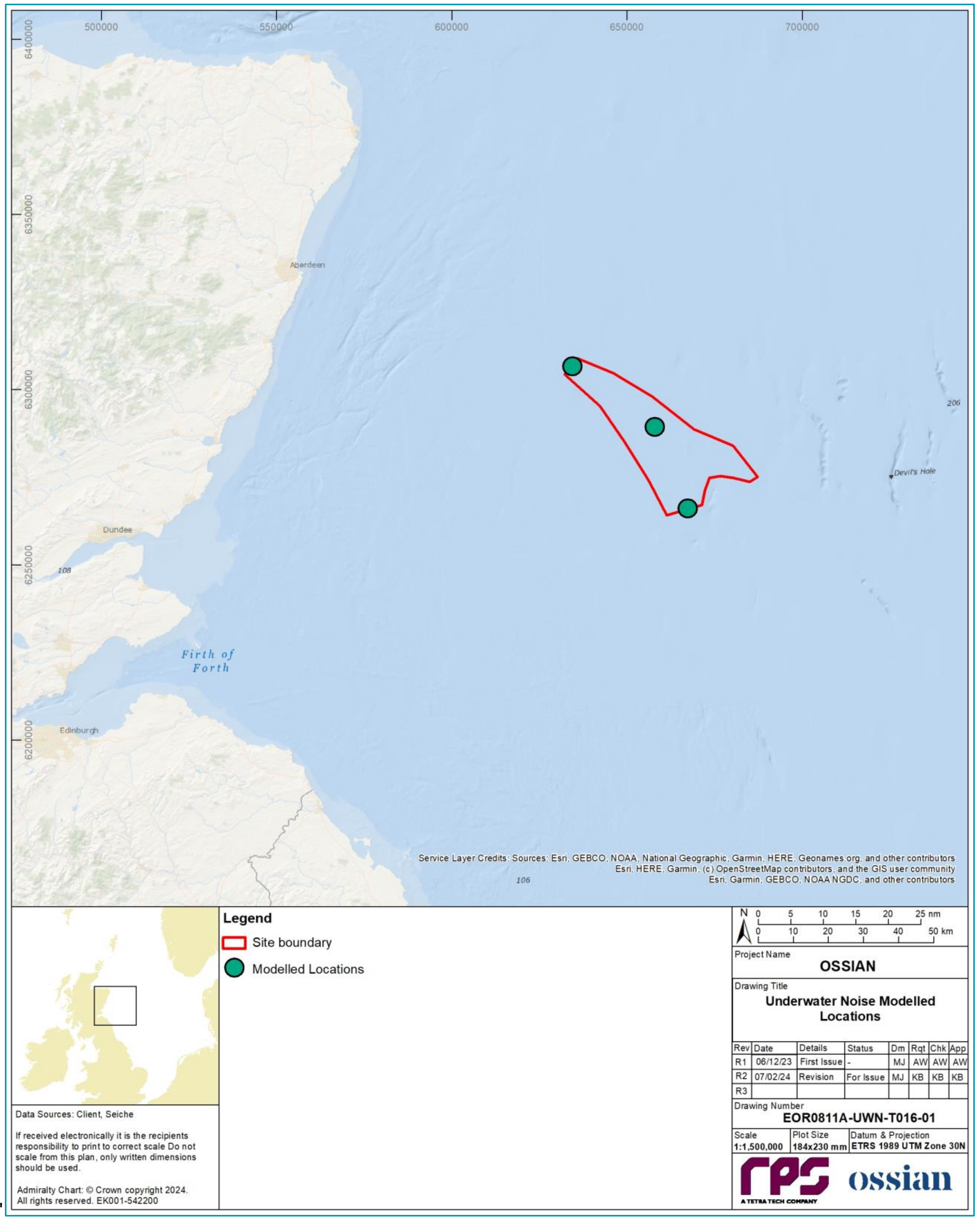
- minimum separation distance of 950 m between concurrent piling events as a MDS for potential injury; and

- maximum separation distance of up to 30 km as a MDS for potential disturbance based on the Project Description and site bathymetry (volume 1, chapter 3).

129. The modelled locations (Figure 10.6) were species-specific, e.g. those that were likely to generate noise contours with the highest potential to overlap with sensitive areas for a given species (e.g. density hotspots). The modelling locations were as follows (detailed in volume 3, appendix 10.1):

- a point at the northern end of the site boundary (closest point to land to capture potential overlap with the coastal distribution of bottlenose dolphins);
- the central point of the site boundary (to capture potential overlap with the coastal distribution of bottlenose dolphins and potential effects on grey seal density hotspots within the Berwickshire and North Northumberland Coast SAC); and
- a point at the southern end of the site boundary (to assess potential effects on grey seal density hotspots within the Berwickshire and North Northumberland Coast SAC and the Southern North Sea SAC designated for harbour porpoise.

130. For the maximum temporal scenario, the assessment focussed on the longest duration of piling and the greatest number of days over which piling could occur. The longest duration of piling per pile for wind turbines (anchors) or OSPs (jackets) is eight hours per pile. Therefore, piling activities can take place over a maximum of 602 days (530 days at wind turbines and 72 days at OSPs) (Table 10.17). For a realistic scenario, the average number of piles that can be installed over 24 hours is more likely to be four for wind turbines and three for OSPs, and this would reduce the temporal scenario to 397.5 days.



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Project Name: OSSIAN

Drawing Title: Underwater Noise Modelled Locations

Rev	Date	Details	Status	Dm	Rqt	Chk	App
R1	06/12/23	First Issue	-	MJ	AW	AW	AW
R2	07/02/24	Revision	For Issue	MJ	KB	KB	KB
R3							

Drawing Number: EOR0811A-UWN-T016-01

Scale	Plot Size	Datum & Projection
1:1,500,000	184x230 mm	ETRS 1989 UTM Zone 30N

Data Sources: Client, Seiche

If received electronically it is the recipients responsibility to print to correct scale Do not scale from this plan, only written dimensions should be used.

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Figure 10.6: Locations Modelled Within the Ossian Array (Red Line)

Summary of interim population consequences of disturbance (iPCoD) modelling

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

132. There is limited understanding of how behavioural disturbance and auditory injury affect survival and reproduction in individual marine mammals and consequently how this translates into potential effects at the population-level. The iPCoD framework was developed by SMRU consulting and the University of St Andrews 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). The iPCoD framework applies simulated changes in vital rates to infer the number of animals that may be affected by disturbance as a means to iteratively project the size of the population. The expert elicitation process has not been undertaken for white-beaked dolphin (only five key species have been included), and as such the current version of iPCoD does not allow modelling of population trajectories for this species. Relevant MUs for modelling were informed by baseline characterisation in volume 3, appendix 10.3.

133. For bottlenose dolphin, the CES^2 MU was used as the relevant reference population. Given the importance of the Moray Firth SAC for bottlenose dolphin in this area, the sensitivity of this population and its known ranging behaviour further south towards St Andrews Bay and the Tay Estuary, and inshore in north-east English waters, it is important to capture the potential impact on this important coastal ecotype which may experience potential barrier effects. Whilst there is an abundance estimate for the Greater North Sea MU (2,022 animals (IAMMWG, 2023)) this large MU extends the entire length of the east coast of the UK and east to Scandinavia, so apportioning numbers of the offshore ecotype to the east coast of Scotland is not possible. It is also unlikely that the Array will create significant barrier effects for this offshore ecotype, given the extent of the MU along the east coast of Scotland. Therefore, the assessment has focussed on the impacts for bottlenose dolphin within the CES^2 MU and Moray Firth SAC.

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

135. The population estimates used to parameterise iPCoD models were taken from IAMMWG (2023) for cetacean species and from SCOS (2023) for grey seal (summarised in Table 10.26), alongside vital rates taken from Sinclair *et al.* (2020), presented in Table 10.27.

Table 10.26: Management Units and Population Estimates for Species Included in iPCoD Models

Species	Management Unit/Seal Management Unit	Population Estimate (Number of Animals)	Source
Harbour porpoise	North Sea MU	346,601	IAMMWG (2023)
Bottlenose dolphin	Coastal East Scotland MU	224	IAMMWG (2023)
Minke whale	Celtic and Greater North Sea MU	20,118	IAMMWG (2023)
Grey seal	East Scotland SMU plus North-east England SMU	36,696	SCOS (2023)

Table 10.27: Marine Mammal Vital Rates Used to Parameterise iPCoD Models (from Sinclair *et al.* (2020))

Species	Calf/Pup Survival	Juvenile Survival	Adult Survival	Fertility	Age of independence (years)	Age of First Birth (years)
Harbour porpoise	0.8455	0.85	0.925	0.34	1	5
Bottlenose dolphin	0.9250	1.00	1.000	0.24	3	9
Minke whale	0.7000	0.77	0.960	0.91	1	9
Grey seal	0.2220	0.94	0.940	0.84	1	6

136. The SPL_{pk} metric has been used to inform the appropriate mitigation range (see Table 10.10) although the dual metric approach is presented in underwater noise modelling and informs the impact assessment. Therefore, the number of animals that may experience PTS to be inputted into the iPCoD models were derived from calculations based upon the maximum numbers of animals experiencing PTS from modelling of SPL_{pk} or SEL_{cum}, so that the assessment of magnitude (which is based on the dual metric approach) aligns with modelling of population effects, even though SPL_{pk} will be used to define the mitigation zone.

137. Furthermore, calculation of the number of animals that may experience PTS assumed a 30 minute implementation of ADD, as per standard industry practice. The numbers of animals for injury taken forward to iPCoD modelling therefore was based upon those with implementation of 30 minute of ADD. This was agreed with NatureScot following Ossian Array Marine Mammal Consultation Note 2 (volume 3, appendix 5.1, annex E), which confirmed that the auditory injury assessment should be based on numbers of animals remaining following 30 minutes of ADD usage (Table 10.10).

138. Both the maximum temporal scenario (e.g. the single piling scenario with fewer animals impacted per day, but over more days) and the maximum spatial scenario (e.g. the concurrent piling scenario with more animals impacted per day, but for fewer days) were modelled.

139. Results of population modelling are presented in full in volume 3, appendix 10.3 the relevant magnitude sections for harbour porpoise, bottlenose dolphin, minke whale and grey seal: key species for which iPCoD functionality is currently available.

Construction phase

Magnitude of impact

Auditory injury (PTS)

140. The summary of potential PTS ranges (for both SPL$_{pk}$ and SEL$_{cum}$) (without use of an ADD) for single pile installation is presented in Table 10.28, and for concurrent piling is presented in Table 10.29.

141. The maximum spatial effect was predicted for concurrent piling at wind turbines and OSPs with a hammer energy of 3,000 kJ and 4,400 kJ, respectively (Table 10.29). Whilst the effect of PTS is considered to result in permanent injury to animals, the risk of animals being exposed to sound levels leading to auditory injury would occur during piling only. As shown in Table 10.17, piling will be intermittent over an eight-year construction piling phase and will occur up to a maximum of 602 days.

142. The instantaneous injury (based on SPL$_{pk}$ metric) could occur out to a maximum range of 1,600 m across all species during single pile installation at OSPs, with the maximum range predicted for harbour porpoise (Table 10.28). Considering cumulative exposure using the SEL$_{cum}$ metric, the risk of PTS was estimated to occur out to a maximum range of 7,200 m and was predicted for minke whale during single pile installation at OSPs (Table 10.28).

143. The maximum spatial effect was estimated using two different concurrent piling scenarios, at wind turbines with a hammer energy of 3,000 kJ with either a wind turbine with a hammer energy of 3,000 kJ or an OSP with hammer energy of 4,400 kJ, respectively (Table 10.29). Given that the potential injury range for the concurrent scenarios based on the SPL$_{pk}$ metric would remain the same as the injury ranges for the single installation scenario (as detailed in volume 3, appendix 10.1) (Table 10.28), these were omitted from the results presented in Table 10.29. Considering cumulative exposure using the SEL$_{cum}$ metric, the risk of PTS was estimated to occur out to a maximum range of 9,740 m and was predicted for minke whale during concurrent pile installation at wind turbine and OSP (Table 10.29).

144. Designed-in mitigation in the form of an outline MMMP (volume 4, appendix 22) will be implemented to reduce the likelihood of PTS. Such mitigation will include deployment of an ADD as recommended in the guidelines (JNCC, 2010a). Pre-scoping advice from NatureScot (see Table 10.10) was to consider ranges predicted using the SPL$_{pk}$ metric only with respect to application of the JNCC (2010) guidance on defining a mitigation zone. The conclusions of significance in the impact assessment with respect to PTS, however, required consideration of both SPL$_{pk}$ and SEL$_{cum}$ ranges as clarified by NatureScot in a subsequent advice note (volume 3, appendix 5.1, annex E). Subsequently, the efficacy of ADD specifically as a mitigation tool was explored with respect to both metrics by applying a 30 minute deployment time prior to hammer initiation (see paragraph 137). The exact duration of ADD activation will, however, be discussed and agreed with consultees as part of the outline MMMP to be submitted post-consent and in respect of any refinements in the Project Description that may be available at a later stage and included within the outline MMMP (volume 1, chapter 3; volume 4, appendix 22).

145. The assessment of magnitude with respect to auditory injury is presented below (paragraph 152 *et seq.*) on a species-specific basis, where the MDS is identified for each species. Humpback whale is considered qualitatively in the same section as minke whale given that both species fall within the low frequency hearing group (Southall *et al.*, 2019).

Table 10.28: Summary of Potential PTS Ranges for Single Pile Installation at Wind Turbines (3,000 kJ) and OSPs (4,400 kJ) Using Both Metrics – SPL$_{pk}$ and SEL$_{cum}$ (N/E = Threshold Not Exceeded)

Species (Hearing Group)	Metric	Threshold for Onset of PTS	Potential PTS Onset Range (m)	
			3,000 kJ (Wind Turbines)	4,400 kJ (OSPs)
Harbour porpoise (VHF)	SPL$_{pk}$	202 dB re 1 µPa (pk)	665	1,600
	SEL$_{cum}$	155 dB re 1 µPa^{2}s	10	70
Bottlenose dolphin, white-beaked dolphin (HF)	SPL$_{pk}$	230 dB re 1 µPa	95	171
	SEL$_{cum}$	185 dB re 1 µPa^{2}s	N/E	N/E
Minke whale, humpback whale (LF)	SPL$_{pk}$	219 dB re 1 µPa	180	353
	SEL$_{cum}$	183 dB re 1 µPa^{2}s	990	7,200
Grey seal (PCW)	SPL$_{pk}$	218 dB re 1 µPa	192	379
	SEL$_{cum}$	185 dB re 1 µPa^{2}s	N/E	N/E

Table 10.29: Summary of Potential PTS Ranges for Concurrent Pile Installation at Wind Turbines (3,000 kJ) and at Wind Turbines (3,000 kJ) and OSPs (4,400 kJ) Using SEL$_{cum}$ (N/E = Threshold Not Exceeded)

Species (Hearing Group)	Metric	Threshold	Potential PTS range (m)	
			3,000 kJ (Wind Turbines)	3,000 kJ (Wind Turbines) and 4,400 kJ (OSPs)
Harbour porpoise (VHF)	SEL$_{cum}$	155 dB re 1 µPa2s	11	203
Bottlenose dolphin, white-beaked dolphin (HF)	SEL$_{cum}$	185 dB re 1 µPa2s	N/E	N/E
Minke whale, humpback whale (LF)	SEL$_{cum}$	183 dB re 1 µPa2s	1,445	9,740
Grey seal (PCW)	SEL$_{cum}$	185 dB re 1 µPa2s	N/E	N/E

Given that the potential injury range for the concurrent scenarios based on the SPL$_{pk}$ metric remain the same as the injury ranges for the single installation (Table 10.28), these were omitted from the results presented in Table 10.29.

146. 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. It is considered to be more effective at reducing the potential for injury to marine mammals compared to actions informed by standard mitigation measures (MMOs[2] and PAM) which may have limitations with respect to effective detection over distance (Parsons *et al.*, 2009, Wright and Cosentino, 2015).

147. There are various ADDs available with different sound source characteristics (McGarry *et al.*, 2022) and a suitable device will be selected based on the key species requiring mitigation for the Array. 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 reducing the additional sound introduced into the marine environment as far as practicable.

148. Therefore, sound modelling was carried out to determine the efficacy of using ADDs to deter marine mammals from the injury zone for a duration of 30 minutes (see volume 3, appendix 10.1) for both the $\mathrm{SPL}_{\mathrm{pk}}$ and $\mathrm{SEL}_{\mathrm{cum}}$ metrics.

149. Using $\mathrm{SPL}_{\mathrm{pk}}$ metric (which has been used to define the mitigation zone), the maximum potential injury ranges were predicted for single pile installation at OSPs with a hammer energy of 4,400 kJ (Table 10.28). Please note that although humpback whale has not been considered quantitively in the assessment, mean swim speeds during control measurements (0.3 m/s) published by Sprogis *et al.* (2020) were used to assess whether it will be able to move away from the injury zone before the commencement of piling. Assuming conservative swim speeds listed in Table 10.30, it was demonstrated that activation of an ADD for 30 minutes would deter all animals beyond the maximum injury zones using the $\mathrm{SPL}_{\mathrm{pk}}$ metric.

Table 10.30: Summary of Maximum Potential PTS Ranges due to Single Pile Installation (at OSPs, Hammer Energy 4,400 kJ) Using $\mathrm{SPL}_{\mathrm{pk}}$ Metric, Indicating Whether the Individual Can Move Beyond the Injury Range During the 30 minutes of ADD Activation

Species (Hearing Group)	Metric	Threshold	Potential PTS Range (m)	Swim Speed (m/s)	Swim Distance (m)	Move Away Beyond the Maximum Injury Zone?
Harbour porpoise (VHF)	$\mathrm{SPL}_{\mathrm{pk}}$	202 dB re 1 μPa (pk)	1,600	1.5	2,700	Yes
Bottlenose dolphin, white-beaked dolphin (HF)	$\mathrm{SPL}_{\mathrm{pk}}$	230 dB re 1 μPa	171	1.52	2,736	Yes
Minke whale (LF)	$\mathrm{SPL}_{\mathrm{pk}}$	219 dB re 1 μPa	353	2.3	4,140	Yes
Humpback whale (LF)	$\mathrm{SPL}_{\mathrm{pk}}$	219 dB re 1 μPa	353	0.3	540	Yes
Grey seal (PCW)	$\mathrm{SPL}_{\mathrm{pk}}$	218 dB re 1 μPa	379	1.8	3,240	Yes

150. The maximum injury ranges using $\mathrm{SEL}_{\mathrm{cum}}$ metric were predicted for concurrent pile installation at wind turbine and OSP with hammer energies of 3,000 kJ and 4,400 kJ, respectively (Table 10.29). Activation of an ADD 30 minutes prior to commencement of piling reduced injury ranges to a level which does not exceed injury thresholds for all species except minke whale (Table 10.31). Based on the underwater noise modelling, there is a residual risk of injury for minke whale across the range of 5,610 m.

151. Initial stakeholder advice provided during the pre-Scoping Workshop (see Table 10.10), suggested to base the assessment of significance for PTS on $\mathrm{SPL}_{\mathrm{pk}}$ metric only as this aligns with the approach to defining the mitigation zone (see paragraph 123 above for further detail on assessment of injury from underwater noise from piling). However, in response to the Marine Mammal Consultation Note 2 (volume 3, appendix 5.1, annex E), NatureScot clarified that whilst the mitigation should based on the $\mathrm{SPL}_{\mathrm{pk}}$ metric, the assessment of significance should consider the dual metric approach (i.e. both $\mathrm{SPL}_{\mathrm{pk}}$ and $\mathrm{SEL}_{\mathrm{cum}}$). Therefore, the Applicant highlights that, whilst the risk of injury to all species can be fully mitigated based on the $\mathrm{SPL}_{\mathrm{pk}}$ metric, the deployment of an ADD does not fully remove the potential for injury to minke whale and humpback whale if considering the $\mathrm{SEL}_{\mathrm{cum}}$ metric. Given the very precautionary nature of modelled predictions using the $\mathrm{SEL}_{\mathrm{cum}}$ metric and the low probability of encountering either species (particularly humpback whale) in the zone of influence (due to low densities) the potential for injury is considered to be very low and therefore no additional mitigation is proposed. As part of the post-consent process, final details of mitigation will be discussed and agreed in consultation with stakeholders and will be fully informed by the final project design.

Table 10.31: Summary of Maximum Potential PTS Ranges due to Concurrent Pile Installation (at Wind Turbine and OSP, Hammer Energies of 3,000 kJ and 4,400 kJ) Using $\mathrm{SEL}_{\mathrm{cum}}$ Metric With and Without 30 Minutes of ADD Activation (N/E = Threshold Note Exceeded)

Species (Hearing Group)	Metric	Threshold	Potential Injury Ranges (m)	
			Without ADD	With 30 Min ADD
Harbour porpoise (VHF)	$\mathrm{SEL}_{\mathrm{cum}}$	155 dB re 1 μPa^{2}s	203	N/E
Bottlenose dolphin, white-beaked dolphin (HF)	$\mathrm{SEL}_{\mathrm{cum}}$	185 dB re 1 μPa^{2}s	N/E	N/E
Minke whale, humpback whale (LF)	$\mathrm{SEL}_{\mathrm{cum}}$	183 dB re 1 μPa^{2}s	9,740	**5,610**
Grey seal (PCW)	$\mathrm{SEL}_{\mathrm{cum}}$	185 dB re 1 μPa^{2}s	N/E	N/E

Harbour porpoise

152. Based on $\mathrm{SPL}_{\mathrm{pk}}$ metric, the maximum potential range for injury to harbour porpoise was estimated as 1,600 m during pile installation at OSPs (Table 10.28). Based on the density value of 0.651 animals per km^2, up to six animals would be at risk of experiencing PTS. However, with designed in measures applied (Table 10.22) which includes ADD, it is predicted that no animals would be affected by peak pressure ($\mathrm{SPL}_{\mathrm{pk}}$) as they would be able to flee the potential injury range (1,600 m) during the 30 minute period of ADD activation (Table 10.30). The maximum potential injury range for harbour porpoise is also not exceeded using the $\mathrm{SEL}_{\mathrm{cum}}$ metric, when including ADD (Table 10.31).

153. The injury range is predicted to be localised to within the Array marine mammal study area and therefore there is no potential for spatial overlap with the Southern North Sea SAC, the closest site designated for harbour porpoise, which is located south at a distance of 130.7 km (Table 10.15).

154. Harbour porpoise typically live between 12 and 24 years and give birth once a year (Lockyer, 2013). The duration of piling is up to 602 days, within an eight-year piling programme (see Table 10.17), and therefore could potentially overlap with a maximum of eight breeding cycles. It should be noted that piling at OSPs with the hammer energy of 4,400 kJ resulting in maximum injury range of 1,600 m would take place over only a fraction of the total piling days (72 days). The total duration (602 days) of the impact in the context of the life cycle of harbour porpoise is classified as long term, as animals will be at the risk of potential injury (albeit very small) over a notable proportion of their lifespan.

155. The impact (elevated underwater noise during piling) is predicted to be of local (small) spatial extent within the relevant geographic range of reference, medium-term duration, intermittent and the effect of PTS is

permanent. It is predicted that the impact will affect the receptor directly. Since injury is assumed to be fully mitigated via designed in measures (Table 10.22), there is considered to be no residual risk of injury and therefore no population-level effects. The magnitude is therefore considered to be negligible.

Bottlenose dolphin and white-beaked dolphin

156. Based on SPL_{pk} metric, the maximum range for injury to bottlenose dolphin and white-beaked dolphin was estimated as 171 m during pile installation at OSPs (Table 10.28). Based on the density values of 0.00303 and 0.120 animals per km^2 for bottlenose dolphin and white-beaked dolphin, respectively, no more than one animal of each species would be at risk of experiencing PTS. However, with designed in measures applied (Table 10.22), it is predicted that no animals would be affected by peak pressure (SPL_{pk}) as they would be able to flee the potential injury range (171 m) during the period of ADD activation (Table 10.30).

157. The injury range is predicted to be localised to within the Array marine mammal study area and therefore there is no potential for spatial overlap with the Moray Firth SAC, the closest site designated for bottlenose dolphin, which is located north west at a distance of 176.5 km (Table 10.15).

158. Bottlenose dolphin typically live between 20 and 30 years. The gestation period is 12 months with calves suckling for 18 to 24 months with females reproducing every three to six years (Mitcheson, 2008). 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), although the typical life expectancy of the white-beaked dolphin is largely unknown. The duration of piling is up to 602 days, within an eight-year piling programme (see Table 10.17), and therefore could potentially overlap with a maximum of three bottlenose dolphin and eight white-beaked dolphin breeding cycles. It should be noted that piling at OSPs with the hammer energy of 4,400 kJ resulting in maximum injury range of 171 m would take place over only a fraction of the total piling days (72 days). The total duration of the impact in the context of the life cycle of bottlenose dolphin and white-beaked dolphin is classified as long term, as animals will be at the risk of potential injury (albeit very small) over a notable proportion of their lifespan.

159. The impact (elevated underwater noise during piling) is predicted to be of local (small) spatial extent within the geographic range of reference, medium-term duration, intermittent and the effect of PTS is permanent. It is predicted that the impact will affect the receptor directly. Since injury is assumed to be fully mitigated via designed in measures (Table 10.22), there is considered to be no residual risk of injury and therefore no population-level effects. The magnitude is therefore considered to be negligible.

Minke whale and humpback whale

160. Based on SPL_{pk} metric (which defines the mitigation zone, as per consultation guidance), the maximum range for potential injury to minke whale and humpback whale was estimated as 353 m during pile installation at OSPs (Table 10.28). For minke whales, based on the density value of 0.0284 animals per km^2, no more than one animal would be at risk of experiencing PTS. However, with designed in measures applied (Table 10.22), it is predicted that no minke whales or humpback whales (see paragraph 149) would be affected by peak pressure (SPL_{pk}) as they would be able to flee the potential injury range (353 m) during the period of ADD activation (Table 10.30).

161. However, based on SEL_{cum} metric with the inclusion of 30 minutes ADD, the maximum range for injury to minke whale and humpback whale was estimated as 5,610 m during concurrent pile installation (Table 10.31). For minke whales, with designed in measures applied and based on the density value of 0.0284 animals per km^2, up to three animals would be at risk of experiencing PTS. However, as discussed in paragraph 116 and acknowledged by NatureScot in their response to Marine Mammal Consultation Note 2 (volume 3, appendix 5.1, annex E), there are caveats to using the SEL_{cum} metric given the layers of conservatism in the assessment which may lead to overestimates in injury ranges.

162. The injury range is predicted to be localised to within the Array marine mammal study area and therefore there is no potential for spatial overlap with the Southern Trench ncMPA, the closest site designated for protection of minke whale, which is located north-west at a distance of 66.9 km (Table 10.15).

163. Minke whale typically lives up to 60 years and females give birth to a calf every 12 to 14 months, with gestation period believed to last up to ten months (Sea Watch Foundation, 2012). Humpback whale calves are born in low latitudes after a gestation period lasting between 11 and 12 months (Mann *et al.*, 2000). Reliable data on life expectancy of humpback whales are lacking with the oldest individuals aged 48 recorded off western Australia (Mann *et al.*, 2000). Interbirth intervals among mature female humpback whales vary from a single year to several years (Mann *et al.*, 2000).

164. The duration of piling is up to 602 days, within an eight-year piling programme (see Table 10.17), and therefore could potentially overlap with a maximum of eight breeding cycles for both species. It should be noted that piling at OSPs with the hammer energy of 4,400 kJ resulting in maximum injury range of 171 m would take place over only a fraction of the total piling days (72 days). Additionally (as described in volume 1, chapter 3) there is anticipated to be limited piling activities carried out during winter months (due to inclement weather) over the eight year construction phase. Based on humpback whale sightings off eastern Scotland, although there are some records of individuals photographed in July and August, most of the sightings took place between December and March (Hague, 2023, O'Neil *et al.*, 2019, Scottish Humpback, 2023). Therefore, given that that humpback whale sightings on the east coast of Scotland are seasonal, the presence of humpback whales within the injury zones is highly unlikely for a notable proportion of the piling days.

165. The residual number of minke whales from SEL_{cum} predicted to experience PTS were carried forward to the iPCoD modelling assessment (see paragraph 183) alongside disturbance to understand the implications at a population-level, following advice from NatureScot in response to Marine Mammal Consultation Note 2 to input whichever metric results in the largest numbers of animals effected to the population model (Table 10.10; volume 3, appendix 5.1, annex E).

166. Overall, the total duration of the impact in the context of the life cycle of minke whale and humpback whale is classified as medium term, as animals will be at the risk of potential injury (albeit very small) over a notable proportion of their lifespan.

167. For minke whale and humpback whale, as discussed in paragraph 160, potential injury can be fully mitigated using the SPL_{pk} metric and therefore the magnitude would likely be negligible. However, given there is a small residual risk to minke whale using the SEL_{cum} metric, and noting this does not define the mitigation zone, the magnitude for minke whale and humpback whale has conservatively been assessed as low (rather than negligible).

168. For minke whale and humpback whale, the impact (elevated underwater noise during piling) is predicted to be of local (small) spatial extent within the relevant geographic range of reference, medium-term duration, intermittent and the effect of PTS is permanent. It is predicted that the impact will affect the receptor directly. Since injury is assumed to be fully mitigated via designed in measures (Table 10.28), there is considered to be a small residual risk of injury albeit no population-level effects. The magnitude is therefore considered to be low.

Grey seal

169. Based on SPL_{pk} metric, the maximum range for injury to grey seal was estimated as 379 m during pile installation at OSPs (Table 10.28). Based on the density value of 0.180 animals per km^2, no more than one animal of each species would be at risk of experiencing PTS. However, with designed in measures applied (Table 10.22), it is predicted that no animals would be affected by peak pressure (SPL_{pk}) as they would be able to flee the potential injury range (379 m) during the period of ADD activation (Table 10.30).

170. The injury range is predicted to be localised to within the Array marine mammal study area and therefore there is no potential for spatial overlap with the Berwickshire and North Northumberland Coast SAC, the

closest site considered in this assessment designated for grey seal, which is located south-west at a distance of 114 km (Table 10.15).

171. Grey seal typically live between 20 to 30 years with gestation lasting between ten to 11 months (SCOS, 2023). The duration of piling is up to 602 days, within an eight-year piling programme (see Table 10.17), and therefore could potentially overlap with a maximum of eight breeding cycles. It should be noted that piling at OSPs with the hammer energy of 4,400 kJ resulting in maximum injury range of 379 m would take place over only a fraction of the total piling days (72 days). The total duration of the impact in the context of the life cycle of grey seal is classified as medium term, as animals will be at the risk of potential injury (albeit very small) over notable proportion of their lifespan.

172. The impact (elevated underwater noise during piling) is predicted to be of local (small) spatial extent within the geographic frame of reference, medium-term duration, intermittent and the effect of PTS is permanent. It is predicted that the impact will affect the receptor directly. Since injury is assumed to be fully mitigated via designed in measures, there is considered to be no residual risk of injury and therefore no population-level effects. The magnitude is therefore considered to be negligible.

Behavioural disturbance

173. Disturbance during piling was predicted to have far-reaching potential impacts across the northern North Sea. It should be noted that the extent of the contours is likely to be an overestimate as it assumes that the sound from piling maintains its impulsive characteristics at large distances, which is considered unlikely to be the case. Since there is no agreed approach to modelling the cross-over point from impulsive to continuous sound and this is an ongoing active area of research (see volume 3, appendix 10.1 for more details), it was not possible to account for it in the underwater noise modelling for the Array. Applying associated impulsive sound thresholds for the whole contour range is likely to overestimate predicted impact distances and therefore leads to a potentially over-precautionary assessment. Considering this, as well as caveats highlighted by Southall *et al.* (2021) (see paragraph 108 *et seq.* for more details), quantitative assessment of disturbance based on SEL_{ss} metric should be interpreted with caution.

174. The application of the harbour porpoise dose-response curve (Figure 10.4) (in the absence of species-specific data for other cetacean species) represents a precautionary approach to assessment of HF and LF cetaceans, as other cetacean species are likely to be less sensitive than harbour porpoise to behavioural disturbance as noted in the literature (Tougaard, 2021). For minke whale, some limited evidence available from studies investigating the effects of sound from naval sonar devices, indicates that they are less sensitive than harbour porpoise by about 40 dB to 50 dB (Kvadsheim *et al.*, 2017, Sivle *et al.*, 2015). However, sound energy of piling is highest in the low frequency range and overlaps more with the hearing range of minke whale for example, than harbour porpoise.

175. Considering the caveats discussed below in paragraph 176, the estimated numbers of animals predicted to experience potential disturbance as a result of different piling scenarios are presented in Table 10.32. To provide additional context and allow an area-based assessment (for HRA purposes) the quantitative impact on marine mammal species has also been presented for relevant fixed thresholds (as described in paragraph 102 *et seq.*).

176. 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).

177. For harbour porpoise, white-beaked dolphin and minke whale, a quantitative assessment of the number of animals predicted to experience disturbance was undertaken by multiplying the density values (Table 10.16) with the areas within each 5 dB isopleth for the piling location that would result in the highest number of animals potentially disturbed. This value was then corrected using the relevant proportional response from Graham *et al.* (2019) for the unweighted SEL_{ss} level (Figure 10.4).

178. For the bottlenose dolphin CES^2 MU population, given its coastal distribution, a piling location taken forward to the assessment was chosen based on the highest overlap of noise disturbance contours with CES^2 MU boundaries. The calculations of the number of animals predicted to experience disturbance were undertaken by multiplying the density values from Lacey *et al.* (2022) with the areas within each 5 dB isopleth that overlap with CES^2 MU boundaries and correcting the value using the relevant proportional response from Graham *et al.* (2019) for the unweighted SEL_{ss} level (Figure 10.4).

179. For grey seal the quantitative assessment was undertaken by overlaying the unweighted SEL_{ss} contours for the piling location that would result in the highest overlap with the density hotspots based on at-sea density maps produced by Carter *et al.* (2022). The number of animals in each 5 km x 5 km grid cell was summed for each isopleth and corrected using the proportional response as per Whyte *et al.* (2020) (Figure 10.5).

Table 10.32: Potential Number of Animals Predicted to be Disturbed Within Weighted SEL$_{ss}$ Sound Contours Based on Relevant Dose-Responses (Graham *et al.*, 2019, Whyte *et al.*, 2020) for the Array Piling Scenarios. Numbers in Bold Represent the Modelling Location Scenarios with the Highest Number of Animals Potentially Impacted

Species (Hearing Group)	Reference Population	Scenario	Hammer energy (kJ)	Number of Animals (Individuals)	% Reference Population
Harbour porpoise (VHF)	North Sea MU	Single	3,000 kJ	3,856	1.11
		Single	4,400 kJ	7,309	2.11
		Concurrent	3,000 kJ + 3,000 kJ	5,950	1.72
		Concurrent	3,000 kJ + 4,400 kJ	**8,309**	**2.4**
Bottlenose dolphin (HF)	Coastal East Scotland MU	Single	3,000 kJ	2	0.89
		Single	4,400 kJ	4	1.79
		Concurrent	3,000 kJ + 3,000 kJ	3	1.34
		Concurrent	3,000 kJ + 4,400 kJ	**5**	**2.23**
White-beaked dolphin (HF)	CGNS MU	Single	3,000 kJ	710	1.62
		Single	4,400 kJ	1,347	3.07
		Concurrent	3,000 kJ + 3,000 kJ	1,096	2.50
		Concurrent	3,000 kJ + 4,400 kJ	**1,531**	**3.48**
Minke whale (LF)	CGNS MU	Single	3,000 kJ	168	0.84
		Single	4,400 kJ	318	1.59
		Concurrent	3,000 kJ + 3,000 kJ	259 (1)[7]	1.29 (<0.01)
		Concurrent	3,000 kJ + 4,400 kJ	**362 (3)**	**1.80 (0.01)**
Grey seal (PCW)	East Scotland and North-east England SMUs	Single	3,000 kJ	131	0.36
		Single	4,400 kJ	343	0.94
		Concurrent	3,000 kJ + 3,000 kJ	231	0.63
		Concurrent	3,000 kJ + 4,400 kJ	**436**	**1.19**

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[7] Values in parentheses indicate numbers of animals, and corresponding percentage of reference population, predicted to experience PTS, based on underwater noise modelling of the SEL$_{cum}$ metric.

Harbour porpoise

180. Based on the most conservative scenario for concurrent piling of the wind turbine (3,000 kJ) in the centre and OSPs (4,400 kJ) at the northern limit of the site boundary, up to 8,309 harbour porpoises are predicted to experience potential disturbance (Table 10.32, Figure 10.9) (based upon maximum numbers derived from dose-response). This equates to 2.4% of the North Sea MU population. The estimated number of individuals potentially impacted is based on conservative densities and the assumption that the peak seasonal site-specific density of 0.651 animals per km^2 is uniformly distributed within all noise contours. Additionally, the underwater noise modelling assumed that the maximum hammer energies are reached and maintained at all piling locations (see volume 3, appendix 10.1 for more details).

181. The Southern North Sea SAC is the only site designated for protection of harbour porpoise within the regional marine mammal study area. The SAC is located approximately 130.7 km to the south-east of the Array marine mammal study area. Given the far-reaching extent of the outer noise contours, there is potential for overlap with the Southern North Sea SAC. Based on the dose-response curve presented in Graham *et al.* (2019), from 1% to 4% of animals are likely to respond within noise contours that overlap with this SAC (120 to 130 dB SEL_{ss}) which is also below the NMFS (2005) threshold for strong disturbance (=160 dB rms) (Figure 10.10). Moreover, there is a possibility that a small number of individuals from these SAC populations may be occasionally present within the mapped disturbance contours outside the site. Therefore, using the area-based approach (see paragraph 105) for the unweighted noise threshold of 143 dB re $1\mu Pa^2s$ disturbance contours were presented for the maximum design case concurrent piling at wind turbines (3,000 kJ) in the centre and OSPs (4,400 kJ) at the southern limit of the site boundary (i.e. the closest to the SAC) (Figure 10.10). This approach, which focuses on a threshold associated with the onset of avoidance behaviour, showed that the 143 dB contour does not extend to the Southern North Sea SAC and therefore animals are unlikely to experience significant disturbance within the SAC. Additionally, at these distances it is unlikely that noise contours would result in barrier effects restricting harbour porpoise from reaching key habitats within the SAC.

182. The different approaches described above suggest that close to the piling the disturbance response is likely to be measurable and the probability of such a response is high such that individuals could change their baseline behaviour or in some cases actively avoid disturbed areas. Moving further away from the piling source, behavioural responses are likely to decrease with some individuals (proportional to the distance from the source) tolerating the increase in elevated underwater sound (Figure 10.4). At ranges beyond the received level of 143 dB re 1 μPa^2s (SEL_{ss}) the disturbance is unlikely to be significant with less likelihood of active avoidance (Brandt *et al.*, 2018, NRW, 2023b).

183. Intermittent piling within an eight-year construction phase could coincide with key breeding periods of harbour porpoise and is considered to be notable in the context of the lifespan of this species (see paragraph 154). In line with the Marine Mammal Methodology Note 1 (Table 10.10; volume 3, appendix 5.1, annex B), 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. Detailed modelling is presented in volume 3, appendix 10.3.

184. Simulated harbour porpoise population trajectories for both the baseline (unimpacted) and the impacted populations (based on the North Sea (NS) MU) are presented in Figure 10.7 for the maximum temporal scenario and Figure 10.8 for the maximum spatial scenario. Results of iPCoD modelling of the maximum temporal scenario for harbour porpoise showed that the median ratio of the impacted population to the unimpacted population at six years was 0.9986 and at 25 years was 0.9985. For the maximum spatial scenario these ratios were 0.9995 at six years and 0.9994 at 25 years. For both scenarios, results indicate no significant difference between the population trajectories for an unimpacted population and the impacted population.

185. The impact (elevated underwater noise arising during piling) is predicted to be of regional spatial extent in the context of the geographic frame of reference, medium term duration, intermittent and the effect of behavioural disturbance is reversible (as receptors are expected to recover within hours/days). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

186. At 25 years after the start of piling, the simulated impacted population was estimated to be 1,878 animals smaller than the unimpacted population for the maximum temporal scenario, equating to 0.005% of the NS MU. For the maximum spatial scenario, there were estimated to be 1,302 fewer animals in the impacted versus unimpacted population, equating to 0.004% of the MU. Given these results, it is expected that there would be no potential long term effects on the NS MU harbour porpoise population resulting from elevated underwater noise arising during piling for the Array.

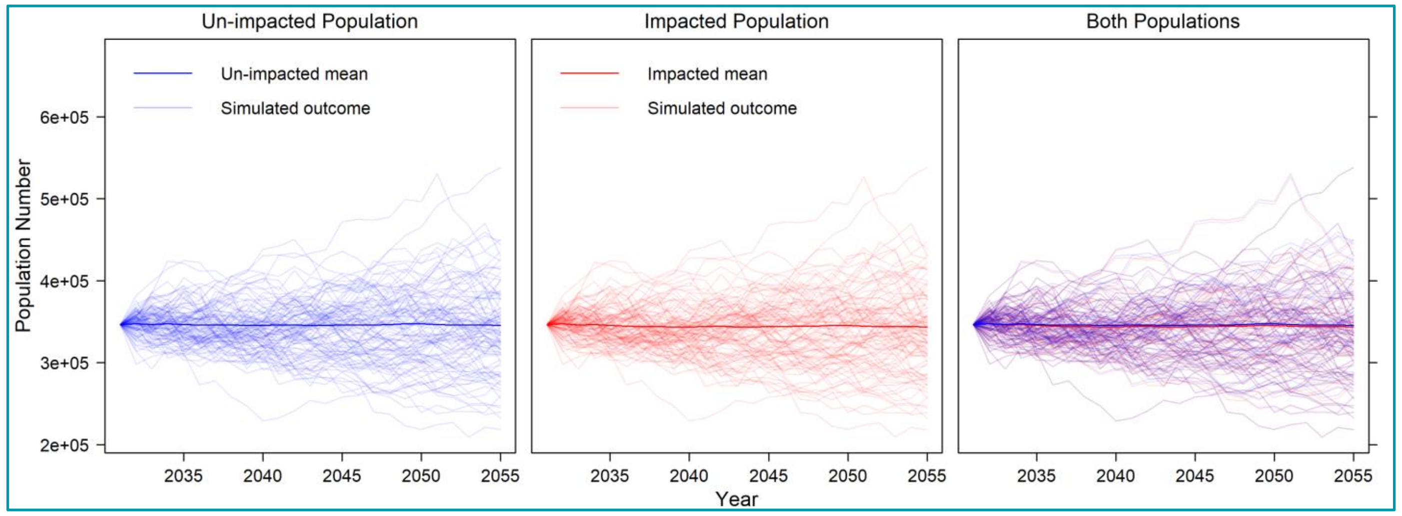

Figure 10.7: Simulated Harbour Porpoise Population Sizes for Both the Baseline (un-impacted) and the Impacted Populations Under the Maximum Temporal Scenario

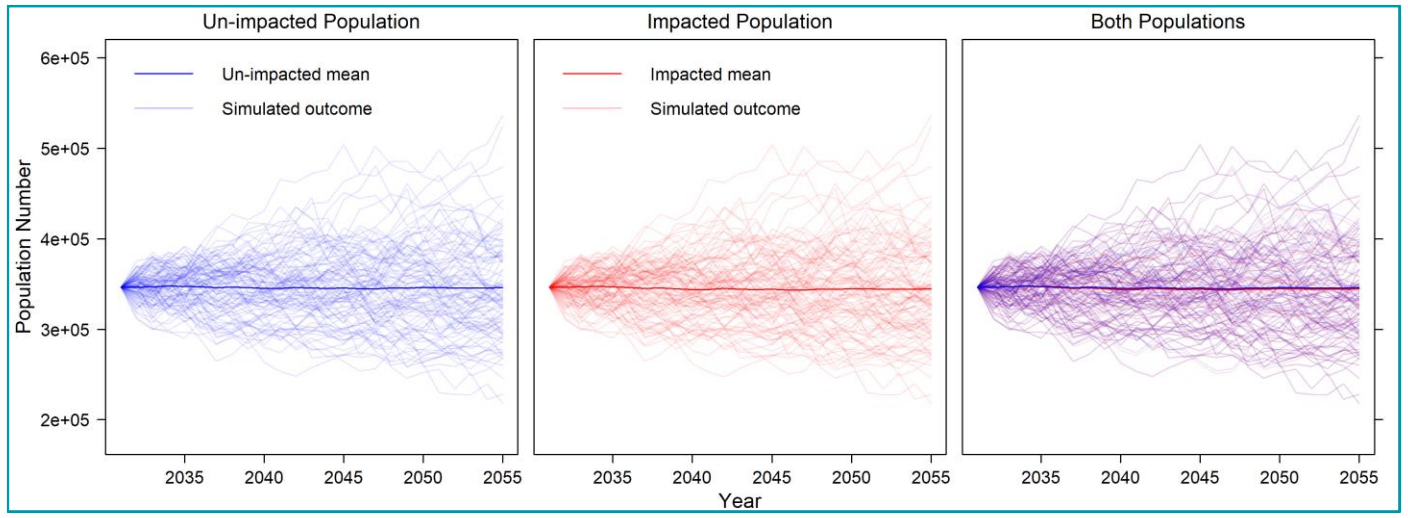

Figure 10.8: Simulated Harbour Porpoise Population Sizes for Both the Baseline (un-impacted) and the Impacted Populations Under the Maximum Spatial Scenario

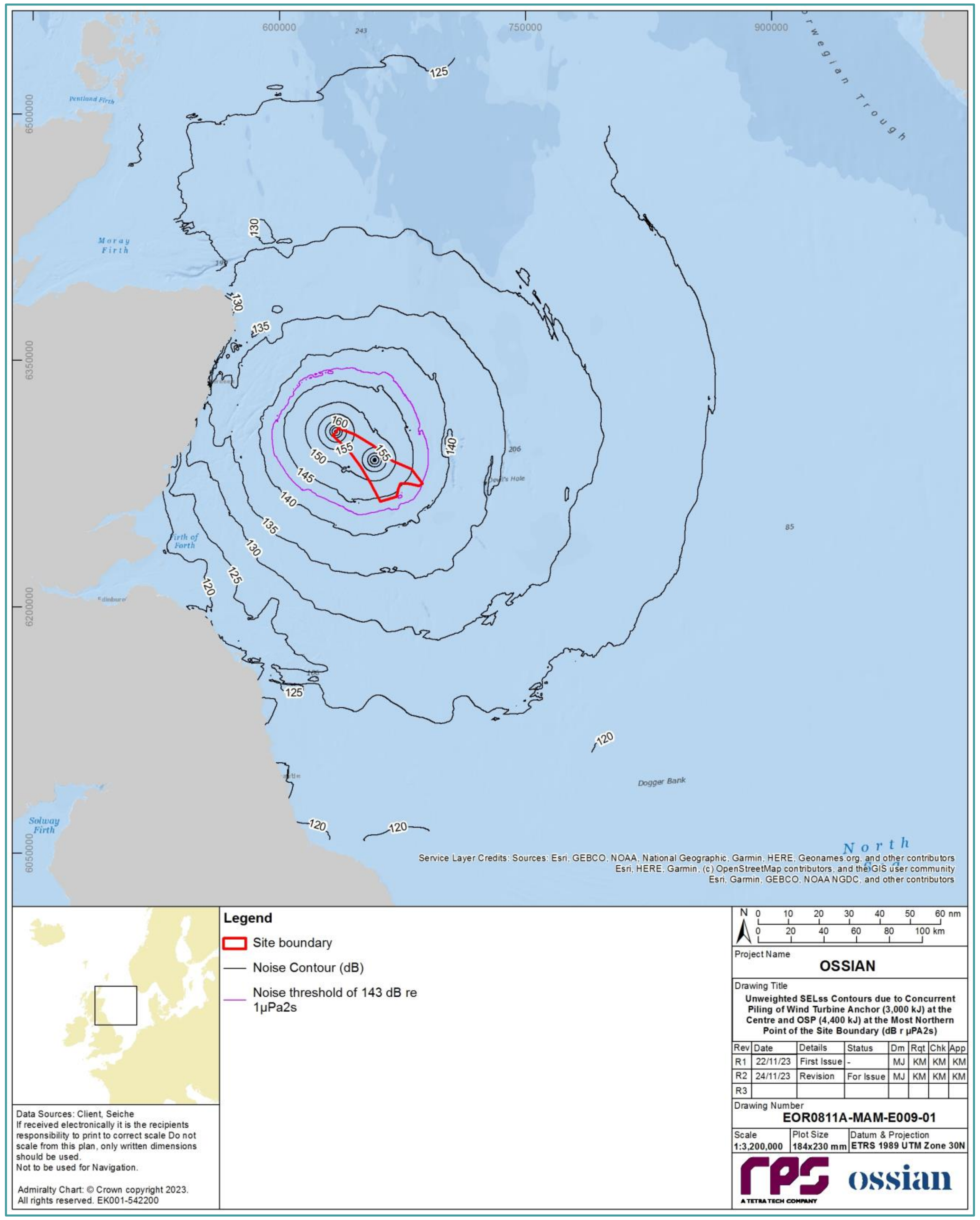

Figure 10.9: Unweighted SEL_{ss} Contours as a Result of Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Northern Limit of the Site Boundary

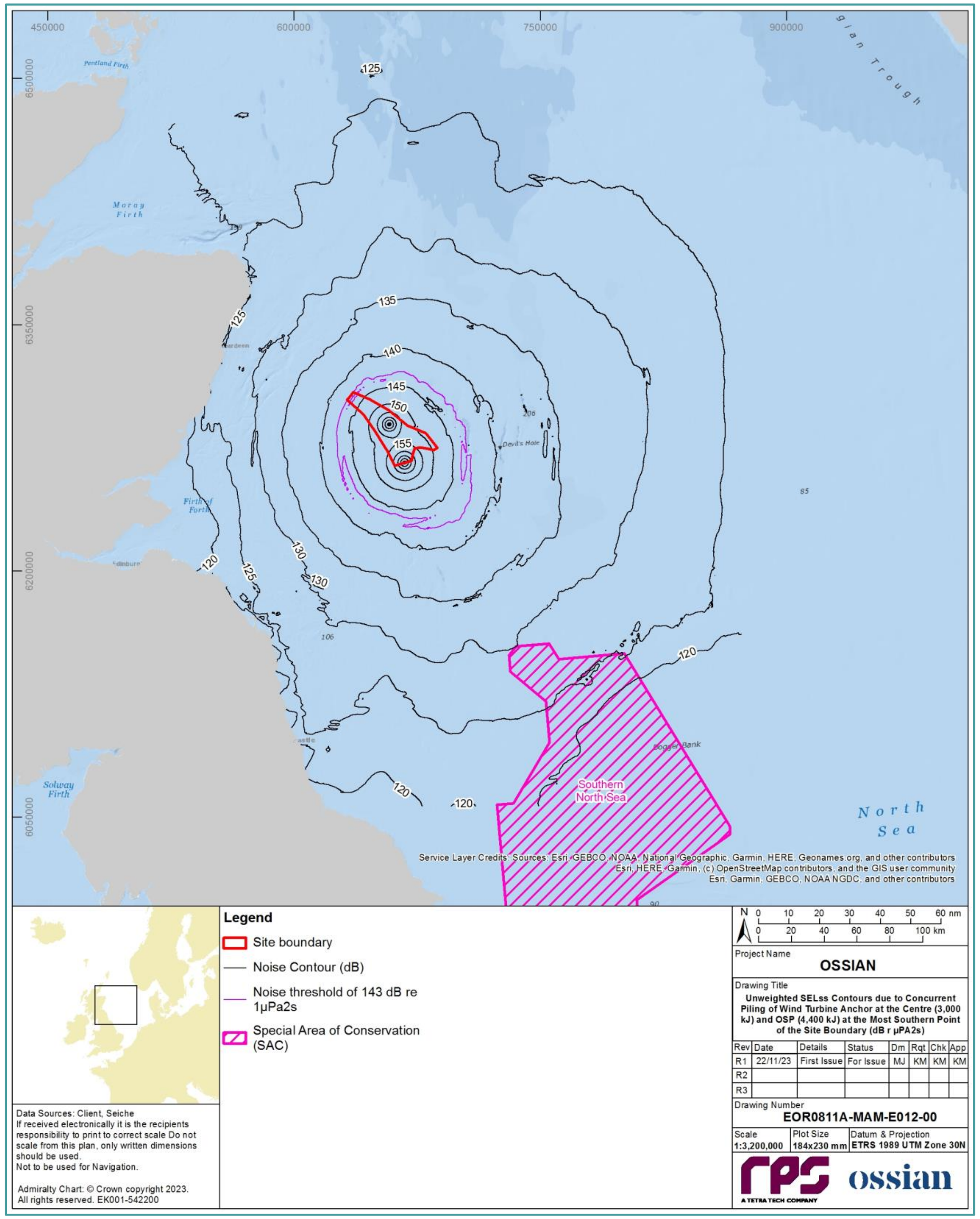

Figure 10.10: Unweighted SEL_{ss} Contours as a Result of Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Southern Limit of the Site Boundary and Southern North Sea SAC

Bottlenose dolphin

187. Based on the most conservative scenario for concurrent piling of the wind turbine (3,000 kJ) in the centre and OSPs (4,400 kJ) at the northern limit of the site boundary, up to five bottlenose dolphins are predicted to experience potential disturbance (Table 10.32, Figure 10.11). This equates to 2.23% of the CES^2 MU population.

188. The assessment assumed precautionarily that bottlenose dolphins from the CES^2 MU can be present within the whole extent of the MU (Figure 10.11), although it should be noted that empirical evidence from studies on this population suggest that they are mostly encountered 2 km to 5 km from the shore (Palmer *et al.*, 2019, Paxton *et al.*, 2016, Quick *et al.*, 2014, Thompson *et al.*, 2015b). Animals from the CES^2 MU are unlikely to be present in the offshore areas that may be exposed to high levels of noise from piling at the Array. However, bottlenose dolphins from the offshore populations may experience behavioural disturbance outside the CES^2 MU. Given that there is an estimate of 2,022 animals for the entire Greater North Sea MU, which extends across to Europe (IAMMWG, 2022) and no further information on offshore populations, the impact has not been quantified for behavioural disturbance during piling outside the CES^2 MU.

189. The CES^2 MU lies approximately 56 km from the site boundary and at this distance the received level from piling will have lost much of the impulsive characteristics (Figure 10.11). The outermost noise contours reach the coastal areas and therefore may overlap with the key inshore distribution of bottlenose dolphin in the CES^2 MU (Figure 10.11), potentially resulting in barrier effects, e.g. restricting animals from moving along the coast. Received sound levels within the CES^2 MU are predicted to reach maximum SEL_{ss} levels of 135 dB (Figure 10.11), which is below the NMFS (2005) threshold for strong disturbance (=160 dB rms) and therefore likely to elicit less severe disturbance reactions. However, the modelled noise contours that overlap with the CES^2 MU are above the threshold for mild disturbance (=140 dB rms). According to the behavioural response severity matrix suggested by Southall *et al.* (2021) such low level disturbance (scoring between 0 to 3 on a 0 to 9 scale) could lead to mild disruptions of normal behaviours, but prolonged or sustained behavioural effects, including displacement are unlikely to occur. Based on the dose-response presented in Graham *et al.* (2019) (Figure 10.4), from 1% to 10% of animals are likely to respond within noise contours (120 to 135 dB SEL_{ss}) that overlap with the CES^2 MU (Figure 10.11).

190. The Moray Firth SAC is the only site designated for protection of bottlenose dolphin within the regional marine mammal study area. The SAC located approximately 176.5 km north-west from the Array marine mammal study area. There is no potential for overlap of the noise contours with the SAC (Figure 10.11). However, as noted in paragraph 188, there is a possibility that a small number of individuals from this SAC population may be occasionally present within the mapped disturbance contours outside the site (though it is not possible to apportion numbers of animals disturbed to the Moray Firth SAC).

191. Intermittent piling within an eight-year construction phase could coincide with key breeding periods of bottlenose dolphin and is considered to be notable in the context of the lifespan of this species (see paragraph 158). In line with the Marine Mammal Methodology Note (Table 10.10; volume 3, appendix 5.1, annex B), 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.

192. Simulated bottlenose dolphin population trajectories for both the baseline (unimpacted) and the impacted populations (using the CES^2 MU) are presented in Figure 10.12 for the maximum temporal scenario, and Figure 10.13 for the maximum spatial scenario. Results of iPCoD modelling for the CES^2 MU bottlenose dolphin population indicated that the median ratio of the impacted population to the unimpacted population was 1.000 at six years and at 25 years, for both the maximum temporal scenario and the maximum spatial scenario. A ratio of 1 corresponds to no significant difference between the population trajectories for an unimpacted population and the impacted population. At 25 years after the start of piling, for the maximum temporal scenario the impacted population was predicted to be seven animals smaller than the unimpacted population, equating to 0.031% of the CES^2 MU. For the maximum spatial scenario, the impacted population was predicted to be four animals smaller than the unimpacted population, equating to 0.018% of the CES^2 MU. It is therefore considered that there would be no potential long term effects upon the coastal bottlenose dolphin population resulting from elevated underwater noise arising during piling.

193. The impact (elevated underwater noise arising during piling) is predicted to be of regional spatial extent in the context of the geographic frame of reference, medium term duration, intermittent and the effect of behavioural disturbance is reversible (as receptors are expected to recover within hours/days). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

White-beaked dolphin

194. Based on the most conservative scenario for concurrent piling of the wind turbine (3,000 kJ) in the centre and OSPs (4,400 kJ) at the northern limit of the site boundary, up to 1,531 white-beaked dolphins are predicted to experience potential disturbance (Table 10.32). This equates to 3.48% of the CGNS MU population. The estimated number of individuals potentially impacted is based on the assumption that the density of 0.120 animals per km^2 is uniformly distributed within all noise contours. Additionally, in the underwater noise modelling it was assumed that the maximum hammer energies are reached at all piling locations (see volume 3, appendix 10.1 for more details). Using the dose-response approach, up to 153 white-beaked dolphins are predicted to experience strong disturbance (160 dB rms), with up to 1,013 experiencing mild disturbance (140 dB rms).

195. There are no designated sites for white-beaked dolphin within the regional marine mammal study area (Table 10.16).

196. Intermittent piling within an eight-year construction phase could coincide with key breeding periods of white-beaked dolphin and is considered to be notable in the context of the lifespan of this species (see paragraph 158). Population modelling for iPCoD does not facilitate white-beaked dolphin, therefore no population modelling was carried out for this species.

197. The impact (elevated underwater noise arising during piling) is predicted to be of regional spatial extent in the context of the geographic frame of reference, medium term duration, intermittent and the effect of behavioural disturbance is reversible (as receptors are expected to recover within hours/days). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Minke whale and humpback whale

198. Based on the most conservative scenario for concurrent piling of the wind turbine (3,000 kJ) in the centre and OSPs (4,400 kJ) at the northern limit of the site boundary, up to 362 minke whale are predicted to experience potential disturbance (Table 10.32, Figure 10.9). This equates to 1.80% of the CGNS MU population. The estimated number of individuals potentially impacted is based on the assumption that the density of 0.0284 animals per km^2 is uniformly distributed within all noise contours. Additionally, in the underwater noise modelling it was assumed that the maximum hammer energies are reached and maintained at all piling locations (see volume 3, appendix 10.1 for more details).

199. Given that no species-specific densities are available for humpback whale, the numbers of animals potentially impacted could not be estimated. However, it can be anticipated that humpback whale may be at risk of experiencing strong disturbance within noise contours above 150 dB (SEL_{ss}).According to the behavioural response severity matrix suggested by Southall *et al.* (2021), beyond this range low level disturbance (scoring between 0 to 3 on a 0 to 9 scale) could lead to mild disruptions of normal behaviours, but prolonged or sustained behavioural effects, including displacement are unlikely to occur.

200. Intermittent piling within an eight-year construction phase could coincide with key breeding periods of minke whale and humpback whale and is considered to be notable in the context of the lifespan of this species. For minke whale, in line with the Marine Mammal Methodology Note (Table 10.10; volume 3, appendix 5.1, annex B), 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.

201. Simulated unimpacted and impacted population trajectories for the CGNS minke whale MU are presented in Figure 10.15 for the maximum temporal scenario and in Figure 10.16 for the maximum spatial scenario. Results of iPCoD modelling based on the SPL_{pk} metric (from which no animals were predicted to experience PTS) showed that the median ratio of the impacted population to the unimpacted population was 1.000 at six years and 25 years, for both the maximum temporal scenario and the maximum spatial scenario. This indicates that there would be no significant difference between population trajectories for an unimpacted population or for an impacted population.

202. At 25 years after piling, for both the maximum temporal scenario and the maximum spatial scenario, there was one less animal in the impacted population compared to the unimpacted population, equating to 0.00005% of the CGNS MU. Therefore, it is considered that there would be no potential long term effects on the minke whale population resulting from elevated underwater noise arising during piling.

203. Underwater noise modelling based upon the SEL_{cum} metric predicted that, under the maximum spatial scenario, up the three animals could experience PTS due to concurrent piling at wind turbine anchors and OSP foundations, with one animal predicted to experience PTS due to single piling at OSP foundations. For the maximum temporal scenario this was one animal only, due to single piling at OSP foundations. Simulated unimpacted and impacted population trajectories for the CGNS minke whale MU, with numbers of affected animals based upon the SEL_{cum} metric, are presented in Figure 10.17 for the maximum temporal scenario and in Figure 10.18 for the maximum spatial scenario.

204. Results of iPCoD modelling showed that for the maximum spatial scenario, based on the SEL_{cum} metric, the median ratio of the impacted population to the unimpacted population was 0.998 at six years and 0.992 at 25 years. For the maximum temporal scenario, based on the SEL_{cum} metric, the median ratio of the impacted population to the unimpacted population was 1.000 at six years and 0.998 at 25 years. The small deviation from a ratio of 1.000 for both scenarios, when based on the SEL_{cum} metric, indicates that there would be no significant difference between population trajectories for an unimpacted population or for an impacted population.

205. At 25 years after piling, for the maximum spatial scenario there was 173 fewer animals in the impacted population compared to the unimpacted population, equating to 0.86% of the CGNS MU. For the maximum temporal scenario this reduced to 55 fewer animals in the impacted population compared to the unimpacted population, equating to 0.27% of the CGNS MU. Therefore, it is considered that there would be no potential long term effects on the minke whale population resulting from elevated underwater noise arising during piling.

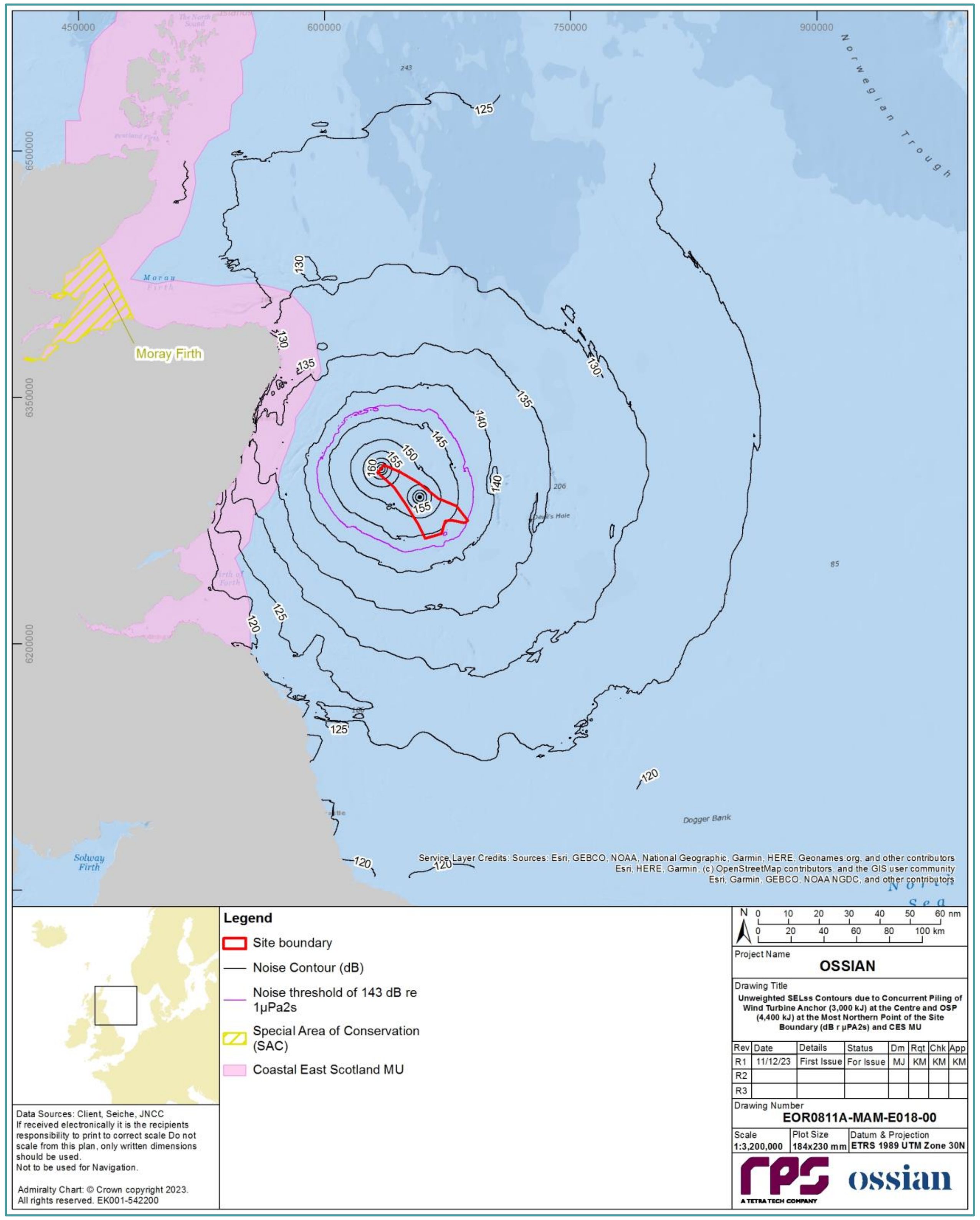

Figure 10.11: Unweighted SEL_{ss} Contours as a Result of Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Northern Limit of the Site Boundary, CES^2 MU and Moray Firth SAC

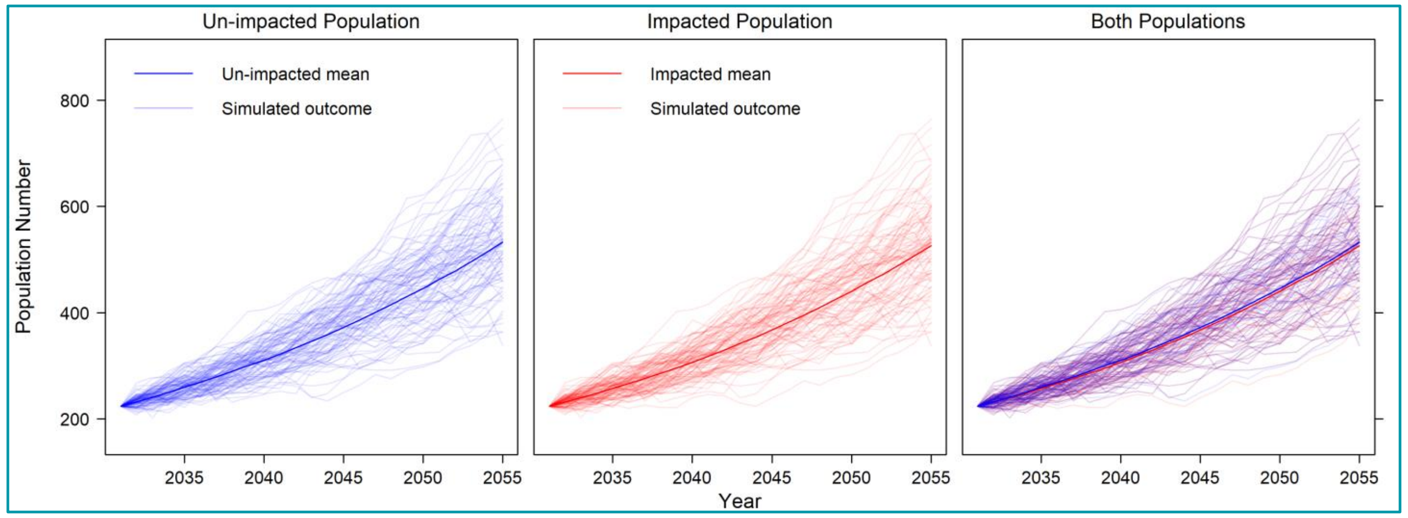

Figure 10.12: Simulated Bottlenose Dolphin Population Sizes for Both the Baseline (un-impacted) and the Impacted Populations Under the Maximum Temporal Scenario

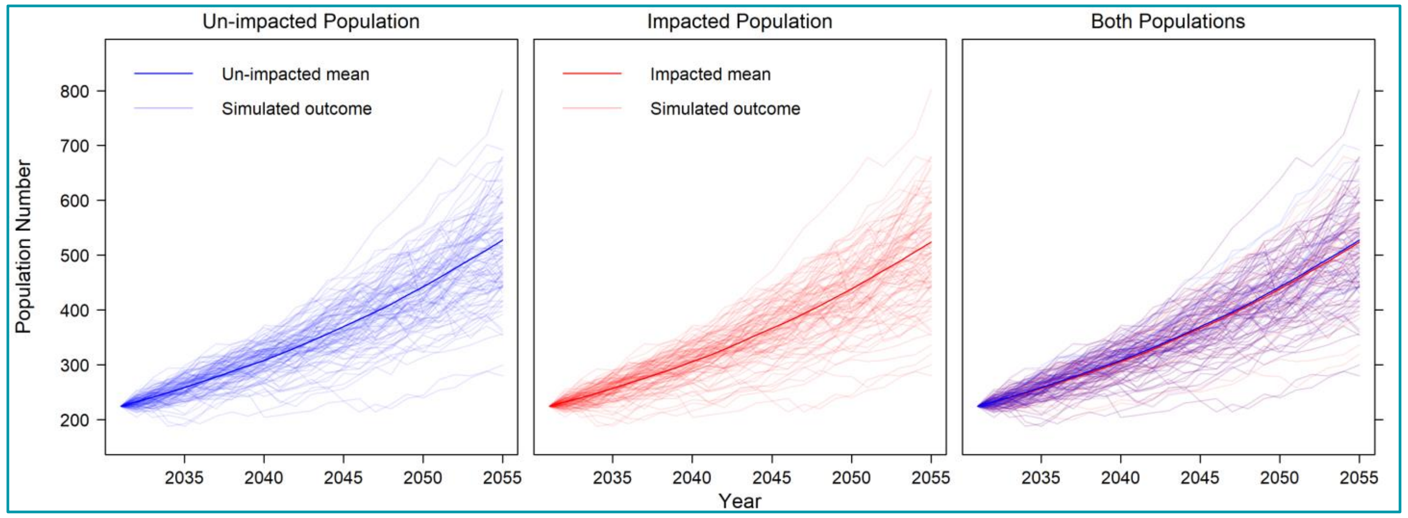

Figure 10.13: Simulated Bottlenose Dolphin Population Sizes for Both the Baseline (un-impacted) and the Impacted Populations Under the Maximum Spatial Scenario

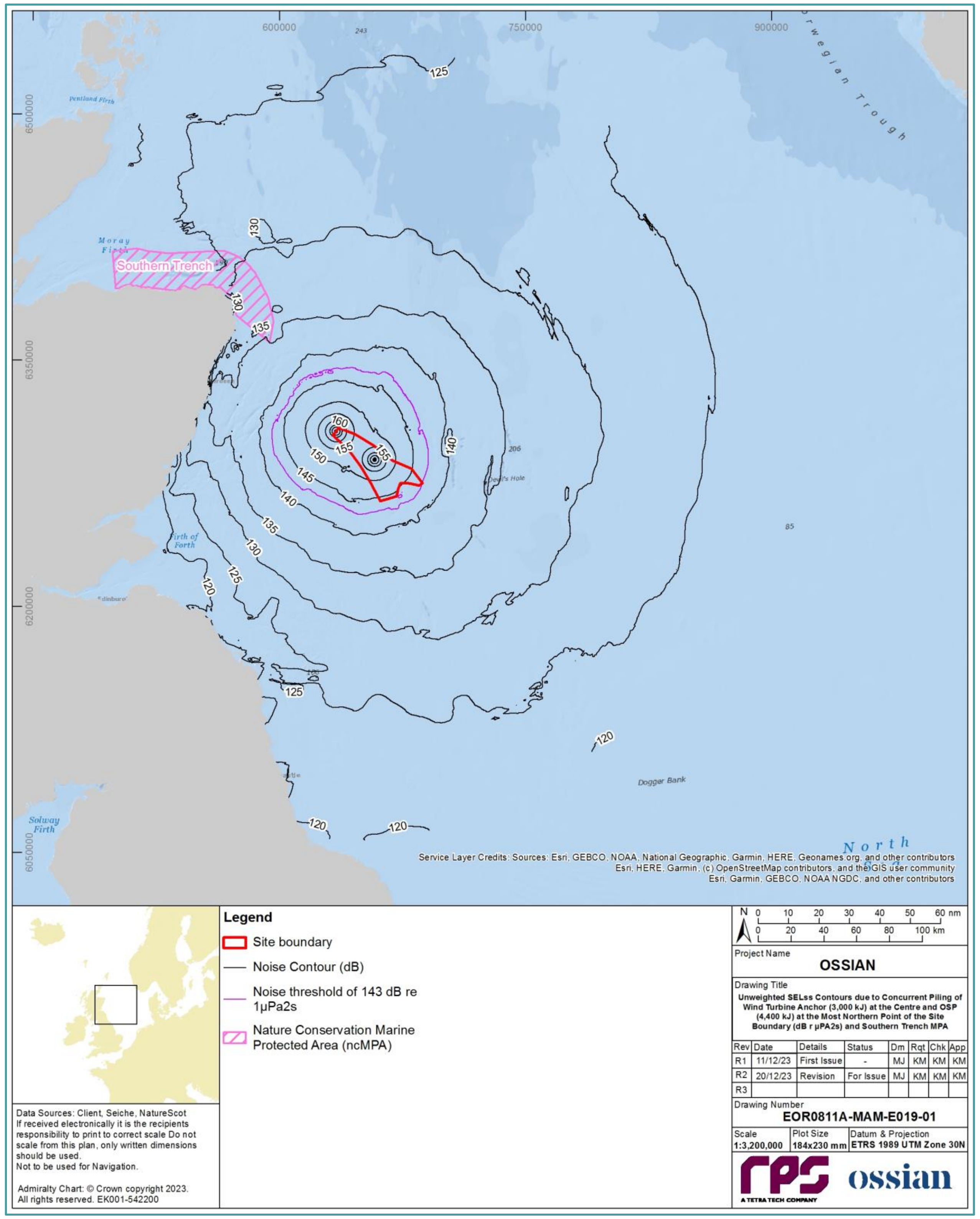

Figure 10.14: Unweighted SEL$_{ss}$ Contours as a Result of Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Northern Limit of the Site Boundary and the Southern Trench ncMPA

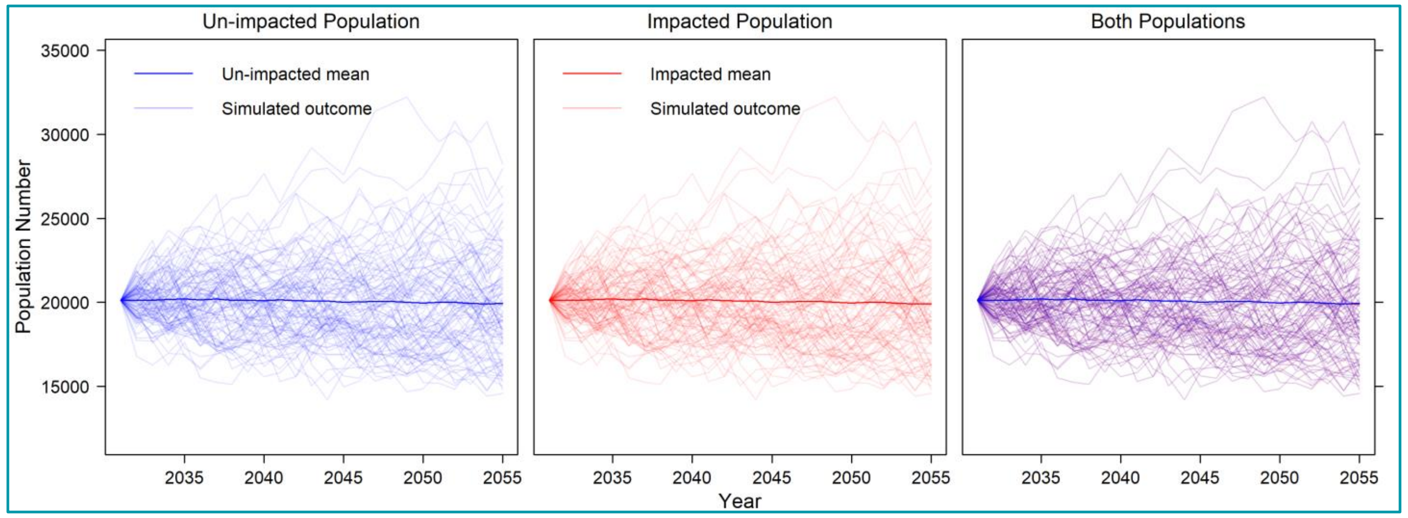

Figure 10.15: Simulated Minke Whale Population Sizes for Both the Baseline (un-impacted) and the Impacted Populations Under the Maximum Temporal Scenario, Based on the SPL$_{pk}$ Metric

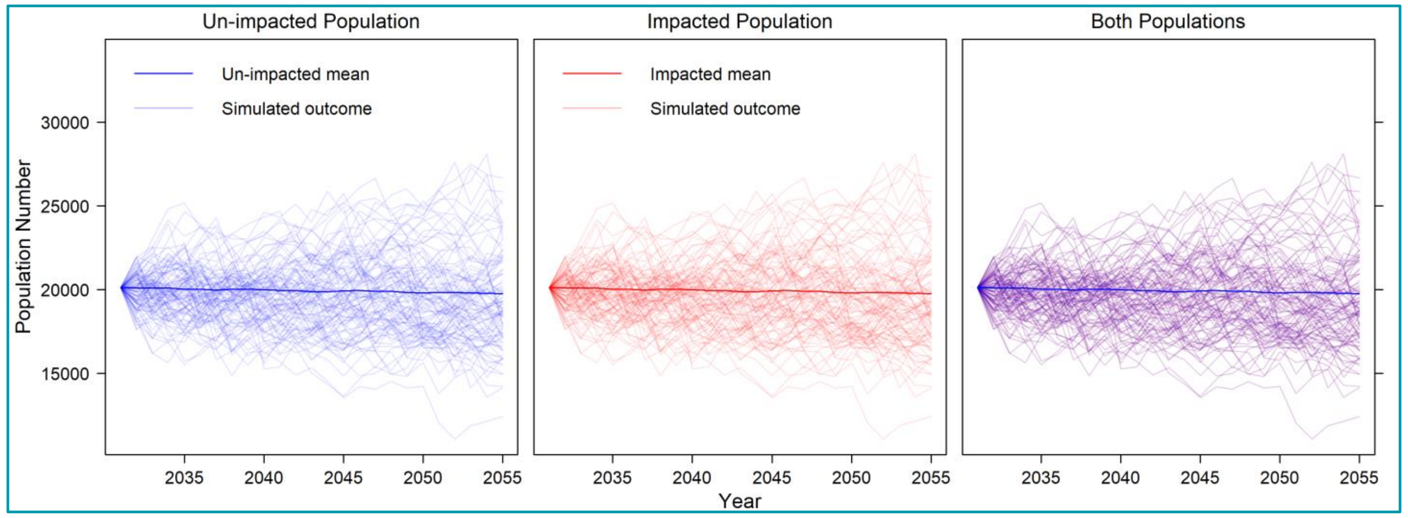

Figure 10.16: Simulated Minke Whale Population Sizes for Both the Baseline (un-impacted) and the Impacted Populations Under the Maximum Spatial Scenario, Based on the SPL$_{pk}$ Metric

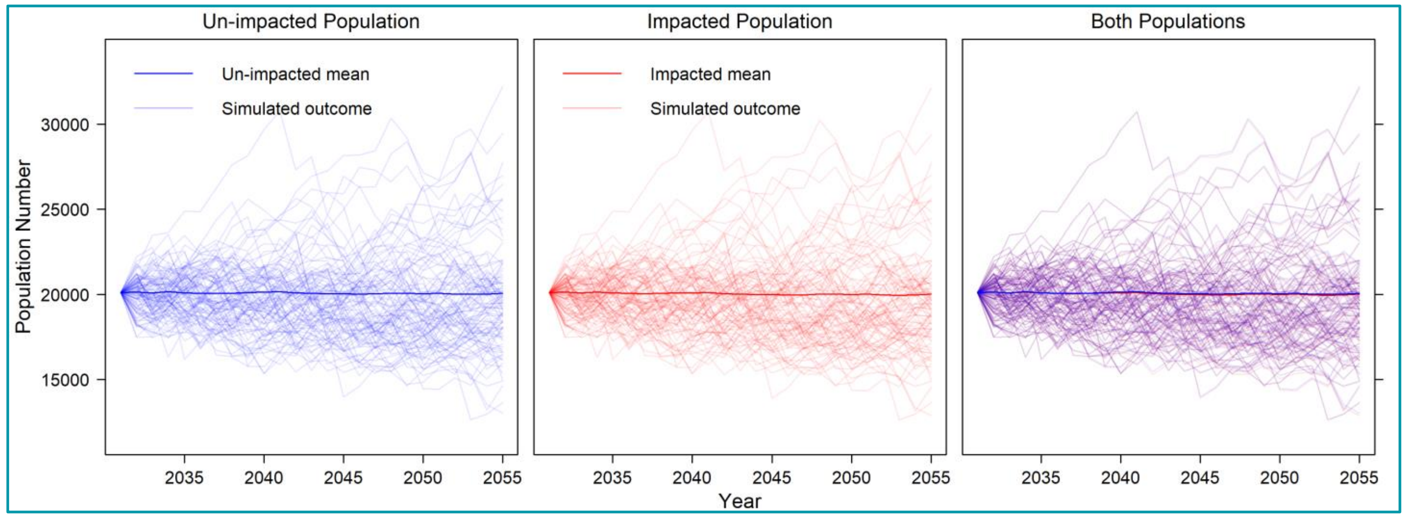

Figure 10.17: Simulated Minke Whale Population Sizes for Both the Baseline (un-impacted) and the Impacted Populations Under the Maximum Spatial Scenario, Based on the SEL$_{cum}$ Metric

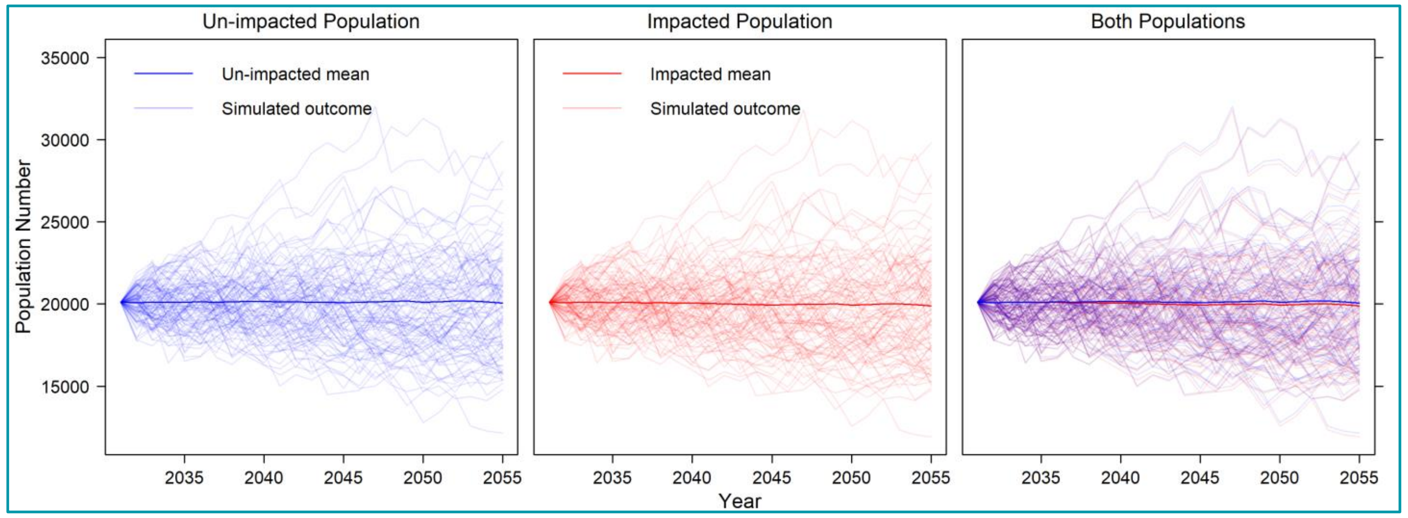

Figure 10.18: Simulated Minke Whale Population Sizes for Both the Baseline (un-impacted) and the Impacted Populations Under the Maximum Temporal Scenario, Based on the SEL$_{cum}$ Metric

206. As reported by Ryan *et al.* (2022), humpback whales in Scottish waters have been matched with both recovering (Guadeloupe) and non-recovering (Cape Verde) populations in the western North Atlantic. The photographs of humpback whale matched to Guadeloupe were made only around Shetland (Scottish Humpback, 2023). The photographs of individuals matched with records from Cape Verde as well as Arctic feeding grounds were taken from various locations in Aberdeenshire (including Aberdeen beach) and Fife (Kinghorn) (Scottish Humpback, 2023) on the eastern coast of Scotland. Leaper *et al.* (2022) suggested that adverse effects on humpback whales occurring in Scottish waters could potentially impact populations in Cape Verde and Wenzel *et al.* (2020) estimated the total number of individual whales that occurred in the Cape Verde between 2010 and 2018 as 272 animals. Sighting records suggest that humpback whale individuals are recorded off east Scotland in consecutive years and identified sighting records suggest that there is only one individual present at any given time (Scottish Humpback, 2023). However, a substantial

number of unidentified sightings is based on heavily cropped photos or the shape of the blow seen at distance and, therefore, it is not feasible to assess how many individuals were present off eastern Scotland in total over recent years. Although it has been suggested that the Firth of Forth may represent a migratory stopover, or a feeding or recovery opportunity (O’Neil *et al.*, 2019) for humpback whales, there is no evidence that the waters in the vicinity of the Array marine mammals study area represent an important feeding ground during their migration for a notable proportion of the population. Considering the above, alongside the seasonality of humpback whale encounters (see paragraph 163) as well as piling activities at the Array concentrated in periods of suitable weather (i.e. piling is less likely during winter due to inclement weather), it is unlikely that potential disturbance of humpback whales during piling could result in measurable long term population consequences.

207. The areas of importance off eastern Scotland were not yet specified for humpback whale. As such, potential for barrier effects is challenging to assess. However, considering that animals may be displaced from the areas only in the vicinity of the noise source during the duration of piling, it can be anticipated that individuals will temporarily shift their foraging efforts to other areas within the regional marine mammal study area.

208. The Southern Trench ncMPA is the only site designated for protection of minke whale within the regional marine mammal study area. The ncMPA is located approximately 66.9 km north of the Array marine mammal study area. Given the far-reaching extent of the noise contours, there is potential for overlap of the outer noise contours with the Southern Trench ncMPA. Received sound levels within the CES^2 MU are predicted to reach maximum SEL$_{ss}$ levels of 135 dB (Figure 10.14) and this is below the NMFS (2005) threshold for strong disturbance (=160 dB rms). However, the modelled noise contours that overlap with the CES^2 MU are above the threshold for mild disturbance (=140 dB rms). According to the behavioural response severity matrix suggested by Southall *et al.* (2021) such low level disturbance (scoring between 0 to 3 on a 0 to 9 scale) could lead to mild disruption of normal behaviours, but prolonged or sustained behavioural effects, including displacement are unlikely to occur. Based on minke whale densities within the ncMPA presented in NatureScot (2020), minke whales prefer the areas in the Outer Moray Firth along the northern Aberdeenshire coast, whilst the overlap of the noise contours with the MPA will be mostly along the eastern Aberdeenshire coast, where minke whale densities are expected to be low. It should also be noted, that as described in paragraph 173, the extent of the SEL$_{ss}$ contours is likely to be an overestimate as it assumes that the sound from piling maintains its impulsive characteristics at large distances, which is considered unlikely to be the case. As such, given the considerable distance to the Southern Trench ncMPA, the received level from piling is expected to have lost much of the impulsive characteristics and therefore the overlap shown in Figure 10.14 should be interpreted with caution.

209. For minke whale and humpback whale, the impact (elevated underwater noise arising during piling) is predicted to be of regional spatial extent in the context of the geographic frame of reference, medium term duration, intermittent and the effect of behavioural disturbance is reversible (as receptors are expected to recover within hours/days). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Grey seal

210. Based on the most conservative scenario for concurrent piling of the wind turbine (3,000 kJ) in the centre and OSPs (4,400 kJ) at the northern limit of the site boundary, up to 436 grey seals are predicted to experience potential disturbance (Table 10.32, Figure 10.17). This equates to 1.19% of the East Scotland MU plus North-east England seal MU population. The estimated number of individuals potentially impacted is based on overlap of noise contours with spatial at-sea density map provided by Carter *et al.* (2022) and the assumption that the maximum hammer energies are reached at all piling locations (see volume 3, appendix 10.1 for more details). Findings presented by Whyte *et al.* (2020) indicate that there will be no measurable response in seal species at sound levels below 145 dB re 1 µPa^2 SEL$_{ss}$ (Figure 10.5). As such, for all piling locations, the outermost noise contours will not reach the coastal areas where grey seal densities are the highest (). Due to relatively low grey seal densities in the offshore waters, barrier effects (i.e. the ability to move between key areas such as haul-out sites and foraging areas offshore) will be unlikely to affect a notable proportion of the population.

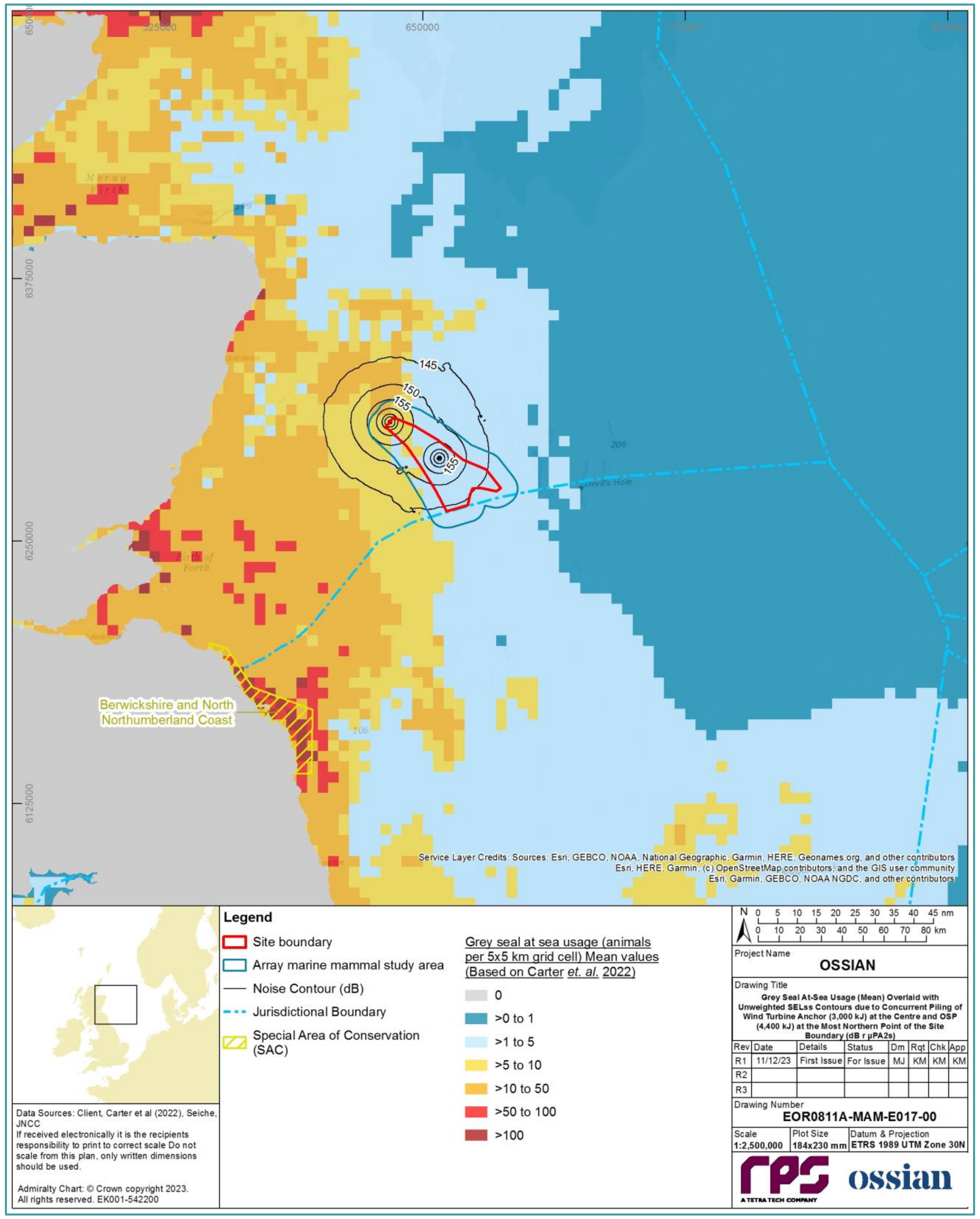

Figure 10.19: Unweighted SELss Contours as a Result of Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Northern Limit of the Site Boundary overlaid with Carter *et al*. (2022) At-sea Density Maps

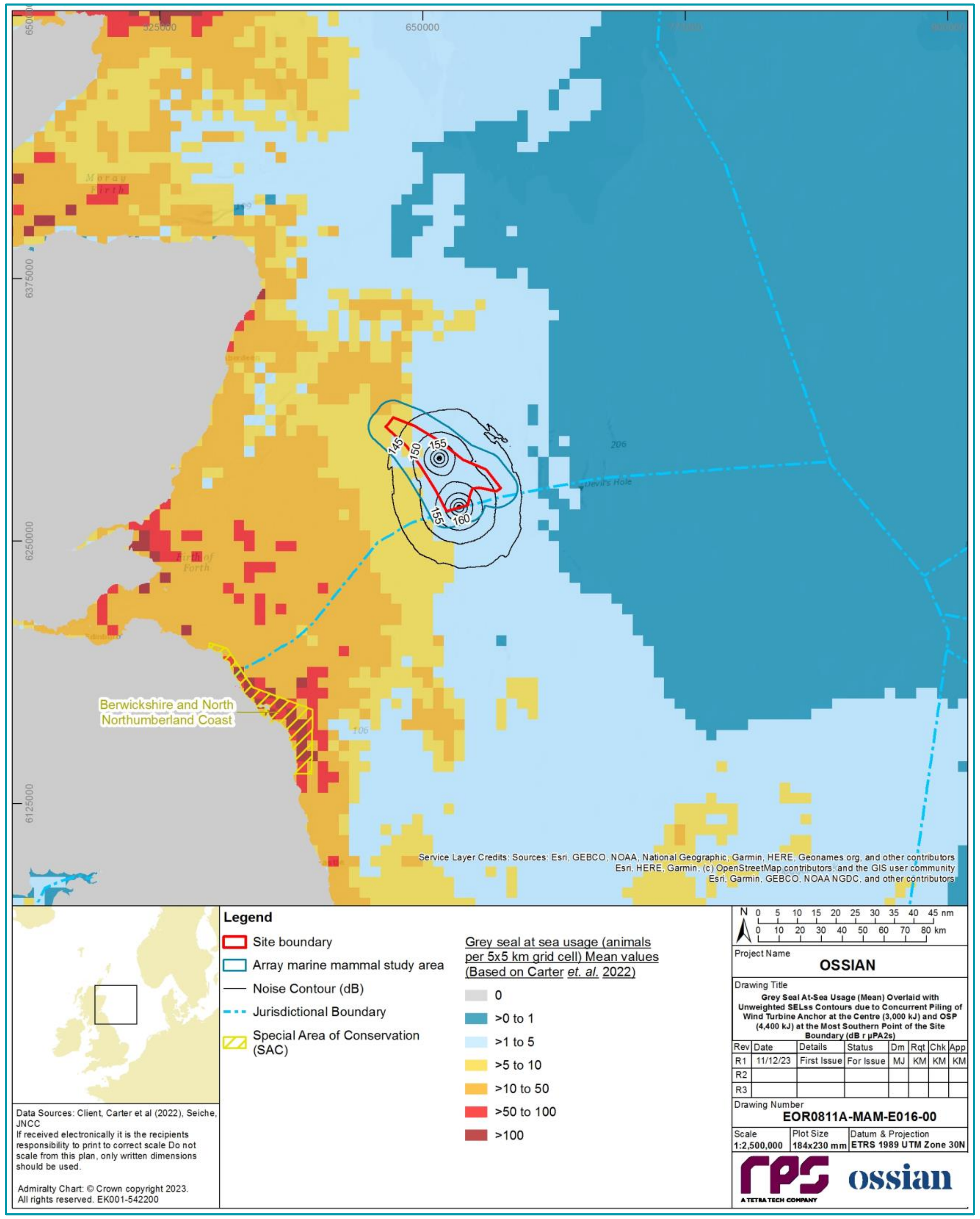

Figure 10.20: Unweighted SELss Contours as a Result of Concurrent Piling at Wind Turbine (3,000 kJ) at the Centre and OSP (4,400 kJ) at the Southern Limit of the Site Boundary Overlaid with Carter *et al.* (2022) At-sea Density Maps and Berwickshire and North Northumberland SAC

211. Following a comprehensive assessment of potential connectivity (see volume 3, appendix 10.2) and consideration of feedback received from stakeholders (Table 10.10), the Berwickshire and North Northumberland Coast SAC is the only site designated for protection of grey seal taken forward to the assessment in the EIA. The SAC located approximately 114 km south-west from the Array marine mammal study area. In line with findings presented in Whyte *et al.* (2020), noise contours within which there could be a measurable grey seal response will not overlap with the SAC (Figure 10.20).

212. Although there is a possibility that a small number of individuals from these SAC populations may be occasionally present within the mapped disturbance contours outside the site, grey seals usually forage within 20 km from the haul-out side during their breeding season and therefore it is unlikely that individuals will travel as far offshore (Figure 10.20). Given that the closest designated haul-out site is located approximately 157 km south-west from the Array marine mammal study area (Kinghorn Rocks, see volume 3, appendix 10.2 for more details), grey seals present within this site and in the vicinity of it are unlikely to be affected by behavioural disturbance during piling.

213. Intermittent piling within an eight-year construction phase could coincide with key breeding periods of grey seal and is considered to be notable in the context of the lifespan of this species (see paragraph 171). In line with the Marine Mammal Methodology Note (Table 10.10; volume 3, appendix 5.1, annex B), 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.

214. Simulated trajectories for both the unimpacted and the impacted grey seal populations (using the total population estimate for the East Scotland seal MU (10,783) and North-east England seal MU (25,913)) are presented in Figure 10.21 for the maximum temporal scenario and Figure 10.22 for the maximum spatial scenario. Results of iPCoD modelling for grey seal against the combined seal MU populations showed that the median ratio of the impacted population to the unimpacted population was 1.000 at six years and 25 years, for both the maximum temporal scenario and the maximum spatial scenario. This indicates that there would be no significant difference between the population trajectories for the unimpacted (baseline) population and the impacted population.

215. At 25 years after the start of piling there was no difference in the number of animals in the impacted population when compared to the unimpacted population, for both the maximum temporal and maximum spatial scenario. It is therefore considered that there would be no potential long term effects on the grey seal population resulting from elevated underwater noise arising during piling.

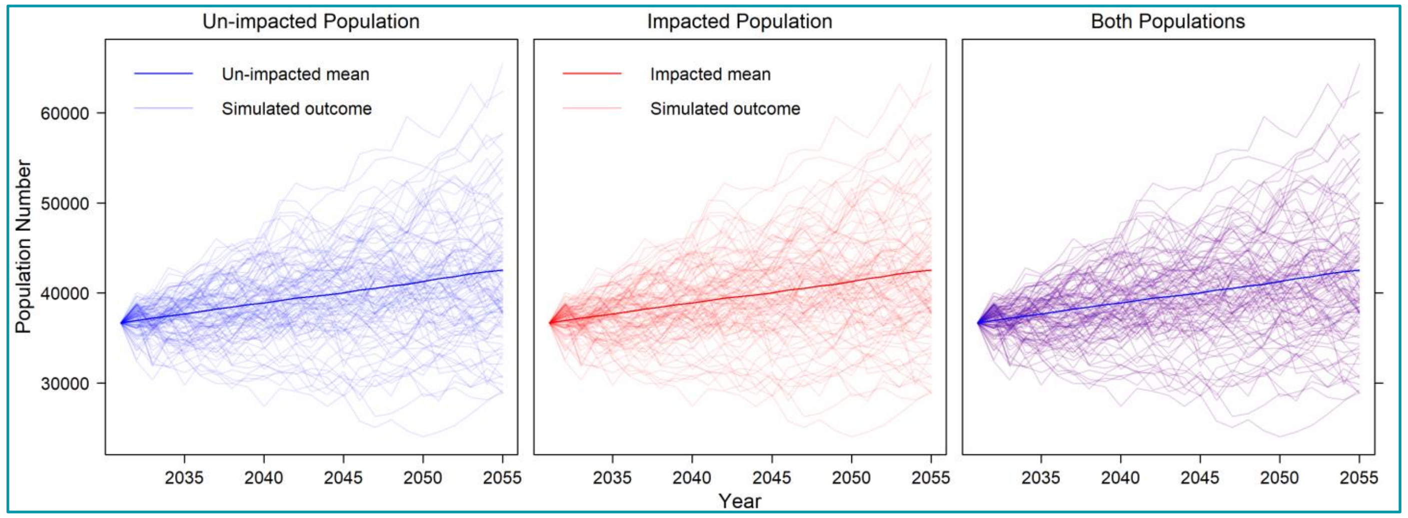

Figure 10.21: Simulated Grey Seal Population Sizes for Both the Baseline (un-impacted) and the Impacted Populations Under the Maximum Temporal Scenario

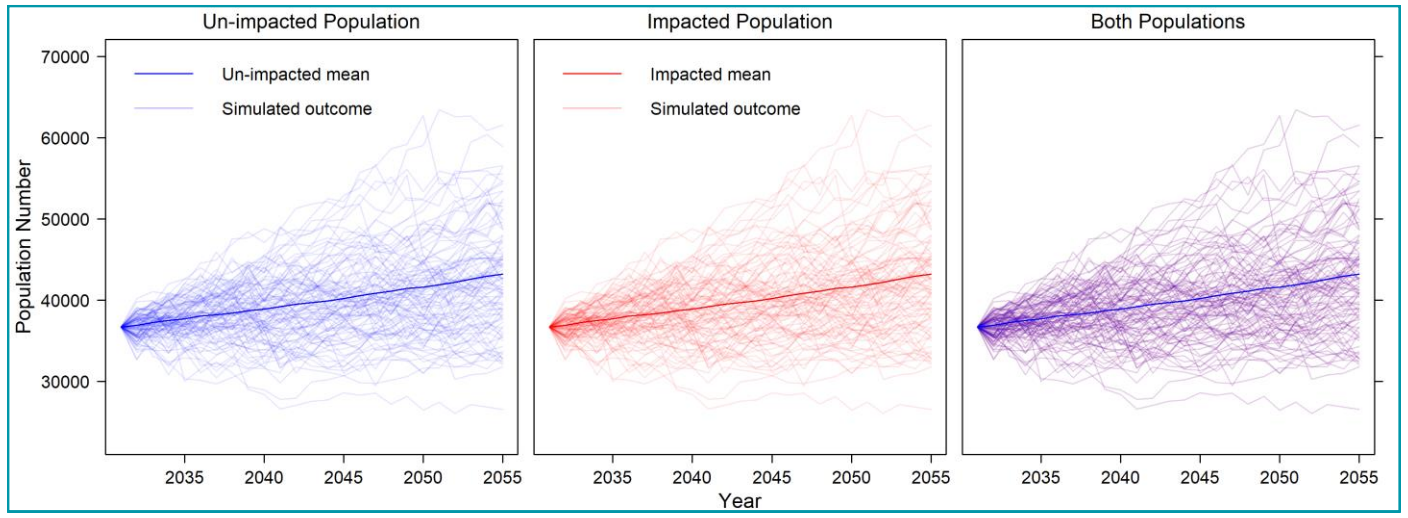

Figure 10.22: Simulated Grey Seal Population Sizes for Both the Baseline (un-impacted) and the Impacted Populations Under the Maximum Spatial Scenario

216. The impact (elevated underwater noise arising during piling) is predicted to be of regional spatial extent, medium term duration, intermittent and high reversibility (the impact itself occurs only during piling). Similarly, the effect of behavioural disturbance is reversible as receptors are expected to recover within hours/days. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be negligible.

Sensitivity of the receptor

Auditory injury (PTS)

Harbour porpoise

217. 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 (2015)) where TTS are experimentally induced (given it is unethical to induce PTS in animals) and thresholds for PTS extrapolated using TTS growth rates. Kastelein *et al.* (2013) demonstrated that hearing impairment as a result of exposure to piling sound is likely to occur where the source frequencies overlap the range of peak sensitivity for the receptor species, rather than across the whole frequency hearing spectrum. The study demonstrated that for simulated piling sound (broadband spectrum), harbour porpoise hearing around 125 kHz (the key frequency for echolocation) was not affected. Rather, a measurable threshold shift in hearing was induced at frequencies of 4 kHz to 8 kHz, noting 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). Kastelein *et al.* (2017) confirmed sensitivity declined sharply above 125 kHz in a following study.

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

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

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

221. The assessment of sensitivity provided below takes into account the uncertainty surrounding the effects of PTS on survival and reproduction and the importance of sound for echolocation, foraging and communication in all cetaceans. Although a threshold shift may occur outside of the most sensitive hearing range, the occurrence of PTS in harbour porpoise, due to the species reliance on hearing, could be detrimental to an individual's capacity for survival and reproduction.

222. Therefore, harbour porpoise is deemed to have limited resilience to PTS, low recoverability or adaptability, and high international value. The sensitivity of the receptor is therefore, considered to be high.

Bottlenose dolphin and white-beaked dolphin

223. 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 HF cetaceans (Southall *et al.*, 2019). As described for harbour porpoise in paragraph 217 *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 kHz 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.

224. Therefore, bottlenose dolphin and white-beaked dolphin is deemed to have limited resilience to PTS, low recoverability or adaptability, and high international value. The sensitivity of both receptors is therefore, considered to be high.

Minke whale and humpback whale

225. Empirical evidence of hearing sensitivities for minke whale is limited, although studies suggest that their vocalisation frequencies are likely to overlap with anthropogenic sounds. Minke whale do 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). Mysticetes have an estimated functional hearing range between 17 Hz and 35 kHz and it is likely that they rely on low frequency hearing (Ketten and Mountain, 2009). A strong reaction to a 15 kHz ADD has been recorded in controlled exposure study on free-ranging minke whale in Iceland, suggesting that this frequency is at the likely upper limit of their hearing sensitivity (Boisseau *et al.*, 2021). As described for harbour porpoise in paragraph 217, there are likely to be frequency-specific differences in the onset and growth of a sound-induced threshold shift in relation to the characteristics of the sound source and hearing sensitivity of the receiving species. 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 baleen cetaceans.

226. Therefore, minke whale is deemed to have limited resilience to PTS, low recoverability or adaptability, and high international value. The sensitivity of both receptors is therefore, considered to be high.

Grey seal

227. In comparison to cetaceans, seals are less dependent on hearing for foraging, but may rely on sound for communication and predator avoidance (e.g. Deecke *et al.*, 2002). Seals can 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. Consequently, the ecological consequences of a noise-induced threshold shift in seals may be a reduction in fitness, reproductive output and longevity (Kastelein *et al.*, 2018). A study by Hastie *et al.* (2015a) 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). Nevertheless, population estimates indicated that the relevant population trend was increasing and therefore (whilst 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.*, 2015b). Hastie *et al.* (2015a) did note that the paucity of data on effects of sound on seal hearing means 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.

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

229. 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.*, 2018). Although this evidence suggests a lower sensitivity of pinnipeds to PTS, based on uncertainties, a precautionary approach has been taken.

230. The telemetry data in of volume 3, appendix 10.2, annex B confirmed some connectivity between the Isle of May SAC (2% of tagged adult grey seals, 13% of tagged juvenile/pups) and Berwickshire and North Northumberland Coast SAC (12% of tagged seals, 20% of tagged juvenile/pups), designated for grey seal within the regional marine mammal study area, and the Array marine mammal study area. No connectivity was observed between these grey seal pups and any SAC outside the East Scotland MU and North-east England seal MU.

231. Grey seal pup production at the Isle of May SAC increased at a rate of 9.9% per year since surveys began (1979), before reaching a peak of approximately 2,000 pups in the late 1990s (SCOS, 2022). However pup production is now considered to be stable or potentially declining (SCOS, 2023, Stevens, 2023). The Berwickshire and North Northumberland Coast SAC contains two large, discrete Annex II grey seal breeding populations at the Farne Islands and Fast Castle, with grey seal pup production at these breeding sites showing a recent, rapid increase (Stevens, 2023). From 2014 to 2019, the mean estimated increase in grey seal pup production at Farne Islands was 53% (SCOS, 2022).

232. Therefore, grey seal is deemed to have limited resilience to PTS, low recoverability or adaptability and high international value. The sensitivity of the receptor is therefore, considered to be high.

Behavioural disturbance

233. It has been demonstrated 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 (Castellote *et al.*, 2010, Castellote *et al.*, 2012, Goold, 1996, Weller *et al.*, 2002). Elevated underwater noise may also cause stress which in turn can lead to a depressed immune function and reduced reproductive success (Anderson *et al.*, 2011, De Soto *et al.*, 2013). The extent to which an animal will be behaviourally affected, however, is very much context-dependent and varies both inter- and intra-specifically as described previously (paragraph 220 *et seq.*). A summary of known behavioural sensitivities of key IEFs to underwater noise from piling at other wind farm sites is provided in paragraph 29 *et seq.,* noting that the conclusions drawn are subject to the limitations of extrapolating results from one project to another.

Harbour porpoise

234. As a small cetacean species, harbour porpoise are vulnerable to heat loss through radiation and conduction. They have a high metabolic requirement, with a need to forage frequently to lay down sufficient fat reserves for insulation. Kastelein *et al.* (1997) found in a study of six, non-lactating, harbour porpoise that they require between 4% and 9.5% of their body weight in fish per day. In the wild, porpoises forage almost continuously day and night to achieve their required calorific intake (Wisniewska *et al.*, 2016), meaning they are vulnerable to starvation if foraging is interrupted. Harbour porpoise were recorded year-round (in 21 out of 24 survey months) in the Array marine mammal study area and therefore could be vulnerable to piling at any time of year (volume 3, appendix 10.2, annex A).

235. It is well documented that there is variance in behavioural responses to increased underwater noise and it 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 piling 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 piling source (Brandt *et al.*, 2011). (Brandt *et al*., 2011). (Graham *et al.*, 2019) demonstrated this dose-response 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%). More recently Graham *et al.* (2019) studied responses of harbour porpoise to piling at the Beatrice Offshore Wind Farm, and suggested that harbour porpoise may adapt to increased noise disturbance over the course of the piling phase, thereby showing a degree of tolerance and behavioural adaptation. Graham *et al.* (2019) 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, (Brandt *et al.*, 2018) at a study of seven offshore wind farms constructed in the German Bight (Brandt *et al.*, 2018) it has been shown that detections of harbour porpoise declined several hours before the start of piling within the vicinity (up to 2 km) of the construction site and were reduced for about one to two hours post-piling. At the maximum effect distances (from 17 km out to approximately 33 km) avoidance only occurred during the hours of piling. Brandt *et al.* (2018) found harbour porpoise detections during piling were found at sound levels exceeding 143 dB re 1 µPa^{2}s and at lower received levels (i.e. at greater distances from the source) there was little evident decline in porpoise detections. 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 re 1 µPa^{2}s to 140 dB re 1 µPa^{2}s), detectable responses may not be apparent from region to region.

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

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

238. 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 in paragraph 235, it is anticipated that there would be some adaptability to the elevated sound levels from piling and therefore survival rates are not likely to be affected. The assessment is highly conservative due to uncertainties associated with the effects of behavioural disturbance on vital rates of harbour porpoise, 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.

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

Bottlenose dolphin and white-beaked dolphin

240. 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 Array 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 Array marine mammal study area and are more abundant during spring and summer compared to autumn and winter months (Paxton *et al.*, 2016). No bottlenose dolphin were observed in the Array marine mammal study area during any of the aerial surveys over 24 months, but white-beaked dolphin accounted for the second highest number of sightings and was recorded in seven months over the 24-month survey period (see volume 3, appendix 10.2).

241. Limited information is available regarding the specific sensitivities of bottlenose dolphin and white-beaked dolphin to disturbance from piling noise as most studies have concentrated 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 Firth coast on days with impulsive noise compared to days without (Fernandez-Betelu *et al.*, 2021). Predicted maximum received levels in coastal areas were 128 dB re. 1 µPa^{2}s and 141 dB re. 1 µPa^{2}s during piling at Beatrice Offshore Wind Farm and Moray Offshore Renewables Ltd (MORL), respectively (Fernandez-Betelu *et al.*, 2021). The authors of this study warn caution these results as increased click changes do not necessarily equate to larger groups sizes but may result from modification in behaviour (e.g. an increase in vocalisations during piling). The results, however, do 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 re 1 µPa^{2}s and 135 dB re 1 µPa^{2}s) that overlap with the CES^{2} MU during piling at the Array, suggesting that disturbance at these lower noise levels is unlikely to lead to displacement effects.

242. The Southall (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 237).

243. White-beaked dolphin and bottlenose dolphin may be able to avoid the disturbed area and whilst there may be 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.

244. Therefore, bottlenose dolphin and white-beaked dolphin are deemed to have some resilience to behavioural disturbance, high recoverability and high international value. The sensitivity of the receptor is therefore considered to be medium.

Minke whale and humpback whale

245. Minke whale occurs seasonally within the Array marine mammal study area, moving into inshore waters during the summer months with peak numbers from July to September, depending on the region (Evans *et al.*, 2003), 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. Volume 2, chapter 9 details the sandeel habitat in the vicinity of the Array. There are low intensity spawning grounds and high intensity nursery grounds for the lesser sandeel *Ammondytes tobianus* within the Array site boundary fish and shellfish ecology study area. Modelling from Langton *et al.* (2021) demonstrated the whole site boundary has extremely low probability of sandeel presence, with areas where predicted density is high closer to the coasts or towards the Firth of Forth. 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.*, 2013b). Christiansen *et al.* (2013a) 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 in the same study area (Christiansen and Lusseau, 2015) 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.

246. It is expected that for minke whale, as described by 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 context, the Array is situated in a region of relatively high levels of shipping, fishing and other vessel activity with up to nine vessels on average per day in the winter survey period and 11 vessels per day within the summer survey period recorded within the shipping and navigation study area (volume 2, chapter 13). Therefore, minke whale that occur within the Array 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.

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

Grey seal

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

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

250. Seal behaviour during offshore wind farm installation has been studied based on empirical data (Russell *et al.*, 2016). Movements of tagged harbour seal during piling at the Lincs Offshore Wind Farm in the Greater Wash showed significant avoidance of the offshore wind farm by harbour seal (Russell *et al.*, 2016). Within this study, seal abundance significantly reduced from the piling activity over a distance of up to 25 km and there was a 19% to 23% decrease in usage within this range. Nevertheless, displacement was limited to pile driving activity only, and harbour seal returned rapidly to baseline levels of activity within two hours of cessation of the piling (Russell *et al.*, 2016). Diverse reactions of tracked grey seal to pile driving during construction of the Luchterduinen and Gemini wind farms was reported in (Aarts *et al.*, 2018). Reactions ranged from altered surfacing and diving behaviour, changes in swimming direction, or coming to a halt. In some cases, however, no apparent changes in diving behaviour or movement were observed Aarts *et al.* (2018). Similar to the conclusions drawn by Hastie *et al.* (2021), the study at the Luchterduinen and Gemini wind farms indicated animals were balancing risk with profit. Approximately half of the tracked grey seal were absent from the pile driving area altogether, but this may be because animals were drawn to other more profitable areas as opposed to active avoidance of the sound, although a small sample size (n = 36 animals) means that no firm conclusions could be reached. It was notable that, in some cases, grey seal exposed to pile driving at distances shorter than 30 km returned to the same area on subsequent trips suggesting that the incentive to go to the area was stronger than potential deterrence effect of underwater sound from pile driving in some animals.

251. Changes in behaviour and subsequent barrier effects have the potential to affect the ability of pinnipeds to accumulate the energy reserves prior to both reproduction and lactation (Sparling *et al.*, 2006). Female seals increase their foraging effort (including increased diving behaviour) before the breeding season, maximising energy allocation to reproduction. Especially during the third trimester of pregnancy, grey seal accumulate reserves of subcutaneous blubber which they use to synthesise milk during lactation (Hall and Thompson, 2009). Therefore, grey seal foraging at-sea may be most vulnerable in this period, as maternal energy storage is extremely important to offspring survival and female fitness (Ailsa J *et al.*, 2001, Mellish *et al.*, 1999). Potential exclusion from foraging grounds during this time could affect reproduction rates and probability of survival.

252. Pinnipeds may also be vulnerable to disturbance during the lactation period, depending on the breeding strategy of particular species. The lactation period for grey seal lasts around 17 days (Sparling *et al.*, 2006) with females remaining mostly on shore, fasting. Furthermore, as grey seal females do not forage often during lactation, it is expected that they may exhibit some tolerance to disturbance as they would not spend as much time at-sea, where they can be affected by underwater sound. Following lactation however female grey seal return to the water and must forage extensively to build up lost energy reserves. Consequences of disturbance may include reduced fecundity, reduced fitness, and reduced reproductive success. Although grey 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.

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

Significance of the effect

Auditory injury (PTS)

Harbour porpoise

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

Bottlenose dolphin and white-beaked dolphin

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

Minke whale and humpback whale

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

Grey seal

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

Behavioural disturbance

Harbour porpoise

258. 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.

Bottlenose dolphin and white-beaked dolphin

259. 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.

Minke whale (and humpback whale)

260. 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.

Grey seal

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

Secondary mitigation and residual effect

Auditory injury (PTS)

262. No marine mammal mitigation is considered necessary (beyond measures adopted) because the likely effect in the absence of mitigation is not significant in EIA terms.

Behavioural disturbance

263. No marine mammal mitigation is considered necessary because the likely effect in the absence of mitigation is not significant in EIA terms.

INJURY AND DISTURBANCE FROM UNDERWATER NOISE GENERATED DURING UNEXPLODED ORDNANCE (UXO) CLEARANCE

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

265. Further detail on underwater noise modelling of UXO clearance is provided in volume 3, appendix 10.1. In the case of high order detonation, acoustic modelling was conducted following the approach outlined in (Soloway and Dahl, 2014). The estimates are conservative, assuming the charge is freely positioned in mid-water, unlike a UXO resting on the seabed, which could experience burial, degradation, or significant attenuation. Additionally, the explosive material is likely to have deteriorated over time, making maximum sound levels probable overestimations of actual sound levels. Frequency-dependent weighting functions were applied to facilitate comparison with marine mammal hearing weighted thresholds.

266. As per Robinson *et al.* (2020), low order deflagration yields a considerably lower amplitude of peak sound pressure compared to high order detonations. Therefore, underwater noise modelling has been based on the methodology outlined in paragraph 265 but with a smaller donor charge size (as described in volume 3, appendix 10.1).

Construction phase

Magnitude of impact

267. Potential impacts of underwater noise resulting from UXO clearance on marine mammals could include mortality, physical injury or auditory injury. The duration of impact (elevated noise) for each UXO detonation is very short (seconds) therefore behavioural effects are considered to be negligible in this context. As such, TTS represents a temporary auditory injury but can be also considered as a threshold for strong behavioural disturbance (for the onset of a moving away response) (see paragraph 285). A

detailed underwater noise modelling assessment was carried out to investigate the potential PTS and TTS to occur, using the latest assessment criteria (volume 3, appendix 10.1). A project-specific outline MMMP (volume 4, appendix 22) will be developed to mitigate the potential for injury.

268. It is anticipated that up to 15 UXOs within the site boundary may require clearance. The maximum UXO size is assumed to be 698 kg NEQ and the most realistic maximum size is 227 kg NEQ (Table 10.17). A low order clearance donor charge of 0.25 kg NEQ is assumed for each clearance event and up to 0.5 kg NEQ clearance shot may be required for neutralisation of residual explosive material at each location. The clearance activities will be tide and weather dependent. The aim is to enable clearance of at least one UXO per tide, during the hours of daylight and good visibility.

269. Whilst the clearance of UXO can result in the high order detonation, in line with the UK Government *et al.* (2022) joint interim position statement, the Applicant commits to prioritise low order clearance techniques (Table 10.17). To ensure a precautionary approach, the assessment of significance for auditory injury (PTS, paragraph 270 *et seq.*) and strong behavioural disturbance (using TTS onset as a proxy, paragraph 285 *et seq.*) is based on the high order clearance of maximum UXO (698 kg NEQ), however noting that the realistic maximum case NEQ of 227 kg is considered the more likely scenario.

Auditory injury (PTS)

270. It is considered that there is a small risk that a low order clearance could result in high order detonation of UXO and therefore the assessment considered both high order and low order techniques. With regard to UXO detonation (low order techniques as well as high order events), due to a combination of physical properties of high frequency energy, the sound is unlikely to still be impulsive in character once it has propagated more than a few kilometres (volume 3, appendix 10.1 for more details). The precise range at which this transition occurs is unknown, however the NMFS (2018) guidance suggests an estimate of 3 km for transition from impulsive to continuous. Hastie *et al.* (2019) suggest that some measures of impulsiveness change markedly within approximately 10 km of the source (for seismic surveys and piling). As such, caution should be used when interpreting any results with predicted injury ranges in the order of tens of kilometres as the PTS ranges are likely to be significantly lower than those predicted.

271. PTS ranges for low order clearance donor charge and clearance shot are presented in Table 10.33 and high order clearance of UXO presented in Table 10.34. The number of animals predicted to experience PTS due to low order clearance donor charge and clearance shot is presented in Table 10.35 and high order clearance in Table 10.36.

272. A high order clearance of 698 kg NEQ yielded the largest PTS ranges for all species, with the greatest injury range (14,540 m) seen for harbour porpoise (SPL$_{pk}$) (Table 10.34). The PTS range as a result of the high order detonation of the realistic maximum case (227 kg NEQ) is reduced to 10,000 m for harbour porpoise (SPL$_{pk}$). Conservatively, the number of harbour porpoise that could be potentially injured, based on the site-specific seasonal peak density of 0.651 animals per km^2, was estimated as 433 animals for 698 kg NEQ UXO high order explosion (SPL$_{pk}$) equating to 0.12% of the North Sea MU (Table 10.36). Predicted numbers are smaller for the realistic maximum case UXO (227 kg NEQ) with up to 205 animals potentially experiencing PTS (SPL$_{pk}$) equating to 0.06 % of the North Sea MU Table 10.36). For low order clearance donor charge (0.25 kg NEQ) and clearance shot (0.5 kg NEQ), the PTS ranges of 1,050 m and 1,320 m were predicted (Table 10.33), which could injure up to three and four harbour porpoises, respectively (Table 10.35).

273. The underwater noise assessment found that the maximum injury (PTS) range estimated for bottlenose dolphin and white-beaked dolphin using the SPL$_{pk}$ metric is 840 m for the high order detonation of 698 kg NEQ, but this is reduced to 577 m for the realistic maximum case (227 kg NEQ) (Table 10.34). Given relatively low densities of both species within the Array marine mammal study area, the high order detonation of 698 kg and 227 kg could result in injury for no more than one individual (Table 10.36). With reference to the wider populations of these species, this equated to small proportions of the relevant MUs (less than 0.01%). For low order clearance donor charge (0.25 kg NEQ) and clearance shot (0.5 kg NEQ), the injury ranges were considerably lower with a maximum of 61 m and 77 m respectively (Table 10.33), and there would be no more than one animal potentially injured within these ranges (Table 10.35).

274. For minke whale, the underwater noise assessment found that the maximum injury (PTS) range estimated is 3,925 m (using the SEL$_{cum}$ metric) for the high order detonation of 698 kg NEQ, but this is reduced to 2,305 m for 227 kg NEQ (Table 10.34). Using the SPL$_{pk}$ metric, the maximum PTS range estimated is 2,575 m for the high order detonation of 698 kg NEQ, but this is reduced to 1,770 m for 227 kg NEQ (Table 10.34). The number of individuals that could be potentially injured was estimated at up to two animals for 698 kg NEQ using the SEL$_{cum}$ (and less than one using the SEL$_{pk}$ metric), which equates to 0.01% of the CGNS MU, and less than one animal for 227 kg NEQ UXO (Table 10.36). For low order techniques, the maximum range predicted was up to 234 m (SPL$_{pk}$) (0.25 kg NEQ) (Table 10.33) and there would be no more than one animal potentially injured within this range (Table 10.35).

275. The maximum injury (PTS) range estimated for grey seal was 2,850 m using the SPL$_{pk}$ metric, for the high order detonation of 698 kg NEQ, but this was reduced to 1,960 m for 227 kg NEQ (Table 10.34). The number of individuals that could be potentially injured, based on average densities within the Array marine mammal study area from Carter *et al.* (2022), was estimated at up to five animals for 698 kg NEQ (Table 10.36), which equates to 0.01% of the East Scotland plus North-east England seal MUs, and up to three animals for the realistic maximum scenario (227 kg NEQ). For low order clearance donor charge (0.25 kg NEQ) and clearance shot (0.5 kg NEQ), the injury ranges were considerably lower with a maximum of 50 m and 259 m (SPL$_{pk}$), respectively (Table 10.33) and there would be no more than one animal potentially injured within these ranges (Table 10.35).

276. The auditory injury (PTS) ranges do not overlap with any known important areas for any of the species, e.g. Southern North Sea SAC (harbour porpoise), CES^2 MU (bottlenose dolphin), Southern Trench ncMPA (minke whale), Berwickshire and North Northumberland SAC (grey seal) (Table 10.15, Figure 10.3).

Table 10.33: Maximum Potential PTS Ranges For Low Order Clearance Donor Charge and Clearance Shot (N/E = Threshold Not Exceeded). Bold Number Represents the Maximum Potential PTS Range For All Species

Species (Hearing Group)	Metric	Threshold	Potential PTS Range (m)	
			0.25 kg NEQ	0.5 kg NEQ
Harbour porpoise (VHF)	SPL$_{pk}$	202 dB re 1 µPa (pk)	1,050	**1,320**
	SEL$_{cum}$	155 dB re 1 µPa^{2}s	337	448
Bottlenose dolphin, white-beaked dolphin (HF)	SPL$_{pk}$	230 dB re 1 µPa	61	77
	SEL$_{cum}$	185 dB re 1 µPa^{2}s	N/E	N/E
Minke whale, humpback whale (LF)	SPL$_{pk}$	219 dB re 1 µPa	186	234
	SEL$_{cum}$	183 dB re 1 µPa^{2}s	88	124
Grey seal (PCW)	SPL$_{pk}$	218 dB re 1 µPa	50	259
	SEL$_{cum}$	185 dB re 1 µPa^{2}s	N/E	24

Table 10.34: Maximum Potential PTS Ranges for High Order Detonation of Maximum and Realistic Maximum Case. Bold Number Represents the Maximum Potential PTS Range For All Species

Species (Hearing Group)	Metric	Threshold	Potential PTS Range (m)	
			227 kg NEQ	698 kg NEQ
Harbour porpoise (VHF)	SPL$_{pk}$	202 dB re 1 µPa (pk)	10,000	**14,540**
	SEL$_{cum}$	155 dB re 1 µPa^{2}s	2,930	3,710
Bottlenose dolphin, white-beaked dolphin (HF)	SPL$_{pk}$	230 dB re 1 µPa	577	840
	SEL$_{cum}$	185 dB re 1 µPa^{2}s	83	139
Minke whale, humpback whale (LF)	SPL$_{pk}$	219 dB re 1 µPa	1,770	2,575
	SEL$_{cum}$	183 dB re 1 µPa^{2}s	2,305	3,925
Grey seal (PCW)	SPL$_{pk}$	218 dB re 1 µPa	1,960	2,850
	SEL$_{cum}$	185 dB re 1 µPa^{2}s	437	745

Table 10.35: Maximum Potential Number of Animals With the Potential to Experience PTS Due to Low Order Clearance Donor Charge and Clearance Shot (N/A = Not Applicable As the Threshold Was Not Exceeded)

Metric	Number of Animals				
	Harbour Porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale	Grey Seal
0.25 kg NEQ Charge Donor					
SPL$_{pk}$	3	<1	<1	<1	<1
SEL$_{cum}$	<1	N/A	N/A	<1	N/A
0.5 kg NEQ Clearance Shot					
SPL$_{pk}$	4	<1	<1	<1	<1
SEL$_{cum}$	<1	N/A	N/A	<1	<1

Table 10.36: Maximum Potential Number of Animals With the Potential to Experience PTS Due to High Order Detonation of Maximum and Realistic Maximum Case (Prior to Any Mitigation)

Metric	Number of Animals				
	Harbour Porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale	Grey Seal
227 kg NEQ					
SPL$_{pk}$	205	<1	<1	<1	3
SEL$_{cum}$	18	<1	<1	<1	<1
698 kg NEQ					
SPL$_{pk}$	433	<1	<1	<1	5
SEL$_{cum}$	29	<1	<1	2	<1

277. With primary mitigation (i.e. using low order techniques, Table 10.22) in place the assessment found that there would be a risk of injury over a range of 1,050 m for harbour porpoise using the SPL$_{pk}$ metric (Table 10.33) for a 0.25 kg NEQ. The injury range for clearance shot of 0.5 kg NEQ was predicted across a range of 1,320 m (Table 10.33).

278. However, if low order clearance is not feasible or accidentally results in high order detonation, there is a maximum risk of injury (predicted for harbour porpoise) out to 14,540 m during detonation of 698 kg NEQ and 10,000 km for a 227 kg NEQ. Therefore, in line with standard industry practice (JNCC, 2010b), mitigation will be applied as a part of the outline MMMP (volume 4, appendix 22) (Table 10.22). In line with stakeholder advice provided in response to Marine Mammal Consultation Note 2 (see Table 10.10; volume 3, appendix 5.1, annex E) the assessment of significance with respect to PTS from UXO clearance will be based on both SPL$_{pk}$ and SEL$_{cum}$, and assumes designed in measures (30 minute ADD and soft-start) (Table 10.22).

279. The maximum injury ranges presented in Table 10.33 and Table 10.34 are larger than the standard 1,000 m mitigation zone recommended for UXO clearance (JNCC, 2010b). The mitigation zone cannot be excessively large (e.g. a few km) as there may be difficulties in detecting marine mammals (particularly harbour porpoise) over large ranges (McGarry *et al.*, 2017) with a significant decline in visual detection rate with increasing sea state (Embling *et al.*, 2010, Leaper *et al.*, 2015).

280. Mitigation set out in the outline MMMP will therefore include the use of ADDs (up to 30 minutes) and soft start (very small scare charges) to deter animals from the injury zone (Table 10.22). The efficacy of such deterrence will depend upon the device selected and reported ranges of effective deterrence vary. The reported effective deterrence range for harbour porpoise vary from 2.5 km out to 12 km (Brandt *et al.*, 2013, Dähne *et al.*, 2017, Kyhn *et al.*, 2015, Olesiuk *et al.*, 2002). A full review of available devices is provided in McGarry *et al.* (2022). In addition to the ADD use, deterrence can also be achieved through the use of soft start charges (JNCC, 2010b). Details of these and other appropriate mitigation are discussed in the outline MMMP (volume 4, appendix 22) and will be discussed with consultees post-consent when further details of the size and type of potential UXOs are understood.

281. Designed in measures include up to 30 minutes of ADD. Table 10.37 presents indicative displacement distances per species, based upon conservative swim speeds presented in Table 10.24. With 30 minutes of ADD, all species except for harbour porpoise will be deterred beyond the maximum injury zone (using the maximum injury range from either the SPL$_{pk}$ or SEL$_{cum}$ metric). With the inclusion of 20 minute of soft start, in addition to 30 minutes of ADD, all species except for harbour porpoise be deterred beyond the maximum injury zone.

282. For harbour porpoise, to illustrate what this may entail for high order clearance of the realistic maximum case (227 kg NEQ), based on a swim speed of 1.5 m/s (Table 10.24), a total of 112 minutes of deterrence activities would be required to allow animals to flee the injury range. This potential further mitigation is discussed in paragraph 318.

Table 10.37: Indicative Displacement Distances based upon Designed in ADD (30 minutes) for Marine Mammal Receptors, based upon Conservative Swim Speeds

Duration of ADD activation	Potential Displacement Distance (m)				
	Harbour Porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale	Grey seal
30 minutes ADD	2,700	2,736	2,736	4,140	3,240
30 minutes ADD plus 20 minutes of soft start charges	4,500	4,560	4,560	6,900	5,400
Move away beyond the maximum injury zone (defined by the maximum PTS range)	No	Yes	Yes	Yes	Yes

283. The impact is predicted to be of local (for all species except harbour porpoise) to regional (harbour porpoise) spatial extent in the context of the relevant geographic frame of reference, very short term duration, intermittent and the effect of injury is permanent. It is predicted that the impact will affect the receptor directly. With designed in mitigation applied it is anticipated that all species except harbour porpoise would be deterred from the injury zone and therefore the likelihood of PTS and population-level effects would be unlikely. The magnitude is therefore considered to be low for bottlenose dolphin, white-beaked dolphin, minke whale, humpback whale and grey seal.

284. For harbour porpoise the ranges of effect are large for high order clearance, and it is likely that following designed-in mitigation measures there will be a residual risk of PTS to a number of individuals (Table 10.36). Therefore conservatively, the magnitude is considered to be medium.

Behavioural disturbance (TTS as a proxy)

285. As discussed in paragraph 267, the duration of effect for each UXO detonation is less than one second and therefore behavioural effects are considered to be negligible in this context. The assessment for behavioural disturbance uses the onset of TTS as a proxy. Although the effect would be a potential temporary loss in hearing and some 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 corresponds to a moving away or 'fleeing response' as this is the threshold at which animals experience disturbance and are likely to move away from the ensonified area. The onset of TTS is also considered to represent the boundary between the most severe disturbance levels and the start of physical auditory impacts on animals. Considering the above, the results of underwater noise modelling based on TTS onset as a proxy, will be hereinafter referred to as 'strong behavioural disturbance'.

286. Strong behavioural disturbance ranges for low order clearance donor charge and clearance shot are presented in Table 10.38 and high order clearance of UXO presented in Table 10.39. The largest ranges using SPL_{pk} metric were predicted for clearance of the 698 kg NEQ with potential strong disturbance over a distance of up to 26,790 m for harbour porpoise (Table 10.39). Ranges predicted for other species using SPL_{pk} only slightly exceeded 5 km for all other species, with the largest strong behavioural disturbance range predicted for grey seal at 5,250 m (Table 10.39). However, based on the SEL_{cum} metric, the strong behavioural disturbance ranges are much larger with a maximum of 32,735 m predicted for minke whale (Table 10.39). It should be noted that impulsive noise thresholds (TTS onset) were used in the underwater noise modelling for strong behavioural disturbance as a result of UXO clearance. As previously described in paragraph 270, the sound is unlikely to be impulsive in character once it has propagated more than a few kilometres and it is particularly important when interpreting results for disturbance within ranges larger than 10 km as these are likely to be significantly lower than predicted see (Hastie *et al.*, 2019) (see volume 3, appendix 10.1 for more details).

Table 10.38: Maximum Potential Strong Behavioural Disturbance Ranges (TTS Used As a Proxy) For Low Order Clearance Donor Charge and Clearance Shot (N/E = Threshold Not Exceeded)

Species (Hearing Group)	Metric	Threshold	Strong Disturbance (TTS) Potential Range (m)	
			0.25 kg NEQ	0.5 kg NEQ
Harbour porpoise (VHF)	SPL_{pk}	196 dB re 1 μPa (pk)	1,930	2,435
	SEL_{cum}	140 dB re 1 μPa^{2}s	2,120	2,510
Bottlenose dolphin, white-beaked dolphin (HF)	SPL_{pk}	224 dB re 1 μPa	112	141
	SEL_{cum}	170 dB re 1 μPa^{2}s	43	60
Minke whale, humpback whale (LF)	SPL_{pk}	213 dB re 1 μPa	342	431
	SEL_{cum}	168 dB re 1 μPa^{2}s	1,225	1,690
Grey seal (PCW)	SPL_{pk}	212 dB re 1 μPa	378	477
	SEL_{cum}	188 dB re 1 μPa^{2}s	232	320

Table 10.39: Maximum Potential Strong Behavioural Disturbance Ranges (TTS Used As a Proxy) for High Order Detonation of Maximum and Realistic Maximum Case

Species (Hearing Group)	Metric	Threshold	Strong Disturbance (TTS) Potential Range (m)	
			227 kg NEQ	698 kg NEQ
Harbour porpoise (VHF)	SPL_{pk}	196 dB re 1 μPa (pk)	18,425	**26,790**
	SEL_{cum}	140 dB re 1 μPa^{2}s	7,515	8,720
Bottlenose dolphin, white-beaked dolphin (HF)	SPL_{pk}	224 dB re 1 μPa	1,065	1,550
	SEL_{cum}	170 dB re 1 μPa^{2}s	870	1,310

Species (Hearing Group)	Metric	Threshold	Strong Disturbance (TTS) Potential Range (m)	
			227 kg NEQ	698 kg NEQ
Minke whale, humpback whale (LF)	SPL$_{pk}$	213 dB re 1 µPa	3,260	4,740
	SEL$_{cum}$	168 dB re 1 µPa^{2}s	22,520	**32,735**
Grey seal (PCW)	SPL$_{pk}$	212 dB re 1 µPa	3,610	5,250
	SEL$_{cum}$	188 dB re 1 µPa^{2}s	4,265	6,120

287. The number of animals predicted to experience strong behavioural disturbance due to low order clearance donor charge and clearance shot is presented in Table 10.40 and high order clearance in Table 10.41.

288. Given the largest strong behavioural disturbance ranges (Table 10.39) and precautionary peak seasonal site-specific densities (Table 10.13), the largest number of animals affected was found for harbour porpoise where up to 1,467 animals could experience strong disturbance as a result of high order detonation of a 698 kg NEQ (based on SPL$_{pk}$ metric, 0.42% of the North Sea MU population). The second largest number of animals disturbed was predicted for minke whale based on SEL$_{cum}$ metric with up to 96 individuals potentially experiencing strong disturbance (0.47% of the CGNS MU) as a result of high order detonation of 698 kg NEQ. Based on SEL$_{cum}$, the number of grey seals at risk of experiencing strong behavioural disturbance within a predicted 6,120 m disturbance range was estimated as 22 animals (0.06% of the East Scotland MU plus the North-east England seal MU). For bottlenose dolphin and white-beaked dolphin the number of animals predicted to be disturbed was very small with no more than one animal within the predicted effect zones (Table 10.40 and Table 10.41).

289. The strong behavioural disturbance ranges will not overlap with any known important areas for any of the species, e.g. Southern North Sea SAC (harbour porpoise), CES^2 MU (bottlenose dolphin), Southern Trench ncMPA (minke whale), Berwickshire and North Northumberland SAC (grey seal) (Table 10.15, Figure 10.3).

Table 10.40: Maximum Number of Animals With the Potential to Experience Strong Disturbance (TTS Used as a Proxy) Due to Low Order Clearance Donor Charge and Clearance Shot

Metric	Number of Animals				
	Harbour porpoise	Bottlenose dolphin	White-beaked dolphin	Minke whale	Grey seal
0.25 kg NEQ Charge Donor					
SPL$_{pk}$	8	<1	<1	<1	<1
SEL$_{cum}$	10	<1	<1	<1	<1
0.5 kg NEQ Clearance Shot					
SPL$_{pk}$	13	<1	<1	<1	<1
SEL$_{cum}$	13	<1	<1	<1	<1

Table 10.41: Maximum Number of Animals With the Potential to Experience Strong Disturbance (TTS Used as a Proxy) Due to High Order Detonation of Maximum and Realistic Maximum Case

Metric	Number of Animals				
	Harbour porpoise	Bottlenose dolphin	White-beaked dolphin	Minke whale	Grey seal
227 kg NEQ					
SPL$_{pk}$	694	<1	<1	<1	8
SEL$_{cum}$	116	<1	<1	46	11
698 kg NEQ					
SPL$_{pk}$	1,467	<1	<1	2	16
SEL$_{cum}$	155	<1	<1	96	22

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

291. For all species a small proportion of the relevant MUs is predicted to be affected by strong behavioural disturbance (Table 10.41). As such, whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects.

292. As previously described in paragraph 269, the assessment considered the magnitude of a high order detonation for the MDS of 698 kg NEQ. The impact (high order detonation) is predicted to be of regional spatial extent in the context of the relevant geographic frame of reference, very short term duration, intermittent and both the impact itself (i.e. the elevation in underwater noise during detonation event) and effect of disturbance is reversible (TTS represents a non-trivial disturbance but not permanent injury). The magnitude is therefore considered to be low for all species.

Sensitivity of the receptor

Auditory injury (PTS)

293. The main characteristic of the acoustical properties of explosives is a short shock wave, comprising a sharp rise in pressure followed by an exponential decay with a time constant of a few hundred microseconds (volume 3, 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).

294. Scientific literature often focuses on harbour porpoises due to their high sensitivity to noise. von Benda-Beckmann *et al.* (2015) studied the range of effects of explosives on harbour porpoise in the southern North Sea; measures of SEL and peak overpressure (in kPa) were taken 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). von Benda-Beckmann *et al.* (2015) investigated 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). In addition, 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). Results demonstrated the largest distance at which a risk of ear trauma could occur was at 500 m. They

also found 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.

295. The study also modelled possible effect ranges for 210 explosions (of up to 1,000 kg charge mass) that had been logged by the Royal Netherland Navy and the Royal Netherlands Meteorological Institute over a two year period (2010 and 2011) (von Benda-Beckmann *et al.*, 2015). Validating the model using the empirical measurements of SEL out to 2 km (see paragraph 294), von Benda-Beckmann *et al.* (2015) 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). Porpoises are known to spend a large proportion of time near the surface (e.g. 55% based on Teilmann *et al.* (2007)) where 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 (given empirical measurements were made out to this point), estimates above this distance required further validation since the uncorrected model systematically overestimates SEL. More recently, Salomons *et al.* (2021) analysed sound measurements performed near two detonations of UXO (with charge masses of 325 kg and 140 kg). Subsequently a PTS effect distance in the range 2.5 km to 4 km was derived (Salomons *et al.*, 2021), using the weighted SEL values and threshold levels from Southall *et al.* (2019). When comparing the experimental data and model predictions, the same study concluded that harbour porpoise are at risk of permanent hearing loss at distances of several kilometres, i.e. distance between 2 km and 6 km based on 140 kg and 325 kg charge masses, respectively (Salomons *et al.*, 2021).

296. In 2019, 24 harbour porpoise were found dead following clearance of ground mines in the Baltic Sea in along the German 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.

297. 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 re 1 µPa were measured. No adverse effects were recorded in the behaviour or appearance of the resident community (dos Santos *et al.*, 2010), even with pressure levels 60 dB higher than ambient noise. 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 *et al.*, 1993).

298. 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. The study 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 (therefore a reduction factor of just over ten in SPL_{pk} and 100 in acoustic energy). It was also demonstrated 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, the study provided the evidence that low order techniques offers the potential for greatly reduced acoustic noise exposure of marine mammals (Robinson *et al.*, 2020).

299. The sensitivity of the receptors to the injury from impulsive underwater noise has been described previously in detail for piling and is presented in paragraphs 217 to 232.

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

Behavioural disturbance (TTS as a proxy)

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

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

303. As TTS is a temporary and reversible hearing impairment, it is anticipated that any animals experiencing this shift in hearing would recover after they have moved beyond the injury zone and are no longer exposed to elevated sound levels. Whilst the implication of animals experiencing TTS, leading to potential displacement, is not fully understood, it is likely that aversive responses to anthropogenic sound could temporarily affect life functions as described for PTS.

304. Therefore, in this respect animals exposed to sound levels that could induce TTS have similar susceptibility as those exposed to sound levels that could induce PTS. There is an important distinction, however, given that TTS is only temporary hearing impairment, it is less likely to lead to acute effects and will largely depend on recoverability. The degree and speed of hearing recovery will depend on the characteristics of the sound the animal is exposed to and the degree of shift in hearing experienced.

Harbour porpoise

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

306. Kastelein *et al.* (2021) found that the susceptibility to TTS depends on the frequency of the fatiguing sound causing the shift and the greatest TTS depends on the SPL (and related SEL). In a series of studies reviewed in Finneran (2015), which measured TTS occurrence in harbour porpoise at a range of frequencies typical of high-amplitude anthropogenic sounds, the greatest shift in mean TTS occurred at 0.5 kHz with hearing recovery within 60 minutes after the fatiguing sound stopped. Scientific understanding of the biological effects of TTS is limited to the results of controlled exposure studies on small numbers of captive animals. 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

307. Finneran *et al*. (2000) investigated the behavioural and auditory responses of two captive bottlenose dolphin 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 peak-to-peak (p-p) was observed. Behavioural shifts, such as delaying approach to the test station and avoiding the 'start' station, were recorded at 196 dB re 1 µPa Pk-Pk and 209 dB re 1 µPa Pk-Pk for the two bottlenose dolphin and continued at higher levels. However, there are several caveats to this study as discussed in (Nowacek *et al*., 2007), with the signals used in this study distant and the study measured

masked-hearing signals. The animals used in the experiment were also trained and rewarded for tolerating high levels of sound and subsequently, it can be anticipated that behavioural disruption would likely be observed at lower levels in other contexts.

308. Whilst there are no available species-specific recovery rates for high frequency cetaceans to TTS, there is no evidence to suggest that recovery will be significantly different to harbour porpoise recovery rates therefore animals can recover their hearing after they are no longer exposed to elevated sound levels. It can be anticipated that both bottlenose dolphin and white-beaked dolphin would be able to tolerate the effect without any impact on reproduction or survival rates with the ability to return to previous behavioural states or activities once the impacts had ceased.

Minke whale and humpback whale

309. There are no species-specific recovery rates for minke whale/humpback whale to TTS, however there is no evidence to suggest that recovery will be significantly different to harbour porpoise recovery rates. A recent study by Boisseau *et al.* (2021) reported that minke whale avoided a 15 kHz ADD and clearly react to signals at the likely upper limit of their hearing sensitivity. It is anticipated that minke whale would be able to tolerate the effect without any impact on reproduction or survival rates and is expected to return to previous behavioural states or activities once the impacts had ceased.

Grey seal

310. Kastelein *et al.* (2018) measured recovery rates of harbour seal following exposure to a sound source of 193 dB re 1 μPa^{2}s (SELcum) over 360 minutes and found that recovery from TTS to the pre-exposure baseline was estimated to be complete within 72 minutes following exposure. These results are in line with findings reported in SEAMARCO (2011), which showed that for small TTS values, recovery in seal species was very fast (around 30 minutes) and the higher the hearing threshold shift, the longer the recovery. Kastelein *et al.* (1995) also reported relatively fast recovery, with full hearing recovery within two hours following exposure.

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

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

Significance of the effect

Auditory injury (PTS)

313. Although the preferred approach is the use of low order techniques to clear UXO (Table 10.22), in the case that a low order technique results in a high order detonation (as per paragraph 270) conclusions presented in paragraph 314 *et seq*. are based on the assessment for high order clearance, which therefore presents a conservative assumption of project parameters (as discussed in paragraph 114).

314. For bottlenose dolphin, white-beaked dolphin, minke whale, humpback whale and grey seal, overall, the magnitude of the impact (auditory injury) is deemed to be negligible and the sensitivity of all receptors is considered to be high. The effect will therefore be of **minor** adverse significance, which is not significant in EIA terms.

315. For harbour porpoise the magnitude of the impact is deemed to be medium and the sensitivity of all receptors is considered to be high. The effect will therefore be of moderate adverse significance, which is significant in EIA terms. Secondary mitigation and residual significance is discussed in paragraph 318 *et seq*.

Behavioural disturbance (TTS as a proxy)

316. As described for PTS in paragraph 313, 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 conclusion presented in paragraph 317 is based on the assessment for high order clearance.

317. Overall, for all species the magnitude of the impact (behavioural disturbance) is deemed to be low and the sensitivity of all receptors 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

Auditory injury (PTS)

318. If required, secondary mitigation (i.e. ADD with a duration over 30 minutes) will be applied to further reduce the potential for injury to harbour porpoise occurring during UXO clearance (detailed in Table 10.22). Final mitigation required will be addressed post consent, in consultation with stakeholders, following more detailed information such as the size, number and quality of UXOs to be cleared (following site-investigation surveys), noting that it may be possible to reduce the ADD activation period and soft start procedure depending on the size and number of UXOs located within the Array. Paragraph 320 *et seq*. therefore details a worked example for mitigation based on the most significant predicted effect, and focused on harbour porpoise (as this is the species with a potential residual risk of injury), which considers the different timescales that would be required to clear the injury zone if ADD and soft-start is required.

319. As described in paragraph 269 *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 270). The secondary mitigation has been therefore tailored based on the size of the UXO and high order detonation scenario.

320. A range of UXO munitions sizes have been considered for the purpose of determining effective mitigation measures, up to a maximum scenario of a UXO size of 698 kg. This approach follows a similar strategy to that which was taken for Seagreen 1 Offshore Wind Farm EPS Risk Assessment and MMMP (volume 4, appendix 22) (Seagreen Wind Energy Ltd, 2021).

321. An outline MMMP (volume 4, appendix 22) has been developed for the purpose of mitigating the risk of auditory injury (PTS) to marine mammals from the proposed UXO clearance activities at the Array. This has been provided as a stand-alone document; however, this section provides an overview of the procedures for ADD and soft start, prior to making conclusions on the potential for residual effects and requirement for secondary mitigation.

322. The designed in measures included as a part of the outline MMMP (volume 4, appendix 22) (Table 10.22) 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 charge application are specific for each of the anticipated UXO sizes. As discussed in paragraph 318, prior to the commencement of UXO clearance works, a more detailed assessment will be produced 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. The approach to mitigating injury to marine mammals involves the monitoring of a 1 km radius mitigation zone in line with current guidance (JNCC, 2010b). Monitoring will be carried out by suitably qualified and experienced personnel within a mitigation team, comprising of two dedicated MMOs[2] and one dedicated PAM operator. The purpose of this monitoring is to clear the mitigation zone of marine mammals prior to detonation.

323. Given the potential for auditory injury from high-order detonations for several marine mammal receptors (harbour porpoise, minke whale, humpback whale and grey seal) is at a greater range than can be mitigated by monitoring the 1 km zone (Table 10.34), an ADD will be deployed to deter marine mammals to a greater distance before any detonation. The assessment of effects provided in paragraph 270 *et seq.* determine the auditory injury range based on high order detonation of a 698 kg NEQ UXO (Table 10.34). At the time of writing, the actual number and size of the UXOs within the Array are unknown and therefore, the example 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. Details of ADD duration of activation is presented in the outline MMMP (volume 4, appendix 22).

324. 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 10.24). 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.

325. Example deterrence distances are provided for all marine mammal IEFs in Table 10.42. Summaries provided in this paragraph refer to harbour porpoise only, as the species with the largest PTS ranges (Table 10.34).

326. Based on the UXO clearance flow chart (Figure 10.23; informed by Seagreen Wind Energy Ltd, 2021), for low order UXO size up to 0.25 kg NEQ, the required time of ADD activation is 12 minutes and this is expected to displace harbour porpoise to 1,080 m (exceeding the PTS distance of 1,050 m). If UXO size of up 0.5 kg NEQ is identified during the survey, then ADD will be activated for 15 minutes and this is expected to deter harbour porpoise to 1,350 m. For all other species, three minutes of ADD would be sufficient to deter the animals from the injury zone.

327. However, for high order UXO clearance, injury ranges are larger. Assuming the ADD is activated for an indicative 60 minutes (Table 10.42), the displacement distance for harbour porpoise would be 5,400 m, meaning there is a need to deter harbour porpoise from larger ranges that cannot be achieved using an ADD for 60 minutes duration alone (i.e. the injury zone exceeds 5,400 m). However, for all other species, a duration of 60 minutes ADD activation will be sufficient to deter animals from the injury zone up to the 698 kg NEQ (Table 10.42).

328. For high order UXO, to reduce the risk of PTS, there is a need to deter animals from larger ranges than can achieved using an ADD alone. Therefore, following an ADD activation period of up to 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 10.42, Figure 10.23). It is expected that up to 80 minutes of combined ADD/soft start procedure (up to 60 minutes of ADD and 20 minutes of soft start) will displace harbour porpoise to ranges of 7,200 m. Whilst this secondary mitigation is considered to be sufficient to deter most animals (noting that use of ADD alone deterred all other species from the injury zone), 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 10,000 for the 227 kg NEQ and 14,580 m for 698 kg NEQ (Table 10.34).

Table 10.42: Recommended ADD Duration for Low Order and High Order UXO Clearance and Sizes, and Associated Displacement Distance

UXO Size	Minimum Duration Prior to Detonation (Based on Harbour Porpoise)	Displacement Distance for Given Duration of ADD (m)				
		Harbour Porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale	Grey seal
Low order UXO						
Up to 0.25 kg NEQ	12 min of ADD	1,080	1,094	1,094	1,656	1,296
Up to 0.5 kg NEQ	15 min of ADD	1,350	1,368	1,368	2,070	1,620
High order UXO						
Up to 227 kg NEQ (realistic maximum case)	112 min of ADD	10,080	10,214	10,214	15,456	12,096
Up to 698 kg NEQ (maximum UXO size)	162 min of ADD	14,580	14,774	14,774	22,356	17,496
Indicative ADD durations						
60 min of ADD only		5,400	5,472	5,472	8,280	6,480
60 min of ADD plus soft start charges for 20 minutes		7,200	7,296	7,296	11,040	8,640

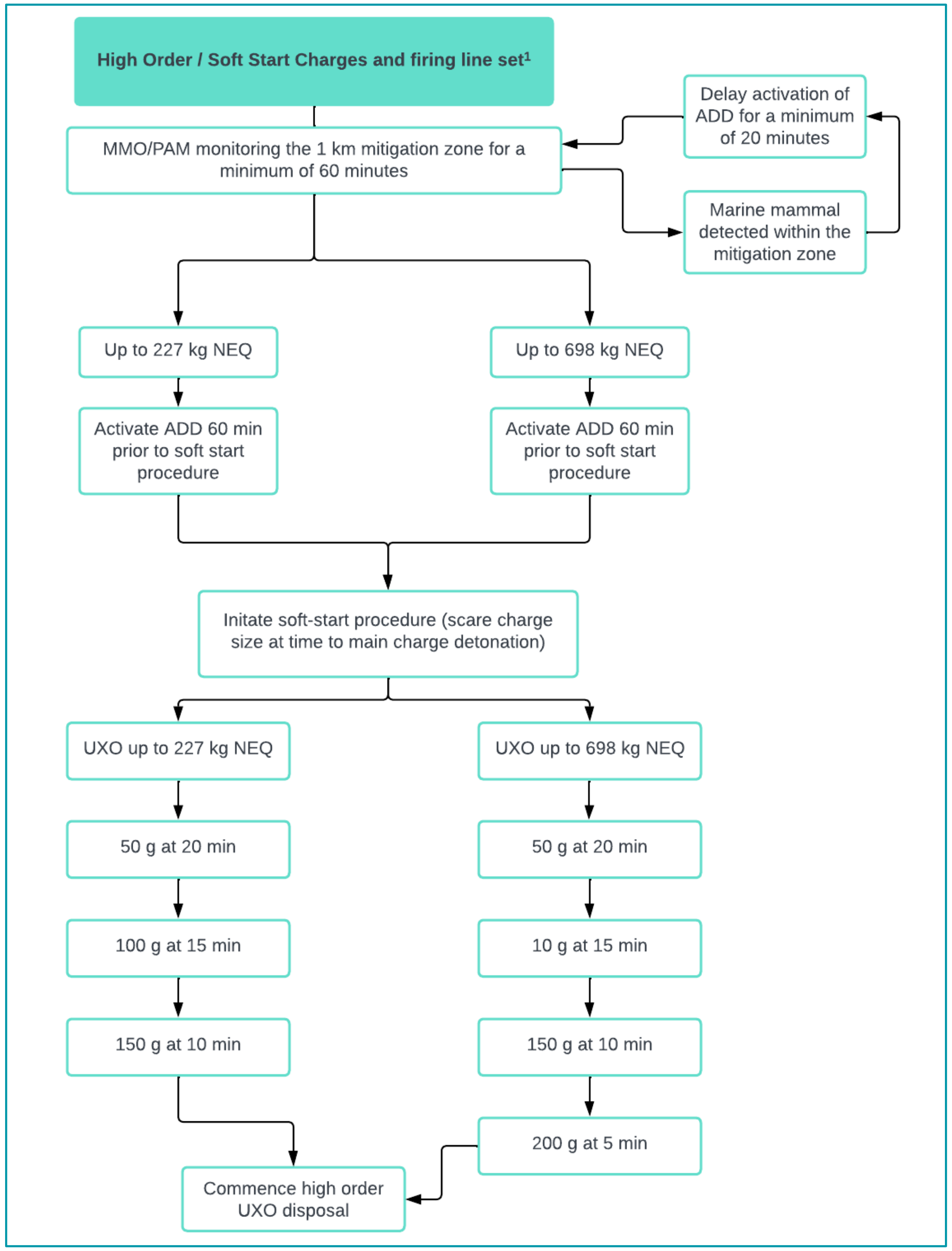

Figure 10.23: High Order UXO Clearance Mitigation Flow Chart for the Array (based upon Seagreen Wind Energy Ltd, 2021)

329. The indicative analysis presented in Table 10.42 suggests that for UXO sizes of up to 698 kg, pre-detonation search and use of 30 minutes of ADD will be sufficient to reduce the potential of experiencing PTS by bottlenose dolphin, white-beaked dolphin, minke whale, and grey seal to negligible magnitude.

330. However, for harbour porpoise, 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 14,580 m.

331. To assess the residual effect, the average and maximum number of animals that may potentially be present within an area of 501 km^2 (difference between the area across which effects could be mitigated and area of effect) could be calculated using harbour porpoise density range (Table 10.34). 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 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). Empirical evidence has suggested such shifts in impulsivity could occur markedly within 10 km from the sound source (Hastie *et al.*, 2019). Since the precise range at which this transition occurs is unknown (not least because the transition also depends on the response of the marine mammals' ear), sound models still adopt the impulsive thresholds at all ranges and this is likely to lead to an overly precautionary estimate of injury ranges at larger distances (tens of kilometres) from the sound source. It is noted defining this transition range is an active area of research and scientific debate, with a number of other potential methods being investigated. Furthermore, 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 ad therefore 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)

332. 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 is underestimated (Table 10.42). 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). However 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.

333. For harbour porpoise, it is expected that small numbers of animals could potentially be exposed to PTS. Given that details about UXO clearance technique to be used and charge sizes will not be available until after the consent is granted (following a pre-construction UXO survey), it is not possible to quantify the effects of UXO detonations and therefore a residual number of animals potentially impacted is not presented within this chapter. At a later stage, when details about UXO sizes and specific clearance techniques to be used become available, it will be possible to tailor the secondary mitigation to specific UXO sizes following the UXO survey and species to reduce the risk of injury.

334. Therefore, prior to the commencement of UXO clearance works, appropriate secondary mitigation measures will be discussed with stakeholders and proposed as a part the final MMMP for UXO clearance works (refer to volume 4, appendix 22 for outline MMMP). It is therefore anticipated that following receipt of more detail regarding size and number of UXO (and tailoring of secondary mitigation measures as described above), the magnitude of this impact will be reduced to low for harbour porpoise.

Auditory injury (PTS)

335. For all species excluding harbour porpoise, no marine mammal mitigation is considered necessary because the likely effect in the absence of mitigation is not significant in EIA terms.

336. For harbour porpoise, following secondary mitigation measures, tailored once a more detailed understanding of the size and number of UXO is available, will be discussed with stakeholders and proposed as part of the final MMMP (volume 4, appendix 22), 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 the population could be potentially injured (PTS), the effect will therefore be of **minor** adverse significance, which is not significant in EIA terms.

Behavioural disturbance (TTS as a Proxy)

337. No marine mammal mitigation is considered necessary because the likely effect in the absence of mitigation is not significant in EIA terms.

INJURY AND DISTURBANCE DUE TO SITE-INVESTIGATION SURVEYS (INCLUDING GEOPHYSICAL SURVEYS)

338. Site-investigation surveys during the construction and operation and maintenance phases have the potential to cause direct or indirect effects (including injury or disturbance) on marine mammal receptors (Table 10.17).

339. 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). Several sonar-like sources will potentially be used for the geophysical surveys, including MBES, SSS, SBP and UHRS. The equipment likely to be used can typically work at a range of signal frequencies, depending on the distance to the seabed and the required resolution. For sonar-like sources the signal is highly directional, acts like a beam and is emitted in pulses. Sonar-based sources are considered by the NMFS (2018) as continuous (non-impulsive) because they generally comprise a single (or multiple discrete) frequency. Unlike the sonar-like survey sources, the UHRS is likely to utilise a sparker, which produces an impulsive, broadband source signal. Additionally, MAG will be used to measure and detect anomalies within the existing magnetic field. The survey parameters, such as source SEL, used in the underwater noise modelling are presented in detail in volume 3, appendix 10.1. For geotechnical surveys, potential equipment to be used may include CPT, vibrocore, piston core, box core and borehole (Table 10.17).

340. The site-investigation surveys as listed in Table 10.17 for the construction phase will involve the use of up to four survey vessels with up to 50 vessel movements in total. The site-investigation surveys will be carried out over five months within a three year period.

Construction phase

Magnitude of impact

Auditory injury (PTS)

341. As detailed in volume 3, appendix 10.1, Injury ranges for impulsive survey sources (UHRS, CPT) are based on a comparison to the Southall *et al.* (2019) thresholds for impulsive noise (with the distances presented in brackets for SPL_{pk} thresholds) whereas non-impulsive survey sources (MBES, SSS, SBP, borehole, vibrocore) results are compared against the non-impulsive thresholds. Please note that for impulsive noise, the injury ranges were larger for the SEL_{cum} metric compared to SPL_{pk} (Table 10.43, Table 10.44).

342. The maximum injury (PTS) range across all geophysical surveys was estimated as 310 m for harbour porpoise due to SBP activity (Table 10.43). For bottlenose dolphin, white-beaked dolphin, minke whale, humpback whale and grey seal the maximum PTS is expected to occur out to 75 m (Table 10.43). However, it should be noted that as sonar-like sources have very strong directivity (as detailed in volume 3, appendix 10.1), there is only potential for injury when a marine mammal is directly underneath the noise source. Once the animal moves outside of the main beam, there is no potential for injury.

343. 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 all marine mammal species, except harbour porpoise (Table 10.44). Harbour porpoises are at risk of potential injury within 45 m from the noise source during the CPT activity (Table 10.44).

344. The number of marine mammals potentially injured within the modelled PTS ranges (Table 10.43, Table 10.44) were estimated using species-specific density estimates (Table 10.45). Given that the potential PTS ranges are relatively low, no more than one animal of each species is deemed to be at risk of experiencing PTS across all types of geophysical and geotechnical surveys (Table 10.45). The auditory injury (PTS) ranges will not overlap with any known important areas for any of the species, e.g. Southern North Sea SAC (harbour porpoise), CES[2] MU (bottlenose dolphin), Southern Trench ncMPA (minke whale), Berwickshire and North Northumberland SAC (grey seal) (Table 10.15, Figure 10.3).

Table 10.43: Potential Injury (PTS) Impact Ranges (m) For Geophysical Site-Investigation Surveys (N/E = Threshold Not Exceeded, Comparison to Ranges for SPL_{pk} Where Threshold was Exceeded Shown in Brackets)

Survey Type	Potential PTS Impact Range (m)				
	Harbour Porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale, Humpback Whale	Grey Seal
MBES	75	65	65	5	5
SSS	75	75	75	10	25
SBP	**310**	75	75	75	75
UHRS	10 (19)	N/E	N/E	N/E	N/E

Table 10.44: Potential Injury (PTS) Impact Ranges (m) For Geotechnical Site-Investigation Surveys (N/E = Threshold Not Exceeded, Comparison to Ranges for SPL_{pk} Where Threshold was Exceeded Shown in Brackets)

Survey Type	Potential PTS Impact Range (m)				
	Harbour Porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale, Humpback Whale	Grey Seal
Borehole drilling	N/E	N/E	N/E	N/E	N/E
CPT	45 (11)	N/E	N/E	N/E	N/E
Vibrocoring	N/E	N/E	N/E	N/E	N/E

Table 10.45: Estimated Number of Animals With the Potential To Experience Injury (PTS) During Geophysical and Geotechnical Site-Investigation Surveys (Number of Animals Based on SPL_{pk} Where Threshold was Exceeded Shown in Brackets)

Survey Type	Estimated Number of Animals with the Potential to Experience Injury (PTS)				
	Harbour Porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale, Humpback Whale	Grey Seal
Geophysical Surveys					
MBES	<1	<1	<1	<1	<1
SSS	<1	<1	<1	<1	<1
SBP	<1	<1	<1	<1	<1
UHRS	<1 (<1)	N/A	N/A	N/A	N/A
Geotechnical Surveys					
Borehole drilling	N/A	N/A	N/A	N/A	N/A
CPT	<1 (<1)	N/A	N/A	N/A	N/A
Vibrocoring	N/A	N/A	N/A	N/A	N/A

345. The site-investigation surveys are considered to be short term as they will take place over a period of five months. In line with good practice guidance, designed in measures during geophysical surveys will involve the use of MMOs[2] and PAM so that the risk of injury over the defined mitigation zone is reduced (JNCC, 2017). The largest PTS range was estimated as 310 m for SBP and it is considered that standard industry measures will be effective at reducing the risk of injury over this distance (JNCC, 2017).

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

Behavioural disturbance

347. For impulsive noise sources (UHRS, CPT) the underwater noise modelling adopted the NMFS (2005) thresholds of 140 dB re 1 µPa for mild disturbance and 160 dB re 1 µPa for strong disturbance. For non-impulsive noise sources (MBES, SSS, SBP, borehole, vibrocore) the underwater noise modelling used the NMFS (2005) threshold of 120 dB re 1 µPa. The underwater noise modelling predicted that the behavioural effects as a result of site-investigation surveys can occur within a range of between 27 m for borehole drilling and up to 9,101 m for vibrocoring (Table 10.46).

348. For impulsive noise sources (UHRS, CPT) the strong behavioural disturbance ranges vary from 80 m during UHRS to 140 m during CPT (Table 10.46). Qualitatively, no more than one animal of each species would be at risk of experiencing strong behavioural disturbance. Mild disturbance may occur within 565 m during UHRS to 1,330 m during CPT and for all species (Table 10.46), except harbour porpoise, no more than one animal could be affected (Table 10.47). Up to four harbour porpoises could experience mild behavioural disturbance during CPT (Table 10.47), however, such low level disturbance could lead to mild disruptions of normal behaviours, but prolonged or sustained behavioural effects, including displacement are unlikely to occur.

349. For non-impulsive noise sources (MBES, SSS, SBP, borehole drilling, vibrocore), the maximum behavioural disturbance ranges vary from 27 m to the maximum 9,101 m for vibrocoring (Table 10.46). Qualitatively, no more than one animal is predicted to be disturbed during MBES, SSS and borehole drilling. With the use of SBP, up to four harbour porpoises are at risk of experiencing disturbance and up to two grey seals. Due to relatively large disturbance ranges predicted for vibrocoring, based on conservative species-specific densities, up to 170 harbour porpoises could experience disturbance (Table 10.47). Vibrocoring may also lead to disturbance of up to one bottlenose dolphin, 32 white-beaked dolphins, eight minke whales and 47 grey seals (Table 10.47). However, for those animals disturbed, there is likely to be a proportional response, e.g. not all animals will be disturbed to the same extent. There is no dose-response curve available to apply in the context of site-investigation surveys, however, Joy *et al.* (2019) derived a dose-response for killer whales and underwater noise from vessels, indicating that marine mammals display a proportional response to non-impulsive noise. It is important to note that the life history of an individual and the context will also influence the likelihood of an individual to exhibit an aversive response to noise. Furthermore, this threshold does not take into account of ambient sound levels in the area, which may be already be above the 120 dB re 1 µPa (Farcas *et al.*, 2020). Considering that the underwater noise modelling used a single threshold that does not take into account the ambient noise, the numbers of animals potentially disturbed presented for vibrocore and other site-investigation surveys are likely to be an overestimate.

350. The behavioural disturbance ranges will not overlap with any known important areas for any of the species, e.g. Southern North Sea SAC (harbour porpoise), CES[2] MU (bottlenose dolphin), Southern Trench ncMPA (minke whale), Berwickshire and North Northumberland SAC (grey seal) (Table 10.15, Figure 10.3).

Table 10.46: Potential Disturbance Ranges For Geophysical and Geotechnical Site-Investigation Surveys

Metric	Potential Disturbance Range (m) For All Species
Geophysical Surveys	
MBES	375
SSS	320
SBP	1,340
UHRS	565 (mild), 80 (strong)
Geotechnical Surveys	
Borehole drilling	27
CPT	1,330 (mild), 140 (strong)
Vibrocoring	9,101

Table 10.47: Estimated Number of Animals With the Potential To Be Disturbed During Geophysical and Geotechnical Site-Investigation Surveys

Survey Type	Estimated Number of Animals with the Potential to Be Disturbed				
	Harbour Porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale, Humpback Whale	Grey Seal
Geophysical Surveys					
MBES	<1	<1	<1	<1	<1
SSS	<1	<1	<1	<1	<1
SBP	4	<1	<1	<1	2
UHRS	<1	<1	<1	<1	<1
Geotechnical Surveys					
Borehole drilling	N/A	N/A	N/A	N/A	N/A
CPT	4	N/A	N/A	N/A	N/A
Vibrocoring	170	<1	32	8	47

351. The impact (elevated underwater noise during site-investigation surveys) is predicted to be of local to regional spatial extent, short term duration, intermittent and the effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after surveys have ceased). It is predicted that the impact will affect the receptor directly. Whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects. The magnitude was therefore considered to be low.

Sensitivity of the receptor

Auditory injury

352. For geotechnical surveys, injury to marine mammals is unlikely to occur beyond a few tens of metres (Table 10.44) and sound from vessels themselves is likely to deter marine mammals beyond this range. For geophysical surveys, the maximum range for PTS (SBP) is 310 m (Table 10.43). Sills *et al.* (2020) evaluated TTS onset levels for impulsive sound in seals following exposure to underwater sound from a seismic air gun. The study found that transient shifts in hearing thresholds at 400 Hz were apparent following exposure to four to ten consecutive pulses (SEL_{cum} 191 dB dB re $1\mu\text{Pa}^2\text{s}$ to 195 dB re $1\mu\text{Pa}^2\text{s}$; 167 dB dB re $1\mu\text{Pa}^2\text{s}$ to 171 dB re $1\mu\text{Pa}^2\text{s}$ with frequency weighting for PCW). Matthews *et al.* (2020) used a modelling approach to compare potential effects of a non-impulsive sound source (marine vibriosis (MV)) and impulsive seismic sources (air gun) on marine mammals and found few marine mammals could be expected to be exposed to potentially injurious sound levels for either source type, but fewer were predicted for MV arrays than air gun arrays. The estimated number of animals exposed to sound levels depended on the choice of evaluation criteria. When using Sound Pressure Level (SPL), more behavioural disturbance was predicted for MV arrays compared to air gun arrays. However, the opposite was observed when using frequency-weighted sound fields and a multiple-step, probabilistic, threshold function. Matthews *et al.* (2020) therefore highlighted the two metrics relate to different characteristics of both impulsive and continuous sound (e.g. SEL_{cum} looks at accumulative exposure over a set duration whilst SPL_{pk} measures acute exposure to high-amplitude sound).

353. More recently, Ruppel *et al.* (2022) categorised marine acoustic sources into four tiers based on their potential to injure marine mammals using physical criteria about the sources (e.g. source level, transmission frequency, directionality, beamwidth, and pulse repetition rate). Those in Tier Four were considered unlikely to result in 'incidental take' (i.e. loss of individuals) of marine mammals and therefore termed *de minimis,* and included most high-resolution geophysical sources (MBES, SSS, SBP, low powered sparkers). For context, Tier 1 refers to high-energy airgun surveys with a total volume larger than 1500 in^3 or arrays with more than 12 airguns, Tier 2 covers the remaining low/intermediate energy airgun and Tier 3 covers most non-airgun seismic sources, which either have characteristics that do not meet the *de minimis* category (e.g., some sparkers) or could not be fully evaluated in Ruppel *et al.* (2022) (e.g., bubble guns, some boomers).The study also suggested surveys that simultaneously deploy multiple, non-impulsive *de minimis* sources are unlikely to result in incidental take of marine mammals.

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

Behavioural disturbance

355. It is widely recognised that the transmission frequencies of commercial sonar systems (approximately 12 kHz to 1800 kHz) overlap with the hearing ranges of many marine mammal species (Richardson *et al.*, 1995). Many frequencies associated with sonar systems are very high and have peak frequencies well above marine mammal hearing ranges, however it is possible that relatively high levels of sound are also produced as sidebands at lower frequencies (Hayes and Gough, 1992) and therefore may result in behavioural responses.

356. A study undertaken by (Hermannsen *et al.*, 2015) confirmed that there are substantial medium-to-high frequency components in airgun pulses, when reporting the source characteristics and propagation of broadband pulses (10 Hz up to 120 kHz) from a small airgun. These findings suggest that small odontocetes and seals could be affected by even a single airgun. However, Ruppel *et al.* (2022) reported that in response to sonar-like sound sources (e.g. MBES, singlebeam echosounder (SBES)) marine mammals may show subtle behavioural responses although species, behavioural context, location, and prey availability are likely to play more of a role than the acoustic signals themselves. In a study undertaken by MacGillivray *et al*. (2014) seven acoustic sources (including air guns, SBP, MBES and SSS) were compared and documented the sound level above hearing threshold as a function of horizontal distance. Weighting sounds according to hearing sensitivity allows assessment of relative risks associated with exposure and whilst this analysis did not directly relate to potential for behavioural responses, it allowed comparison of modelled acoustic sources. The modelling undertaken in MacGillivray *et al.* (2014) suggested that odontocetes were most likely to hear sounds from mid-frequency sources (such as fisheries, communication, and hydrographic systems), whilst mysticetes, were most likely to hear sounds from low frequency sources (SBP and airguns), and pinnipeds from both mid and low frequency sources. For all species included within the study, modelled sensation levels were lowest for the high frequency sources (e.g. SSS and MBES) which operate at the upper limits of the audible spectrum.

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

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

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

360. 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, 2023), with small odontocetes showing strongest lateral spatial avoidance, moving out of the area, whilst mysticetes and killer whale showed more localised spatial avoidance, orienting away from the vessel and increasing distance from source but not leaving the area completely.

361. A recent 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. Considering findings of other studies ((Dyndo *et al.*, 2015, Tougaard *et al.*, 2015) harbour porpoise disturbance ranges due to airgun sound are predicted to be smaller than to piling sound at the same energy. The reason for this is that the perceived loudness of the airgun pulses is predicted to be lower than for piling sound due to less energy at the higher frequencies where porpoise hearing is better (Sarnocińska *et al.*, 2020). Likewise, Thompson *et al.* (2013) used PAM and DAS to study changes in the occurrence of harbour porpoise across a 2,000 km^2 study area during a commercial two-dimensional seismic survey in the North Sea. The study 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 survey period (ten days) suggesting exposure led to some tolerance of the activity (Thompson *et al.*, 2013). Thompson *et al.* (2013) therefore suggested that prolonged seismic survey sound did not lead to broader-scale displacement into sub-optimal or higher risk habitat. Similarly, a ten-month study of overt responses to seismic exploration in humpback whale, sperm whale *Physeter macrocephalus* and Atlantic spotted dolphin *Stenella frontalis*, demonstrated no evidence of prolonged or large scale displacement of each species from the region during the survey (Weir, 2008).

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

363. Aside from displacement or avoidance, other behavioural responses have been demonstrated (Wright and Cosentino, 2015). Responses to seismic surveys have included cessation of singing (Melcón *et al.*, 2012) and alteration of dive and respiration patterns which may lead to energetic burdens on the animals (Gordon *et al.*, 2003). In some cases, behavioural responses may lead to greater effects, such as strandings (Cox *et al.*, 2001, Tyack *et al.*, 2006) or interruptions to migration (Heide-Jørgensen *et al.*, 2013). However such responses are highly context-dependent and variable, contingent on factors such as the activity of the animal at the time (Robertson, 2014), prior experience to exposure (Andersen *et al.*, 2012), extent or type of disturbance (Melcón *et al.*, 2012), environment in which they inhabit (Heide-Jørgensen *et al.*, 2013) and the type of survey.

364. It is expected that, to some extent, marine mammals will be able to withstand temporary elevated levels of underwater sound during site-investigation surveys and behavioural responses are highly species and context specific (as evidenced in paragraphs 359 to 363).

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

Significance of the effect

Auditory injury

366. Overall, for all IEFs, the magnitude of the impact is deemed to be negligible and the sensitivity of the receptor is considered to be high. The effect will therefore be of **minor** adverse significance, which is not significant in EIA terms.

Behavioural disturbance

367. Overall, for all IEFs, 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

368. 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 (45 m predicted for harbour porpoise only) that it is considered that animals are likely to be deterred beyond this range (i.e. out to 3,259 m) by the vessel noise itself (see Table 10.49). Additionally, as a part of designed in measures (Table 10.22) standard mitigation from JNCC (2017) will be adhered to for the geophysical surveys, which will involve the use of MMOs[2]/PAM monitoring of a standard 500 m mitigation zone for a period of up to 30 minutes prior to the start of surveys (Table 10.22). Soft starts will be applied for electromagnetic equipment (such as SBP and SSS) as well as seismic sources (UHRS).

369. 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 paragraph 368 and in Table 10.22 is not significant in EIA terms.

Operation and maintenance phase

Magnitude of impact

370. Elevated underwater noise generated during the site-investigation surveys may lead to injury and/or disturbance to marine mammals during the operation and maintenance phase. The MDS comprises of routine geophysical surveys such as MBES and SBP (Table 10.17), which will take place once every 24 months for wind turbines and OSP foundations, as well as wind turbines interior and exterior and annually for the first 3 years, then every 24 months for inter-array cables and interconnector cables (Table 10.17). Duration of each geophysical survey campaign will be up to 3 months (Table 10.17).

371. The potential impacts from auditory injury due to elevated underwater noise during site-investigation surveys is described in paragraph 342 *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 347 *et seq*. In terms of behavioural disturbance, although the underwater noise from geophysical surveys could result in a negligible alteration to the distribution of marine mammals, these surveys are anticipated to be short term in nature, targeted to localised areas and occur intermittently over the operation and maintenance phase. Therefore, the impact is likely to be the same or less (due to highly targeted short surveys), than the impact assessed in the construction phase.

372. For injury, the impact (elevated underwater noise during the geophysical surveys) is predicted to be of local spatial extent within the relevant geographic range of reference, short term duration, intermittent and the effect of PTS is permanent. It is predicted that the impact will affect the receptor directly. Since the injury is assumed to be fully mitigated via designed in measures there is considered to be no residual risk of injury and therefore no population-level effects. The magnitude for PTS was therefore considered to be negligible.

373. For the behavioural disturbance, the impact (elevated underwater noise during the geophysical surveys surveys) is predicted to be of local to regional spatial extent within the relevant geographic range of reference, short term duration, intermittent and the effect of behavioural disturbance is reversible (with animals returning to baseline levels soon after surveys have ceased). It is predicted that the impact will affect the receptor directly. Whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects. The magnitude was therefore considered to be low.

Sensitivity of the receptor

374. 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 (auditory injury and behavioural disturbance) is as described previously in paragraph 352 *et seq.*, where it has been assessed as high for auditory injury and medium for behavioural disturbance.

Significance of the effect

Auditory injury (PTS)

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

Behavioural disturbance

376. 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

377. No marine mammal mitigation is considered necessary therefore because the likely effect in the absence of mitigation (beyond designed in measures) is not significant in EIA terms.

INJURY AND DISTURBANCE FROM UNDERWATER NOISE GENERATED DURING VESSEL USE AND OTHER NOISE PRODUCING ACTIVITIES

378. Increased vessel movements and other noise producing activities during the construction, operation and maintenance, and decommissioning phases have the potential to result in a range of effects to marine mammals such as injury, avoidance behaviour or displacement and masking of vocalisations or changes in vocalisation rate.

379. The assessment of LSE[1] from elevated underwater noise due to vessel use and other (non-piling) sound producing activities is based on a vessel and/or activity basis, considering the maximum injury/disturbance range as modelled in volume 3, appendix 10.1. However, it should be noted that several activities could be potentially occurring at the same time and therefore ranges of effects may extend from several vessels/locations where the activity is carried out and potentially overlap.

Construction phase

Magnitude of impact

Auditory injury

Vessel noise

380. During the construction phase of the Array, the increased levels of vessel activity will contribute to background underwater noise levels. The MDS for construction activities associated with the Array assumes up to a total of 97 vessels to be present within the site boundary at any one time making up to 7,902 return trips over the duration of site preparation and construction phases (72 months). Detailed information about numbers of each type of vessel along with number of return trips for each is provided in Table 10.17.

381. Whilst there will be an uplift in vessel activity during the site preparation and construction phases of the Array, the movements will be limited to within the site boundary and are likely to follow existing shipping routes to and from the ports. Based on long term vessel Automatic Identification System (AIS) traffic data from the entire 12 month period of 2023, on average, nine to ten unique vessels per day were recorded within the shipping and navigation study area (site boundary plus 10 nm buffer, see volume 3, appendix 13.1 for more details). Out of the vessels recorded within the shipping and navigation study area, 21% intersected the site boundary and the most common vessel types to intersect was cargo vessels (47%), oil and gas vessels (21%), and tankers (15%). Oil and gas vessels showed seasonal variation with only slight seasonality present in cargo vessels and tankers. Fishing vessels were recorded all year-round with higher volumes between March and September 2022. Additionally, visual observation surveys undertaken in winter 2022 (07 December 2022 to 21 December 2022) and summer 2023 (02 July 2023 to 18 July 2023)

covering the shipping and navigation study area (see volume 3, appendix 13.1 for more details). During the winter vessel traffic survey period, there was an average of nine unique vessels per day recorded within the shipping and navigation study area, with two to three per day within the site boundary. The busiest full day during winter within the site boundary was 16 December 2022, when eight unique vessels were recorded. During the summer vessel traffic survey period, there was an average of 11 unique vessels per day recorded within the shipping and navigation study area, with three to four per day within the site boundary. The busiest full day during summer within the site boundary was the 05 July 2023, when seven unique vessels were recorded.

382. The main drivers influencing the magnitude of the impact are vessel type, speed and ambient sound levels (Wilson *et al.*, 2006b). As described in the navigational risk assessment for the Array, baseline levels of vessel traffic within the site boundary are at a relatively high-level largely due to movements of cargo, followed by oil and gas, tankers, tugs and fishing vessels (refer to volume 3, appendix 13.1 for more details).

383. A detailed underwater sound modelling assessment has been carried out to investigate the potential for injurious and behavioural effects on marine mammals resulting from elevated underwater noise from vessels and non-piling activity, using the latest criteria from Southall *et al.* (2019) (vessel noise is classed as non-impulsive, see 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 interspecific variation or context-dependent differences). This is a precautionary approach as in reality, the distance over which effects may occur will vary according to the species, the ambient sound levels, hearing ability, vertical space use and behavioural response differences. Furthermore, vessel noise will be temporary and transitory, as opposed to permanent and fixed. Due to the mobile nature of marine mammals, it is highly unlikely that any marine mammal would stay at a stationary location or within a fixed radius of a vessel and therefore the underwater noise modelling has been undertaken based on an animal swimming away from the source (or the source moving away from an animal, see volume 3, appendix 10.1 for more details).

384. The underwater noise modelling results indicate that the threshold for PTS was not exceeded for all species for all vessels, except harbour porpoise (Table 10.48). There is a risk of injury (PTS) to harbour porpoise within 15 m from the noise source for sand wave clearance, main installation vessels, cable laying and rock placement vessels. However, it should be noted that the PTS ranges based on SEL threshold do not take into account any ambient noise levels and therefore are likely to be over-precautionary. With designed in measures in place, e.g. adherence to a Navigational Safety and Vessel Management Plan (NSVMP) (volume 4, appendix 24) where vessels will not deliberately approach animals and will remain at low speeds, the risk of auditory injury to marine mammals is considered to be negligible. The designed in measures to reduce the risk of injury to marine mammals (such as the NSVMP, see Table 10.22) will be followed at all times.

Table 10.48: Estimated Potential PTS Ranges From Different Vessels For Marine Mammals (N/E = Threshold Not Exceeded)

Source/Vessel	Potential PTS Ranges (m)			
	VHF	HF	LF	PCW
Sand Wave Clearance	15	N/E	N/E	N/E
Boulder Clearance, Offshore Construction Vessel, Excavator, Backhoe Dredger	N/E	N/E	N/E	N/E
Main Installation Vessels (Barge/DP[1] Vessel)	15	N/E	N/E	N/E
Jack-up Rig/Jack-up Vessel	N/E	N/E	N/E	N/E
Tug/Anchor Handlers	N/E	N/E	N/E	N/E
Cable Laying, Installation Vessels	15	N/E	N/E	N/E
Rock Placement Vessels	15	N/E	N/E	N/E
Guard Vessels, Workboats	N/E	N/E	N/E	N/E
Survey Vessels, Geophysical/Geotechnical Survey Vessels	N/E	N/E	N/E	N/E
Crew Transfer Vessels (CTVs), Service Operation Vessels, Support Vessels, Construction Support Vessels (CSVs), Trenching Support Vessels, UXO Clearance Vessel, PLGR Vessel, Dive Support Vessels (DSVs), SOV Vessels	N/E	N/E	N/E	N/E

Drilled piling

385. Additionally, up to 10% of piles at wind turbine anchors (159 piles) and OSPs (216 piles) are anticipated to require drilling (Table 10.17) and may be a source of underwater noise. The underwater noise modelling found that the PTS threshold will not be exceeded for all marine mammals exposed to drilled pile installation (see volume 3, appendix 10.1 for more details).

386. With regard to injury, the impact (elevated underwater noise during vessel activity and other noise producing activities) is predicted to be of local spatial extent, medium-term duration, intermittent and, although the impact itself is reversible (i.e. the elevation in underwater noise only occurs during vessel activity and other noise producing activities), the effect of PTS is permanent. It is predicted that the impact will affect the receptor directly. Given very small potential injury ranges for harbour porpoise only and considering the application of designed in measures (the NSVMP, volume 4, appendix 24), there is considered to be no residual risk of injury and therefore no population-level effects. The magnitude was therefore considered to be negligible.

Behavioural disturbance

387. Behavioural disturbance from vessel noise is likely to occur only where vessel sound associated with the site-investigation and construction phases of the Array exceeds the background ambient sound level. As discussed in paragraph 381 above, the site boundary is located in waters with relatively high traffic associated with maritime transport, hence the presence of a high proportion of cargo vessels amongst all recorded vessels. Additionally, the site boundary is located in proximity to oil and gas structures in the North Sea and as such the traffic of oil and gas vessels is substantial. Considering the current levels of vessel traffic, it can be anticipated that marine mammals present in the vicinity of the Array marine mammal study area are exposed to some level of background noise.

388. For non-impulsive (continuous) sound sources such as from vessels, there is a single available threshold (120 dB re 1 µPa (rms) based on NMFS (2005)), which is proposed as the basis for the onset of a strong

behavioural reaction. However, it must be noted that thresholds that relate single exposure parameters (e.g. received sound level) to behavioural responses across species and sound types may lead to over-simplification in prediction of effects. Ideally differences between species, situational context, spatial scales and interacting effects of multiple stressors would be quantified to predict effects, but Southall (2021) highlights few studies report this critical data in a systematic structured way. Using a single threshold assumes that 100% of animals above this threshold are disturbed, whilst in reality, for those animals disturbed there is likely to be a proportional response (i.e. not all animals will be disturbed to the same extent). Joy *et al.* (2019) derived a dose-response for killer whales and underwater noise from vessels, indicating that marine mammals display a proportional response to non-impulsive noise. However, there is no dose-response curve available to apply in the context of non-impulsive sound sources for key species in the North Sea.

389. JNCC *et al.* (2010) state that "*it is most unlikely that a passing vessel would cause more than trivial disturbance. It is the repeated or chronic exposure to vessel noise that could cause disturbance*". Therefore, it is important to note that the 120 dB re 1 µPa (rms) criterion is very precautionary and that ambient sound levels in the North Sea could well exceed this value (NMFS, 2005, Xodus, 2014). This conservative assumption has been corroborated by Farcas *et al.* (2020), where the authors constructed a computational model of underwater noise levels in the North-east Atlantic using AIS data and environmental parameters and found that the annual median broadband noise level exceeded 120 dB re 1 µPa around offshore installations in the northern North Sea. Given the close proximity of the site boundary to the offshore oil and gas installations, it is anticipated that the background noise levels within the Array marine mammal area are close to or exceeding the 120 dB re 1 µPa (rms) criterion. Therefore, behavioural disturbance ranges and number of animals potentially disturbed presented in this section should be interpreted with caution.

390. The estimated ranges within which there is a potential for disturbance to marine mammals are presented in Table 10.49. Survey vessels, CTVs, SOVs, support vessels, CSVs, trenching support vessels, UXO clearance vessel, PLGR vessels and DSVs resulted in the greatest modelled disturbance out to 3,259 m for all marine mammal species (Table 10.49). The greatest disturbance range for other non-vessel continuous sound behavioural effects was predicted to be 2,224 m due to underwater sound from sand wave clearance, cable laying and rock placement activities (Table 10.49). In comparison, behavioural disturbance ranges for activities such as boulder clearance, offshore construction vessels, excavators and backhoe dredgers were predicted out to only 302 m (Table 10.49).

Table 10.49: Estimated Potential Disturbance Ranges From Different Vessels For All Marine Mammals (N/E = Threshold Not Exceeded)

Source/Vessel	Potential Disturbance Range (m)
	All species
Sand Wave Clearance	2,224
Boulder Clearance, Offshore Construction Vessel, Excavator, Backhoe Dredger	302
Main Installation Vessels (Barge/DP[1] vessel)	2,224
Jack-up rig/Jack-up Vessel	N/E
Tug/Anchor Handlers	1,131
Cable Laying	2,224
Rock Placement Vessels	2,224
Guard Vessels, Workboats	1,131
Survey Vessels	3,259
CTVs, Service Operation Vessels, Support Vessels, CSVs, Trenching Support Vessels, UXO Clearance Vessel, PLGR Vessel, DSVs, SOV Vessels	3,259

391. Additionally, up to 10% of piles at wind turbine anchors (159 piles) and OSPs (216 piles) are anticipated to require drilling (Table 10.17) and may be a source of underwater noise. The underwater noise modelling found that disturbance range for drilled piling was out to 309 m, comparable to disturbance ranges from boulder clearance, offshore construction vessel, excavator, backhoe dredger vessels.

392. The number of animals predicted to experience behavioural disturbance due to vessel use and other noise producing activities is presented in Table 10.50. Given the largest behavioural disturbance ranges and precautionary peak seasonal site-specific densities (Table 10.13), the largest number of animals affected was found for harbour porpoise where up to 22 animals could experience strong disturbance as a result of activity of survey vessels, CTVs, SOVs, support vessels, CSVs, trenching support vessels, UXO clearance vessel, PLGR vessels and DSVs (0.01% of the North Sea MU population). The second and third largest number of animals disturbed was predicted for grey seal and white-beaked dolphin with up to six and four individuals potentially disturbed respectively (0.02% of the East Scotland MU plus North-east England seal MU for grey seal and 0.01% of the CGNS MU for white-beaked dolphin) due to the activity of the same type of vessels as listed for harbour porpoise (Table 10.50). For bottlenose dolphin and minke whale the number of animals predicted to be disturbed was very small with no more than one animal within the predicted effect zones (Table 10.49, Table 10.50). It is important to highlight that multiplying numbers of animals presented in Table 10.50 by the numbers of vessels expected over the site preparation and construction phases (Table 10.17) could lead to unrealistic estimates as it does not allow for any overlap between vessels (and therefore would double count), nor does it account for periods when vessels are stationary.

393. The behavioural disturbance ranges will not overlap with any known important areas for any of the species, e.g. Southern North Sea SAC (harbour porpoise), CES[2] MU (bottlenose dolphin), Southern Trench ncMPA (minke whale), Berwickshire and North Northumberland SAC (grey seal) (Table 10.15, Figure 10.3).

Table 10.50: Maximum Number of Animals With the Potential to Experience Disturbance Due to Vessel use and Other Noise Producing Activities

Source/Vessel	Number of Animals				
	Harbour Porpoise	Bottlenose Dolphin	White-beaked Dolphin	Minke Whale	Grey Seal
Sand Wave Clearance	11	<1	2	<1	3
Boulder Clearance, Offshore Construction Vessel, Excavator, Backhoe Dredger	<1	<1	<1	<1	<1
Main Installation Vessels (Barge/DP[1] vessel)	11	<1	2	<1	3
Tug/Anchor Handlers	3	<1	<1	<1	<1
Cable Laying	11	<1	2	<1	3
Rock Placement Vessels	11	<1	2	<1	3
Guard Vessels, Workboats	3	<1	<1	<1	<1
Survey Vessels	22	<1	4	<1	6
CTVs, Service Operation Vessels, Support Vessels, CSVs, Trenching Support Vessels, UXO Clearance Vessel, PLGR Vessel, DSVs, SOV Vessels	22	<1	4	<1	6

394. The impact (elevated underwater noise during vessel use and other noise producing activities) is predicted to be of local to regional spatial extent, medium-term duration, intermittent and the effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after they moved from the impact zone). It is predicted that the impact will affect the receptor directly. Whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects. The magnitude was therefore considered to be low.

Sensitivity of the receptor

Auditory injury

395. The sensitivity of marine mammal receptors to auditory injury has been assessed in detail in paragraph 217 *et seq.,* and therefore is not reiterated here. PTS ranges that are a result of vessels involved in the construction phase (non-impulsive sound) are far lower than PTS ranges for piling (impulsive sound) and the numbers of animals potentially injured are very low for all species.

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

Behavioural disturbance

397. 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 (International Whaling Commission (IWC), 2006, Senior *et al.*, 2008).

398. It is understood that 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). It varies by species, for example Anderwald *et al.* (2013) showed that bottlenose dolphin were beneficially correlated with total number of boats and number of utility vessels, but minke whale and grey seal were displaced by high levels of vessel traffic.

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

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

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

402. Reactions of marine mammals to vessel sound are often linked to changes in the engine and propeller speed (Richardson *et al.*, 1995). Watkins (1986) reported avoidance behaviour in mysticetes from loud or rapidly changing sound sources, particularly where a boat approached an animal. Disturbance in dolphins and porpoises is likely to be associated with the presence of small, fast-moving vessels as they are more sensitive to high frequency sound, whilst mysticetes, such as minke whale, are likely to be more sensitive to slower moving vessels emitting lower frequency sound. Pirotta *et al.* (2015) found that transit of vessels (moving motorised boats) in the Moray Firth resulted in a reduction (by almost half) of the likelihood of recording bottlenose dolphin prey capture buzzes. The study also suggested that vessel presence, not just vessel sound, resulted in disturbance.

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

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

405. The presence of vessels in foraging grounds could also result in reduced foraging success. The presence of whale-watching boats within an important feeding ground for minke whale led to a reduction in foraging activity Christiansen and Lusseau (2015). As a capital breeder, such a reduction could lead to reduced reproductive success since female body condition associated with foetal growth (Christiansen *et al.*, 2014). However, it is worth noting that the study by Christiansen and Lusseau (2015) was conducted in Faxafloi Bay in Iceland where baseline sound levels (compared to the North Sea) are very low (McGarry *et al.*, 2017). In addition, a subsequent study in the same area found no significant long term effects of disturbance from whale-watching on vital rates, as whales moved into disturbed areas when sandeel numbers were lower across their wider foraging area (Albert *et al.* (2022). Hastie *et al.* (2021) demonstrated how foraging context is important when interpreting avoidance behaviour in grey seals, and should be considered when predicting the effects of anthropogenic activities. Avoidance rates appeared to depend on the perceived risk (e.g. silence, pile driving sound, operational sound from tidal turbines) versus the quality of the prey patch Hastie *et al.* (2021). Therefore, it must be highlighted 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 Array shipping and navigation study area, it is expected that marine mammals could tolerate the effects of disturbance without any impact on reproduction and survival rates and would return to previous activities once the impact had ceased.

406. There is indication of tolerance to boat traffic (and anthropogenic sounds and activities in general) and so a slight increase from the existing levels of traffic in the vicinity of the Array may not necessarily result in high levels of disturbance (Vella *et al.*, 2001). Whilst it cannot be assumed that tolerance to a stressor is evidence of absence of detrimental consequences for targeted animals (e.g. physiological responses are not easily detectable in free-ranging wild animals), there is evidence of animals (from multiple species) remaining in areas of high vessel traffic, described in paragraphs 407 *below*.

407. For example, high co-occurrence between grey seal/harbour seal and shipping traffic within 50 km of the coastline near to haul-out sites were shown in a national scale assessment of seals and shipping in the UK (Jones *et al.*, 2017). Thompson *et al.* (2011) (Scottish Natural Heritage (SNH) commissioned report) undertook a modelling study which predicted that increased vessel movements associated with offshore wind development in the Moray Firth would not have an adverse effect on the local population of bottlenose dolphin (although, similar to Benhemma-Le Gall *et al.* (2021), it did note that foraging may be disrupted by disturbance from vessels).

408. Potlock *et al.* (2023) used cetacean porpoise detector (C-POD) detections of sonar activity as a proxy for vessel disturbance during construction of wind turbines foundations off Blyth, Northumberland. The vessel sonar variable was significant in both the dolphin (potentially bottlenose dolphin and/or white-beaked dolphin) and harbour porpoise models. The effect size was substantial in both species, with around eight minutes of sonar occurrence per hour leading to a 50% decline in harbour porpoise occurrence and around 13 minutes of sonar occurrence per hour leading to a 50% decline in dolphin occurrence. Despite this, dolphin occurrence during and after construction were not significantly different to the occurrence before the construction phase. Similarly, the increase in harbour porpoise occurrence across this study suggests that construction and after construction vessel activity did not result in any overall decline in area usage (Potlock *et al.*, 2023).

409. Bottlenose dolphins have been found to both increase and decrease whistle frequencies in noisy environments, avoiding acoustic masking and improving signal transmission (Heiler *et al.*, 2016, La Manna *et al.*, 2013, May-Collado and Wartzok, 2008, Peters, 2018, Rako Gospić and Picciulin, 2016). Therefore, it is suggested that if marine mammals depend on specific areas to maintain their activities, and the benefits exceed the cost of disturbance, animals may show increased tolerance instead of site avoidance (Antichi *et al.*, 2022). Marine mammals therefore could continue to regularly visit the areas where they may be affected by the vessel presence (Antichi *et al.*, 2022, Rako Gospić and Picciulin, 2016). Wisniewska *et al.* (2018a) found tagged porpoises did not appear to avoid highly trafficked areas, potentially because these overlapped with important foraging habitats (deep waters which may aggregate important prey items).

410. Additionally, Joy *et al.* (2019) conducted a voluntary commercial vessel slowdown trial through 16 nm of shipping lanes which overlapped with critical habitat of at-risk southern resident killer whales. Disturbance metrics were simplified to a “lost foraging time” measure and demonstrated (when compared to baseline sound levels in the region) the slowdown trial achieved 22% reduction in ‘potential lost foraging time’ for killer whales (with 40% reductions when 100% of vessels were under the 11 knot speed limit). With the exception of CTVs, most vessels involved in the construction phase are likely to be travelling considerably slower than 11 knots (with all vessels travelling at at safe speeds at all times and reduce speed if appropriate when a marine mammal is in the vicinity, detailed in the NSVMP (volume 4, appendix 24, Table 10.22).

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

Significance of the effect

Auditory injury

412. Designed in measures adopted as part of the Array include the development of and adherence to a NSVMP, volume 4, appendix 24 (or equivalent) (Table 10.22) which includes requirements to not deliberately approach marine mammals as a minimum, avoid abrupt changes in course or speed should marine mammals approach the vessel to bow-ride and to remain at safe speeds at all times and reduce speed when a marine mammal is in the vicinity. Therefore, these measures will further reduce the potential risk of injury and the scale of effect (injury radius and number of animals affected) was predicted to be very small.

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

Behavioural disturbance

414. 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

415. No further marine mammal mitigation is considered necessary (beyond design-in measures detailed in Table 10.22) because the likely effect in the absence of mitigation is not significant in EIA terms.

Operation and maintenance phase

Magnitude of impact

416. During the operation and maintenance phase of the Array, the increased levels of vessel activity will contribute to background underwater noise levels. The MDS for operation and maintenance activities associated with the Array assumes up to a total of 30 vessels to be present within the site boundary at any one time making up to 508 return trips over the duration of operation and maintenance phase (35 years). Detailed information about numbers of each type of vessel along with number of return trips for each is provided in Table 10.17.

417. The uplift in vessel activity during the operation and maintenance phase is considered to be relatively small in the context of the baseline levels of vessel traffic in the vicinity and within the site boundary (see paragraph 381 above). Presence of the operational wind farm may divert some of the vessel routes and therefore, current traffic within the site boundary, which is not associated with the Array, is likely to be reduced. It is likely that this reduction will ultimately be counterbalanced by presence of maintenance vessels. Vessel movements will be limited to within the site boundary and are likely to follow existing shipping routes to and from the ports. The designed in measures to reduce the behavioural disturbance to marine mammals (such as the NSVMP, volume 4, appendix 24, see Table 10.22) will be followed at all times.

418. The size and sound 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 (Table 10.48 and Table 10.49). However, the number of vessels and round trips is much lower for the operation and maintenance phase compared to the construction phase.

Auditory injury

419. An overview of potential impacts from elevated underwater noise due to vessel use and other (non-piling) noise producing activities as well as associated effects (auditory injury) are described in paragraph 380 *et seq.* for the construction phase and have not been reiterated here for the operation and maintenance phase of the Array.

420. The impact (elevated underwater noise during vessel activity and other noise producing activities) is predicted to be of local spatial extent in the context of the geographic frame of reference, long term duration, intermittent and the effect of PTS is permanent. It is predicted that the impact will affect the receptor directly. The magnitude was therefore considered to be negligible.

Behavioural disturbance

421. An overview of potential impacts from elevated underwater noise due to vessel use and other (non-piling) noise producing activities as well as associated effects (behavioural disturbance) are described in paragraph 387 *et seq.* for the construction phase and have not been reiterated here for the operation and maintenance phase of the Array.

422. The impact (elevated underwater noise during vessel use and other noise producing activities) is predicted to be of local to regional spatial extent in the context of the geographic frame of reference, long term duration, intermittent and the effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. Whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects. The magnitude was therefore considered to be low.

Sensitivity of the receptor

Auditory injury

423. The sensitivity of marine mammal receptors to auditory injury has been considered in detail in paragraph 217 *et seq.*, and therefore is not reiterated here. PTS ranges that are a result of vessels involved in the operation and maintenance 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.

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

Behavioural disturbance

425. 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, which is described previously in paragraph 397 *et seq.* and is deemed to be medium.

Significance of the effect

Auditory injury

426. Designed in measures adopted as part of the Array includes the development of and adherence to a NSVMP (volume 4, appendix 24) (or equivalent) (Table 10.22) which includes requirements to not deliberately approach marine mammals as a minimum, avoid abrupt changes in course or speed should marine mammals approach the vessel to bow-ride and to remain at safe speeds at all times . Therefore, these measures will further reduce the potential risk of injury and the scale of effect (injury radius and number of animals affected) was predicted to be very small.

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

Behavioural disturbance

428. 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

429. No further marine mammal mitigation is considered necessary (beyond design-in measures detailed in Table 10.22) because the likely effect in the absence of mitigation is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

Vessel noise

430. During the decommissioning phase of the Array, the increased levels of vessel activity will contribute to background underwater noise levels. Vessel types which will be required during the decommissioning phase include those used during removal of foundations, cables and cable protection, however the exact number of vessels and return trips is unknown at this stage.

Underwater cutting

431. It is anticipated that maximum levels of underwater noise during the decommissioning phase would originate from underwater cutting required to remove structures (e.g. jacket foundations at OSPs). This is likely to be much less than pile driving and therefore impacts are likely to be less than as assessed during the construction phase. Given that the types of vessels used to remove infrastructure (and hence their size and outputs) are expected to be similar to those used for installation, the potential impacts from elevated underwater noise due to vessel use and other (non-piling) noise producing activities is expected to result in a similar maximum design spatial scenario as the construction phase. As such, the magnitude of the impact of the decommissioning phase for both auditory injury and behavioural disturbance for all marine mammal receptors, is not expected to differ or be greater than that assessed for the construction phase (paragraph 380 *et seq.)*.

Auditory injury

432. An overview of potential impacts from elevated underwater noise due to vessel use and other (non-piling) noise producing activities as well as associated effects (auditory injury) are described in paragraph 380 *et seq.* for the construction phase and have not been reiterated here for the decommissioning phase of the Array.

433. The impact (elevated underwater noise during vessel activity and other noise producing activities) is predicted to be of local spatial extent, medium term duration, intermittent and, although the impact itself is reversible (i.e. the elevation in underwater noise only occurs during vessel activity and other noise producing activities), the effect of PTS is permanent. It is predicted that the impact will affect the receptor directly. Given very small potential injury ranges for harbour porpoise only and considering the application of designed in measures (NSVMP, volume 4, appendix 24), there is considered to be no residual risk of injury and therefore no population-level effects. The magnitude was therefore considered to be negligible.

Behavioural disturbance

434. An overview of potential impacts from elevated underwater noise due to vessel use and other (non-piling) noise producing activities as well as associated effects (behavioural disturbance) are described in paragraph 387 *et seq.* for the construction phase and have not been reiterated here for the decommissioning phase of the Array.

435. The impact (elevated underwater noise during vessel use and other noise producing activities) is predicted to be of local to regional spatial extent, medium-term duration, intermittent and the effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after they moved from the impact zone). It is predicted that the impact will affect the receptor directly. Whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects. The magnitude was therefore considered to be low.

Sensitivity of the receptor

Auditory injury

436. The sensitivity of marine mammal receptors to auditory injury has been considered in detail in paragraph 217 *et seq.*, and therefore is not reiterated here. PTS ranges that are a result of vessels involved in the decommissioning 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.

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

Behavioural disturbance

438. The sensitivity of the receptors during the decommissioning phase is not expected to differ from the sensitivity of the receptors during the construction phase, which is described previously in paragraph 397 *et seq.* and is deemed to be medium.

Significance of the effect

Auditory injury

439. Designed in measures adopted as part of the Array includes the development of and adherence to a NSVMP, volume 4, appendix 24 (or equivalent) (Table 10.22) which includes requirements to not deliberately approach marine mammals as a minimum, avoid abrupt changes in course or speed should marine mammals approach the vessel to bow-ride and to remain at safe speeds at all times. Therefore, these measures will further reduce the potential risk of injury and the scale of effect (injury radius and number of animals affected) was predicted to be very small.

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

Behavioural disturbance

441. 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

442. No further marine mammal mitigation is considered necessary (beyond design-in measures detailed in Table 10.22) because the likely effect in the absence of mitigation is not significant in EIA terms.

INJURY DUE TO COLLISION WITH VESSELS

Construction phase

Magnitude of impact

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

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

445. 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 (Helker *et al.*, 2017, NMFS, 2023). In contrast, non-serious injury is likely to result in short term impacts which may have long term effects on health and lifespan.

446. As discussed in paragraph 380, vessel traffic associated with the construction activities will result in an increase in vessel movements within the Array marine mammal study area, as up to 7,902 return trips by construction vessels may be made throughout the construction phase (Table 10.17). This increase, described in more detail in paragraph 380 *et seq*., could lead to an increase in interactions between marine mammals and vessels. Vessels travelling at 7 m/s (~14 knots) or faster are those most likely to cause death or serious injury to marine mammals (Laist *et al.*, 2001, Wilson *et al.*, 2006a). All vessels will be required to adhere to the NSVMP which includes not deliberately approaching marine mammals as a minimum, to avoid abrupt changes in course or speed should marine mammals approach the vessel to bow-ride and to remain at safe speeds at all times (as detailed in Table 10.22) and reduce speed when a marine mammal is in the vicinity, which is therefore appropriate to reduce risk of collision for species found within the regional marine mammal study area as far as practicable. Therefore, with the designed in measures as part of the Array in place, the risk of collision is anticipated to be reduced and would only be present for transiting vessels (as opposed to stationary).

447. Furthermore, a proportion of vessels involved in construction will be relatively small in size (e.g. tugs, vessels, support vessels, CTVs, dive boats, barges) and due to good manoeuvrability would be able to move to avoid marine mammals where detected (Schoeman *et al.*, 2020). Larger vessels such as cargo-barges and installation vessels with lower manoeuvrability may need larger distances to avoid an animal, however they will also be travelling at slower speeds and have more time to react when a marine mammal is detected. In addition, the sound emissions from vessels involved in the construction phase are likely to deter animals from the potential zone of impact. The vessel movements will likely be contained within the site boundary.

448. The impact is predicted to be of local spatial extent in the context of the geographic frame of reference, medium term duration, intermittent and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of the receptor

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

450. As discussed in paragraphs 443 to 444 vessel strikes are known to be a cause of mortality in marine mammals (Carrillo and Ritter, 2010), and it is possible that mortality from vessel strikes is under-recorded (Van Waerebeek *et al.*, 2007), particularly for smaller marine mammals (Schoeman *et al.*, 2020). Collisions between vessels and large whales can often lead to death or serious injury (Kraus, 1990) collisions between cetaceans and vessels are not necessarily lethal on all occasions (Van Waerebeek *et al.*, 2007). Although all types of vessels may hit whales, most lethal and serious injuries are caused by large ships (e.g. 80 m or longer) and vessels travelling at speeds faster than 14 knots (Laist *et al.*, 2001).

451. Given harbour porpoise, as the most abundant cetacean species in the regional marine mammal study area, are small and highly mobile and considering their potential avoidance responses to vessel noise (see paragraph 380), it can be assumed that they will largely avoid vessel collisions. UK 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 may have resulted from vessel strikes (CSIP, 2015).

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

453. However, 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). A study in the Moray Firth, Scotland Onoufriou *et al.* (2016) 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 and only three instances over the 2,241 days of recorded seal activity resulted in passes at <20 m.

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

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

Significance of the effect

456. Overall, the magnitude of the impact is deemed to be low (particularly with the adoption of the NSVMP, volume 4, appendix 24) 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

457. No marine mammal mitigation is considered necessary, in addition to the measures adopted as part of the array, because the likely effect in the absence of further mitigation is not significant in EIA terms.

Operation and maintenance phase

Magnitude of impact

458. Vessel use during operation and maintenance phase of Array may lead to injury to marine mammals due to collision with vessels. Vessel types which will be required during the operation and maintenance phase including CTVs, SOVs, jack-up vessels, cable repair vessels, CSVs and DSVs (Table 10.17). 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 443 *et seq*. for the construction phase and have not been reiterated here for the operation and maintenance phase.

459. The impact is predicted to be of local spatial extent in the context of the geographic frame of reference, long term duration, intermittent and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of the receptor

460. 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 449 *et seq.,* where it has been assessed as medium.

Significance of the effect

461. Overall, the magnitude of the impact is deemed to be low (particularly with the adoption of the NSVMP, volume 4, appendix 24) 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

462. No marine mammal mitigation is considered necessary, in addition to the measures adopted as part of the array, because the likely effect in the absence of further mitigation is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

463. Vessel use during decommissioning phase of the Array may lead to injury to marine mammals due to collision with vessels. Vessels will be required for activities such as removal of foundation, cables and cable protection (Table 10.17). Noise from vessels is assumed to be as per vessel activity described for construction phase, with an overview of the potential impacts described in paragraph 443 *et seq*. for the construction phase and have not been reiterated here for the decommissioning phase.

464. The impact is predicted to be of local spatial extent, medium term duration, intermittent and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of the receptor

465. 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 449 *et seq.,* where it has been assessed as medium.

Significance of the effect

466. Overall, the magnitude of the impact is deemed to be low (particularly with the adoption of the NSVMP, volume 4, appendix 24) 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

467. No marine mammal mitigation is considered necessary, in addition to the measures adopted as part of the array, because the likely effect in the absence of further mitigation is not significant in EIA terms.

EFFECTS ON MARINE MAMMALS DUE TO EMFS FROM SUBSEA ELECTRICAL CABLING IN THE WATER COLUMN

468. The marine environment features natural magnetic and electric fields associated with both physical and biological sources, alongside anthropogenic EMFs that permeate it (Gill *et al.*, 2014). This section involves the assessment of the LSE[1] of EMFs from the dynamic inter-array cables on marine mammals.

Operation and maintenance phase

Magnitude of impact

469. Electricity transfer through AC and DC submarine cables generates EMFs consisting of an electric field component and a magnetic field component (Normandeau Associates Inc *et al.*, 2011). The introduction of subsea cabling within the Array marine mammal study area will increase EMFs in the marine environment. These fields have the potential to alter the behaviour and distributions of species that rely on electric and/or magnetic signals for navigation and hunting.

470. As outlined in Table 10.17, the Array is designed to have up to 116 km of dynamic inter-array cables within the water column. While EMFs from inter-array cables may be lower than those from offshore export cables due to the reduced amount of power being transmitted (Thomsen *et al.*, 2015a), several factors can influence the strength of EMFs generated from the inter-array cables. These factors include the distance between conductors, the balance of the load and the type of cable (Copping and Hemery, 2020). Different dynamic cable hanging configurations for FOW structures exist, but the specific arrangement for the Array within the Project Description (e.g. catenary, taut, semi-taut; volume 1, chapter 3) is to be determined post-consent. There is consensus among marine renewable energy (MRE) researchers, developers, and regulators that EMFs travelling through cables from single or small numbers of devices will have relatively low EMF intensities and therefore of very localised extent, resulting in low potential for encounter with animals, and therefore pose a low risk to sensitive marine species (Copping *et al.*, 2020, Hasselman *et al.*, 2023). The intensity of EMF from subsea cables decreases at approximately the inverse square/power of the distance away from the cable (Hutchison *et al.*, 2021), and this attenuation is the same for buried, unburied, and dynamic cables (Hutchison *et al.*, 2021). Therefore, levels of EMF are expected to return to baseline levels with a few metres of the cable.

471. Marine mammals have been observed to be affected more by the magnetic fields (Gill *et al.*, 2014, Kirschvink *et al.*, 1986, Klinowska, 1990, Tricas and Gill, 2011) rather than electric fields, with passive electroreception inferred as a sensory modality in only two species of odontocetes (Czech-Damal *et al.*, 2012, Hüttner *et al.*, 2022). Whales and dolphins are believed to form a useful "magnetic map" which allows them to travel in areas of low magnetic intensity and gradient ("magnetic valleys" or "magnetic peaks") (Walker *et al.*, 2003). The current lack of data on magnetic fields within commercial scale FOW farms poses challenges for a comprehensive understanding of the associated risks, and knowledge gaps exist around the estimates of cumulative EMF (i.e. repeated exposure through time and space) (Ocean Science Consulting Ltd., 2022). Therefore, at this stage it is difficult to quantify the exact effects of EMF on marine mammals. Even direct calculations of magnetic fields from dynamic cables alone are considered insufficient for a general risk assessment (Tricas and Gill, 2011). Interactions between the cable system and the Earth's magnetic field are site-specific and depend on factors such as the intensity, shape, direction, and spatial extent of the resultant magnetic field (Tricas and Gill, 2011).

472. Furthermore, the distance between cables can influence the resulting magnetic intensity. The specific mooring arrangement for the Array is yet to be determined and therefore the potential for electric and magnetic fields from dynamic cables in the Array is currently not feasible to assess in detail. The effects of EMFs for arrays may be additive (rather than synergistic) as some cables may be in close proximity to each other directly under the wind turbine at the cable stiffener, with each cable generating its own near-field magnetic field (Hasselman *et al.*, 2023). Any interaction of EMF would therefore only occur in very close proximity to the underside of the floating foundation. However, most cables will be significantly further apart than this, and the minimum turbine spacing at the Array will be 1000 m, as detailed in volume 1, chapter 3. Magnetic fields from cables are anticipated to dissipate in close proximity to the cable. The likelihood of substantial additive effects of EMF or interaction from adjacent cables is therefore considered to be minimal. . At these ranges, any exposures to EMF are expected to be very short (e.g. few minutes) and occur only when the marine mammal swims through the highly localised area with elevated EMF surrounding the cable (CSA Ocean Sciences Inc and Exponent, 2019). The high mobility of cetaceans means they are unlikely to remain under the influence of EMFs for any prolonged period (Ocean Science Consulting Ltd., 2022), and the spacing (1000 m) between wind turbines at the Array allows influence-free spaces. Furthermore, the length of dynamic cables (up to 116 km) is small in the context of the large site boundary and the water depths within it, and the rapid decay (i.e. within metres) of EMFs with horizontal and vertical distance (Bochert and Zettler, 2006) would also reduce the extent of potential impacts. The area in which EMF is elevated will be very small around each cable and represents a very small portion of the available habitat for marine mammals, who utilise large areas of the ocean (evidenced by the large MUs given for marine mammals). So whilst EMF levels from dynamic cables will be higher than those from buried cables, beyond the range of a few metres, levels of EMFs will be expected to be at baseline levels for this part of the North Sea, resulting in potential impacts that would therefore be highly localised. CSA Ocean Sciences Inc and Exponent (2019) considered the area around undersea power cables to be small (less than 10 m) around the cable, and localised and transient.

473. To date, studies on EMF-receptor interactions in marine mammals have primarily taken place in controlled settings, such as laboratories or field-deployed enclosures (Copping and Hemery, 2020). However, there is a lack of research on EMF-receptor interactions specifically related to multiple subsea cables, particularly in the vicinity of existing FOW farms (Copping and Hemery, 2020). Consequently, there is no available evidence to facilitate assessments for large scale FOW projects, and there is paucity of data on this topic from other industries. Copping and Hemery (2020) concluded that although odontocetes and mysticetes are likely to detect and respond to the EMFs from underwater cables, there is no evidence that species are likely to be adversely affected. EMF-receptive species may respond to low intensity changes, but the range at which animals respond behaviourally (e.g. attraction or avoidance) is unknown and highly difficult to identify (Albert *et al.*, 2020, Hutchison *et al.*, 2020). Similarly, Geelhoed *et al.* (2022b) investigated the potential effect of EMFs from export cables at the Borssele Offshore Wind Farm to influence acoustic activity in harbour porpoise, and no relationship was observed.

474. Across all marine mammal species likely to be encountered in the vicinity of the Array, only humpback whales are known for travelling long annual migration distances that could be potentially affected by magnetic fields (Rizzo and Schulte, 2009, Tricas and Gill, 2011). There is evidence that humpback whales are seasonally present in waters off the east coast of Scotland and that these waters may represent a migratory stopover, or a feeding or recovery opportunity during a longer migration (O'Neil *et al.*, 2019). Whilst it has been suggested that adverse effects on humpback whales occurring in Scottish waters could potentially impact populations in Cape Verde, it is not feasible to assess how many individuals are present off eastern Scotland in total over recent years (see paragraph 206 for more details). There is no evidence that the waters in the vicinity of the Array marine mammals study area represent an important feeding ground during their migration for notable proportion of the population. Considering the above, alongside the seasonality of humpback whale encounters (see paragraph 163), it is unlikely that potential effects associated with EMFs could result in measurable population consequences.

475. The impact is predicted to be of local spatial extent within the geographic frame of reference, long term duration, continuous 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.

Sensitivity of the receptor

476. Sensitivity of marine mammals to EMF is not widely understood (Ocean Science Consulting Ltd., 2022, Taormina *et al.*, 2018). As of now, there is limited information available regarding the existence and functionality of an electric sense in cetaceans. Czech-Damal *et al.* (2012) observed that the hairless vibrissal crypts on the rostrum of the Guiana dolphin *Sotalia guianensis*, initially associated with mammalian whiskers, serve as electroreceptors. The reported perception threshold for the dolphin was 4.6 μV/cm. Considering that fish can produce bioelectric fields above this level, the observed sensitivity is well-suited for detecting bioelectric fields generated by prey items (Czech-Damal *et al.*, 2012). Subsequently, Hüttner *et al.* (2022) conducted a study on the electroreceptive abilities of bottlenose dolphins and proposed the hypothesis that bottlenose dolphins can perceive electric DC fields well below 0.5 mV/cm^{-1}. Both studies suggested that passive electroreception functions as a supplementary sense to echolocation during benthic feeding, also described for bottlenose dolphins as crater-feeding (Czech-Damal *et al.*, 2012, Hüttner *et al.*, 2022).

477. Many cetacean species migrate seasonally, covering distances of up to thousands of kilometres each year as they travel between summer feeding grounds in northern waters and wintering grounds in southern waters (Tricas and Gill, 2011). Both mysticetes (e.g. humpback whales) and odontocetes (e.g. dolphins and porpoises), have displayed beneficial correlations with geomagnetic field differences (Tricas and Gill, 2011). While the studies have not determined the precise mechanism for magneto-sensitivity, the observational, theoretical (based on correlation studies), behavioural, physiological, and anatomical evidence, including the presence of magnetite, collectively suggest that cetaceans can sense the Earth's

magnetic field and potentially use it for long-distance migrations (Kirschvink *et al.*, 1986, Klinowska, 1990, Tricas and Gill, 2011, Walker *et al.*, 2003). Cetaceans seem to use the Earth's magnetic field for migration in two primary ways: as a map by moving parallel to the contours of the local field topography and as a timer based on the regular fluctuations in the field, allowing animals to monitor their progress on this map (Klinowska, 1990). As such, there exists the potential for animals to react to local variations in the geomagnetic field caused by EMFs from a large number of cables (Walker *et al.*, 2003). Depending on the magnitude and persistence of these changes, such effects could result in trivial temporary alterations in swim direction or longer detours during the animal's migration (Gill *et al.*, 2005).

478. Hutchison *et al.* (2021) in the context of buried cables, suggested that the proximity of an animal to the seabed is a contributing factor to the distance from the source and will influence the intensity of EMF to which the animal is exposed. If it is assumed to be the same for the dynamic cables in the water column, it is believed that despite being magneto-sensitive, marine mammals have a relatively low likelihood of being affected by inter-array cable EMFs as their high mobility would limit the duration of exposure (Tricas and Gill, 2011). Furthermore, given marine mammals must surface for air to breathe at intervals (deemed necessarily pelagic), the time experiencing EMF would be further limited (US Wind Inc., 2023). The risk of EMF may increase in the event an animal encounters multiple cables, with fewer EMF-free spaces to navigate. However, in a recent literature review on the effects of EMFs from FOW (Ocean Science Consulting Ltd., 2022), the risk from EMF is still considered to be minimal.

479. To date no studies have provided direct evidence of magnetoreception in pinnipeds (Ocean Science Consulting Ltd., 2022), it is possible they may detect B-fields, with observations of animals correcting to follow constant headings over large distances (Tricas and Gill, 2011).

480. All receptors, except humpback whale, are deemed to be of high resilience, high adaptability and recoverability and international value. The sensitivity of these receptors is therefore, considered to be low.

481. Humpback whale is conservatively deemed to be of medium resilience and adaptability and high recoverability. The sensitivity of humpback whale is therefore, considered to be medium.

Significance of the effect

482. Overall, for all marine mammal species, the magnitude of the impact is deemed to be low and the sensitivity is considered to be low for all species except humpback whale, which is assessed as medium. Due to the variance associated with the magnitude (i.e. low to medium), the effect is assessed precautionarily as being of **minor** adverse significance (rather than negligible), which is not significant in EIA terms.

Secondary mitigation and residual effect

483. No marine mammal mitigation is considered necessary because the likely effect in the absence of mitigation is not significant in EIA terms.

INJURY AND DISTURBANCE FROM UNDERWATER NOISE GENERATED DURING THE OPERATION OF FLOATING WIND TURBINES AND ANCHOR MOORING LINES

484. Throughout the operation and maintenance phase of the Array, there is a potential for mooring lines as well as wind turbine structures to generate underwater noise. Due to a limited number of operational floating wind farms at the time of writing, and those in operation being of small scale (in terms of wind turbine numbers and size), a representative operational sound source level for use in modelling was not defined (see volume 3, appendix 10.1). As such, the operational noise from wind turbines and mooring lines have been assessed qualitatively, and was agreed with NatureScot following the Marine Mammal Methodology Note (Table 10.10; volume 3, appendix 5.1, annex B).

Operation and maintenance phase

Magnitude of impact

Auditory injury (PTS)

485. The periods of mooring line slackening and tensioning have the potential to produce transient ‘pinging’ or ‘snapping’ noises during the operation and maintenance phase of the Array (Liu, 1973). As described in volume 3, appendix 10.1, presence of snapping transient noise was identified during acoustic underwater noise measurements at the Hywind Demonstrator Project in Norway in 2011 (Martin *et al.*, 2011). The data was subsequently analysed and Stephenson (2015) extrapolated results from a single wind turbine to a theoretical array and it was found that with up to 115 snapping events per day, the resultant potential cumulative SEL over a 24 hour period was 156 dB re 1 μPa^2s at 150 m from the wind turbines. This value is below the PTS and TTS onset acoustic thresholds detailed in paragraph 92 (Southall *et al.*, 2019).

486. Underwater noise measurements were also taken at the completed Hywind site in Scotland (Burns *et al.*, 2022), with analysis of data recorded at 14 km from the site to determine different sound signatures from the Hywind structures. The study reported three distinct transient sounds from mooring systems, characterised as ‘bang’, ‘creak’ and ‘rattle’ (Burns *et al.*, 2022) and their presence was found to be positively correlated with wave height, and to a limited extent with wind speed. Burns *et al.* (2022) speculated therefore that transient occurrence was related to the greater influence of waves rather than wind speed on the heave motion of the structure (which may lead to a dynamic response of the mooring system. The sounds were shown to originate from close to the wind turbine as opposed to further down a mooring line. There was little evidence of the sharp and impulsive “snap” noise that was found in the Hywind demonstration system recordings from 2011, and this is possibly explained by the lack of ballast weight on catenary chains (to add tension) at the Hywind Scotland site, compared to the Hywind Demo system.

487. In terms of turbine related noise, Burns *et al.* (2022) stated the dominant operational noise from the Hywind system appeared to be distinct tonal sounds, which were relatively narrowband and continuous, typically associated with running machinery. Two dominant tones, largely stable in frequency, were apparent: below 100 Hz and between 350 and 460 Hz. However, the study highlighted it remained unclear which component generated this noise.

488. A quantitative analysis of the impulsiveness of the soundscape at Hywind showed that sounds generated by FOW farms should be considered as non-impulsive i.e. continuous (Burns *et al.*, 2022). Analysis of the combination of tonal, turbine and mooring transient noises for different wind speeds resulted in the lowest derived broadband source level as 156.7 dB re 1 μPa^2m^2 (and occurred in 10 kn wind speed). The highest (95th percentile) was 172.0 dB re 1 μPa^2m^2 in 25 kn wind speed. The dominant turbine-related tonal noise was measured at 24 Hz and 71 Hz. These source levels were then used to define a noise field across the array to determine the potential impact on marine mammals. Burns *et al.* (2022) found little difference in the daily marine mammal weighted SEL between the Hywind and control site, and no exceedances of the TTS threshold occurred. The maximum distance at which the TTS could occur across all hearing groups was estimated for harbour porpoise at 50 m from a wind turbine assuming that the animal would remain stationary for the 24 hour period (Burns *et al.*, 2022), which is highly precautionary given the mobile nature of marine mammal receptors. Potential TTS ranges for all species are presented in Table 10.51. The study concluded that even at a wind speed of 25 knots, the noise footprint is negligible and in the relatively noisy soundscape of the North Sea, it does not present any realistic threat of auditory injury (PTS) to marine mammal receptors.

Table 10.51: Modelled Maximum Distances to Weighted SEL$_{cum}$ TTS Threshold for 15 Knots Wind Speed (Burns *et al.*, 2022)

Species (Hearing Group)	TTS Onset Level (dB re 1 µPa^{2}s)	TTS Range (m)
Harbour porpoise (VHF)	153	50
Bottlenose dolphin, white-beaked dolphin (HF)	178	10
Minke whale (LF)	179	40
Grey seal, harbour sea (PCW)	181	20

489. A recent project by Risch *et al.* (2023a) collected acoustic data from two FOW farms, currently deployed off the Scottish east coast: Kincardine and Hywind Scotland. At Kincardine five wind turbines rated at 9.5 MW were deployed on semi-submersible foundations, while at Hywind Scotland five 6 MW rated wind turbines were deployed on spar-buoys. The study found noise emissions from FOW turbines were concentrated in the frequencies below 200 Hz, similar to the operational noise of fixed offshore wind turbines, and showed distinct tonal features likely related to rotational speed (between 50 Hz and 80 Hz at Kincardine and 25 Hz and 75 Hz at Hywind Scotland). The median one-third-octave band levels below 200 Hz were between 95 dB re 1 µPa and 100 dB re 1 µPa at about 600 m from the closest wind turbine for both wind farms, well below the level of mild disturbance for cetaceans. The study found the biggest difference between fixed and FOW turbines in relation to underwater noise generation is mooring-related noise, rather the operational wind turbine noise. Risch *et al.* (2023b) found that during higher wind speeds the number of impulsive sounds or transients from mooring-related structures increased at both Kincardine and Hywind Scotland. Source levels for turbine operational noise (25 Hz to 20 kHz) increased with wind speed at both recording locations, with levels ~3 dB higher at Kincardine than Hywind which may be due to power ratings or difference in mooring structure (semi-submersible versus spar-buoy). The study predicted noise fields for unweighted sound pressure levels were above median ambient noise levels in the North Sea for maximum distances of 3.5 km to 4.0 km from the Kincardine five wind turbine array, and 3.0 km to 3.7 km for the five wind turbine array at Hywind Scotland. At both FOW farm locations, recorded harbour porpoise detections were reduced at the recording site closest to the wind turbine compared to the site further away, but Risch *et al.* (2023a) does highlight these FOW farms have only been operational for a short period and these observed occurrence patterns may change over time as FOW farms become more mature.

490. Fixed-foundations may be used as a proxy for operational noise from floating wind turbines, with the main source of noise derived from the moving mechanical parts in the nacelle (which is generally below 1 kHz in frequency). Volume 3, appendix 10.1 highlights measurement data for operational wind farms is lacking, with few empirical investigations, and summarises the relevant literature available (Table 8.27 in volume 3, appendix 10.1). The majority of studies at various wind farms (e.g. Horns Rev, North Hoyle, Scroby Sands, Kentish Flats, Barrow, Burbo Bank, Thorntonbank, Bligh Bank and Princess Amalia Wind Farm) concluded sound levels will be audible by marine mammal receptors, but not at a level that would cause injury or behavioural change (Betke, 2006, Jansen, 2016, Nedwell *et al.*, 2007, Norro *et al.*, 2011, Ward *et al.*, 2006). Norro *et al.* (2011) reviewed a range of foundation and turbine types and found a slight increase in SPL compared to ambient noise measured prior to construction. It should be noted however, that operational noise will be long term (i.e. over the lifetime of the project) and there is very little understanding of this on marine species.

491. As discussed in volume 3, appendix 10.1, though existing empirical studies on operational noise from offshore floating wind of any foundation type are limited, there is a general consensus that the risk of injury to marine mammals from both structure-borne noise (regardless of foundation type) and additional noise such as those by moving mooring lines, is very low.

492. The impact (elevated underwater noise from floating wind turbines and mooring lines) is predicted to be of local spatial extent in the context of the geographic frame of reference, long term duration, continuous and high reversibility (the elevation in underwater sound occurs only during the operation and maintenance phase of the Array). The effect of injury, which is highly unlikely to occur, would be of medium (TTS) to low (PTS) reversibility. It is predicted that the impact will affect the receptor directly. Given that animals are highly unlikely to stay within the injury ranges continuously for 24 hours, injury and therefore population-level effects are highly unlikely to occur. The magnitude is therefore considered to be negligible.

Behavioural disturbance

493. Although the underwater noise study carried out at completed Hywind site makes no attempt to quantify the disturbance (Burns *et al.*, 2022), the semi-qualitative assessment provided in volume 3, appendix 10.1 concluded that the areas of disturbance are unlikely to extend further than those for fixed wind turbine foundations.

494. The underwater noise from operational offshore wind turbines comes from vibration in the gear box and generator, which is transmitted down the tower and radiated from the tower wall. Given that there is a paucity of qualitative data on sound radiation from the FOW towers, qualitative assessment is presented with respect to fixed wind turbines (considered as maximum design case when compared to floating). The desktop review carried out in volume 3, appendix 10.1 suggests that although sound levels are likely to be audible within the hundreds of metres from the wind turbine, these will not be at levels sufficient to cause behavioural changes in marine mammals. However, these findings are based on data collected for wind turbines with capacity between 2 MW to 5 MW and a hub height of up to 95 m (see Table 8.27 in volume 3, appendix 10.1). The wind turbines for the Array will likely be larger than those in the desktop review (Table 10.17) and therefore it is likely that there will be an increase of a few dB compared to smaller wind turbines. However, considering that the Array will be located in the North Sea with relatively high shipping traffic, the difference in ambient sounds is anticipated to be minimal.

495. The impact (elevated underwater noise from floating wind turbines and mooring lines) is predicted to be of local spatial extent in the context of the relevant geographic frame of reference, long term duration, continuous and the effect of behavioural disturbance is of high reversibility. It is predicted that the impact will affect the receptor directly. Although noise levels are likely to be audible to marine mammals, animals are unlikely to experience behavioural disturbance including displacement as a result of the increased underwater noise during operational phase. The magnitude is therefore considered to be negligible.

Sensitivity of the receptor

496. Compared to increasing robust scientific literature on fixed-foundation wind turbines, very little is known about FOW turbines, even less so on the impacts of noise generated during operation (Maxwell *et al.*, 2022) and therefore assessing the responses of marine mammal receptors to these more novel impacts means the assessment is based on highly conservative assumptions (as discussed in paragraph 114). Whilst noise during construction is likely to be less than from pile-driven fixed foundations, noise levels are expected to be similar during operation and it is largely unknown how noise levels differ for floating versus fixed-foundation wind turbines (Maxwell *et al.*, 2022). Farr *et al.* (2021) conducted a systematic review to estimate potential effects of deepwater FOW farms during operation, which included potential effects of underwater noise on marine species. Effect magnitudes were determined using a four-level classification scheme (negligible, minimal, moderate, and major, defined in Minerals Management Service (MMS (Minerals Management Service) (2007) and suggested noise effects on marine mammals were classified as ‘minimal’. Noise effects are unlikely to pose a risk to marine species as the operation noise is low frequency (with dominant frequencies of ~1 kHz or less) and at low levels (Madsen *et al.*, 2006, NYSERDA (New York State Energy Research and Development Authority), 2017, Thomsen *et al.*, 2015b). Farr *et al.* (2021) did state empirical measurements are still needed for FOW farms.

497. While operational noise is continuous, it is unlikely that these noise levels would result in physiological damage (Madsen *et al*., 2006, Marmo *et al*., 2013, Tougaard *et al*., 2009a). Early measurements of underwater noise due to operational wind turbines concluded that the underwater noise from operating wind turbines is limited to low frequencies (below 1 kHz) and of low intensity and would therefore be unlikely to affect marine mammals with main hearing sensitivities at higher frequencies (i.e. VHF and HF cetaceans and PCW) (Madsen *et al*., 2006). Even so, behavioural responses by marine species to operational wind turbine noise appears to be minimal. Modelled predictions by Marmo *et al.* (2013) suggested that only a small proportion (<10%) of minke whales and harbour porpoises would display behavioural responses up to ~18 km away from an offshore wind farm, and the majority of animals studied would not show a behavioural response, indicating low potential for displacement.

498. Monitoring using acoustic recordings (with towed passive acoustic monitoring devices, T-PODs) at Horns Rev Offshore Wind Farm in the North Sea revealed, whilst there was a weak adverse effect on harbour porpoise from the construction on porpoises, no detectable effects were observed on abundance from the operating wind farm (Tougaard *et al*., 2006). It must be noted however there was a significant difference between when intensive maintenance work took place (termed ‘semi-operation’) in the study, and operation. Acoustic and ship survey data indicated more porpoises in the area as a whole during the operational period than for any other of the periods, baseline included.

499. However, field measurements and modelling efforts to estimate operational noise levels have predominantly focused on fixed-bottom offshore wind farms in shallow, near-shore environments. Analysis of noise measurements from two Danish (Middelgrunden and Vindeby) and one Swedish (Bockstigen-Valar) fixed-bottom offshore wind farms, concluded that operational noise levels are unlikely to harm or mask acoustic communication in harbour porpoises and harbour seals (Tougaard *et al*., 2009b). Tougaard *et al.* (2009a) reported at 100 m distance from 1.5 MW wind turbines, underwater sound would be audible to both harbour porpoise and harbour seal. However, at a greater distance of 1,000 m the signal to ambient sound ratio is too low for detection in harbour porpoise as a VHF cetacean (detection by harbour seal might be possible). Furthermore, the authors caveat these results, as ambient sound values used in this study were extrapolated from measurements obtained in the Baltic and the ambient sound in most parts of the North Sea is much higher and will decrease the radius of detection significantly. The study concluded that the sound is unlikely to exceed injury thresholds at any distance from the wind turbines and was considered incapable of masking acoustic communication by harbour porpoise.

500. Studies using long term frequency data from wind farms with 5 MW wind turbines (Alpha Ventus, Germany) found that whilst operational sound can be identified, levels hardly exceed beyond ambient sound levels in areas near main shipping traffic routes negligible (Stober and Thomsen, 2021). Therefore, marine mammals in high traffic areas may not be able to discern operational wind turbine sound from background levels. Analysis of individual frequencies predicted a correlation between SPLs and the operational status of the wind turbines as well as the wind speed, but the total impact of the operational sound was mostly negligible (Stober and Thomsen, 2021). Nedwell *et al.* (2007) analysed measurements of underwater sound inside and outside of four different offshore wind farms in British waters and found operational sound levels were low and only exceeded background levels close to the wind turbines (<1 km).

501. Risch *et al.* (2023b) collected acoustic data from two FOW farms (Kincardine and Hywind) and found recorded porpoise detections were reduced at the recording site closest to the wind turbine compared to the site further away for both FOW locations.

Auditory injury

502. Since there is no empirical information on responses of marine mammals to floating wind turbine and mooring line noise during operation, it has been assumed that the sensitivity of marine mammal receptors to auditory injury (PTS) is the same or less than as a result of underwater noise during piling (paragraphs 217 *et seq.*) and is not reiterated here.

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

Behavioural disturbance

504. Since there is no empirical information on responses of marine mammals to floating wind turbine and mooring line noise, it has been assumed that the sensitivity of marine mammal receptors to behavioural disturbance is the same or less than as a result underwater noise during piling (233 *et seq.*) and is not reiterated here.

505. Therefore, all receptors are deemed to have some resilience to behavioural disturbance, high recoverability and high international value. The sensitivity of the receptor is therefore considered to be medium.

Significance of the effect

Auditory injury

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

Behavioural disturbance

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

Secondary mitigation and residual effect

508. No marine mammal mitigation is considered necessary because the likely effect in the absence of mitigation is not significant in EIA terms.

EFFECTS ON MARINE MAMMALS DUE TO ENTANGLEMENT ASSOCIATED WITH THE ARRAY

509. To provide stability and the fixed positioning of floating wind turbines within the Array, effective mooring systems will be implemented. Additionally, a connection to dynamic inter-array cables will facilitate interlinking between individual wind turbines.

510. There are concerns regarding the hazards that mooring lines and dynamic cables may pose to marine mammals, which could inadvertently become entangled or entrapped (MD-LOT, 2023). The entanglement risk can be categorised into two types: primary and secondary (Synthesis of Environmental Effects Research (SEER), 2022). Primary entanglement refers to the direct entanglement of marine life with mooring lines or dynamic cables. Secondary entanglement occurs when marine life becomes entangled with marine debris, such as derelict fishing gear, that has become snagged on a mooring line or dynamic cable (SEER, 2022). According to Benjamins *et al.* (2014), the entanglement risk is contingent upon various physical and biological parameters.

511. Physical parameters, integral to the wind farm design, encompass mooring tension characteristics, cable/mooring line diameter, swept volume and curvature. This section will comprehensively assess these parameters in terms of magnitude. In parallel, biological parameters, including body size, the ability of

animals to detect moorings, body flexibility and general feeding modes will undergo evaluation in the sensitivity section in paragraphs 522 *et seq.* below.

Operation and maintenance phase

Magnitude of impact

512. The design of the Array will incorporate dynamic inter-array cables and mooring lines in the water column, introducing the potential for injury or death from entanglement to marine mammals.

513. As outlined in Table 10.17, the Array is designed to have up to 116 km of dynamic inter-array cables within the water column. Each wind turbine will be equipped with a mooring system, which introduces the additional potential for entanglement, with up to 1,590 mooring lines. The Project Description for the Array considers various mooring line design options for semi-submersible floating wind turbines, including full chain catenary, semi-taut and taut, both incorporating a top fibre rope section (nylon or polyester) and a bottom chain section (volume 1, chapter 3).

514. According to Benjamins *et al.* (2014), tension characteristics in moorings significantly affect entanglement risk, with taut moorings under high tension being less likely to cause entanglement than flexible ones under low tension. The potential impact of dynamic moorings can be assessed by the concept of swept volumes, as it considers the volume of the water column occupied by mooring lines under energetic conditions (Benjamins *et al.*, 2014). A useful physical parameter in the assessment of entanglement is also curvature, as it assesses the bending of mooring lines, with taut configurations exhibiting smaller curvatures compared to catenary configurations (Benjamins *et al.*, 2014). Harnois *et al.* (2015) found that the catenary moorings with chains configuration shows the highest curvature values.

515. Benjamins *et al.* (2014) findings indicate a greater risk of entanglement to marine mammals with catenary moorings, particularly those containing nylon. Across all potential mooring line types considered for the Array, catenary moorings represent the MDS for entanglement risk. It can be anticipated that, especially for catenary mooring type, there will be some horizontal movement of the floating wind turbine and therefore the mooring line may experience stretching (representing the maximum length in the water column) or slackness (representing the maximum length resting on the seabed). To address this, clump weights may be strategically placed around the touchdown point to mitigate the length of the mooring line between the anchor and the wind turbine.

516. While Harnois *et al.* (2015) suggest that certain features of mooring systems may influence entanglement risk, the study also concluded that the absolute risk of primary entanglement is low regardless of mooring configuration. Garavelli (2020) suggested that all mooring configurations (catenary/taut) have too much tension to create a loop that could entangle a whale. This has been corroborated by SEER (2022), as the study also concluded that the risk of primary entanglement at FOW farms is very low due to the weight of the cable systems. The potential for heavy mooring gear combined with relatively taut mooring lines to entangle whales has been shown to be negligible (Wursig and Gaily, 2002) and MRE device moorings are unlikely to pose a major threat (Benjamins *et al.*, 2014). Statoil (2015) stated for mooring lines at the Hywind Pilot Park, it was a design requirement that no line should ever go into slack, even in extreme weather conditions, and it was considered effectively impossible for entanglement on a marine mammal to occur. For inter-array cables in the water column cables have a very high bending stiffness and therefore the cable cannot bend around a marine mammal (Statoil, 2015). Therefore, the magnitude assessment of primary entanglement considers the very small likelihood that entanglement can actually occur.

517. Research on the risk to marine mammals has focussed on injury or mortality by entanglement of fishing gear (e.g. nets of slack lines) or submarine telecommunication cables, however these have loose ends or loops that could ensnare animals (Benjamins *et al.*, 2014, Moore *et al.*, 2006) and therefore mooring lines/cables are not comparable and has not been considered a significant concern (Copping *et al.*, 2020). Evidence of entanglement of marine animals with MRE mooring lines and cables has not been observed to date (Isaacman and Daborn, 2011, Offshore Renewables Joint Industry Programme (ORJIP) Ocean Energy, 2022, Sparling *et al.*, 2013) and even entanglement with offshore aquaculture is rare (Fujita *et al.*, 2023), but it is important to consider absence of evidence is not evidence of absence of risk. However, there is a risk of entanglement in anthropogenic debris caught in mooring lines/cables (Clavelle *et al.*, 2019).

518. The Array will use fibre rope diameters ranging from 110 mm to 300 mm and chain diameters between 76 mm to 175 mm. Fishing gear, which pose the greatest entanglement risk to marine species, were reported to fall between 1 mm to 9.5 mm in diameter (Knowlton *et al.*, 2016, Wilcox *et al.*, 2015). Thus, marine mammals are more likely to be at risk from secondary entanglement through interactions with fishing gears than through direct entanglement with the large, thick mooring and cable components.

519. Lost fishing gear is made of synthetic materials, including nylon, polyethylene, and polypropylene, that resist natural biodegradation and can endure in the marine environment for extended periods, promoting the phenomenon known as 'ghost fishing' (Stelfox *et al.*, 2016). This phenomenon occurs when lost or discarded gear continues to catch wildlife from various taxa, including marine mammals. Indirect entanglement in anthropogenic debris caught on mooring lines and inter-array cables, e.g. secondary entanglement, poses the risk of direct injury and is anticipated to result in significant fitness reduction for the affected marine mammals through tissue damage, infection, and mobility restrictions that prevent foraging or migration (Garavelli, 2020, Van Der Hoop *et al.*, 2016). However, the quantification of the actual amount of abandoned, lost, or discarded fishing gear and other anthropogenic debris poses significant challenges due to its elusive nature.

520. As a part of the designed in measures (Table 10.22), mooring lines and dynamic inter-array cables will undergo regular inspections during the operation and maintenance phase. The inspection frequency for mooring lines and dynamic inter-array cables is anticipated to be more frequent initially (e.g. years 1 and 2), and likely to decline in frequency after this, following a risk based approach. Any inspected or detected debris on the floating lines and cables will be recovered based on a risk assessment which considers impact on environment including risk to marine mammal, risk to asset integrity, and health & safety. In addition, Ossian OWFL will consider new technologies for monitoring of mooring lines/snagged gear and will agree approach to monitoring of mooring lines and associated removal of gear with NatureScot and MD-LOT prior to the operation and maintenance phase. As such, the removal of debris from mooring lines and cables further reduces the likelihood of secondary entanglement.

521. The impact (risk of entanglement due to presence of mooring lines and inter-array cables in the water column) is predicted to be of very local spatial extent in the context of the geographic frame of reference, long term duration, continuous and the effect is irreversible when entanglement does occur. It is predicted that the impact will affect the receptor directly in the case of both (rare) primary entanglement and secondary entanglement, however the risk of potential secondary entanglement is sufficiently reduced with the application of the designed in measures (Table 10.22) regular inspections of mooring lines and dynamic inter-array cables and removal of marine debris recovered based on risk assessment, and any population-level effects are highly unlikely. As such, following application of designed in measures, the magnitude of primary and secondary entanglement is considered to be low.

Sensitivity of the receptor

522. In line with the approach applied in Benjamins *et al.* (2014), for the purpose of assessing marine mammal sensitivity to primary entanglement, animals were classified into broad groups based on taxonomic relationship as well as body size:

- odontocetes – harbour porpoise, bottlenose dolphin, white-beaked dolphin;
- mysticetes – minke whale and humpback whale; and
- pinnipeds – grey seal.

523. Due to paucity of empirical evidence for secondary entanglement associated with FOW farms components, sensitivity to secondary entanglement will be assessed based on potential entanglement with fisheries materials (mostly nets, lines) that are most likely to be caught on the Array infrastructure.

Primary entanglement

524. The Array will utilise mooring lines and inter-array cables in exceedance of 76 mm and 110 mm, respectively, e.g. dynamic components will be relatively large in diameter, particularly compared to fishing gear/submarine telecommunications cables, on which most entanglement evidence has been based upon (Benjamins *et al.*, 2014, Moore *et al.*, 2006).

525. When considering the size of marine animals, mooring lines and cables may pose a reduced risk to smaller animals compared to larger ones simply because smaller animals 'cannot physically become entangled' (Benjamins *et al.*, 2014). Consequently, odontocetes as well as pinnipeds, face a lower risk of primary entanglement with mooring lines and inter-array cables compared to larger mysticetes.

526. In terms of flexibility, marine mammals exhibit variations in the degree to which they flex their bodies while swimming. Benjamins *et al.* (2014) made an assumption that animals with greater flexibility would be able to avoid entanglement more easily compared to those with more rigid bodies. The study assigned a consistent entanglement risk based on body flexibility for both mysticetes and odontocetes. Pinnipeds, presumed to be relatively flexible, were consequently assigned a lower score for the risk of entanglement when compared to odontocetes and mysticetes (Benjamins *et al.*, 2014). As discussed in paragraph 516, it is highly unlikely that the mooring cables will be flexible enough (they have high bending stiffness) however to loop around passing marine mammal receptors.

527. Due to the size of mooring lines and inter-array cables considered for the Array (see paragraph 518), they are detectable at considerable distances for echolocating odontocete cetaceans. Various mooring components are likely to influence audibility, with chain, for instance, being inherently noisier than fibre rope due to metal-on-metal movement and a larger surface area that can generate turbulence (Benjamins *et al.*, 2014). The smoothness of mooring elements surface will also impact the amount of turbulence produced, which is likely to be detectable by pinnipeds (Benjamins *et al.*, 2014). Nevertheless, detectability at a distance may be altered under adverse conditions such as storms or turbid waters, regardless of the sensory modality used or the extent of device motion. Benjamins *et al.* (2014) assessment of the entanglement risk across marine mammal groups, based on their ability to detect moorings, revealed that odontocetes who possess echolocation are more likely to detect mooring components at larger distances than mysticetes and pinnipeds which rely on passive acoustic detection or pressure wave detection. Pinnipeds however possess acute mechanosensitivity through their vibrissae or whiskers (Dehnhardt *et al.*, 2001, Hanke and Dehnhardt, 2013) which may allow them to detect wakes formed downstream of a mooring or cable.

528. Foraging behaviour appears to be an important risk factor contributing to entanglement in fishing gears. Entanglements in ropes often occur as the rope wraps around animals' extremities or passes through their mouths, particularly during foraging activities (Benjamins *et al.*, 2014). Mysticetes are at a higher risk of entanglement when lunge feeding as opposed to filter feeding (Benjamins *et al.*, 2014), noting that studies have been based upon entanglement in fishing gear (Knowlton and Kraus, 2020), rather than mooring lines. The substantial thickness of mooring lines and inter-array cables associated with the Array, in comparison to the ropes used in fishing gears, may largely prevent such entanglements except in very specific cases (Benjamins *et al.*, 2014). Considering the mode of foraging alone, odontocetes and pinnipeds are assessed to be at a low risk of primary entanglement.

529. It must be noted that it is considered that marine mammals are highly unlikely to get entangled in the first place, given their advanced hearing and echolocation which would allow them to detect any noise from cables (such as 'bangs', 'creaks', 'rattle', 'snapping' or 'pinging' as described in Burns *et al.* (2022) and Liu (1973). Statoil (2015) assessed the sensitivity of marine mammal entanglement as low, given the risk of entanglement is considered highly unlikely. Furthermore, the evidence base for sensitivity is largely based off fishing gear or submarine telecommunications cables and therefore it is unlikely that the design of cables (see paragraphs 516 to 517) will physically allow primary entanglement of marine mammals to an extent that would entrap them and cause drowning. Thus, on the basis that primary entanglement is considered highly unlikely and the lack of any evidence for entanglement from MRE, there is considered to be some resilience and survivability largely due to avoidance behaviour of MRE structures.

530. Taking into account all biological parameters and the difficulty in attributing sensitivity to such a novel impact with no direct evidence from scientific study, mysticetes are precautionarily identified as being at a slightly higher risk of direct entanglement with mooring lines and inter-array cables, which is attributed to their large size and distinctive foraging techniques.

531. As such, the mysticetes are deemed to have some resilience to primary entanglement (largely due to avoidance and design of mooring lines/cables), some adaptability, limited recoverability and are of international value. The sensitivity of the receptors (minke whale and humpback whale) is therefore, conservatively, considered to be medium.

532. Odontocetes and pinnipeds are perceived to be at a lower risk of inadvertently becoming entangled in moorings (as discussed in paragraph 528) and inter-array cables associated with Array infrastructure.

533. As such, the odontocetes and pinnipeds are deemed to have some resilience to primary entanglement (largely due to avoidance and design of mooring lines/cables), high adaptability, limited recoverability and are of international value. The sensitivity of the receptors (harbour porpoise, bottlenose dolphin, white-beaked dolphin and grey seal) is therefore, considered to be low.

Secondary entanglement

534. The primary source of small cetacean bycatch is thought to be gillnets (Read *et al.*, 2006). One hypothesis explaining cetacean entanglement in gillnets suggests that these animals may either be incapable of detecting the nets due to low target strength or may detect the nets too late to avoid entanglement (Mackay, 2011). Limited information is available regarding how odontocete cetaceans utilise echolocation in the wild and the ecological as well as behavioural contexts in which the echolocation is used (Mackay, 2011). Bottlenose dolphins, for example, have been observed to use echolocation sparingly in the wild, predominantly relying on passive listening to detect prey (Gannon *et al.*, 2005). In contrast, free-ranging harbour porpoises have been documented to echolocate frequently (Akamatsu *et al.*, 2007).

535. Cox and Read (2004) reported that harbour porpoises are often found in the vicinity of commercial gillnets more frequently than actual entanglement events occur. Kastelein *et al.* (1995) examined the circumstances in which three captive harbour porpoises reacted to gillnets in a pool. The initial encounters of the animals with standing gillnets resulted in entanglement, and the harbour porpoise would have faced the risk of drowning if not rescued. Subsequent to these experiences, the animals in the study learned from one or more encounters and developed behaviours that reduced their chances of colliding with or becoming entangled in the gillnet (Kastelein *et al.*, 1995). It is important to note that this learning process may not occur in the wild, where animals do not have the opportunity to be rescued. The authors also suggested that harbour porpoises learned to detect the gillnet by using echolocation in complete darkness, highlighting the adaptability of their sensory capabilities in response to the new environmental challenge posed by the gillnet (Kastelein *et al.*, 1995).

536. Read *et al.* (2003) investigated the fine-scale movements of bottlenose dolphins around commercial Spanish mackerel gillnets and found that the most commonly recorded interaction was avoidance, wherein dolphins altered their course to navigate around the net and then resumed their original path once past it. Avoidance behaviours were observed at distances of up to 100 metres from the net (Read *et al.*, 2003). The authors concluded that bottlenose dolphins frequently interact with gillnets but rarely become entangled (Read *et al.*, 2003). When entanglement does occur, it is attributed to dolphins being either unaware of the net or distracted by other stimuli in the net's vicinity, such as fish (Read *et al.*, 2003).

537. The welfare assessment of free-swimming white-beaked dolphins off the coast of Northumberland in the North Sea revealed that the majority of the recorded injuries were caused by interactions with fishing devices (Van Bressem *et al.*, 2018).

538. Between August 1990 and September 1995, a comprehensive examination of 422 cetacean carcasses representing 12 species that had died around the coasts of England and Wales was conducted (Kirkwood *et al.*, 1997). Among the examined specimens, there were 234 harbour porpoises, 138 common dolphins, and 50 individuals from ten other species of dolphins and whales. In both harbour porpoises and common dolphins, the most frequent cause of death was entanglement in fishing gear (Kirkwood *et al.*, 1997). A more recent study by Reeves *et al.* (2013) showed that bycatch continues to affect many odontocete species, as 61 of 74 studied species (82%) have reportedly been bycaught in some kind of fishing gear within their range between 1990 and 2011. Harbour porpoise faces significant challenges due to high bycatch rates in coastal gillnet fisheries across its range, leading to conservation concerns for several populations (Kindt-Larsen *et al.*, 2023).

539. Based on sighting records and a photo-identification catalogue from a haul-out site in south-west England, Allen *et al.* (2012) reported that over the period from 2004 to 2008, the annual mean entanglement rates fluctuated between 3.6% and 5%. Among the 58 entangled cases in the catalogue, 64% exhibited injuries classified as serious and in 15 cases where the entangling debris was visible, 14 were found to be entangled in fisheries materials (Allen *et al.*, 2012).

540. In waters around the coast of Scotland, entanglement in fishing gear is a particular welfare and conservation concern for mysticetes, particularly minke whales and humpback whales (Leaper *et al.*, 2022, MacLennan, 2018, MacLennan, 2021). These entanglements can occur through various body parts such as the mouth, around the body, pectoral fins, and the tail (MacLennan, 2018). It can impact an animal's ability to feed, swim, and reproduce, depending on the part of the body that becomes restrained. Ropes can cut through baleen and blubber and lead to amputation of fins and flukes (MacLennan, 2018, Rolland *et al.*, 2017). More than half of the post-mortems conducted on mysticetes found dead around the Scottish coast have identified entanglement as the cause of death (Northridge *et al.*, 2010).

541. According to estimates by Leaper *et al.* (2022), approximately six humpback whales and 30 minke whales become entangled in Scotland each year. The data from reports from strandings, live disentanglements and interviews with Scottish inshore creel fishers indicated that 83% of minke whale entanglements and 50% of humpback whale entanglements occurred in the groundlines between creels (Leaper *et al.*, 2022). Whales become entangled in ground lines because the buoyant rope used in creel fishing floats in loops between pots rather than lying on the seabed. Leaper *et al.* (2022) reported that while disentanglement efforts have seen success in several incidents involving humpback whales, the majority (84%) of minke whale discovered were already deceased. The behaviour of whales swimming away with gear is more commonly associated with humpback whales than minke whales as humpbacks are known to be powerful swimmers capable of towing gear over substantial distances (Knowlton *et al.*, 2016). This ability may contribute to the relative success of disentanglement efforts for humpbacks. Minke whales are considered particularly vulnerable to gillnet entanglement for various reasons (Reeves *et al.*, 2013). These include their near-shore and shelf occurrence, their tendency to prey on fish species targeted by net fisheries, and their smaller size, making it more challenging for them (compared to larger mysticetes) to rescue themselves once entangled (Reeves *et al.*, 2013).

542. As presented in paragraph 206 humpback whales photographed off eastern Scotland have been matched with a non-recovering population breeding in Cape Verde and Arctic feeding grounds (Scottish Humpback, 2023). Although it has been suggested that adverse effects on humpback whales occurring in Scottish waters could potentially impact populations in the north-east Atlantic (Leaper *et al.*, 2022), only individual humpback whales were recorded seasonally and there is no evidence that the waters in the vicinity of the Array marine mammals study area represent an important feeding ground during their migration.

543. Statoil (2015) considered the risk of marine mammal entanglement in mooring lines and inter-array cable to be unlikely, but concluded that it is possible for smaller whales and dolphins (e.g. minke whale and smaller cetaceans using the offshore area) to become entangled in lost or derelict fishing gear which may become entangled in mooring lines and cables Based on the species most likely to be at risk, the sensitivity of marine mammals to entanglement was concluded to be low (Statoil, 2015). It must be noted that these smaller species (such as bottlenose dolphin and grey seal) are found in lower densities in the Array marine mammal study area, though small cetaceans such as harbour porpoise and white-beaked dolphin may be present in greater numbers around the Array. Quantifying sensitivity on the basis of little scientific evidence is difficult, with only few examples of sensitivity given to date (Statoil, 2015).

544. It is important to consider that mooring lines and dynamic inter-array cables will undergo regular inspections during the operation and maintenance phase. The inspection frequency for mooring lines and dynamic inter-array cables is anticipated to be more frequent initially (e.g. years 1 and 2), and likely to decline in frequency after this following a risk based approach. Any inspected or detected debris on the floating lines and cables will be recovered based on a risk assessment which considers impact on environment including risk to marine mammal, risk to asset integrity, and health & safety. In addition, Ossian OWFL will consider new technologies for monitoring of mooring lines/snagged gear and will agree approach to monitoring of mooring lines and associated removal of gear with NatureScot and MD-LOT prior to the operation and maintenance phase. This is considered to further reduces the potential risk to marine mammals from secondary entanglement.

545. Therefore, marine mammals are deemed to have some resilience to secondary entanglement (largely via avoidance), medium adaptability, limited recoverability and are of international value. Although the risk of entanglement is likely to be low, and some species (particularly bottlenose dolphin and grey seal) are expected to occur around the Array in very low abundance, due to the paucity of information on secondary entanglement and the irreversible nature if entanglement does occur, the sensitivity of all marine mammals is conservatively considered to be medium.

Significance of the effect

Primary entanglement

546. Overall, the magnitude of the impact (primary entanglement) is deemed to be low for all marine mammals and the sensitivity of the receptor is considered to be low for odontocetes/pinnipeds and medium for mysticetes. Considering that studies on primary entanglement assessed it as low risk, especially for odontocetes and pinnipeds (Benjamins *et al.*, 2014, Harnois *et al.*, 2015), the effect will therefore be of **minor** adverse significance for all marine mammal species, which is not significant in EIA terms.

Secondary entanglement

547. Overall, the magnitude of the impact (secondary entanglement) is deemed to be low for all marine mammals and the sensitivity of all receptors (odontocetes, pinnipeds and mysticetes) is considered to be medium. The effect will, therefore, be of **minor** adverse significance for all marine mammals, which is not significant in EIA terms.

Secondary mitigation and residual effect

548. No marine mammal mitigation is considered necessary because the likely effect in the absence of mitigation is not significant in EIA terms.

EFFECTS ON MARINE MAMMALS DUE TO ALTERED PREY AVAILABILITY

549. Potential effects on fish and shellfish during the construction, operation and maintenance and decommissioning phases of the Array, as identified in volume 2, chapter 9, could lead to indirect effects

on marine mammals. The assessment includes temporary and long term habitat loss/disturbance, colonisation of hard structures, underwater noise and increased SSCs and associated deposition.

550. The key prey species for marine mammals include sandeels, gadoids (including cod *Gadus morhua*, haddock *Melanogrammus aeglefinus,* whiting *Merlangius merlangus*), clupeids (including herring *Clupea harengus*) plaice *Pleuronectes platessa*, *Pleuronectiformes* and *Scomber scombrus* (see volume 3, appendix 10.2 for detail on marine mammal feeding ecology). These prey species have been identified as being of regional importance within the fish and shellfish ecology study area, except for sandeel which is deemed to be of national importance (see volume 2, chapter 9). For example, volume 2, chapter 9 reports that the Array overlaps with low intensity spawning grounds for lemon sole *Microstomus kitt*, cod, whiting, sandeel, mackerel, Norway pout *Trisopterus esmarkii,* sprat *Sprattus sprattus* and plaice based on Coull *et al.* (1998) and Ellis *et al.* (2012). For herring, volume 2, chapter 9 states that no high intensity spawning grounds identified by Coull *et al.* (1998) directly overlap with the Array (noting low intensity grounds overlap). Volume 2, chapter 9 also presents the outputs of recent modelling conducted by Langton *et al.* (2021) within the Array, this modelling shows that the whole Array has extremely low probability of sandeel presence, corresponding to the low-intensity nursery/spawning grounds presented in Coull *et al.* (1998) and Ellis *et al.* (2012), with areas where predicted density is high closer to the coasts or towards the Firth of Forth.

551. Consequently, adverse effects on fish receptors that are key prey species for marine mammal receptors (detailed in paragraph 550) may have indirect adverse effects on marine mammal receptors.

Construction phase

Magnitude of impact

552. 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 on prey species include temporary habitat loss/disturbance, long term habitat loss and disturbance, injury and/or disturbance to fish and shellfish from underwater noise from piling and UXO clearance.

553. The installation of infrastructure within the Array will lead to temporary habitat loss/disturbance as a result of a range of activities including boulder and sand wave clearance, disturbance from inter-array and interconnector cables, and use of jack-up vessels for the OSP installation. There is the potential for temporary habitat loss/disturbance to affect up to 40.95 km^2 of the seabed during the construction phase, which equates to 5.82% of the Array and represents a relatively small proportion of the fish and shellfish ecology study area. Temporary habitat loss and disturbance has the potential to affect spawning, nursery or feeding grounds of fish and shellfish receptors, and therefore impact prey availability for marine mammals. Due to the highly localised nature of the effects (i.e. spatially restricted to within the Array) and the small proportion of habitats affected as a proportion of the northern North Sea and medium term duration with recovery beginning immediately following cessation of the construction activity, temporary habitat loss/disturbance during the construction phase was assessed as being of low magnitude in volume 2, chapter 9.

554. As outlined in volume 2, chapter 9, only a small proportion of the maximum footprint of temporary habitat loss and 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 allowing mobile species, such as sandeel and other fish and shellfish species, to repopulate the areas of previous disturbance. 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 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, some species including larger crustacea (e.g. *Nephrops*, European lobster *Homarus gammarus*) and sandeel were assessed as having medium sensitivity to the impact. As described in paragraph 553, he overall magnitude of the impact was considered to be low. Consequently, the impact temporary habitat loss and disturbance was assessed as being of minor adverse significance.

555. Long term habitat loss within the fish and shellfish ecology study area will occur during construction (i.e. through placement of infrastructure) although effects will extend throughout the operation and maintenance phase. Long term habitat loss will occur under mooring lines and anchors on the seabed, OSP foundations inter-array and interconnector cable protection and cable crossing protection, inter-array junction boxes and associated scour protection.

556. The presence of infrastructure within the Array will result in long term habitat loss of up to 19,270,958 m^2, which represents 2.25% of the total site boundary. Additionally, up to 812,808 m^2 of long term seabed disturbance may exist due to the movement of foundation mooring lines, which is subject to movement and, as such, seabed disturbance. Many species of fish and shellfish are reliant upon the presence of suitable sediment/habitat (notably herring and sandeel) 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 (2.25% of the total site boundary). The Array fish and shellfish ecology study area is located over low intensity spawning and low intensity nursery grounds for sandeel, and a mix of preferred, marginal and unsuitable habitat type, with the preferred habitat types in the north-west of the Array (see volume 3, annex 9.1). Herring spawning habitat is largely unsuitable within the fish and shellfish ecology study area, with core spawning grounds existing outside the site boundary. Therefore, the area of herring spawning grounds affected by this impact is expected to be very limited, in the context of available favourable sediments habitat outside the fish and shellfish ecology study area.

557. Monitoring at Belgian offshore wind farms has reported that fish assemblages undergo no drastic changes due to the presence of offshore wind farms (Degraer *et al.*, 2020). They reported slight, but significant increases in the density of some common soft sediment-associated fish species within the offshore wind farm (Degraer *et al.*, 2021). There was also some evidence of increases in numbers of species associated with hard substrates, including crustaceans (including *Cancer pagurus*), *Dicentrarchus labrax* and common squid *Alloteuthis subulata* (potentially an indication that foundations were being used for egg deposition (Degraer *et al.*, 2021). The sensitivity of fish and shellfish receptors ranged from low (most fish and shellfish) to medium (sandeel) 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 long term habitat loss was assessed as being of minor adverse significance.

558. There is the potential for underwater noise during construction (from piling and UXO) 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 in volume 2, chapter 9, the maximum recoverable injury range is estimated at 226 m to 414 m from the piling location. The potential for mortality or mortal injury to fish eggs would also occur at distances of up to 414 m. However, this is considered to be highly conservative due to the implementation of soft starts during piling activities 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 metres) are likely to be more realistic. Using the SEL_{cum} metric, underwater noise modelling showed that injury may occur out to ranges of tens to a few hundred metres (e.g. mortality ranges for the 3,000 kJ hammer energy of 15 m to 50 m for fleeing receptors and 328 m to 1,460 m for static receptors). TTS, from which animals will recover, was predicted to occur out to a maximum distance of 26,960 m (based on static fish) for single piling scenario at 4,400 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 33 km to 49 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 (Popper *et al.*, 2014). For the least sensitive species (e.g. flatfish), the risk of behavioural effects is moderate to high in the nearfield (tens of metres) and intermediate field (i.e. hundreds of metres). For more sensitive species (e.g. herring, gadoids, sprat etc.) behavioural effects may occur further away from the source (i.e. over several kilometres or more from the source). The magnitude of underwater noise effects was considered to be low and the sensitivity of the fish and shellfish receptors was assessed as low to medium. Therefore, as detailed in volume 2, chapter 9, the effect of underwater noise from piling and UXO on fish and shellfish receptors was minor adverse significance.

559. 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 140 *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. Whilst there may be certain prey species that comprise the main part of their diet (as discussed in volume 3, appendix 10.2), all marine mammals in this assessment are considered to be generalist opportunistic feeders and are thus not reliant on a single prey species. Given that marine mammals are wide-ranging in nature with the ability to exploit numerous food sources, there would be a variety of prey species available for marine mammal foraging.

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

561. 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 Array, which are not significant in EIA terms.

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

Sensitivity of the receptor

563. The fish and shellfish communities found within the fish and shellfish ecology study area (see volume 2, chapter 9) are deemed to be characteristic of the fish and shellfish assemblages in the wider northern North Sea. It is considered highly likely, and therefore reasonable to assume that, considering the highly mobile nature of marine mammals, there will be similar prey resources available in the wider norther North Sea region for marine mammals. Foraging over greater distances could however result in an energetic cost with this effect being particularly pertinent for harbour porpoise. Harbour porpoise has a high metabolic rate and only a limited energy storage capacity, which limits their ability to buffer against diminished food. Despite this, if animals do have to travel further to alternative foraging grounds, the impacts are expected to be short term in nature and reversible (i.e. elevated underwater noise would occur during piling only).

564. 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. However, as outlined in paragraph 550 (as presented in volume 2, chapter 9) modelling by Langton *et al.* (2021) shows that the Array marine mammal study area has extremely low probability of sandeel presence, with areas where predicted density is high closer to the coasts or towards the Firth of Forth. For sandeels, volume 2, chapter 9 concluded that all impacts would be of minor adverse significance, which is not significant in EIA terms, therefore minke whale are not considered to be affected indirectly through impacts to sandeel.

565. All receptors are deemed to be of high resilience and adaptability, high recoverability and high international value. The sensitivity of the receptor is therefore considered to be low.

Significance of the effect

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

Secondary mitigation and residual effect

567. No marine mammal mitigation is considered necessary because the likely effect in the absence of mitigation is not significant in EIA terms.

Operation and maintenance phase

Magnitude of impact

568. 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 fish and shellfish receptors. The assessment includes temporary and long term habitat loss/disturbance, colonisation of hard structures, underwater noise, increased SSCs and associated deposition, and EMF.

569. The maximum design scenario is for up to 51,411,500 m^2 of temporary habitat loss/disturbance during the operation and maintenance phase. This equates to 5.99% of the total site boundary and therefore this represents a very small proportion of the fish and shellfish ecology study area. The maximum design scenario is for up to 19,270,958 m^2 of long term subtidal habitat loss representing 2.25% of the total site boundary, however long term subtidal habitat loss is assessed above in paragraph 556 for the construction phase. Given that these impacts will be similar to those identified for temporary habitat loss/disturbance the construction phase (as discussed in paragraph 554) 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.

570. Increased SSCs and associated deposition may arise from mooring lines or cables making contact with and moving on the seabed, disturbing seabed materials and increasing SSCs within the water column. The greatest potential for the increase in SSCs is from catenary moorings which have the greatest length of mooring lines in contact with the seabed. The MDS is considered to be the foundations with the greatest length of mooring line on the seabed per foundation, rather than over the site as a whole, as the effects are considered to be very localised. The length of each mooring line on the seabed is 680 m, which

amounts to 6,120 m per foundation. With a mooring line radius of 700 m, the maximum potential volume of sediment disturbance resulting from the movement of mooring lines was estimated to be over a surface area greater than 1,539,380 m^2, therefore the magnitude of the increase in SSCs and associated deposition was deemed to be low. Disturbed materials are more likely to move along the seabed, rather than becoming fully suspended in the water column, and due to the low current speeds near the seabed, will not be transported for any significant distance before being re-deposited on the seabed.

571. In terms of potential increases in SSC, adult fish species are more mobile than many of the other fish and shellfish IEFs, and therefore would be likely to show avoidance behaviour within areas affected by increased SSC (EMU, 2004), making them less susceptible to physiological effects of this impact. Juvenile fish are more likely to be affected by habitat disturbances such as increased SSC than adult fish, which is well researched for commercially important salmonid species (Berli *et al.*, 2014, Bisson and Bilby, 1982). However, as outlined in paragraph 550, for herring, volume 2, chapter 9 states that no high intensity spawning grounds were identified by Coull *et al.* (1998) within the site boundary. Low intensity nursery grounds were reported to be present within the site boundary and low intensity spawning grounds nearby (Coull *et al*., 1998). With respect to the effects of sediment deposition on herring spawning activity, it has been shown that herring eggs may be tolerant of very high levels of SSC (Kiørboe *et al.*, 1981, Messieh *et al.*, 1981). Detrimental effects may be seen if smothering occurs and the deposited sediment is not removed by the currents (Birklund and Wijsman, 2005), however this natural removal by the currents and tidal physical processes would be expected to occur quickly in this case (i.e. within a couple of tidal cycles). The impact of increased SSCs and associated deposition is predicted to be of local spatial extent, long term duration, intermittent, and of high reversibility. The magnitude is therefore considered to be low.

572. Increased SSC could also 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 560). The overall significance of the effect was therefore deemed to be of negligible to minor adverse significance.

573. The presence and operation of inter-array and interconnector cables will result in emissions of localised electrical and magnetic fields, which could potentially affect the sensory mechanisms of some species of fish and shellfish. 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* (CSA Ocean Sciences Inc and Exponent, 2019, Gill *et al.*, 2005). 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 Associates Inc *et al.*, 2011). Given that the range over which species can detect EMF will be very localised to within a few centimetres of the 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.

574. Artificial structures introduced to the marine environment, such as wind turbine anchors, mooring lines 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.

575. The impact on marine mammals is predicted to be of local spatial extent in the context of the geographic frame of reference, long term duration, continuous and the effect on marine mammals is of high reversibility. The magnitude is therefore, considered to be low.

Sensitivity of the receptor

576. Following placement on the seabed, submerged infrastructure (e.g. anchors and mooring lines) provide hard substrate for the potential colonisation by various marine life. Faecal deposits from animals colonising structures, such as suspension feeders are likely to alter the surrounding seafloor communities by increasing food availability in the locality of the Array (Degraer *et al.*, 2020). This increased food availability is likely to attract higher trophic levels, such as fish and marine mammals, who can exploit the increased foraging opportunities in the Array.

577. However, there is still a considerable amount of uncertainty around marine mammal behaviour and distribution within the vicinity of offshore anthropogenic structures. Species such as harbour porpoise, minke whale, white-beaked dolphin, harbour seal and grey seal have been frequently recorded around offshore oil and gas structures (Delefosse *et al.*, 2018, Lindeboom *et al.*, 2011, Todd *et al.*, 2015).Fernandez Betelu *et al.* (2022) deployed an array of C-PODs within the vicinity of four offshore structures. The probability of porpoise occurrence and foraging activity was found to decrease with distance from offshore structures. A significant increase in porpoise occurrence and foraging was detected during night-time compared to daytime around all four offshore structures (<200 m). These findings demonstrated that marine mammals are attracted to man-made structures and that porpoises modify their diel patterns of occurrence and foraging activity around them (Fernandez-Betelu *et al.*, 2022). Acoustic results from a T-POD measurement within a Dutch wind farm found that relatively more harbour porpoises were found in the wind farm area compared to the two reference areas (Lindeboom *et al.*, 2011, Scheidat *et al.*, 2011). This study concluded that the presence within the wind farm area was due to increased food availability as well as the exclusion of fisheries and reduced vessel traffic in the wind farm (shelter effect). Further evidence suggesting that wind farms are used for foraging includes a study by Russell *et al.*(2014) where the movements of tagged harbour seals commonly exhibited grid-like movement patterns within two active wind farms in the North Sea. However, other studies have detected no statistical differences in the presence of harbour porpoises inside and outside a Danish wind farm (Brandt *et al.*, 2009). Brandt *et al.* (2009) suggested, however, that a small increase in detections during the night at hydrophones deployed in close proximity to single wind turbines may indicate increased foraging behaviour near the monopiles. Whilst there is some mounting evidence of potential benefits of man-made structures in marine environment (Coolen *et al.*, 2020), the statistical significance of such benefits and details about trophic interactions in the vicinity of artificial structures and their influence on ecological connectivity remain largely unknown (Elliott and Birchenough, 2022, Inger *et al.*, 2009, McLean *et al.*, 2022, Rouse *et al.*, 2020). Additional details about inter-related effects on marine organisms are provided in section 10.15.

578. 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 560 *et seq*. The sensitivity of the receptor is therefore, considered to be low.

Significance of the effect

579. 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.

580. 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

581. No 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.

Decommissioning phase

Magnitude of impact

582. 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.

583. Magnitude of impacts are as described for the construction phase in paragraph 552 *et seq*. The impact on marine mammal receptors 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

584. The sensitivity of marine mammal receptors during the decommissioning phase is not expected to differ from the sensitivity of the receptors during the construction phase described in paragraph 560 *et seq*. The sensitivity of the receptor is therefore, considered to be low.

Significance of the effect

585. 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

586. No marine mammal mitigation is considered necessary because the likely effect in the absence of further mitigation is not significant in EIA terms.

10.12. CUMULATIVE EFFECTS ASSESSMENT

10.12.1. METHODOLOGY

587. The CEA assesses the LSE[1] associated with the Array together with other relevant plans, projects and activities. Cumulative effects are defined as the combined effect of the Array in combination with the effects from a number of different projects, on the same receptor or resource. Further details on CEA methodology are provided in volume 1, chapter 6.

588. The plans and projects 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 Array 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 plan or project has been considered on a case-by-case basis for screening in or out of this chapter's assessment based upon data confidence, impact-receptor pathways and the spatial/temporal scales involved.

589. In undertaking the CEA for the Array, it should be noted that other plans and projects under consideration will have differing potential for proceeding to an operational phase and hence a differing potential to ultimately contribute to a cumulative impact alongside the Array. Therefore, a tiered approach has be adopted which 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 Array CEA employs the following tiers:

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

590. For consistency with the CEA long list presented in volume 3, appendix 6.4, (which was finalised at the end of March 2024, three months prior to submission of the Array EIA Report), Table 10.52 provides a detailed overview of all screened in projects. However, it is important to note that the cumulative assessment only covers projects and their statuses up to January 2024 (six months prior to submission of the Array EIA Report), as outlined in the Array EIA Scoping Report (Ossian OWFL, 2023) and agreed as part of the Ossian Array Scoping Opinion (MD-LOT, 2023).

591. The specific projects scoped into the CEA for marine mammals are outlined in Table 10.52. There will be no cumulative effects with onshore elements (those above MHWS) of the proposed offshore export cable corridor(s) and Proposed onshore transmission infrastructure for marine mammal receptors as all onshore works are above MHWS and there is therefore no receptor-impact pathway. The Proposed onshore transmission infrastructure is therefore screened out of further assessment.

592. To note, whilst the Proposed offshore export cable corridor(s) is in Tier 1 for the CEA, due to uncertainty in the final grid connection design and location details of the Proposed offshore export cable corridor(s), it was not possible to undertake a full detailed quantitative assessment at the time of writing. However, it is assumed offshore export cables in the vicinity of the Array and would be installed and buried as the primary means of protection.

593. The range of potential cumulative impacts that are identified and included in Table 10.52, is a subset of those considered for the Array alone assessment. This is because some of the potential impacts identified and assessed for the Array alone, are localised and temporary in nature. It is considered therefore, that these potential impacts have limited or no potential to interact with similar changes associated with other plans or projects. These have therefore not been taken forward for detailed assessment.

594. Similarly, some of the potential impacts considered within the Array 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 Array 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.

595. The CEA screening area for marine mammals initially focussed on projects within the regional marine mammal study area (as described in section 10.3) (Figure 10.24), as agreed with Statutory Nature Conservation Bodies (SNCBs). Spatial and temporal scale of impacts is critical in the CEA and has been considered on an impact by impact basis to ensure a proportionate approach to the CEA and is discussed in detail in section 10.12.2. To note, for piling as a precautionary approach, projects whose construction phase finishes in the two years preceding the commencement of construction phase at the site boundary (2031) were also screened in as the sequential piling at respective projects could lead to a longer duration of effects and whilst are likely to be operational, allows for potential delays in offshore construction (up to two years).

596. Given the limited data about Tier 3 projects available at the time of writing, projects were screened in initially based on temporal and/or spatial overlap as a precautionary approach. There was limited/no information on the construction/operation dates, nor foundation types proposed, however, with which to undertake any kind of meaningful assessment. Therefore, for potential impacts arising from piling for example which require these more detailed parameters, there is not sufficient information to carry out a full quantitative assessment.

597. Where ScotWind projects / projects screened into the CEA will receive grid connections as part of Holistic Network Design (HND) and HND Follow-up Exercise (FUE) associated transmission infrastructure is only considered where there is sufficient information in the public domain, i.e. through project Scoping reports, to inform the assessment. Other project where there is a lack of information in the public domain on cable routing, development timescales, and grid connection for the transmission infrastructure has not been considered further within this CEA.

Table 10.52: List of Other Projects and Plans Considered within the CEA for Marine Mammals

Project/Plan	Status [i.e. Application, Consented, Under Construction, Operational]*	Distance from Array (km)	Description of Project/Plan	Dates of Construction (If Applicable)	Dates of Operation (If Applicable)	Overlap with the Array
Tier 1						
Proposed offshore export cable corridor(s)	Planned	0.00	Proposed offshore export cable corridor(s) for the Array.	2030 to 2037	2038 to 2072	Considered as part of the Tier 1 assessment alongside the Array. The construction and operation and maintenance phases of Proposed offshore export cable corridor(s) overlap with those of the Array.
Offshore Wind Projects and Associated Cables						
Berwick Bank Wind Farm	Planning	56.84	Up to 4.1 GW (up to 307 wind turbines).	2025 to 2032	2033 to 2066	The construction and operational phase of Berwick Bank overlaps with the construction and operation and maintenance phase of the Array and the operational phases of the Berwick Bank Wind Farm overlap with the construction and operation and maintenance phases of the Array.
Green Volt Offshore Wind Farm	Planning	97.90	Offshore wind farm proposed for up to 35 wind turbines at a capacity of 560 MW.	2025 to 2029	2030 to 2065	The operation and maintenance phases of the Green Volt Offshore Wind Farm overlap with those of the Array.
Hornsea Project Three (HOW03)	Consented	319.38	Offshore wind farm consented for up to 231 wind turbines with no maximum generating capacity.	2025 to 2030	2031 to 2066	The construction phase of Hornsea Project Three overlaps with the two year period preceding the construction phase of the Array (therefore screening in for piling), and the operation and maintenance of the Hornsea Project Three overlap with the construction and operation and maintenance phases of the Array.
Tier 2						
Offshore Wind Projects and Associated Cables						
Broadshore Hub Offshore Wind Farms	Scoping	148.14	Broadshore Hub Offshore Wind Farms (comprising Broadshore Offshore Wind Farm, Sinclair Offshore Wind Farm and Scaraben Offshore Wind Farm) is proposed for up to 72 turbines at a capacity of 1,100 MW across the three projects.	2028 to 2029	2030 onwards	The operation and maintenance phase of Broadshore Hub Offshore Wind Farms overlaps with the construction and operation and maintenance phase of the Array.
Buchan Offshore Wind Farm	Scoping	151.62	Floating offshore wind farm proposed for up to 60 turbines at a capacity of 960 MW.	2028 to 2030	2031 onwards	The operation and maintenance phase of Buchan Offshore Wind Farm overlaps with the construction and operation and maintenance phase of the Array.
Caledonia Offshore Wind Farm	Scoping	157.49	Caledonia Offshore Wind Farm is proposed for up to 150 wind turbines at a capacity of 2000 MW.	2028 to 2029	2030 onwards	The operation and maintenance phase of Caledonia Offshore Wind Farm overlaps with the construction and operation and maintenance phase of the Array.
Cenos Offshore Wind Farm	Scoping	91.70	Cenos Offshore Wind Farm is proposed for up to 1350 MW	Unknown	Unknown	Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Cenos Offshore Wind Farm to overlap with the construction phase and operation and maintenance phase of the Array.

Project/Plan	Status [i.e. Application, Consented, Under Construction, Operational]*	Distance from Array (km)	Description of Project/Plan	Dates of Construction (If Applicable)	Dates of Operation (If Applicable)	Overlap with the Array
Dogger Bank South East - RWE Renewables	Scoping	241.02	Dogger Bank South East is proposed for up to 150 wind turbines at a capacity of 750 MW.	Unknown	Unknown	Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Dogger Bank South East to overlap with the construction phase and operation and maintenance phase of the Array.
Dogger Bank South West - RWE Renewables	Scoping	219.40	Dogger Bank South West is proposed for up to 150 wind turbines at a capacity of 750MW.	Unknown	Unknown	Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Dogger Bank South West to overlap with the construction phase and operation and maintenance phase of the Array.
Marram	Scoping	123.55	Marram Offshore Wind Farm is proposed for up to 150 turbines at a capacity of 3,000 MW.	2031 to 2038	2039 onwards	The construction phase and operation and maintenance phase of Marram Offshore Wind Farm overlaps with the construction and operation and maintenance phase of the Array.
Morven BP-EnBW	Scoping	5.50	Morven BP-EnBW is proposed for up to 191 wind turbines at a capacity of 2,300 MW.	2031 to 2037	2038 onwards	The construction phase and operation and maintenance phase of Morven BP-EnBW overlaps with the construction and operation and maintenance phase of the Array.
Muir Mhor Offshore Wind Farm	Scoping	51.38	Project construction expected to start construction in 2026 with commercial operation starting in 2030	2027 to 2029	2030 onwards	The operation and maintenance phase of Muir Mhor Offshore Wind Farm overlaps with the construction and operation and maintenance phase of the Array.
Salamander Offshore Wind Farm	Scoping	79.49	Salamander Offshore Wind Farm is proposed for up to 100 MW.	Unknown	Unknown	Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Salamander Offshore Wind Farm to overlap with the construction phase and operation and maintenance phase of the Array.
Stromar	Scoping	182.39	Floating offshore wind farm with 1,000 MW capacity.	2025 to 2032	2033 to 2059	The construction phase and operation and maintenance phase of Stromar to overlap with the construction phase and operation and maintenance phase of the Array.
Nordsren I	Planned	429.07	Capacity of up to 17,445 MW.	2028 to 2029	2030 onwards	The operation and maintenance phases of Nordsren I overlaps with the construction and operation and maintenance phases of the Array.
Nordsren II	Planned	395.76	Capacity of up to 15,000 MW.	Unknown	Unknown	Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Nordsren II to overlap with the construction phase and operation and maintenance phase of the Array.
Nordsren II vest	Planned	386.65	Unknown	Unknown	Unknown	Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Nordsren II vest to overlap with the construction phase and operation and maintenance phase of the Array.
Nordsren III	Planned	386.82	Unknown	Unknown	Unknown	Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Nordsren III to overlap with the construction phase and operation and maintenance phase of the Array.
Nordsren III vest	Planned	330.10	Unknown	Unknown	Unknown	Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Nordsren III vest to overlap with the construction phase and operation and maintenance phase of the Array.
N-10.1	Planned	436.69	N-10.1 Offshore Wind Farm is proposed for up to ten turbines at a capacity of 2,000 MW.	2028 to 2029	2030 onwards	The operation and maintenance phase of N-10.1 overlaps with the construction and operation and maintenance phase of the Array.

Project/Plan	Status [i.e. Application, Consented, Under Construction, Operational]*	Distance from Array (km)	Description of Project/Plan	Dates of Construction (If Applicable)	Dates of Operation (If Applicable)	Overlap with the Array
N-10.2	Planned	420.78	N-10.2 Offshore Wind Farm is proposed for up to ten turbines at a capacity of 500 MW.	2028 to 2029	2030 onwards	The operation and maintenance phase of N-10.2 overlaps with the construction and operation and maintenance phase of the Array.
N-9.4	Planned	421.20	N-9.4 Offshore Wind Farm is proposed for up to ten turbines at a capacity of 1,000 MW.	2026 to 2029	2030 onwards	The operation and maintenance phase of N-9.4 overlaps with the construction and operation and maintenance phase of the Array.
Ten Noorden van de Waddeneilanden	Planned	437.03	Ten Noorden van de Waddeneilanden is proposed for a capacity of 700 MW.	2029 to 2030	2031 onwards	The operation and maintenance phase of Ten Noorden van de Waddeneilanden overlaps with the construction and operation and maintenance phase of the Array.
Tier 3						
Arven Offshore Wind Farm	Pre-Planning	363.92	Floating offshore wind farm with proposed capacity of 3 GW.	Unknown	Unknown	The construction and operation and maintenance phases of Arven Offshore Wind Farm overlaps with the construction and operation and maintenance phases of the Array.
Ayre Offshore Wind Farm	Pre-Planning	219.96	Floating offshore wind farm with proposed for up to 60 turbines at a capacity of 1000 MW.	Unknown	Unknown	The construction and operation and maintenance phases of Ayre Offshore Wind Farm overlaps with the construction and operation and maintenance phases of the Array.
Bellrock Offshore Wind Farm	Pre-Planning	8.67	Floating offshore wind farm with proposed capacity of 1,200 MW.	Unknown	Unknown	The operation and maintenance phases of Bellrock overlaps with the construction and operation and maintenance phases of the Array.
Bowdun Offshore Wind Farm	Pre-Planning	25.36	Offshore wind farm with proposed 60 wind turbines at a capacity of 1000 MW.	Unknown	Unknown	The construction and operation and maintenance phases of Bowdun Offshore Wind Farm overlaps with the construction and operation and maintenance phases of the Array.
Campion Offshore Wind Farm	Pre-Planning	44.15	Floating offshore wind farm with up to proposed 100 wind turbines at a capacity of 2000 MW.	Unknown	Unknown	The construction and operation and maintenance phases of Campion Offshore Wind Farm overlaps with the construction and operation and maintenance phases of the Array.
Flora Floating Windfarm	Pre-Planning	68.41	Innovation and Targeted Oil & Gas (INTOG) project, using floating wind to electrify oil/gas infrastructure. Flora Floating Wind Farm is proposed for up to 50 MW.	Unknown	Unknown	Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Flora Floating Windfarm to overlap with the construction phase and operation and maintenance phase of the Array.
Aspen	Pre-Planning	85.61	INTOG project, using floating wind to electrify oil/gas infrastructure. Aspen Offshore Wind Farm is proposed for up to 1008 MW.	Unknown	Unknown	Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Aspen to overlap with the construction phase and operation and maintenance phase of the Array.
INTOG Site 8: Harbour Energy	Pre-Planning	154.62	INTOG project, using floating wind to electrify oil/gas infrastructure.	Unknown	Unknown	Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of INTOG Site 8: Harbour Energy to overlap with the construction phase and operation and maintenance phase of the Array.
Beech	Pre-Planning	160.41	INTOG project, using floating wind to electrify oil/gas infrastructure. Beech Offshore Wind Farm is proposed for up to 1008 MW.	Unknown	Unknown	Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Beech to overlap with the construction phase and operation and maintenance phase of the Array.

Project/Plan	Status [i.e. Application, Consented, Under Construction, Operational]*	Distance from Array (km)	Description of Project/Plan	Dates of Construction (If Applicable)	Dates of Operation (If Applicable)	Overlap with the Array
Cedar	Pre-Planning	51.65	INTOG project, using floating wind to electrify oil/gas infrastructure. Cedar Offshore Wind Farm is proposed for up to 1008 MW.	Unknown	Unknown	Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Cedar to overlap with the construction phase and operation and maintenance phase of the Array.
INTOG Site 13: Harbour Energy	Pre-Planning	135.28	INTOG project, using floating wind to electrify oil/gas infrastructure.	Unknown	Unknown	Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of INTOG Site 13: Harbour Energy to overlap with the construction phase and operation and maintenance phase of the Array.
Yell Sound Array	Pre-Planning	399.72	Tidal energy array with capacity of 15 MW.	Unknown	Unknown	Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Yell Sound Array to overlap with the construction phase and operation and maintenance phase of the Array.
BP Exploration Operating Company Limited	Agreement / Option for Lease	246.47	Carbon Capture Storage	Unknown	Unknown	Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of BP Exploration Operating Company Limited to overlap with the construction phase and operation and maintenance phase of the Array.
Morven BP-EnBW Offshore Export Cable Corridor	Pre-Planning	5.50	Morven Offshore Export Cable Corridor connecting Morven Offshore Wind Farm to onshore grid connection	Unknown	Unknown	Though dates are unknown, there is the potential for the construction phase and operation and maintenance phase of Morven BP-EnBW Offshore Export Cable Corridor to overlap with the construction phase and operation and maintenance phase of the Array.

**Correct as of CEA list freeze on 28 March 2024.*

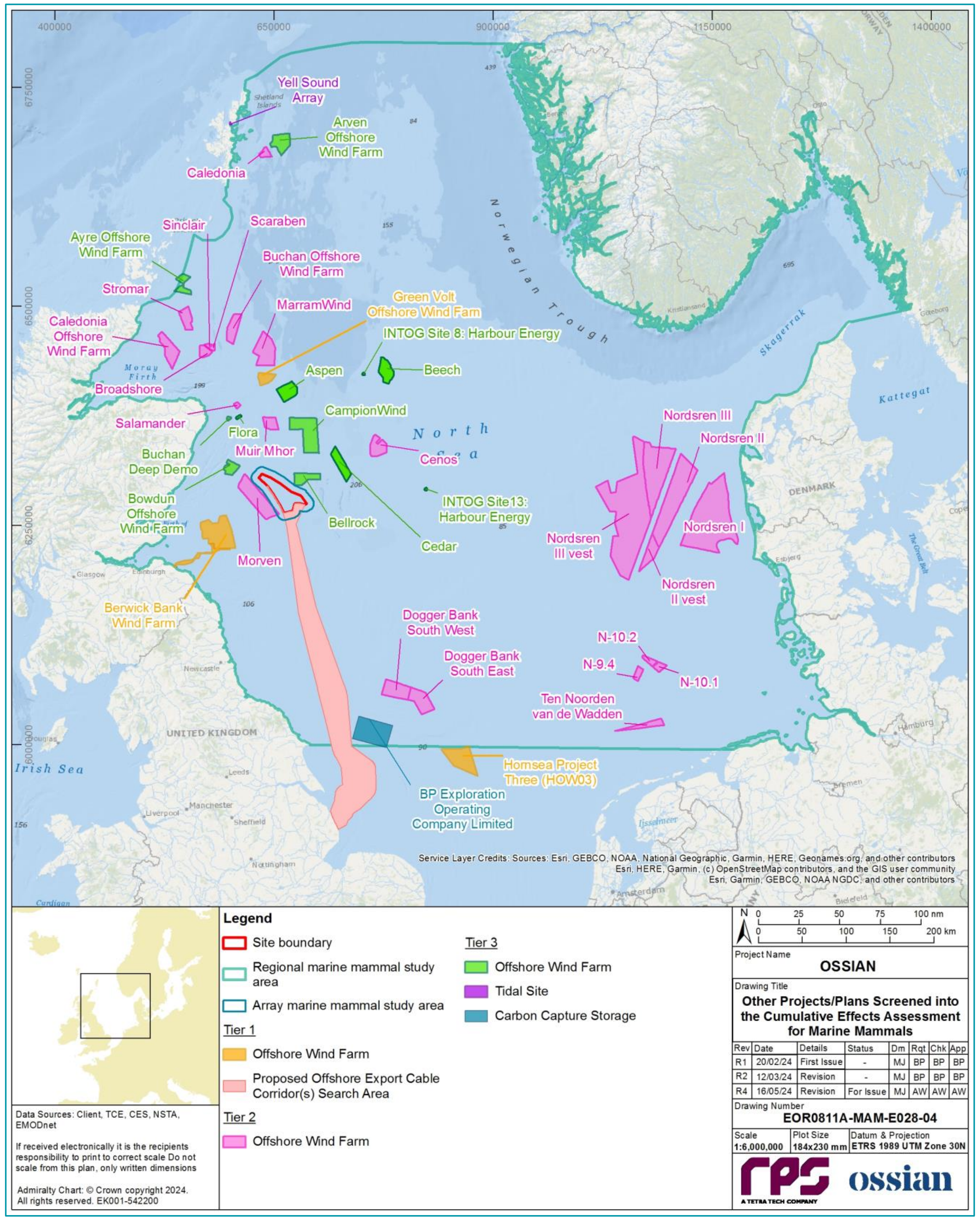

Figure 10.24: Other Projects/Plans Screened into the CEA for Marine Mammals

10.12.2. MAXIMUM DESIGN SCENARIO

598. The maximum design scenarios identified in Table 10.17 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 Array 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 volume 1, chapter 3 (e.g. different wind turbine layout), to that assessed here, be taken forward in the final design scheme.

599. As discussed in paragraph 594, where there is no spatial or temporal overlap with the activities during certain phases of the Array, impacts associated with other projects listed in Table 10.52, may be excluded from further consideration.

600. During the initial screening exercise for marine mammals, projects were considered over the whole of the regional marine mammal study area. Further to this, for each impact, the extent of the cumulative assessment was refined depending on the scale of the potential impact. For the purposes of the marine mammal assessment of effects, cumulative effects have been screened in/out on the following basis per impact:

- **Injury and disturbance from underwater noise generated during piling (construction phase)** – the ZoI for piling 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 whose construction phases overlap with the construction phase for the site boundary. As a precautionary approach, projects whose construction phase finishes in the two years preceding the commencement of construction phase at the site boundary (two years prior to 2031) were screened in as the sequential piling at respective projects could lead to a longer duration of effect. Where a project finishes offshore construction prior to the two years before construction at the site boundary begins, animals are anticipated to recover fully to baseline levels and therefore these projects are screened out on the basis of no receptor impact pathway.
- **Injury/disturbance to marine mammals from underwater noise during UXO clearance (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 100 km of the site boundary (which is greater than the largest disturbance range of ~32 km for the Array alone, and acknowledges that disturbance ranges from other projects may be substantial) whose construction phases (which would include pre-construction UXO clearance) overlap with the construction phase for the site boundary. Projects with completed UXO clearance campaigns are screened out of the assessment. Projects whose construction phase finishes in the year preceding the commencement of construction phase at the site boundary (i.e. one year prior to 2031) were screened in as the sequential UXO clearance at respective projects could lead to a longer duration of effect.
- **Disturbance due to site-investigation surveys (including geophysical surveys) (Construction and operation and maintenance phase)** – it is anticipated that the magnitude of the impacts will be of a similar scale to that described for the site boundary (i.e. metres), 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 close vicinity (up to 50 km buffer) of the site boundary and whose construction phase temporally overlaps with the site boundary. For the construction phase, where surveys are known to have been completed, this impact has been screened out of the CEA.
- **Injury and disturbance to marine mammals from underwater noise due to vessel use and other noise producing 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 (for example the maximum disturbance range from vessels for the Array was

3,259 m) and as such the assessment has focussed only on projects within a 50 km buffer of the Array as a conservative but proportionate approach.

- **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 a 50 km buffer of the Array as a conservative but proportionate approach.
- **Effects on marine mammals due to EMFs from subsea electrical cabling in the water column** – the impact of EMF is expected to be localised to within the close vicinity of the respective projects and transient for marine mammals, and as such the assessment has focussed only on projects within a representative 10 km buffer of the Array as a proportionate approach.
- **Injury and disturbance from underwater noise generated during the operation of floating wind turbines and anchor mooring lines (operation and maintenance phase)** – this impact is included for which operation and maintenance phase overlaps with the operation and maintenance phase of the Array. However the potential to experience injury and disturbance by marine mammal receptors would be expected to be localised to within the close vicinity of the respective projects (for example the maximum TTS range for the Array was 50 m) and as such the assessment has focussed only on FOW projects within a 50 km buffer of the Array as a conservative but proportionate approach. (Risch *et al.*, 2023b) highlighted the importance of considering the cumulative noise output of large FOW turbine arrays, particular where boundaries overlap, and therefore the wider 50 km buffer captures this wider spatial scale of effect.
- **Effects on marine mammals due to entanglement associated with the Array (operation and maintenance phase)** – this impact is included for which operation and maintenance phase overlaps with the operation and maintenance phase of the Array. 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 FOW projects within a 50 km buffer of the Array as a conservative but proportionate approach.
- **Effects on marine mammals due to altered 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 50 km buffer of the Array fish and shellfish ecology study area. This 50 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.

601. 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 2 projects) or the EIA Report (Tier 1 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 10.12.3. Impacts scoped out from individual assessments of respective projects are not considered further.

602. It should be noted that the CEA presented in this marine mammal chapter has been undertaken on the basis of information presented in the EIA Reports for the other projects, plans and activities, which is based upon the respective MDSs. The level of impact on marine mammal would likely be reduced significantly from those presented here.

Table 10.53: 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	O	D	Tier	Maximum Design Scenario
Injury and disturbance from underwater noise generated during piling	✓	×	×	1	**Construction Phase** MDS as described for the construction phase in Table 10.17 assessed cumulatively with construction of the following marine projects within the regional marine mammal study area and whose offshore construction phase finished within two years of 2031: • Proposed offshore export cable corridor(s) for the Array; • Hornsea Project Three; and • Berwick Bank Offshore Wind Farm.
	✓	×	×	2	**Construction Phase** MDS as described for the construction phase in Table 10.17 assessed cumulatively with construction of the following marine projects within the regional marine mammal study area: • Broadshore Hub Offshore Wind Farms; • Buchan Offshore Wind Farm; • Caledonia Offshore Wind Farm; • Cenos Offshore Wind Farm; • Dogger Bank South East – RWE Renewables; • Dogger Bank South West – RWE Renewables; • Marram Offshore Wind Farm; • Morven BP-EnBW; • Muir Mhor Offshore Wind Farm; • Salamander Offshore Wind Farm; • Stromar; • Nordsren I; • Nordsren II; • Nordsren II vest; • Nordsren III; • N-10.1; • Nordsren III vest; • N-10.2; • N-9.4; • Ten Noorden van de Waddeneilanden; and • Tier 1 Projects.

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

Potential Cumulative Effect	Phase[8]			Tier	Maximum Design Scenario
	C	O	D		
	✓	×	×	3	**Construction Phase** MDS as described for the construction phase in Table 10.17 assessed cumulatively with construction of the following marine projects within the regional marine mammal study area: • Arven Offshore Wind Farm; • Ayre Offshore Wind Farm; • Bellrock Offshore Wind Farm; • Bowdun Offshore Wind Farm; • Campion Offshore Wind Farm; • Flora Floating Wind Farm; • Aspen; • INTOG Site 8: Harbour Energy; • Beech; • Cedar; • INTOG Site 13: Harbour Energy; • Yell Sound Array; • BP Exploration Operating Company Limited; • Morven BP-EnBW Offshore Export Cable Corridor and • Tier 1 Projects and Tier 2 Projects.
Injury and disturbance from underwater noise generated during Unexploded Ordnance (UXO) clearance	✓	×	×	1	**Construction Phase** MDS as described for the construction phase in Table 10.17 assessed cumulatively with construction of the following marine projects within the 100 km buffer of the Array and whose construction phase finishes in the year preceding the commencement of construction phase at the site boundary (2030): • Proposed offshore export cable corridor(s); and • Berwick Bank Offshore Wind Farm.
	✓	×	×	2	**Construction Phase** MDS as described for the construction phase in Table 10.17 assessed cumulatively with construction of the following marine projects within the 100 km buffer of the Array and whose construction phase finishes in the year preceding the commencement of construction phase at the site boundary (2030): • Cenos Offshore Wind Farm ; • Morven BP-EnBW; • Muir Mhor Offshore Wind Farm; • Salamander Offshore Wind Farm and • Tier 1 Projects.
	✓	×	×	3	**Construction Phase** MDS as described for the construction phase in Table 10.17 assessed cumulatively with construction of the following marine projects within the 100 km buffer of the Array and whose construction phase finishes in the year preceding the commencement of construction phase at the site boundary (2030): • Bellrock Offshore Wind Farm; • Bowdun Offshore Wind Farm; • Campion Offshore Wind Farm; • Flora Floating Wind Farm; • Aspen; • Cedar; • Morven BP-EnBW Offshore Export Cable Corridor; and • Tier 1 and Tier 2 Projects.

Potential Cumulative Effect	Phase[8]			Tier	Maximum Design Scenario
	C	O	D		
Disturbance due to site-investigation surveys (including geophysical surveys)	✓	×	×	1	**Construction Phase** MDS as described for the construction phase in Table 10.17 assessed cumulatively with construction of the following marine projects within the 50 km buffer of the Array: • Proposed offshore export cable corridor(s). **Operation and Maintenance Phase** MDS as described for the construction phase in Table 10.17 assessed cumulatively with operational phase of the following marine projects within the 50 km buffer of the Array: • Proposed offshore export cable corridor(s).
	✓	×	×	2	**Construction Phase** MDS as described for the construction phase in Table 10.17 assessed cumulatively with construction of the following marine projects within the 50 km buffer of the Array: • Morven BP-EnBW; and • Tier 1 Projects. **Operation and Maintenance Phase** There are currently no known projects which will result in a cumulative effect during the operation and maintenance phase of the Array.
	✓	×	×	3	**Construction Phase** MDS as described for the construction phase in Table 10.17 assessed cumulatively with construction of the following marine projects within the 50 km buffer of the Array: • Bellrock Offshore Wind Farm; • Bowdun Offshore Wind Farm; • Campion Offshore Wind Farm; • Morven BP-EnBW Offshore Export Cable Corridor; and • Tier 1 Projects and Tier 2 Projects. **Operation and Maintenance Phase** There are currently no known projects which will result in a cumulative effect during the operation and maintenance phase of the Array.

Potential Cumulative Effect	Phase[8]			Tier	Maximum Design Scenario
	C	O	D		
Injury and disturbance from underwater noise generated during vessel use and other noise producing activities	✓	✓	✓	1	**Construction Phase** MDS as described for the construction phase in Table 10.17 assessed cumulatively with the following marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Proposed offshore export cable corridor(s). **Operation and Maintenance Phase** MDS as described for the Operation and Maintenance phase in Table 10.17 assessed cumulatively the following marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Proposed offshore export cable corridor(s). **Decommissioning Phase** MDS as described for the decommissioning phase in Table 10.17 assessed cumulatively with the following marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Proposed offshore export cable corridor(s).
	✓	✓	✓	2	**Construction Phase** MDS as described for the construction phase in Table 10.17 assessed cumulatively with construction of the following marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Morven BP-EnBW; and • Tier 1 Projects. **Operation and Maintenance Phase** MDS as described for the operation and maintenance phase in Table 10.17 assessed cumulatively with the following marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Morven BP-EnBW; and • Tier 1 Projects. **Decommissioning Phase** MDS as described for the decommissioning phase in Table 10.17 assessed cumulatively the following marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Morven BP-EnBW; and • Tier 1 Projects.

Potential Cumulative Effect	Phase[8] C	 O	 D	Tier	Maximum Design Scenario
	✓	✓	✓	3	**Construction Phase** MDS as described for the construction phase in Table 10.17 assessed cumulatively with construction of the following marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Bellrock Offshore Wind Farm; • Bowdun Offshore Wind Farm; • Campion Offshore Wind Farm; • Morven BP-EnBW Offshore Export Cable Corridor; and • Tier 1 Projects and Tier 2 Projects. **Operation and Maintenance Phase** MDS as described for the operation and maintenance phase in Table 10.17 assessed cumulatively with construction of the following marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Bellrock Offshore Wind Farm; • Bowdun Offshore Wind Farm; • Campion Offshore Wind Farm; • Morven BP-EnBW Offshore Export Cable Corridor; and • Tier 1 Projects and Tier 2 Projects. **Decommissioning Phase** MDS as described for the decommissioning phase in Table 10.17 assessed cumulatively with following marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Bellrock Offshore Wind Farm; • Bowdun Offshore Wind Farm; • Campion Offshore Wind Farm; • Morven BP-EnBW Offshore Export Cable Corridor; and • Tier 1 Projects and Tier 2 Projects.
Injury due to collision with vessels	✓	✓	✓	1	**Construction Phase** MDS as described for the construction phase in Table 10.17 assessed cumulatively with the following marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Proposed offshore export cable corridor(s). **Operation and Maintenance Phase** MDS as described for the Operation and Maintenance phase in Table 10.17 assessed cumulatively the following marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Proposed offshore export cable corridor(s). **Decommissioning Phase** MDS as described for the decommissioning phase in Table 10.17 assessed cumulatively with the following marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Proposed offshore export cable corridor(s).

Potential Cumulative Effect	Phase[8] C	 O	 D	Tier	Maximum Design Scenario
	✓	✓	✓	2	**Construction Phase** MDS as described for the construction phase in Table 10.17 assessed cumulatively with construction of the following marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Morven BP-EnBW; and • Tier 1 Projects. **Operation and Maintenance Phase** MDS as described for the Operation and Maintenance phase in Table 10.17 assessed cumulatively with the following marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Morven BP-EnBW; and • Tier 1 Projects. **Decommissioning Phase** MDS as described for the decommissioning phase in Table 10.17 assessed cumulatively the following marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Morven BP-EnBW; and • Tier 1 Projects.

Potential Cumulative Effect	Phase[8]			Tier	Maximum Design Scenario
	C	O	D		
	✓	✓	✓	3	**Construction Phase** MDS as described for the construction phase in Table 10.17 assessed cumulatively with construction of the following marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Bellrock Offshore Wind Farm; • Bowdun Offshore Wind Farm; • Campion Offshore Wind Farm; • Morven BP-EnBW Offshore Export Cable Corridor; and • Tier 1 Projects and Tier 2 Projects. **Operation and Maintenance Phase** MDS as described for the operation and maintenance phase in Table 10.17 assessed cumulatively with construction of the following marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Bellrock Offshore Wind Farm; • Bowdun Offshore Wind Farm; • Campion Offshore Wind Farm; • Morven BP-EnBW Offshore Export Cable Corridor; and • Tier 1 Projects and Tier 2 Projects. **Decommissioning Phase** MDS as described for the decommissioning phase in Table 10.17 assessed cumulatively with following marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Bellrock Offshore Wind Farm; • Bowdun Offshore Wind Farm; • Campion Offshore Wind Farm; • Morven BP-EnBW Offshore Export Cable Corridor; and • Tier 1 Projects and Tier 2 Projects.
Effects on marine mammals due to EMFs from subsea electrical cabling in the water column	✗	✓	✗	1	**Operation and Maintenance Phase** MDS as described for the operation and maintenance phase in Table 10.17 MDS as described for the operation and maintenance phase in Table 10.17 assessed cumulatively with construction of the following marine projects within 10 km buffer around the Array, within the regional marine mammal study area: • Proposed offshore export cable corridor(s).
	✗	✓	✗	2	**Operation and Maintenance Phase** MDS as described for the operation and maintenance phase in Table 10.17 assessed cumulatively with operation and maintenance of the following marine projects within 10 km buffer around the Array, within the regional marine mammal study area: • Morven BP-EnBW; and • Tier 1 Projects.
	✗	✓	✗	3	**Operation and Maintenance Phase** MDS as described for the operation and maintenance phase in Table 10.17 assessed cumulatively with operation and maintenance of the following marine projects within 10 km buffer around the array, within the regional marine mammal study area: • Bellrock Offshore Wind Farm; • Tier 1 Projects and Tier 2 Projects.

Potential Cumulative Effect	Phase[8]			Tier	Maximum Design Scenario
	C	O	D		
Injury and disturbance from underwater noise generated during the operation of wind turbines and anchor mooring lines	×	✓	×	1	**Operation and Maintenance Phase** There are currently no known projects within 50 km buffer around the Array which will result in a cumulative effect during the operation and maintenance phase of the Array.
	×	✓	×	2	**Operation and Maintenance Phase** MDS as described for the operation and maintenance phase in Table 10.17 assessed cumulatively with construction of the following marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Morven BP-EnBW.
	×	✓	×	3	**Operation and Maintenance Phase** MDS as described for the operation and maintenance phase in Table 10.17 assessed cumulatively with construction of the following marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Bellrock Offshore Wind Farm; • Bowdun Offshore Wind Farm; • Campion Offshore Wind Farm; and • Tier 2 Projects.
Effects on marine mammals due to entanglement associated with the Array	×	✓	×	3	**Operation and Maintenance Phase** MDS as described for the operation and maintenance phase in Table 10.17 assessed cumulatively with construction of the following floating marine projects within 50 km buffer around the Array, within the regional marine mammal study area: • Bellrock Offshore Wind Farm; and • Campion Offshore Wind Farm.
Effects on marine mammals due to altered prey availability	✓	✓	✓	Tiers 1, 2 and 3	MDS as described in Table 9.31 in chapter 2, volume 9 for each impact. CEA impacts on fish and shellfish include temporary habitat loss and disturbance, long term habitat loss and disturbance, colonisation of hard structures, underwater noise from piling and UXO clearance and effects due to EMF from subsea electrical cabling.

10.12.3. CUMULATIVE EFFECTS ASSESSMENT

603. An assessment of the likely significance of the cumulative effects of the Array upon marine mammal receptors arising from each identified impact is given below.

INJURY AND DISTURBANCE FROM UNDERWATER NOISE GENERATED DURING PILING

604. There is potential for cumulative injury and disturbance from underwater noise generated during piling as a result of piling associated with the array and the other plans and projects.

605. For the purposes of this EIA Report, the likely significance of this effect has been assessed using the tiered approach outlined in section 10.12.1. The plans and projects screened into the CEA for this impact and their respective tiers are outlined in Table 10.52.

Tier 1

Construction phase

Magnitude of impact

606. There were three Tier 1 projects identified with potential for cumulative effects associated with this impact:

- the construction and operation and maintenance phases of the Proposed offshore export cable corridor(s);
- the construction and operation and maintenance phases of Berwick Bank; and
- the construction and operation and maintenance phases of Hornsea Project Three (Table 10.52)

607. Whilst the construction phase at Green Volt Offshore Wind Farm is anticipated to be completed in 2029 , the Green Volt Offshore Wind Farm EIA (GreenVolt, 2023) states offshore construction is anticipated to take approximately 24 months from Q4 2025 to the end of Q3 2027 and therefore there is no temporal overlap in piling between Green Volt Offshore Wind Farm and the Array. There will be a period of three years between offshore construction at Green Volt Offshore Wind Farm and the Array and therefore animals are anticipated to recover fully in this period and Green-Volt Offshore Wind Farm will not contribute to the cumulative effect with the Array and is excluded from the CEA for piling.

608. There is no offshore piling during the construction and operation and maintenance phases of the Proposed offshore export cable corridor(s) and therefore will not contribute to the cumulative effect with the Array and is excluded from the CEA for piling.

609. Piling at each of these projects will occur as a discrete stage within the overall construction phase and therefore the periods of piling may not coincide. These timelines are, however, indicative and may be subject to change. Where cumulative numbers of animals potentially disturbed are presented (e.g. paragraph 627), the calculations consider the timelines of respective projects. Given that Hornsea Project Three completes the construction prior to the commencement of construction activities at the Array (see paragraph 590), animals are likely to recover from the disturbance between piling events and therefore the numbers of animals potentially disturbed at respective projects are not added together. If construction timelines directly overlap (such as between Berwick Bank and Hornsea Project Three), animals could be disturbed during piling for both projects simultaneously and therefore numbers of animals potentially disturbed during piling are summed. Nevertheless, to ensure the most precautionary approach, cumulative iPCoD modelling incorporates numbers of animals affected by all projects throughout construction phases (see paragraph 131 *et seq.* for more details about iPCoD modelling).

610. 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 Array). 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 effects for injury from elevated underwater noise during pilling and the cumulative assessment focuses on disturbance only.

611. Each project screened into the 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) was widely used to assess the effects of noise on marine mammals, and was used in the assessment of disturbance for Dogger Bank Creyke Beck A, Dogger Bank Creyke Beck B (Forewind, 2014). 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. However, 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 Offshore Limited, 2018), Moray West (Moray West OWF Limited, 2018c) and Hornsea Project Three (Ørsted, 2018), Hornsea Project Four (Ørsted, 2021) and the Array (cetaceans only, see paragraph 105 *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. Some projects present the range of area from which animals are excluded and numbers of animals disturbed, whilst others only present number of animals disturbed and no ranges. Various densities were used to derive these numbers of animals (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 may also use different reference populations. Therefore, assessment of the potential effects on marine mammals predicted by other wind farms is not always directly comparable to those presented for the Array 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.

612. Based upon the programme presented in the Berwick Bank Offshore Wind Farm EIA (SSE Renewables, 2022c), the construction phase of Berwick Bank Offshore Wind Farm is expected to run from 2025 to 2032 with the final piling phase in 2031 (SSE Renewables, 2022c), therefore offshore construction may overlap with the construction phase of the Array by two years, and an overlap of piling for one year and therefore lead to cumulative effects from piling. Located 56.84 km south-west from the Array, the MDS for piling at Berwick Bank Offshore Wind Farm assumed that 5.5 m diameter piled jacket foundations will be installed using a maximum hammer energy of 4,000 kJ. The EIA states piling will be required at up to 179 wind turbine foundations and ten OSP/Offshore convertor station platform foundations, with the MDS based on concurrent piling at wind turbine foundations with the largest separation between piling locations as this leads to the MDS for disturbance (piling could occur concurrently at a wind turbine and OSP/Offshore convertor station platform foundation but these locations would be closer together compared to two wind turbine foundations). The maximum number of days (24 hours) within which piling could occur on the basis of two piling operations was 287 piling days (concurrent vessel) for the 179 wind turbines and 85 piling days (single vessel) for the ten OSPs/Offshore convertor station platforms. Piling activity at Berwick Bank Offshore Wind Farm will take place in three campaigns, and an indicative piling schedule was presented in the iPCoD report which give a realistic installation programme (SSE Renewables, 2022b), and this was carried forward to population modelling in this CEA. With mitigation measures in place (MMO[2], PAM, ADD for 30 minutes, low hammer initiation, soft start and ramp up, such as those in Table 10.22), the residual number of individuals potentially affected by PTS was zero for all species. Numbers of animals disturbed for marine mammal IEFs, as presented in the Berwick Bank Offshore Wind Farm EIA (SSE Renewables, 2022c), is given in Table 10.54.

Table 10.54 Numbers Predicted to be Disturbed as a Result of Underwater Noise During Piling for Berwick Bank Offshore Wind Farm (SSE Renewables, 2022c)

Species	Scenario	Number of Animals	Magnitude	Residual Significance
Harbour porpoise	Concurrent Piling Wind Turbine (1% conversion factor)	2,822	Low	Minor adverse significance
	Single Piling OSP/Offshore Convertor Station Platform	1,754		
Bottlenose dolphin	Concurrent Piling Wind Turbine (1% conversion factor)	5 (Coastal)102 (Offshore)	Low	Minor adverse significance
	Single Piling OSP/Offshore Convertor Station Platform	4 (Coastal) 64 (Offshore)		
White-beaked dolphin	Concurrent Piling Wind Turbine (1% conversion factor)	830	Low	Minor adverse significance
	Single Piling OSP/Offshore Convertor Station Platform	516		
Minke whale	Concurrent Piling Wind Turbine (1% conversion factor)	132	Low	Minor adverse significance
	Single Piling OSP/Offshore Convertor Station Platform	82		
Grey seal	Concurrent Piling Wind Turbine (1% conversion factor)	1,358	Low	Minor adverse significance
	Single Piling OSP/Offshore Convertor Station Platform	705		

613. The construction of Hornsea Project Three is anticipated to occur until 2030 (Table 10.52), one year prior to the construction of the Array. Therefore, whilst the construction of Hornsea Project Three will be completed prior to commencement of piling at the Array, it could lead to a longer duration of piling operations (i.e. sequential rather than concurrent piling). It must be noted however that Hornsea Three is at the furthest extent of the regional marine mammal study area (a very small overlap therefore was screened in), located 319.38 km from the Array, and therefore cumulative effects are highly unlikely at this distance. The regional study area is a precautionary screening area for assessment to account for the mobile nature of marine mammals, and does not account for the levels of precaution in each respective projects MDS assessment (see paragraph 116 *et seq.* for examples of conservatism in underwater noise modelling*)*. The cumulative assessment of Hornsea Project Three is based upon the original EIA submitted alongside applications for Development Consent Orders to the Planning Inspectorate (Ørsted, 2018). As detailed in the EIA, piling at Hornsea Three is likely to occur in two short phases (each of approximately one year and a half), with a maximum duration of three years between phases where no piling will occur and it is expected animals will recover in this period.

614. The MDS for marine mammals for Hornsea Project Three included both a maximum spatial scenario and maximum temporal scenario. The maximum spatial scenario consisted of concurrent piling of 319 monopiles (300 turbine foundations and 19 foundations for other infrastructure and platform foundations) installed over 193.8 days, which comprises 189 days for monopiles over a 2.5 year period (divided into two phases and a gap of up to three years between phases), and 4.8 days for offshore High Voltage Alternating Current (HVAC) booster (over eight months within the 2.5 year piling period, single piling only), with a maximum hammer energy of up to 5,000 kJ (although Ørsted (2018) noted typically the maximum hammer energy will be considerably less than this and would not be required at all locations). The MDS states concurrent piling will occur only for infrastructure located within the Hornsea Three Array Area and not for infrastructure located within the offshore HVAC booster station search area in which only a single vessel scenario is possible.

615. The maximum temporal scenario for Hornsea Project Three consisted of single piling of 1,848 pin piles (1,200 for jacket foundations and 648 for other infrastructure and platform foundations) over 554.4 days, over a 2.5 year period with two phases and a gap of up to three years between phases, and 28.8 days for offshore HVAC booster over eight months within the 2.5 year piling period), with an absolute maximum hammer energy of up to 2,500 kJ.

616. The assessment in Hornsea Three was based on the definition of MDS piling parameters for each turbine foundation type (i.e. 5,000 kJ hammer energy for the monopiles and 2,500 kJ for the pin piles), however both a 'most likely' ramp up scenario (i.e. maximum hammer energy for most of the piling events = 3,500 kJ hammer energy for monopiles and 1,750 kJ for pin piles) and an overall 'average' hammer energy were defined (i.e., average typical hammer energy = 2,000 kJ for monopiles and 1,500 kJ for pin piles). Ørsted (2018) stated the number of animals disturbed under the maximum design scenario is highly precautionary as these hammer energies will not be representative of most of the actual piling activity. Whilst five representative locations were modelled, the highest impact ranges were found at the north-east modelling location within the Hornsea Three array (Hornsea Three NE) and at the south modelling location within the HVAC search area (HVAC S) and therefore used in the assessment for cetaceans. For grey seal, the Hornsea Three north-west (NW) location overlapped with higher seal density areas and therefore used for the assessment for grey seal. For concurrent scenarios, the MDS was modelled for monopiles at locations Hornsea Three NE and NW.

617. A range of density estimates were used for the assessment of disturbance, as presented in Table 10.55, alongside the dose-response method, with use of dose-response from Graham *et al.* (2017) for cetaceans and Russell *et al.* (2016) for seal species.

Table 10.55 Sources for Density Estimates used in Hornsea Three Assessment of Piling (Ørsted, 2018)

Species	Site-specific Density Estimate	Wider Area (Beyond Survey Area)
Harbour porpoise	• Density surface modelled using acoustic survey data collected over Hornsea Zone plus 10 km buffer; and • Corrected density from DAS surveys of Hornsea Three study area.	SCANS III
Minke whale	• Density surface modelled using acoustic survey data collected over Hornsea Zone plus 10 km buffer.	SCANS III
White-beaked dolphin	• Density surface modelled using acoustic survey data collected over Hornsea Zone plus 10 km buffer.	SCANS III
Grey seal	• Seal-usage maps (Russell *et al.*, 2017).	SCANS III

Harbour porpoise

618. The assessment for Berwick Bank Wind Farm predicted 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 (SSE Renewables, 2022c), which equates to 0.81% of the NS MU population and 7.3% of SCANS III Block R estimated abundance. This was based upon a 1% conversion factor and peak seasonal density of 0.826 animals per km^{2,} assuming all animals are uniformly distributed within all noise contours to provide a precautionary assessment. The EIA stated the duration of piling could potentially affect harbour porpoise over a maximum of five breeding cycles, with the magnitude of the impact having the potential to 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. Results of the iPCoD modelling for Berwick Bank Wind Farm 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 (SSE Renewables, 2022c) and therefore, it was considered that there is no potential for a long term effect. The magnitude for Berwick Bank Wind Farm, for behavioural impacts from piling, was considered to be low.

619. The assessment for Hornsea Project Three predicted up to 7,330 porpoises to be exposed to behavioural disturbance during concurrent piling events (monopiles), 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 (Ørsted, 2018)). The effect of disturbance of harbour porpoise from piling was predicted to be of minor adverse significance. Population (iPCoD) modelling of the cumulative assessment for Hornsea Project Three on the North Sea harbour porpoise population as a result of a number of scenarios of offshore wind farm construction in the North Sea was carried out, as presented in Hornsea Project Three EIA (Ørsted, 2018)). The assessment found that even with 15% of the population potentially disturbed due to multiple Tier 2 projects (Dogger Bank Creyke Beck A, Dogger Bank Creyke Beck B, Dogger Bank Teesside A, Dogger Bank Teesside B (Sofia) and East Anglia Three), 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.

620. Given that Hornsea Project Three completes the construction prior to the commencement of construction activities at the Array, animals are likely to recover from the disturbance between piling events and therefore the numbers of animals potentially disturbed at respective projects are not added together. However, there is the potential overlap of one year of piling with Berwick Bank Wind Farm which may lead to cumulative effects. Up to 11,131 animals may be disturbed at any one time if concurrent piling of wind turbines at Berwick Bank Wind Farm and concurrent piling at the Array occur simultaneously (Table 10.56). However, Berwick Bank Wind Farm is located 56.84 km from the Array, and the likelihood of cumulative effects with projects located at large distances is considered to be reduced; impulsive sound is likely to undergo transition into non-impulsive sound at distance from the sound source (see paragraphs 95 and 121). Furthermore, in reality, it is highly unlikely piling will occur at exactly the same time, and strike at exactly the same rate, therefore this assessment is highly precautionary.

621. Many projects refer to the North Sea MU as a reference population, which, as presented in the original Seagreen 1 Offshore Array EIA (Seagreen Wind Energy Limited, 2012) stretches across an area of 750,000 km^2. The number of harbour porpoise potentially disturbed has been considered for projects located in the marine mammal study area, which means some, including Hornsea Three, lie over 300 km from the Array (Table 10.52). 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 (Clarke 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 10.52), the likelihood of cumulative effects with projects located at large distances (e.g. >100 km) from the Array (i.e. Hornsea Three) is considered to be low.

Table 10.56 Harbour Porpoise Cumulative Assessment – Numbers Predicted to be Disturbed as a Result of Underwater Noise During Piling for Tier 1 Projects

Project	Hammer Energy	Scenario	No. Animals Disturbed	MU used in EIA	% Reference Population	Residual Impact presented in EIA
The Array	Maximum hammer energy: 4,400 kJ OSP + 3,000 kJ wind turbine (anchors)	Concurrent piling of wind turbine and OSP	8,309	346,601 NS MU (IAMMWG, 2022)	2.40%	Low
Berwick Bank Wind Farm (SSE Renewables, 2022c)	Maximum hammer energy up to 4,000 kJ	Concurrent piling wind turbines	2,822	346,601 NS MU (IAMMWG, 2021)	0.81%	Low
		Single OSPs	1,754		0.51%	
Hornsea Three (Ørsted, 2018)	Maximum hammer energy up to 4,000 kJ	Concurrent piling wind turbines	7,330	227,298 NS (IAMMWG, 2015)	3.22%	Low
		Single (offshore booster stations)	964		0.42%	

622. Population modelling (see volume 3, appendix 10.3) considered Berwick Bank Wind Farm and Hornsea Project Three alongside the Array, with respective numbers of animals potentially impacted against the MU population (Figure 10.25). The construction phase of Hornsea Project Three ends in 2030, prior to the commencement of the Array construction phase. Furthermore, unsuitable weather conditions in the northern North Sea, particularly during the winter months, are likely to result in forced construction down time, reducing the duration that piling will take place for the Array, thus allowing a further cessation of the impact between the two projects. Results of the cumulative iPCoD modelling for harbour porpoise showed that the median of the ratio of impacted population to unimpacted population approaches a ratio of 1 at all modelled time points. Although there was a difference in the number of animals between the disturbed and undisturbed populations, it was not considered that there is a potential for a long term effect on this species as a result of cumulative piling at the Array and respective Tier 1 projects.

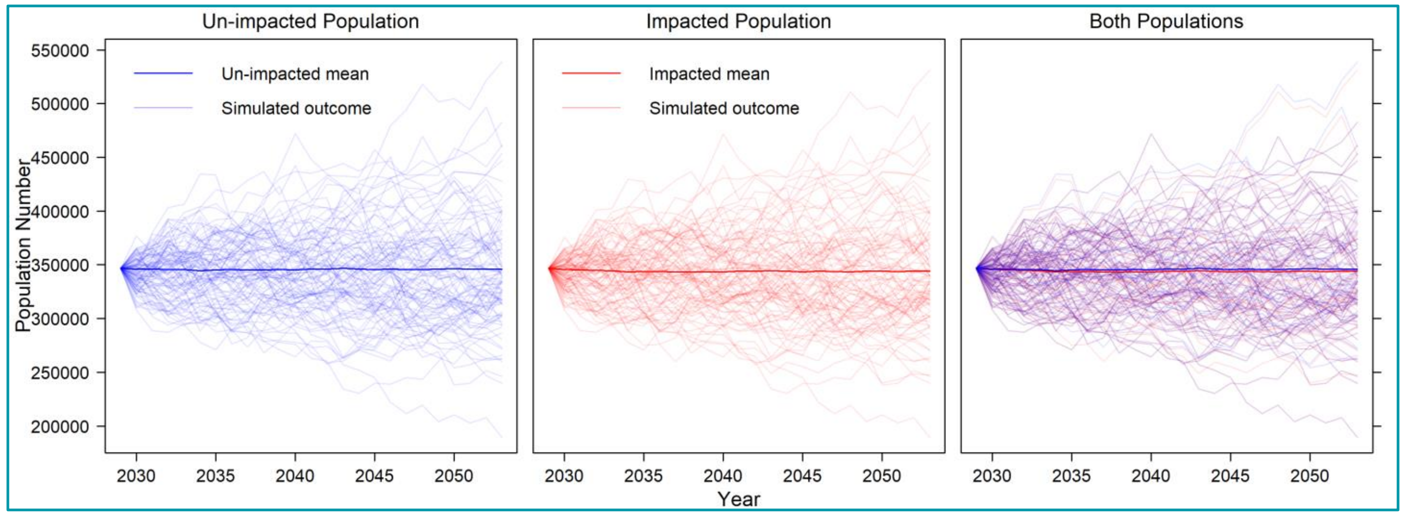

Figure 10.25: Simulated Harbour Porpoise Population Sizes for Both the Baseline and the Impacted Populations Under the Cumulative Scenario and no Vulnerable Subpopulation

623. The cumulative impact (elevated underwater noise arising during piling) is predicted to be of regional spatial extent within the relevant geographic frame of reference, medium-term duration, intermittent and the effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Bottlenose dolphin

624. Bottlenose dolphin was not scoped in as a key species for Hornsea Project Three (Ørsted, 2018) and there is no information available for Proposed offshore export cable corridor(s). However, it was considered in Berwick Bank Wind Farm (SSE Renewables, 2022c) and therefore can be included in the cumulative assessment.

625. Berwick Bank Wind Farm (SSE Renewables, 2022c) used a dual approach to estimate bottlenose dolphin disturbed, using noise contours overlaid with 2 m to 20 m depth contours and numbers of animals in those areas calculated using a density of 0.197 animals per km2 from Peterhead to Farne Islands and 0.294 animals per km2 for the outer Firth of Tay (where the density is higher). Furthermore, 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 km2. Up to five bottlenose dolphin are predicted to have the potential to experience disturbance from concurrent piling in coastal waters (2.25% of the CES^2 MU population) based upon 1% constant conversion factor and maximum hammer energy of 4,000 kJ. 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^2 MU population) animals affected.

626. Potential effects on the offshore bottlenose dolphin population were also assessed in the EIA for Berwick Bank Wind Farm. During concurrent piling at maximum 4,000 kJ hammer energy, up to 102 individuals occurring in offshore waters have the potential to experience disturbance (5.29% of SCANS III Block R). For the single piling scenario, up to 64 individuals have the potential to experience disturbance offshore, which equates to 3.29% of the SCANS III Block R estimated abundance. The EIA did state the densities were considered to be conservative as these are based on highly precautionary coastal and offshore density estimates. Population modelling for bottlenose dolphin against the MU population showed that the median of the ratio of the impacted population to the unimpacted population was a ratio of 1 at 25 years and there was no potential for a long term effect on this species. The magnitude for Berwick Bank Wind Farm, for behavioural impacts from piling, was considered to be low.

627. As detailed in paragraph 620, numbers from Hornsea Three are not added together as its construction completes a year prior to the commencement for the Array, but there is the potential overlap of one year of piling at the Array with Berwick Bank Wind Farm which may lead to cumulative effects. Up to ten animals (in the CES^2 MU) may be disturbed if concurrent piling of wind turbines at Berwick Bank Wind Farm and concurrent piling at the Array occur simultaneously. However, Berwick Bank Wind Farm is located 56.84 km south-east from the Array, and the likelihood of cumulative effects with projects located at large distances is considered to be reduced; impulsive sound is likely to undergo transition into non-impulsive sound at distance from the sound source (see paragraphs 95 and 121). Furthermore, in reality, it is highly unlikely piling will occur at exactly the same time, and strike at exactly the same rate, therefore this assessment is highly precautionary.

Table 10.57 Bottlenose Dolphin Cumulative Assessment – Numbers Predicted to be Disturbed as a Result of Underwater Noise During Piling for Tier 1 Projects

Project	Hammer Energy	Scenario	No. Animals Disturbed	MU Reference Population used in EIA	% Reference Population	Residual Impact
The Array	Maximum hammer energy: 4,400 kJ OSP + 3,000 kJ wind turbine (anchors)	Concurrent piling of wind turbine and OSP	5	224 CES^2 MU (IAMMWG, 2023)	2.23%	Low
Berwick Bank Wind Farm (SSE Renewables, 2022c)	Maximum hammer energy up to 4,000 kJ	Concurrent piling wind turbines	51	224 CES^2 MU (Arso Civil *et al.* 2019)	2.23%	Low
		Single OSPs	41		1.79%	

[1] Animals disturbed is based upon the CES^2 MU presented in Berwick Bank Wind Farm for comparison with the Array which uses CES^2 MU, rather than offshore numbers.

628. Population modelling (see volume 3, appendix 10.3) considered Berwick Bank Wind Farm alongside the Array (Hornsea Three lies outside of the CES^2 MU and did not assess bottlenose dolphin), with respective numbers of animals potentially impacted against the MU population (Figure 10.26). For bottlenose dolphin, the CES^2 MU was used as the relevant reference population for cumulative population modelling. Given the importance of the Moray Firth SAC for bottlenose dolphin in this area, the sensitivity of this population and its known ranging behaviour further south towards St Andrews Bay and the Tay Estuary, and inshore in north-east English waters, it is important to capture the potential impact on this important coastal ecotype which may experience potential barrier effects. Whilst there is an abundance estimate for the Greater North Sea MU (2,022 animals (IAMMWG, 2023)) this large MU extends the entire length of the east coast of the UK and east to Scandinavia, so apportioning numbers of the offshore ecotype to the east coast of Scotland is not possible. It is also unlikely that the Array will create significant barrier effects for this offshore ecotype. Therefore, the cumulative modelling assessment for the Array used the CES^2 MU as the relevant reference population.

629. Results of the cumulative iPCoD modelling for bottlenose dolphin showed that the median of the ratio of impacted population to unimpacted population approaches had a ratio of 1 at all modelled time points, with ten fewer animals in the impacted population at 25 years after the start of piling, compared to the impacted population. Therefore, it was not considered that there is potential for a long term effect on this species as a result of cumulative piling at the Array and respective Tier 1 projects. Furthermore, given the population modelling used the CES^2 MU, and the Array sits outside of this MU, it is considered further unlikely to have long term effects on the offshore ecotype.

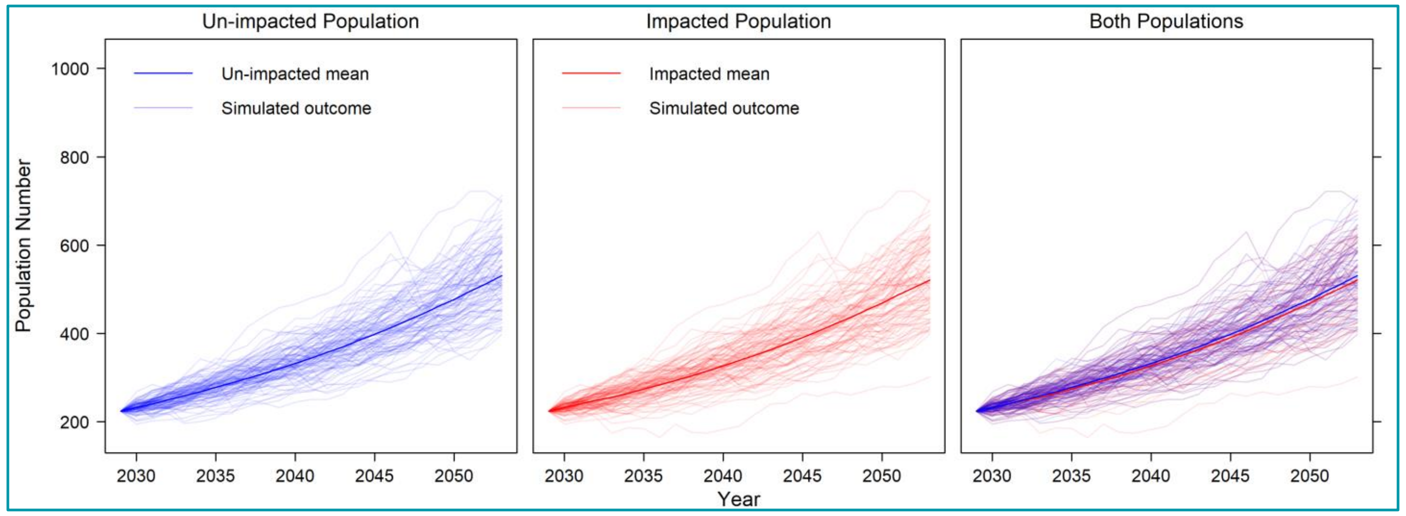

Figure 10.26: **Simulated Bottlenose Dolphin Population Sizes for Both the Baseline and the Impacted Populations Under the Cumulative Scenario and no Vulnerable Subpopulation.**

630. The cumulative impact (elevated underwater noise arising during piling) is predicted to be of regional spatial extent within the geographic frame of reference, medium term duration, intermittent and high reversibility (with animals returning to baseline levels within hours/days after piling have ceased). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

White-beaked dolphin

631. The assessment for Berwick Bank Wind Farm predicted up to 830 animals have the potential to experience disturbance during concurrent piling at a maximum hammer energy of 4,000 kJ (1.89% of the CGNS MU population), based on SCANS III Block R white-beaked dolphin density estimates and 1% constant conversion factor. 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, with up to 516 (1.17% of the CGNS MU population) disturbed. The EIA determined the duration of piling could potentially affect white-beaked dolphin over a maximum of five breeding cycles but the area of effect is small in relation to the extensive distribution of the population for this species (CGNS MU, IAMMWG (2021)). The magnitude for Berwick Bank Wind Farm, for behavioural impacts from piling on white-beaked dolphin, was considered to be low.

632. The assessment for Hornsea Project Three predicted up to 12 white-beaked dolphin to be exposed to behavioural disturbance during concurrent piling events, by combining the site-specific density surface and the SCANS III density data (Ørsted, 2018). The CGNS MU white-beaked dolphin reference population of 15,895 individuals was used for this assessment (Ørsted, 2018), which is different to the estimate used in Berwick Bank Wind Farm and the Array. The residual effect of disturbance of white-beaked dolphin from piling was predicted to be of negligible adverse significance.

633. As detailed in paragraph 620, numbers from Hornsea Three are not added together as it finishes construction a year prior to the Array, but there is the potential overlap of one year of piling at the Array with Berwick Bank Wind Farm which may lead to cumulative effects. Up to 2,361 animals (5.37% of the CGNS MU) may be disturbed if concurrent piling of wind turbines at Berwick Bank Wind Farm and concurrent piling at the Array occur simultaneously. However, Berwick Bank Wind Farm is located 56.84 km south-west from the Array, and the likelihood of cumulative effects with projects located at large distances is considered to be reduced; impulsive sound is likely to undergo transition into non-impulsive sound at distance from the sound source (see paragraphs 95 and 121). Furthermore, in reality, it is highly unlikely piling will occur at exactly the same time, and strike at exactly the same rate, therefore this assessment is highly precautionary.

Table 10.58 **White-Beaked Dolphin Cumulative Assessment – Numbers Predicted to be Disturbed as a Result of Underwater Noise During Piling for Tier 1 Projects**

Project	Hammer Energy	Scenario	No. Animals Disturbed	MU used in EIA	% Reference Population	Residual Impact
The Array	Maximum hammer energy: 4,400 kJ OSP + 3,000 kJ wind turbine (anchors)	Concurrent piling of wind turbine and OSP	1,531	43,951 CGNS MU (IAMMWG, 2023)	3.48%	Low
Berwick Bank Wind Farm (SSE Renewables, 2022c)	Maximum hammer energy up to 4,000 kJ	Concurrent piling wind turbines	830	43,951 CGNS MU (IAMMWG, 2021)	1.89%	Low
		Single OSPs	516		1.17%	
Hornsea Three (Ørsted, 2018)	Maximum hammer energy up to 4,000 kJ	Concurrent piling wind turbines	12.4	15,895 CGNS MU (Ørsted, 2018)	0.08%	Low
		Single (offshore booster stations)	2.2		0.01%	

634. As discussed in paragraph 131, the current version of iPCoD does not allow modelling for this species and therefore population modelling has not been carried out for this species.

635. The cumulative impact (elevated underwater noise arising during piling) is predicted to be of regional spatial extent in the context of the geographic frame of reference, medium term duration, intermittent and the effect of behavioural disturbance is reversible (with animals returning to baseline levels within hours/days after piling have ceased). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Minke whale

636. The assessment for Berwick Bank Wind Farm (SSE Renewables, 2022c) predicted 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 (based on SCANS III Block R minke whale density estimates) (equating to 0.66% of the CGNS MU). 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 with up to 82 (0.41% of the CGNS MU population) animals affected. The EIA determined the duration of piling could potentially affect minke whale over a maximum of five breeding cycles, with magnitude of the impact resulting in a small but measurable alteration to the distribution of marine mammals during piling only. However, population modelling showed that the median of the ratio of the impacted population to the unimpacted population was 0.989 at 25 years and it was considered that there was no potential for a long term effect on this species from Berwick Bank Wind Farm. The magnitude for Berwick Bank Wind Farm, for behavioural impacts from piling on minke whale, was considered to be low.

637. 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 (Ørsted, 2018). The CGNS MU minke whale reference population was used for this assessment (23,528 individuals). The effect of disturbance on minke whale from piling was predicted to be of minor adverse significance.

638. As detailed in paragraph 620, numbers from Hornsea Three are not added together as it finishes construction a year prior to the Array, but there is the potential overlap of one year of piling at the Array with Berwick Bank Wind Farm which may lead to cumulative effects. Up to 495 animals may be disturbed if concurrent piling of wind turbines at Berwick Bank Wind Farm and concurrent piling at the Array occur simultaneously (2.46% of the CGNS MU). However, Berwick Bank Wind Farm is located 56.84 km south-west from the Array, and the likelihood of cumulative effects with projects located at large distances is considered to be reduced; impulsive sound is likely to undergo transition into non-impulsive sound at distance from the sound source (see paragraphs 95 and 121). Furthermore, in reality, it is highly unlikely piling will occur at exactly the same time, and strike at exactly the same rate, therefore this assessment is highly precautionary.

639. Population modelling (see volume 3, appendix 10.3) considered Berwick Bank Wind Farm and Hornsea Project Three alongside the Array are not available at this stage), with respective numbers of animals potentially impacted against the MU population (Figure 10.27). Results of the cumulative iPCoD modelling for minke whale showed that the median of the ratio of impacted population to unimpacted population was 1 at all modelled time points, with a difference of one animal between the impacted and unimpacted population 25 years after the start of piling. 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 Array and respective Tier 1 projects.

Table 10.59: Minke Whale Cumulative Assessment – Numbers Predicted to be Disturbed as a Result of Underwater Noise During Piling for Tier 1 Projects

Project	Hammer Energy	Scenario	No. Animals Disturbed	MU Reference Population used in EIA	% Reference Population	Residual Impact
The Array	Maximum hammer energy: 4,400 kJ OSP + 3,000 kJ wind turbine (anchors)	Concurrent piling of wind turbine and OSP	362	20,118 CGNS MU (IAMMWG, 2023)	1.80%	Low
Berwick Bank Wind Farm (SSE Renewables, 2022c)	Maximum hammer energy up to 4,000 kJ	Concurrent piling wind turbines	132	20,118 CGNS MU (IAMMWG, 2021)	0.66%	Low
		Single OSPs	82		0.41%	
Hornsea Three (Ørsted, 2018)	Maximum hammer energy up to 4,000 kJ	Concurrent piling wind turbines	51	23,528 CGNS MU (Ørsted, 2018)	0.22%	Low
		Single (offshore booster stations)	11		0.05%	

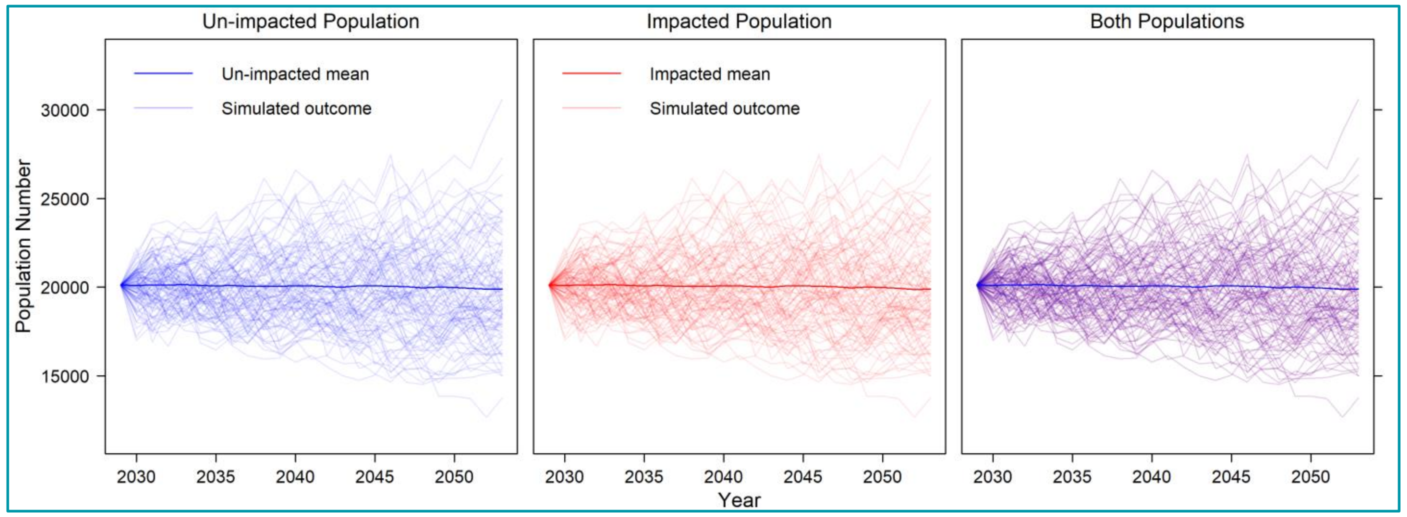

Figure 10.27: Simulated Minke Whale Population Sizes for Both the Baseline and the Impacted Populations Under the Cumulative Scenario and no Vulnerable Subpopulation

640. The cumulative impact (elevated underwater noise arising during piling) is predicted to be of regional spatial extent in the context of the geographic frame of reference, medium term duration, intermittent and the effect of behavioural disturbance is reversible (with animals returning to baseline levels within hours/days after piling have ceased). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Grey seal

641. The assessment for Berwick Bank Wind Farm (SSE Renewables, 2022c) predicted 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 (3.19% of the East Scotland plus North East England MUs population), based upon Carter *et al*. (2020) maps. 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 with up to 705 (1.66% of the East Scotland plus North East England MUs population) animals disturbed. In the EIA population 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 and it was considered that there is no potential for a long term effect on this species. The magnitude for Berwick Bank Wind Farm, for behavioural impacts from piling on grey seal, was considered to be low.

642. The assessment for Hornsea Project Three predicted 53 grey seal to be exposed to behavioural disturbance during concurrent piling events (monopiles), based upon noise contours overlain on grey seal at-sea density surfaces from Russell *et al*. (2017). Given that Hornsea Project Three completes the construction prior to the commencement of construction activities at the Array, animals are likely to recover from the disturbance between piling events and therefore the numbers of animals potentially disturbed at respective projects are not added together.

Table 10.60: Grey Seal Cumulative Assessment – Numbers Predicted to be Disturbed as a Result of Underwater Noise During Piling for Tier 1 Projects

Project	Hammer Energy	Scenario	No. Animals Disturbed	MU Used in EIA	% Reference Population	Residual Impact
The Array	Maximum hammer energy: 4,400 kJ OSP + 3,000 kJ wind turbine (anchors)	Concurrent piling of wind turbine and OSP	436	36,696 ES and North-East England MUs	1.19%	Low
Berwick Bank Wind Farm (SSE Renewables, 2022c)	Maximum hammer energy up to 4,000 kJ	Concurrent piling wind turbines	1,358	42,600 ES and North-East England MUs	3.19%	Low
		Single OSPs	705		1.65%	
Hornsea Three (Ørsted, 2018)	Maximum hammer energy up to 4,000 kJ	Concurrent piling wind turbines	53	40,040 South-East England and NEE combined	0.13%	Low

643. Population modelling (see volume 3, appendix 10.3) considered Berwick Bank Wind Farm and Hornsea Project Three alongside the Array, with respective numbers of animals potentially impacted against the MU population. Results of the cumulative iPCoD modelling for grey seal showed that the median of the ratio of impacted population to unimpacted population was 1 at all modelled time points, and there was no difference in the mean size of the impacted and unimpacted populations at all 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 Array and respective Tier 1 projects.

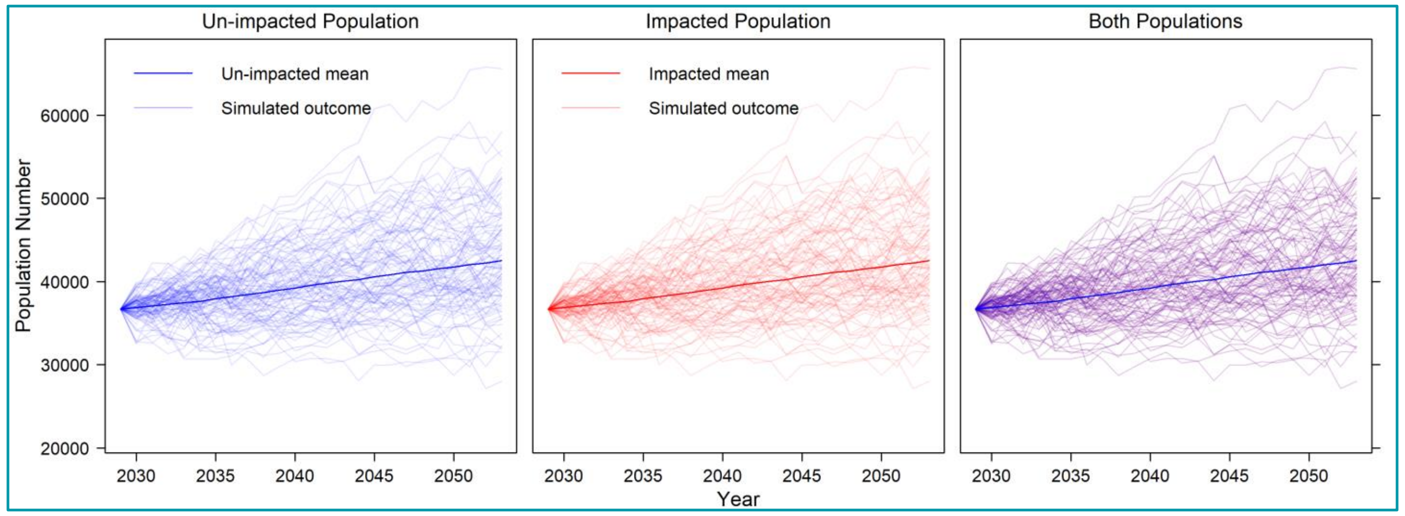

Figure 10.28: Simulated Grey Seal Population Sizes for Both the Baseline and the Impacted Populations Under the Cumulative Scenario and no Vulnerable Subpopulation

644. The cumulative impact (elevated underwater noise arising during piling) is predicted to be of regional spatial extent in the context of the geographical frame of reference, medium term duration, intermittent and the effect is reversible (with animals returning to baseline levels within hours/days after piling have ceased). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of receptor

645. The sensitivities of marine mammals to cumulative disturbance from piling are as previously described above for the assessment of the Array alone (paragraphs 234 to 253) for the construction phase and therefore is not repeated here.

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

Significance of effect

647. Overall, the magnitude of the cumulative impact is deemed to be low for harbour porpoise, bottlenose dolphin, white-beaked dolphin, minke whale and grey seal, 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

648. No 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.

Tier 2

Construction phase

Magnitude of impact

649. There were 20 Tier 2 projects identified with potential for cumulative effects associated with this impact:

- Broadshore Hub Offshore Wind Farms
- Buchan Offshore Wind Farm
- Caledonia Offshore Wind Farm;
- Cenos Offshore Wind Farm
- Dogger Bank South East – RWE Renewables;
- Dogger Bank South West – RWE Renewables;
- Marram;
- Morven BP-EnBW;
- Muir Mhor Offshore Wind Farm;
- Salamander Offshore Wind Farm;
- Stromar;
- Nordsren I;
- Nordsren II;
- Nordsren II vest;
- Nordsren III;
- N-10.1;
- Nordsren III vest;
- N-10.2;
- N-9.4; and
- Ten Noorden van de Waddeneilanden

650. Broadshore Hub Offshore Wind Farms are located 148.14 km from the Array and includes areas of seabed as part of INTOG leasing rounds to develop the 900 MW Broadshore Offshore Wind Farm Project (the Broadshore Project), the 99.5 MW Sinclair Offshore Wind Farm Project (the Sinclair Project) and the 99.5 MW Scaraben Offshore Wind Farm Project (the Scaraben Project), collectively known as the Broadshore Hub Offshore Wind Farms (Broadshore Offshore Wind Farm Limited *et al.*, 2024). All projects will comprise wind turbines, station keeping systems and inter-array cables. The Broadshore Project will comprise up to 60 wind turbines, whilst the Sinclair and the Scaraben Projects will comprise up to six wind turbines. The Broadshore Hub Offshore Wind Farms Scoping Report (Broadshore Offshore Wind Farm Limited *et al.*, 2024) scoped in underwater noise during impact piling (using hydraulic hammer or vibropiling) of anchors of fixed bottom substructures and/or floating substructures. Anchor driven piles may have up to 12 anchor driven piles per floating substructure estimated at 3.5 m diameter with hammer energy of up to 3,000 kJ. Fixed bottom substructures may comprise either jacket (tripod or quadruped) up to 4 m pile with hammer energy of up to 4,000 kJ, either impact or drill piled, or cable supported monopile with pile diameter of 16 m. The construction phase is expected to begin in 2028 until 2029 and therefore piling will be completed a year prior to the start of the Array, allowing some recovery before piling begins at the Array. Information on the numbers of animals is not available at this time to undertake a quantitative assessment.

651. Buchan Offshore Wind Farm is located 151.62 km from the Array and is a FOW farm with up to 70 wind turbines and associated supporting structures, including floating foundations, mooring systems and anchors, interarray cables, up to three OSPs and export cable corridor (Buchan Offshore Wind Limited, 2023). The Buchan Offshore Wind Farm scoped in increased underwater noise from pile driving for floating wind turbines, OSPs and Intermediate Reactive Compensation (IRC) platform (if piled foundations are used). The construction phase is expected to begin in 2028 until 2030 and therefore piling may be sequential with the start of the construction of the Array, however the large distance means cumulative effects are unlikely. Information on the numbers of animals is not available at this time to undertake a quantitative assessment.

652. The Caledonia Offshore Wind Farm is located in the Moray Firth, 157.49 km from the Array, indicatively 75% of the Array Area could be constructed using fixed foundations, and is considering the use of floating foundations for remaining sites (Ocean Winds, 2022). Fixed-foundation types currently being considered include: monopile; fully restrained platform; jacket with pin piles; jacket with suction caissons; Gravity Based Structure (GBS). Floating foundation types include semi-submersible and tension leg platform. A maximum of 150 wind turbine generators will be located within the Array Area, with an estimated split of up to 111 fixed foundations and 39 floating foundations. An indicative spatial distribution on fixed foundations (an area approximately 307 km^2 across the north of the Caledonia Array Area) and floating foundations (approximately 122 km^2 across the south of the Caledonia Array Area) is presented within the Offshore Scoping Report. The MDS considers up to six OSPs. The final type and design for the foundations will be subject to further site investigations, however jacket with pin piles, jacket with suction caissons, monopile and GBS currently under consideration. The construction phase is expected to begin in 2028 until 2029 and therefore piling will be completed a year prior to the start of the Array, allowing some recovery before piling begins at the Array. Information on the numbers of animals is not available at this time to undertake a quantitative assessment.

653. Cenos Offshore Wind Farm is located 91.70 km from the Array and is a proposed FOW farm (part of the INTOG leasing process) with up to 1.4 GW and footprint of 333 km^2. The Cenos Offshore Wind Farm Scoping Report (Flotation Energy, 2023) gives potential development size of 70 to 100 turbines with floating substructures with 3 to 6 mooring lines/anchor substructures. The Cenos Offshore Wind Farm scoped in underwater noise from percussion piling as a potential impact on marine mammals, but stated no significant effects on marine mammals due to noise are expected (Flotation Energy, 2023). The Cenos Offshore Wind Farm Scoping Report details an indicative schedule from 2027 to 2030 with installation of all the turbines expected to take two to three years, and therefore piling may be sequential with the start of the construction of the Array. Information on the numbers of animals is not available at this time to undertake a quantitative assessment.

654. Dogger Bank South Offshore Wind Farms comprise Dogger Bank South East (located 363.35 km from the Array) and Dogger Bank South West (located 499.03 km from the Array). The Project Description (volume 1, chapter 3) allows for up to 150 rbines for each project, and the Scoping Report details a range of foundation options, including monopiles, jackets on pin piles; and jackets on suction buckets (RWE Renewables UK, 2022) (volume 1, chapter 3). Construction of the Dogger Bank Offshore Wind Farms is expected to begin no earlier than 2026, however the programme for construction will depend on the final confirmation of the grid connection date and there is no indication currently of a construction timeline (therefore precautionary it is considered there may be some overlap with the Array construction phase). It is anticipated that the two Dogger Bank projects will be built concurrently and sequentially (RWE Renewables UK, 2022). The large distance between the Dogger Bank South Offshore Wind Farms and the Array (363.35 km to 499.03 km south from the Array) means cumulative effects are unlikely Information on the numbers of animals is not available at this time to undertake a quantitative assessment.

655. Marram Offshore Wind Farm is located 123.55 km from the Array and is a FOW farm proposed for up to 150 wind turbines at a capacity of 3000 wind turbines (MarramWind Ltd., 2023). Depending on the final wind turbine size selected, Marram Offshore Wind Farm is expected to have in the region of 126 to 225 wind turbines including floating units (platforms and station keeping system). The Marram Offshore Wind Farm Scoping report (MarramWind Ltd., 2023) scoped in increased underwater noise during installation, operation and maintenance, and decommissioning, from anchor piles. The overall duration of construction of the offshore infrastructure is anticipated to be up to eight years, from 2031 to 2038 and therefore may overlap with the construction programme of the Array. Information on the numbers of animals is not available at this time to undertake a quantitative assessment.

656. The Morven Offshore Wind Project is a proposed large scale fixed-foundation offshore wind farm located 5.50 km from the Array. The Offshore Scoping Report (Morven Offshore Wind Limited, 2023) considers up

to 191 wind turbines and up to 11 OSPs. The following foundation types will be considered: monopile foundations, gravity base foundations, piled jacket foundations (three or four legs for wind turbines; three, four or six legs for OSPs), suction bucket jacket foundations (three or four legs for wind turbines; three, four or six legs for OSPs) (Morven Offshore Wind Limited, 2023). The Array Project is estimated to occur over a duration of up to seven years, with construction phase from 2027 to 2033, meaning a potential of three years overlap with the construction phase of the Array. Information on the numbers of animals is not available at this time to undertake a quantitative assessment.

657. Muir Mhor Offshore Wind Farm is a FOW project located 51.38 km from the Array, comprising up to 67 wind turbine foundations with a spacing of ≥ 1000 m. The turbines will be supported by a floating foundation with associated mooring and anchoring systems to keep the foundation 'on station'. There are a number of floating foundation types under consideration, which include: semi-submersible, barge, tension leg platform, spar, multi-tower semi- submersible, buoy and semi-spar. The construction of the Muir Mhor Offshore Wind Farm is expected to occur between 2027 and 2030, and therefore whilst there is potential for no direct temporal overlap with the Array construction phase, piling at the Muir Mhor Offshore Wind Farm could lead to a longer duration of piling operations (i.e. sequential piling). Information on the numbers of animals is not available at this time to undertake a quantitative assessment.

658. Salamander Offshore Wind Farm (Simply Blue Energy (Scotland) Limited, 2023) is located 79.49 km from the Array and is a proposed floating wind farm with an installed capacity of up to 100 MW. Up to seven offshore wind turbines with supporting floating substructures and mooring and anchoring systems, inter-array cables Underwater noise associated with piling activity is scoped in (from potential installation of piles associated with the mooring and anchoring system) in the Salamander Offshore Wind Farm Scoping Report (Simply Blue Energy (Scotland) Limited, 2023). A detailed construction programme with specific construction dates is not given in the scoping report, therefore a potential temporal overlap with construction at the Array cannot be discounted, but an indicative construction programme presents offshore construction from Q2 in year two and year three for six months per time, therefore potential temporal overlap is limited. Information on the numbers of animals is not available at this time to undertake a quantitative assessment.

659. Stromar is located 170 km away from the Array, with the Stromar Array Area approximately 256 km^2 in size. The EIA states up to 71 wind turbines with associate floating wind turbine substructures, with mooring and anchoring systems and inclusion of dynamic and static inter-array/interlink cable and up to three OSPs. Floating substructures may include spar, tension-leg platform, semi-submersible and barge. The indicative programme presented in the EIA Scoping Report assumes Stromar becomes commercially operational between 2030 and 2033 and has an offshore construction programme of six years (7 years construction phase for onshore and offshore). Information on the numbers of animals is not available at this time to undertake a quantitative assessment.

660. For Nordsren I, Nordsren II, Nordsren II vest, Nordsren III, N-10.1, Nordsren III vest, N-10.2, N-9.4 and Ten Noorden van de Waddeneilanden, whilst scoping reports cannot be obtained, it has been assumed piling is scoped in as a precautionary approach to assessment. However, these projects lie between ~330 km and ~437 km away from the Array and therefore any cumulative effect from piling is highly unlikely given the contours presented for piling for the Array alone (section 10.11.2).

661. The cumulative impact (elevated underwater noise arising during piling) is predicted to be of regional spatial extent in the context of the geographic frame of reference, medium term duration, intermittent and the effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of receptor

662. The sensitivities of marine mammals to cumulative disturbance from piling are as previously described above for the assessment of the Array alone (paragraphs 234 to 253) for the construction phase and therefore is not repeated here.

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

Significance of effect

664. Overall, the magnitude of the cumulative impact is deemed to be low for all receptors, 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

665. No 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.

Tier 3

Construction phase

Magnitude of impact

666. There were 14 Tier 3 projects identified within the regional marine mammal study area with potential for cumulative effects associated with this impact:

- Arven Offshore Wind Farm;
- Ayre Offshore Wind Farm;
- Bellrock Offshore Wind Farm;
- Bowdun Offshore Wind Farm;
- Campion Offshore Wind Farm;
- Flora Floating Wind Farm;
- Aspen;
- INTOG Site 8: Harbour Energy;
- Beech;
- Cedar;
- INTOG Site 13: Harbour Energy;
- Yell Sound Array;
- BP Exploration Operating Company Limited; and
- Morven BP-EnBW Offshore Export Cable Corridor.

667. Tier 3 projects are in a pre-application phase and no EIA Scoping Report or EIA Report is available to inform a quantitative assessment. Therefore, a qualitative assessment is provided below.

668. The construction of the Array, together with construction phase of Tier 1, Tier 2 and Tier 3 projects (Table 10.52) may lead to cumulative injury and disturbance to marine mammals from underwater noise generated during piling.

669. The data in relation to Tier 3 projects available at the time of writing is limited and it is not possible to carry out a quantitative assessment at this stage. This is particularly the case for INTOG projects, which are a new concept and very little is known about the scale of the potential environmental impacts associated with these projects, though it is likely many will be floating projects. Tier 3 projects were screened in precautionarily based on their location (they lie within the regional marine mammal study area), though there is limited/no information on the construction/operation dates or project design with regards to piling. It should be acknowledged that there is a potential for piling activities to be taking place and therefore

projects cannot be discounted, however it is not possible to undertake any kind of meaningful assessment for potential cumulative impacts as a result of elevated underwater noise due to piling with Tier 3 projects to take place intermittently across the North Sea.

670. The cumulative impact (elevated underwater noise arising during piling) predicted to be of regional spatial extent in the context of the geographic frame of reference, medium term duration, intermittent and the effect of behavioural disturbance is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low for all species.

Sensitivity of receptor

671. The sensitivities of marine mammals to cumulative disturbance from piling are as previously described above for the assessment of the Array alone (paragraphs 234 to 253) for the construction phase and therefore is not repeated here.

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

Significance of effect

673. Overall, the magnitude of the cumulative impact is deemed to be low for all receptors, 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

674. No 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.

INJURY AND DISTURBANCE FROM UNDERWATER NOISE GENERATED DURING UNEXPLODED ORDNANCE (UXO) CLEARANCE

Tier 1

Construction phase

Magnitude of impact

675. There were two Tier 1 projects within the 100 km buffer identified with potential for cumulative effects associated with this impact:

- the construction phases of the Proposed offshore export cable corridor(s); and
- the construction phases of Berwick Bank Wind Farm (Table 10.52).

676. Potential impacts 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 also 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 and if any residual risk of injury remains it will be mitigated further post-consent, 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 for each project.

677. As previously presented for the Array alone in paragraph 267 *et seq*. (which uses TTS as a proxy for disturbance), 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.

678. Projects screened in for this cumulative assessment are expected to involve similar construction activities to those described for the Array 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.

679. Berwick Bank Wind Farm based their assessment on 14 UXOs requiring clearance (SSE Renewables, 2022c) (Table 10.61) (up to 70 UXOs are likely to be found within the Berwick Bank Array Area and the Berwick Bank Proposed offshore export cable corridor(s), however, only 14 of these will require clearance based upon experience at Seagreen Wind Energy Ltd (2021)) and noise modelling was undertaken for UXO clearance (both low order and high order detonation) using the methodology described in Soloway and Dahl (2014). The EIA did state the precise details and locations of potential UXOs was unknown at the time of assessment. For the purposes of the UXO assessment, it was assumed that the maximum design scenario is UXO size up to 300 kg, and the maximum frequency would be up to two detonations within 24 hours. Berwick Bank Wind Farm stated low order techniques will be applied as the intended methodology for clearance of UXO (in which case cumulative effects would be further reduced) however highlighted there is a small risk that a low order clearance could result in high order detonation of UXO, and some UXOs may need to be cleared with high order methods and therefore whilst both low and high order clearance was assessed, the MDS was based upon high order clearance (300 kg).

Table 10.61 UXO Clearance Parameters for the Array and Berwick Bank Wind Farm

Project	UXO Clearance Method	Maximum UXO Size Assessed		Number of UXOs
		PTS	Disturbance (TTS)	
The Array	High order detonation	698 kg	698 kg	15
Berwick Bank	High order detonation	300 kg	300 kg	14

Auditory injury (PTS)

680. For a given marine mammal hearing group, exceedance of the threshold for the onset of PTS may result in a permanent hearing loss which in turn could inhibit ecological functioning, such as communication, foraging, navigation and predator avoidance. The inability to continue with these important activities could eventually lead to a decline in vital rates of an individual, including growth, reproduction and subsequently survival. Depending on the type of detonation and size of UXO, UXO clearance activities may have residual effects in respect to marine mammals and PTS injury. 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 (JNCC, 2010b).

681. For the Array alone, with measures adopted as part of the Array applied 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 low. 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 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, an EPS licence will be sought as required based on the detailed information on UXOs available at the time and with the application of appropriate secondary mitigation measures as a part of the MMMP (volume 4, appendix 22). It is therefore anticipated that following the application of secondary mitigation (volume 4, appendix 22), the residual magnitude of this effect will be reduced to low.

682. The assessment for Berwick Bank Offshore Wind Farm determined harbour porpoise were likely to be the most sensitive species to potential injury from high order UXO clearance. The EIA 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. Conservatively, the number of harbour porpoise that could be potentially injured during each high order detonation of UXO was up to 293 individuals (0.08% of the NS MU population and 0.76% of SCANS III Block R). Using the SEL metric, to the predicted number of animals potentially affected was 38. In the assessment, up to 16 grey seals had the potential to be injured during each high order detonation of the UXO (0.04% of the East Scotland plus North East England MUs). Less than one individual has the potential to be injured for all other species considered in the assessment (bottlenose dolphin, white-beaked dolphin, minke whale).

683. The Berwick Bank Wind Farm EIA (SSE Renewables, 2022c) detailed designed in measures will be adopted as part of a MMMP (volume 4, appendix 22) to reduce the potential of experiencing injury. However, the mitigation zones required of 10 km are considerably larger than the standard 1,000 m mitigation zone recommended for UXO clearance (JNCC, 2010b). 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, the EIA details additional mitigation will be applied in the form of soft start charges and ADDs to minimise residual risk of injury. The assessment therefore determined that with the application of secondary mitigation measures (following receipt of more detail regarding size and number of UXO post-consent as part of the EPS licence supporting information for UXO clearance), the magnitude of this impact will be reduced to low. Therefore, Berwick Bank EIA assessed the residual effect of auditory injury as minor adverse, with the residual magnitude as low following application of secondary measures (the unmitigated magnitude was medium based upon high order UXO clearance).

Table 10.62 Number of Animals with the Potential to Experience PTS During UXO Clearance at Tier 1 Projects prior to any mitigation, and residual magnitude assessed in the EIA

Project	Species	Estimated Number in Impact Area (unmitigated)	Based upon UXO size	Measures adopted	Residual Magnitude Assessed in EIA
Ossian Array	Harbour porpoise	433	698 kg	Low order as the methodology intended Outline MMMP (volume 4, appendix 22) (ADD, soft start charges)[1]	Low
	Bottlenose dolphin	<1			Negligible
	White-beaked dolphin	<1			Negligible
	Minke whale	<1			Negligible
	Grey seal	5			Negligible
Berwick Bank	Harbour porpoise	293 (based on SPLpk)	300 kg	Low order methodology as intended Outline MMMP (volume 4, appendix 22) (ADD, soft start charges) [1]	Low
	Bottlenose dolphin	<1			Negligible
	White-beaked dolphin	<1			Negligible
	Minke whale	<1			Negligible
	Grey seal	16 (based on SPLpk)			Negligible

[1] *Detailed mitigation to be agreed post-consent to fully mitigate injury.*

684. Although development of the Proposed offshore export cable corridor(s) will also be undertaken by the Applicant, UXO surveys have not yet been completed and the HND approach dictates that its development will be informed by that of the Array. Therefore, there is currently no information by which to determine if UXO is scoped in or out of the impact assessment. Furthermore, there is uncertainty of the final design and location details of the Proposed offshore export cable corridor(s) and therefore it is not possible to provide any sort of quantitative assessment of UXO clearance. It can be reasonably assumed, however, that the extent of the impacts for the Proposed offshore export cable corridor(s) are expected to be of a similar extent than those represented by the MDS for the Array alone, since 698 kg represents a large munition size for the North Sea. As outlined in paragraphs 283 to 284, the magnitude of impact is predicted to be of local (for all species except harbour porpoise) to regional (harbour porpoise) spatial extent, very short term duration, intermittent and, although the impact itself is reversible (i.e. the elevation in underwater sound only occurs during the detonation event), the effect of injury on sensitive receptors is permanent.

685. UXO clearance at each of these projects will occur as a discrete stage within the overall construction phase and therefore will not coincide continuously over the duration of temporal overlap. Furthermore, each clearance event results in a very short duration of sound emission (seconds) so the impact will be short in duration and therefore the overlap is unlikely. For example, whilst there is uncertainty in the final grid connection design and location details of the Proposed offshore export cable corridor(s), the Proposed

offshore export cable corridor(s) is predicted to begin construction one year prior to the Array construction phase (as per the volume 3, appendix 6.4 of the Array EIA Report) and therefore there is potential for some overlap of UXO clearance associated with the Array and Proposed offshore export cable corridor(s), however, this is expected to be minimal and of very short duration.

686. Given that the risk of injury will be reduced by the appropriate standard industry measures at respective projects to minimise the risk of PTS to marine mammal receptors, the cumulative risk of injury is expected to be reduced further. At the Array with designed-in measures applied (Table 10.22) it is anticipated that all species except harbour porpoise would be deterred from the injury zone and therefore the likelihood of PTS and population-level effects would be unlikely. However, following the application of secondary mitigation as described in paragraph 318 *et seq*. and more detail regarding size and number of UXO, the magnitude of this cumulative impact is considered to be low, as a reduction in impact to a non-significant level will reduce the project's contribution to any cumulative impact on harbour porpoise in the North Sea MU (i.e., the cumulative assessment takes into account the project alone commitments to reducing the potential for significant auditory injury to a non-significant level). Therefore, with the residual magnitude for harbour porpoise for both the Array alone and Berwick Bank Wind Farm as low, and the residual magnitude for other marine mammal receptors as negligible, it is anticipated that the cumulative impact will be reduced to a non-significant level.

687. The cumulative impact (high order detonation) is predicted to be of local (for all species except harbour porpoise) to regional (harbour porpoise) spatial extent in the context of the relevant geographic frame of reference, very short term duration, intermittent and the effect of injury is permanent. It is predicted that the impact will affect the receptor directly. With the adoption of secondary mitigation for the Array, as detailed in paragraph 318 *et seq.*, the magnitude is therefore considered to be negligible for bottlenose dolphin, white-beaked dolphin, minke whale, humpback whale and grey seal.

688. For harbour porpoise the ranges of effect are large for high order clearance, and it is likely that following designed in mitigation measures there will be a residual risk of PTS to a small number of individuals. With the adoption of secondary mitigation for the Array, as detailed in paragraph 318 *et seq.*, the magnitude is therefore considered to be low.

Behavioural disturbance (TTS as proxy)

689. For this impact TTS is applied as a proxy for strong disturbance although noting that TTS onset could potentially result in a temporary loss in hearing. Whilst some behaviours (e.g. feeding, communication, socialisation) could be inhibited in the short term due to disruptions in ecological function (including a temporary hearing shift), these are reversible and therefore not considered likely to lead to any long term effects on the individual. As discussed in paragraph 267, the duration of effect for each UXO detonation is less than one second and therefore behavioural effects are considered to be negligible in this context.

690. For Berwick Bank Wind Fam, the maximum range across which animals have the potential to experience disturbance (using TTS as a proxy) due to high order detonation of a 300 kg charge (as the MDS) was assessed for minke whale as approximately 34 km. Harbour porpoise could potentially experience disturbance within a maximum of ~19 km from the source. The disturbance ranges for HF cetaceans (bottlenose dolphin and white-beaked dolphin) as well as seals are relatively small with a maximum of approximately 1 km and 6 km, respectively.

691. Production of underwater sound during detonation of UXOs as a part of the cumulative projects as well as the Array have the potential to cause disturbance (TTS) in marine mammal receptors, however, this effect will be very short-lived (during detonation only) and reversible. A spatial maximum design scenario would occur where UXO clearance activities occur concurrently at the respective projects considered in the cumulative assessment. Sequential UXO clearance at respective projects could lead to a longer duration of effect. However, as described in paragraph 685, each clearance event results in a very short duration of sound emission (seconds) so the impact will be short in duration and therefore the overlap is unlikely, particularly given the construction phases of Hornsea Three, Berwick Bank Wind Farm and Proposed offshore export cable corridor(s) is likely to be completed several years (as due to safety reasons the UXO clearance activities takes place before other construction activities commence (JNCC, 2023a)) before the construction phase of the Array begins.

692. Since each clearance event results in no more than a one second ensonification event and since animals are anticipated to recover quickly, the potential for cumulative effects with respect to disturbance is considered to be very limited. Furthermore, Berwick Bank Wind Farm lies over ~50 km away from the Array and therefore (given the maximum effect range was 32.7 km for minke whale, using SEL_{cum} metric) it is unlikely to lead to cumulative behavioural effects.

693. The cumulative impact (high order detonation) is predicted to be of regional spatial extent in the context of the geographic frame of reference, very short term duration, intermittent and both the impact itself (i.e. the elevation in underwater noise during detonation event) and effect of disturbance is reversible (onset of TTS represents a non-trivial disturbance but not permanent injury). It is predicted that the impact will affect the receptor directly. The cumulative magnitude is therefore considered to be low for all species.

Sensitivity of receptor

Auditory injury

694. The sensitivities of marine mammals to cumulative auditory injury from UXO are as previously described above for the assessment of the Array alone (paragraphs 293 to 300) for the construction phase and therefore is not repeated here.

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

Behavioural disturbance (TTS as a proxy)

696. The sensitivities of marine mammals to cumulative disturbance from UXO are as previously described above for the assessment of the Array alone (paragraphs 301 to 312) for the construction phase and therefore is not repeated here.

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

Significance of effect

Auditory injury

698. Considering that only up to 29 UXOs cumulatively from Tier 1 projects (Table 10.61) require clearing and with low order techniques being prioritised, it is expected that UXO clearance would not manifest to population-level effects due to the small proportion of the North Sea MU potentially affected. In addition, as discussed in the Array alone assessment (paragraph 318) the project will apply further mitigation to reduce the project's contribution to the cumulative effect assessment.

699. Overall, for bottlenose dolphin, white-beaked dolphin, minke whale, humpback whale and grey seal, the magnitude of the cumulative impact (auditory injury from UXO clearance) is deemed to be negligible and the sensitivity of all receptors is considered to be high. The effect will therefore be of **minor** adverse significance, which is not significant in EIA terms.

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

Behavioural disturbance (TTS as a proxy)

701. Overall, for all species the magnitude of the impact (behavioural disturbance) is deemed to be low and the sensitivity of all receptors is considered to be low. The effect will therefore be of **minor** adverse significance, which is not significant in EIA terms.

Further mitigation and residual effect

Auditory injury

702. No 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.

Behavioural disturbance (TTS as a proxy)

703. No 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.

Tier 2

Construction phase

Magnitude of impact

704. There were four Tier 2 projects identified in the 100 km buffer of the Array within regional marine mammal study area with potential for cumulative effects associated with this impact:

- Cenos Offshore Wind Farm;
- Morven BP-EnBW;
- Muir Mhor Offshore Wind Farm; and
- Salamander Offshore Wind Farm.

705. The Cenos Offshore Wind Farm (Flotation Energy, 2023) included removal of UXO in construction impacts and stated if UXO is found, an underwater noise assessment specific to the UXO (the current presence and characteristics of UXO cannot be predicted) found will be completed to inform mitigation and EPS application. The dates of construction at Cenos Offshore Wind Farm are unknown, but potential overlap is unlikely given the short timescales of UXO clearance, and in combination with the distance from the Array (approximately 91.70 km) means that there is minimal spatial overlap from PTS and behavioural disturbance ranges and therefore potential for cumulative effects are unlikely.

706. The Morven Offshore Wind Project scoped in injury and disturbance from UXO clearance (Morven Offshore Wind Limited, 2023). The Scoping Report detailed that a range of UXO sizes and clearance methodologies will be explored to develop the MDS (e.g. largest and most likely size/type of UXO, number of possible UXOs requiring clearance, high order vs low order/low yield clearance methodologies). Construction at Morven begins in 2027, and therefore it is likely that UXO clearance will have been undertaken four years before UXO clearance will begin at the Array and therefore there is no potential for cumulative effects.

707. The EIA Scoping Report for Muir Mhor Offshore Wind Farm (Fred Olsen Seawind and Vattenfall, 2023) proposed that noise related impacts associated with construction activities resulting in auditory injury (i.e. PTS) and behavioural disturbance is scoped into the EIA, and included UXO clearance. The impact assessment of the risk of auditory injury scoped in as a result of UXO clearance operations will include an assessment for both high order detonations and low order detonations, whilst aligning with recent recommendations and position statements on UXO clearance for similar offshore wind farm developments in the area. Construction at Muir Mhor Offshore Wind Farm is planned from 2027 to 2030, and any UXO clearance is likely to be undertaken prior to the construction phase, therefore it is unlikely there will be overlap of UXO clearance with the Array as it will be carried out prior to the Array construction phase. This, in combination with the distance from the Array (approximately 51.38 km north) means that there is minimal spatial overlap from PTS and behavioural disturbance ranges and therefore potential for cumulative effects are unlikely.

708. The EIA Scoping Report for Salamander Offshore Wind Farm (Simply Blue Energy (Scotland) Limited, 2023) stated while UXO clearance will be subject to a separate Marine Licence application, an indicative assessment of the potential for noise impacts to marine mammals from UXO clearance during the construction phase will be included in the EIA, and therefore scoped in UXO clearance. The underwater noise assessment will likely include a quantitative assessment of the risk of injury and disturbance (using TTS-onset as a proxy) to all species scoped-in as a result of UXO clearance operations, based on indicative example UXO sizes supported by noise propagation modelling. The Salamander Offshore Wind Farm Scoping Report states the MMMP will be implemented for UXO clearance if needed. The dates of construction at Salamander Offshore Wind Farm are unknown, but potential overlap is unlikely given the short timescales of UXO clearance, and in combination with the distance from the Array (approximately 79.49 km) means potential for cumulative effects are unlikely.

709. It is expected than given that the risk of injury will be reduced by standard industry measures (including visual and acoustic monitoring) at respective projects, the cumulative risk of injury is expected to be reduced further. As discussed in paragraph 686, the cumulative assessment considers the Array's commitments to reducing any potential significant auditory injury to a non-significant level by implementation of designed-in measures described in Table 10.22 (i.e. soft starts to piling and UXO clearance, deployment of ADDs up to 30 mins prior to commencement of piling or UXO clearance, application of low-order deflagration of UXO (where practicable) and implementation of an outline MMMP) and secondary mitigation measures discussed in section 10.11.2 (i.e. deployment of ADDs beyond 30 mins for prior to UXO clearance).

Auditory injury

710. The cumulative impact (high order clearance) is predicted to be of local (for all species except harbour porpoise) to regional (harbour porpoise) spatial extent in the context of the geographic frame of reference, very short term duration, intermittent and the effect of injury is permanent. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be negligible for bottlenose dolphin, white-beaked dolphin, minke whale, humpback whale and grey seal.

711. For harbour porpoise, the magnitude of the cumulative impact for harbour porpoise is considered to be low (as a reduction in impact to a non-significant level (see paragraph 709) will reduce the Array's contribution to any cumulative impact on harbour porpoise in the North Sea MU).

TTS (proxy for disturbance)

712. The cumulative magnitude of disturbance resulting from a high order detonation is predicted to be of regional spatial extent, very short term duration, intermittent and both the impact itself (i.e. the elevation in underwater noise during detonation event) and effect of disturbance is reversible (TTS represents a non-trivial disturbance but not permanent injury). It is predicted that the impact will affect the receptor

directly, however, for all species a small proportion of the relevant MUs is predicted to be affected by strong behavioural disturbance. As such, whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects. The cumulative magnitude is therefore considered to be low for all species.

Sensitivity of receptor

Auditory injury

713. The sensitivities of marine mammals to cumulative auditory injury (PTS) from UXO are as previously described above for the assessment of the Array alone (paragraphs 293 to 300) for the construction phase and therefore is not repeated here.

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

Behavioural disturbance

715. The sensitivities of marine mammals to cumulative disturbance from UXO are as previously described above for the assessment of the Array alone (paragraphs 301 to 312) for the construction phase and therefore is not repeated here.

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

Significance of effect

Auditory injury

717. Overall, for bottlenose dolphin, white-beaked dolphin, minke whale, humpback whale and grey seal, the magnitude of the impact (auditory injury) is deemed to be negligible and the sensitivity of all receptors is considered to be high. The effect will therefore be of **minor** adverse significance, which is not significant in EIA terms.

718. For harbour porpoise only, overall, the magnitude of the impact is deemed to be low and the sensitivity of all receptors is considered to be high. The effect will therefore be of **minor** adverse significance, which is not significant in EIA terms.

Behavioural disturbance (TTS as a proxy)

719. Overall, for all species the magnitude of the impact (behavioural disturbance) is deemed to be low and the sensitivity of all receptors is considered to be low. The effect will therefore be of **minor** adverse significance, which is not significant in EIA terms.

Further mitigation and residual effect

Auditory injury

720. No marine mammal mitigation for all receptors 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.

Behavioural disturbance (TTS as a proxy)

721. No 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.

Tier 3

Construction phase

Magnitude of impact

722. There were eight Tier 3 projects identified in the regional marine mammal study area with potential for cumulative effects associated with this impact:

- Bellrock Offshore Wind Farm;
- Bowdun Offshore Wind Farm;
- Campion Offshore Wind Farm;
- Flora Floating Wind Farm;
- Aspen;
- Cedar; and
- Morven BP-EnBW Offshore Export Cable Corridor.

723. Tier 3 projects are in a pre-application phase and no EIA Scoping Report or EIA Report is available to inform a quantitative assessment. Therefore, a qualitative assessment is provided below.

724. The construction of the Array, together with construction phase of Tier 1, Tier 2 and Tier 3 projects (Table 10.52) may lead to cumulative injury and disturbance to marine mammals from underwater noise generated during UXO clearance. Tier 3 projects screened into the assessment within the regional marine mammal study area include: Bellrock Offshore Wind Farm, Bowdun Offshore Wind Farm, Campion Offshore Wind Farm, Flora Floating Wind Farm, Aspen, Cedar and Morven BP-EnBW Offshore Export Cable Corridor.

725. As described in paragraph 669, the data in relation to Tier 3 projects available at the time of writing is limited, this is particularly the case for INTOG projects which as a new concept very little is known about the scale of the potential environmental impacts associated with these projects, though it is likely they will be largely floating projects. Tier 3 projects were screened in precautionarily based on their location within 100 km of the Array within the regional marine mammal study area (noting this is a highly precautionary screening area for UXO clearance), though there is limited/no information on the construction/operation dates or project design with regards to UXO clearance. It should be acknowledged that there is a potential for UXO clearance activities to be taking place at these Tier 3 projects, and therefore cumulative effects cannot be discounted. However, at this point in time, is not possible to undertake any kind of meaningful assessment for potential cumulative impacts as a result of underwater noise generated during UXO clearance from the Array and other Tier 3 projects.

726. The cumulative impact of behavioural disturbance with respect to marine mammal IEFs is predicted to be of regional spatial extent in the context of the geographic frame of reference, medium term duration, intermittent and the effect is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of receptor

727. The sensitivities of marine mammals to cumulative auditory injury from UXO are as previously described above for the assessment of the Array alone (paragraphs 293 to 300) for the construction phase and therefore is not repeated here.

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

729. The sensitivities of marine mammals to cumulative disturbance from UXO are as previously described above for the assessment of the Array alone (paragraphs 301 to 312) for the construction phase and therefore is not repeated here.

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

Significance of effect

Auditory injury

731. Overall, for bottlenose dolphin, white-beaked dolphin, minke whale, humpback whale and grey seal, the magnitude of the cumulative effect (auditory injury) is deemed to be negligible and the sensitivity of all receptors is considered to be high. The cumulative effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

732. For harbour porpoise only, overall, the magnitude of the cumulative effect is deemed to be low and the sensitivity of all receptors is considered to be high. The cumulative effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Behavioural disturbance (TTS as a proxy)

733. Overall, for all species, the magnitude of the cumulative effect (behavioural disturbance) is deemed to be low and the sensitivity of all receptors is considered to be low. The cumulative effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Further mitigation and residual effect

Auditory injury

734. No 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.

Behavioural disturbance (TTS as a proxy)

735. No 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.

DISTURBANCE DUE TO SITE-INVESTIGATION SURVEYS (INCLUDING GEOPHYSICAL SURVEYS)

736. 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 Array found that the maximum impact range was 310 m for geophysical surveys and 45 m for geotechnical surveys (based on harbour porpoise) and this highly localised, with 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. Furthermore, any risk of injury will be mitigated via the outline MMMP (volume 4, appendix 22) and no potential for cumulative impacts for injury and is not considered further in cumulative assessment. The cumulative assessment provided in paragraph 737 *et seq.* focuses on disturbance only.

Tier 1

Construction phase

Magnitude of impact

737. One Tier 1 project was identified with potential for cumulative effects associated with this impact within the 50 km buffer, within in the regional marine mammal study area:

- Proposed offshore export cable corridor(s) (construction phase and operation and maintenance phase).

738. As discussed in paragraph 592, there is uncertainty of the final design and location details of the Proposed offshore export cable corridor(s) and therefore it is not possible to provide a quantitative assessment of the impact from site-investigation surveys. It can be reasonably assumed the extent of the impacts for the Proposed offshore export cable corridor(s) are expected to be similar to those of the Array (see paragraph 251 *et seq.*), as, whilst the geographical location of the geophysical survey areas of other projects will differ, the extent of the disturbance per survey equipment at any one point will likely be very similar. The construction phase (and associated pre-construction surveys) of the Proposed offshore export cable corridor(s) (2029 to 2036) overlaps with that of the Array and therefore there is the potential for temporal overlap in site-investigation surveys. However, it should 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. Site-investigation surveys for Proposed offshore export cable corridor(s) are likely to be carried out at the start of the construction phase (2030) and therefore direct overlap with the site-investigation surveys for the Array is unlikely (particularly given the need for limited resource to undertake site-investigation surveys).

739. For the Array, the maximum disturbance range across all geophysical surveys was estimated as 1,340 m (SBP activity) and the maximum range across geotechnical activities was 9,101 m (vibrocoring) for harbour porpoise. Given that the distance between the Array and Proposed offshore export cable corridor(s) is less than the estimated disturbance ranges from geophysical surveys there is potential for spatial overlap. However, the likelihood of temporal overlap of site investigation surveys at these projects is very low, and it is therefore unlikely, due to the temporal separation, that site-investigation surveys at the Array and Proposed offshore export cable corridor(s) will spatially overlap at any one time given the small disturbance ranges and no application of dose-response (see paragraph 349 for detail).

740. Surveys are anticipated to be short term in nature (weeks to a few months) and occur intermittently over the construction phase. For example, the site-investigation surveys for the Array will be carried out over 5 months within a 3 year period.

741. The cumulative impact is predicted to be of local to regional spatial extent in context of the relevant geographic frame of reference, short term duration, intermittent and the effect of behavioural disturbance is of reversible (with animals returning to baseline levels soon after surveys have ceased). It is predicted that the impact will affect the receptor directly. Whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects. The cumulative magnitude was therefore considered to be low.

Sensitivity of the receptors

742. The sensitivities of marine mammals to cumulative disturbance from site-investigation surveys are as previously described above for the assessment of the array alone (paragraphs 355 to 365) for the construction phase and therefore is not repeated here. It is expected that, to some extent, marine mammals will be able to withstand temporary elevated levels of underwater sound during site-investigation surveys and behavioural responses are highly species and context specific.

743. All receptors are deemed to have some resilience to cumulative behavioural disturbance, high recoverability and adaptability and high international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of effect

744. 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

745. No 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.

<u>Operation and maintenance phase</u>

Magnitude of impact

746. The operation and maintenance activities of the Array will overlap with Tier 1 projects identified in Table 10.55 and may lead to disturbance to marine mammals from site-investigation surveys:

- Proposed offshore export cable corridor(s) (construction and operation and maintenance phases).

747. For the Array, routine geophysical surveys will take place once every 24 months for wind turbines and OSP foundations as well as wind turbines interior and exterior. For inter-array cables and interconnector cables routine geophysical surveys will be undertaken annually for the first three years, then every 24 months. The duration of routine geophysical survey campaign is up to three months.

748. The Proposed offshore export cable corridor(s) is currently at planned status and therefore there is no information in the public domain in which to determine the impact from site-investigation surveys. However, it can be reasonably assumed the extent of the impacts for the Proposed offshore export cable corridor(s) are expected to be similar to those of the Array (see paragraph 251 *et seq.*), as (as detailed in paragraph 738) the extent of disturbance per survey equipment is likely to be similar even if in a different location. It is possible that routine geophysical surveys for the Proposed offshore export cable corridor(s) will be similar to those of the inter-array cables and interconnector cables for the Array and therefore, there is potential for geophysical surveys during the operation phase to temporally overlap with the Proposed offshore export cable corridor(s). Surveys are anticipated to be short term in nature (weeks to a few months) and occur intermittently over the operation and maintenance phase.

749. With measures adopted as part of the Array implemented for the geophysical surveys, the cumulative impact is predicted to be of local to regional spatial extent in context of the relevant geographic frame of reference, short term duration, intermittent and the effect of behavioural disturbance is reversible (with animals returning to baseline levels soon after surveys have ceased). It is predicted that the impact will affect the receptor directly. Whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects. The cumulative magnitude was therefore considered to be low.

Sensitivity of the receptors

750. The sensitivity of marine mammals to elevated underwater noise due to site-investigation surveys is as described in paragraphs 355 *et seq.*

751. All receptors are deemed to have some resilience and adaptability to cumulative behavioural disturbance, high recoverability and high international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of effect

752. 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

753. No 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. Therefore, the residual effect is considered to be of minor adverse significance which is not significant in EIA terms.

Tier 2

<u>Construction phase</u>

Magnitude of impact

754. One Tier 2 project was identified (in addition to Tier 1 projects) with potential for cumulative effects associated with this impact, which lies within the 50 km buffer used for site-investigation surveys:

- Morven BP-EnBW.

755. Disturbance to marine mammals from pre-construction site-investigation surveys is scoped in for Morven Offshore Wind Project (Morven Offshore Wind Limited, 2023). The Scoping Report details comparative sound modelling for geophysical activities will be undertaken to inform an assessment of possible effects from elevated levels of underwater sound. At this point in time, there is not quantitative information upon which to take a more detailed assessment of site-investigation surveys. The Array lies, at the closest point,

5.5 km from the Morven Array and based on the maximum disturbance range predicted for the Array (1,340 m for SBP and 9,101 m for vibrocoring) there is likely to be spatial overlap between these two projects. However, the likelihood of temporal overlap of site investigation surveys at the Array and Morven Offshore Wind Project is very low (e.g. there are limitations on the number of survey vessels that could carry out such surveys at one time) and it is therefore unlikely, due to the temporal separation, that site-investigation surveys at Morven Offshore Wind Project would overlap with the area disturbed during site-investigation surveys at the other Tier 1 project, Proposed offshore export cable corridor(s) (see paragraph 349 for detail).

756. The cumulative impact is predicted to be of local to regional spatial extent in context of the relevant geographic frame of reference, 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. Whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects. The cumulative magnitude was therefore considered to be low.

Sensitivity of the receptors

757. The sensitivity of marine mammals to elevated underwater noise due to site-investigation surveys is as described in paragraphs 355 *et seq.*

758. All receptors are deemed to have some resilience to cumulative behavioural disturbance, high recoverability and adaptability and high international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of effect

759. 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

760. No 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.

Tier 3

Construction phase

Magnitude of impact

761. Three Tier 3 projects were identified with potential for cumulative effects associated with this impact, which lies within the 50 km buffer used for site-investigation surveys:

- Bellrock Offshore Wind Farm;
- Bowdun Offshore Wind Farm;
- Campion Offshore Wind Farm; and
- Morven BP-EnBW Offshore Export Cable Corridor.

762. Tier 3 projects are in a pre-application phase and no EIA Scoping Report or EIA Report is available to inform a quantitative assessment. Therefore, a qualitative assessment is provided below.

763. Whilst there is no information on the timeline for construction at Bellrock Offshore Wind Farm and therefore it cannot be excluded from the CEA, the likelihood of direct temporal overlap with site-investigation surveys at Bellrock Offshore Wind Farm and the Array is unlikely given the different stages of status of development. Furthermore, surveys are likely to be short term and intermittent and disturbance ranges associated with these projects would be highly localised. Bellrock Offshore Wind Farm is located 8.57 km north-west from the Array and therefore site-investigation surveys will have no spatial overlap given the small disturbance ranges presented for the Array assessment (paragraph 347).

764. Whilst there is no information on the timeline for construction at Bowdun Offshore Wind Farm and therefore it cannot be excluded from the CEA, the likelihood of direct temporal overlap with site-investigation surveys at Bowdun Offshore Wind Farm and the Array is unlikely given the different stages of status of development. Furthermore, surveys are likely to be short term and intermittent and disturbance ranges associated with these projects would be highly localised. Bowdun Offshore Wind Farm is located 25.35 km north-west from the Array and therefore site-investigation surveys will have no spatial overlap given the small disturbance ranges presented for the Array assessment (paragraph 347).

765. The likelihood of direct temporal overlap with site-investigation surveys at Campion Offshore Wind and the Array is unlikely given the different stages of status of development. Furthermore, surveys are likely to be short term and intermittent and disturbance ranges associated with these projects would be highly localised. Campion Offshore Wind Farm is located 44.15 km north-east from the Array and therefore site-investigation surveys will have no spatial overlap given the small disturbance ranges presented for the Array assessment (paragraph 347).

766. The cumulative impact is predicted to be of local to regional spatial extent, short term duration, intermittent and the effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after surveys have ceased). It is predicted that the impact will affect the receptor directly. Whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects. The cumulative magnitude was therefore considered to be low.

Sensitivity of the receptors

767. The sensitivity of marine mammals to elevated underwater noise due to site-investigation surveys is as described in paragraphs 355 *et seq.*

768. All receptors are deemed to have some resilience to cumulative behavioural disturbance, high recoverability and adaptability and high international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of effect

769. 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

770. No 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.

INJURY AND DISTURBANCE FROM UNDERWATER NOISE GENERATED DURING VESSEL USE AND OTHER NOISE PRODUCING ACTIVITIES

771. 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 Array found that the impact ranges for PTS were extremely small (maximum at 15 m for harbour porpoise) and the number of animals impacted was less than one for all species, as discussed in paragraph 384 *et seq.*, and the magnitude of the impact with respect to auditory injury occurring in marine mammals has been assessed as low. Furthermore, it is expected that all projects will adhere to project-specific mitigation plans to reduce the potential risk of auditory injury.

772. 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 737 *et seq.* focuses on disturbance only.

Tier 1

Construction phase

Magnitude of impact

773. One Tier 1 project was identified with potential for cumulative effects associated with this impact within the 50 km buffer, in the regional marine mammal study area:

- Proposed offshore export cable corridor(s) (construction and operation and maintenance phases).

774. As discussed in paragraph 592, there is uncertainty of the final design and location details of the Proposed offshore export cable corridor(s) and therefore it is not possible to provide a quantitative assessment but it can be reasonably assumed vessel noise will be assessed in the EIA.

775. The Proposed offshore export cable corridor(s) (2030 to 2037) and operation and maintenance phase (2037 onwards) overlaps with the construction phase of the Array, by seven years (2031 to 2036). The highest number of vessels movements was predicted during the construction phase of the Array, and it is likely this would be the case for the Proposed offshore export cable corridor(s) construction also, leading to an uplift in the number of vessels from the baseline. 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 Array alone (paragraph 387 *et seq.*).

776. Whilst the Proposed offshore export cable corridor(s) will overlap directly spatially with the Array at the closest point, the cable route will extend further from the Array with vessels following existing routes or confined cable routes and therefore cumulative effects of disturbance are minimal and reduce with further distance from the array. Based upon the results of the Array assessment, disturbance could occur over larger ranges compared to PTS, with underwater noise modelling predicted a range of 3,259 m disturbance range for vessels such as CTVs, Service Operation Vessels, support vessels, CSVs, trenching support vessels, UXO clearance vessel, PLGR Vessel, DSVs, SOV vessels and support vessels (described in Table 10.49) and therefore, only disturbance effects (rather than PTS) are likely to occur cumulatively (see paragraph 772).

777. Given that construction activities for other offshore wind projects in the region will have been well underway by 2031 when the Array construction phase begins, and that this is already an area of high vessel traffic (see paragraph 387 *et seq.* for more details), it can be anticipated that marine mammals present in the vicinity of the Array demonstrate some degree of habituation to vessel noise.

778. Vessel movements will be confined to the Ossian Array and Proposed offshore export cable corridor(s) and will follow existing shipping routes to/from port. In the longer-term, there may be increases in wind farm related traffic associated with the ScotWind developments north and east of the Array. However, given the lack of publicly available data 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.

779. Given the minor temporal overlap (in the scheme of the total project lifetime) in construction activities associated with the relevant projects will not add substantially to the total number of vessel round trips associated with the Array, the magnitude of the impact will not be substantially greater than that assumed for the project alone.

780. The cumulative impact is predicted to be of local to regional spatial extent in the context of the geographic frame of reference, medium-term duration, intermittent and the effects of behavioural disturbance are reversible (with animals returning to baseline levels soon after they moved from the impact zone). It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Sensitivity of the receptors

781. The sensitivities of marine mammals to cumulative disturbance from elevated underwater noise during vessel activity and other noise producing activities are as previously described for the assessment of the Array alone (paragraph 396) for the construction phase and therefore is not repeated here.

782. All marine mammals are deemed to have some resilience to cumulative behavioural disturbance from vessel noise, high recoverability and adaptability and high international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of effect

783. 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

784. No 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.

Operation and maintenance phase

Magnitude of impact

785. One Tier 1 project was identified with potential for cumulative effects associated with this impact within the 50 km buffer, in the regional marine mammal study area:

- Proposed offshore export cable corridor(s) (construction and operation and maintenance phases).

786. The maximum design scenario for the operation and maintenance phase of the Array is presented in Table 10.17 with up to 352 return trips per year over the operational lifetime (35 years). Vessel use during the operation phase of the Array is described in more detail in paragraph 416 *et seq.* The impacts due to disturbance to marine mammals from vessel use and other activities for the Array alone during the operation and maintenance phase were assessed as negligible to minor. The uplift in vessel activity during the operation and maintenance phase is considered to be relatively small in the context of the baseline levels of vessel traffic in the vicinity and within the site boundary (see paragraph 381).

787. Vessels involved in the operation and maintenance of other projects will include a similar suite of vessels as those described for the Array alone (see paragraph 384 *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 Array) and therefore a precautionary approach has been taken in assessing the magnitude.

788. There is the potential for the operation and maintenance phase of the Array to temporally overlap with the operation and maintenance phase and decommissioning phase of the Proposed offshore export cable corridor(s). The operational lifetime of the Proposed offshore export cable corridor(s) is expected to run from 2037 to 2066. Vessel numbers for decommissioning are likely to be at worst, similar to those for construction phases, and it is expected animals will have some degree of habituation to vessel traffic that has been present throughout the operation and maintenance phases of CEA projects. Additionally, it can be expected that after more than ten years of construction activities taking place in the wider vicinity of the Array (within the regional marine mammal study area), marine mammals may have further habituated to higher vessel numbers.

789. Therefore, the cumulative magnitude of the impact of the operation and maintenance phase as a result of elevated underwater noise due to vessel use, for all marine mammal receptors, is considered to be equivalent to and potentially lower than the maximum design scenario effects assessed for the construction phase.

790. The cumulative effect is predicted to be of local to regional spatial extent in the context of the geographic frame of reference, long term duration, intermittent and the effects of behavioural disturbance are of high reversibility (with animals returning to baseline levels soon after they moved from the impact zone). It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Sensitivity of the receptors

791. The sensitivity of marine mammals to cumulative disturbance from elevated underwater noise due to vessel use and other activities is as described in paragraph 781 *et seq*. for the construction phase.

792. All marine mammals are deemed to have some resilience to cumulative behavioural disturbance from vessel noise, high recoverability and adaptability and high international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of effect

793. 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

794. No 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.

Decommissioning phase

Magnitude of impact

795. During the decommissioning phase there will be a range of vessels used for decommissioning activities such as removal of foundations, cables and cable protection. Noise from vessels is assumed to be as per vessel activity described for construction phase.

796. All Tier 1 projects screened into the CEA and within the 50 km buffer for vessel noise are expected to have undergone or commenced decommissioning by the commencement of the decommissioning phase of the Array and therefore the impact is not expected to differ or be substantially greater than that assessed for the decommissioning phase of project alone (paragraph 434). Additionally, it can be expected that after several decades of construction and operation and maintenance activities taking place in the wider vicinity of the Array (i.e. within the regional marine mammal study area), marine mammals may have further habituated to higher vessel numbers.

797. The cumulative impact (elevated underwater noise during vessel use and other noise producing activities) is predicted to be of local to regional spatial extent in the context of the geographic frame of reference, medium-term duration, intermittent and the effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after they moved from the impact zone). It is predicted that the impact will affect the receptor directly. The magnitude was therefore considered to be low.

Sensitivity of the receptors

798. The sensitivities of marine mammals to cumulative disturbance from elevated underwater noise during vessel activity and other noise producing activities are as previously described above for the assessment of the array alone (paragraph 396) for the construction phase and therefore is not repeated here.

799. All marine mammals are deemed to have some resilience to cumulative behavioural disturbance from vessel noise, high recoverability and adaptability and high international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of effect

800. 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

801. No 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.

Tier 2

Construction phase

Magnitude of impact

802. There was one Tier 2 project identified within the 50 km buffer considered for potential for cumulative effects associated with this impact:

- Morven BP-EnBW.

803. The construction of the Array, together with construction phase of Tier 1 and Tier 2 projects (Table 10.52) may lead to cumulative underwater noise generated during vessel use and other noise producing activities. Morven BP-EnBW is located within 50 km of the Array (5.5 km), all other Tier 2 Projects are located over 50 km away. The other Tier 2 Projects which are located >50 km from the Array are considered to be located at a distance great enough that cumulative impacts are highly unlikely.

804. The Morven Offshore Scoping Report scopes in disturbance to marine mammals from vessel use and other (non-piling) sound producing activities for all phases of the Morven Offshore Wind Project (Morven Offshore Wind Limited, 2023). There is however no information on the numbers and types of vessels which will be associated with the construction phase of the Morven Offshore Wind Project. Based upon what the Array assessment presented, disturbance could occur over larger ranges compared to PTS, with underwater noise modelling predicted a range of 3,259 m disturbance range for vessels and therefore given Morven Offshore Wind Project is located 5.5 km from the Array it is unlikely disturbance ranges will significantly overlap. As outlined in paragraph 778 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. In the longer-term, there may be increases in wind farm related traffic associated with the ScotWind developments north and east of the Array. 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.

805. The cumulative impact (elevated underwater noise during vessel use and other noise producing activities) is predicted to be of local to regional spatial extent in the context of the geographic frame of reference, medium-term duration, intermittent and the effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after they moved from the impact zone). It is predicted that the impact will affect the receptor directly. Whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects. The magnitude was therefore considered to be low.

Sensitivity of the receptors

806. The sensitivities of marine mammals to cumulative disturbance from elevated underwater noise during vessel activity and other noise producing activities are as previously described above for the assessment of the Array alone (paragraph 396) for the construction phase and therefore is not repeated here.

807. All marine mammals are deemed to have some resilience to cumulative behavioural disturbance from vessel noise, high recoverability and adaptability and high international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of effect

808. 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

809. No 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.

Operation and maintenance phase

Magnitude of impact

810. There was one Tier 2 project identified within the 50 km buffer considered for potential for cumulative effects associated with this impact:

- Morven BP-EnBW.

811. The construction of the Array, together with construction phase of Tier 1 and Tier 2 projects (Table 10.52) may lead to cumulative underwater noise generated during vessel use and other noise producing activities. Morven BP-EnBW is located within 50 km of the Array, all other Tier 2 Projects are located over 50 km away. The other Tier 2 Projects which are located >50 km from the Array are considered to be located at a distance great enough that cumulative impacts are highly unlikely.

812. There is the potential for the construction phase of Morven BP-EnBW to overlap with the operation and maintenance phase of the Array. However, as described in paragraph 786, maintenance of cables or turbines typically involves considerably smaller numbers of vessels and round trips compared to construction. Considering the vessel activity within the North Sea, it is anticipated that these will not add substantially to the number of vessels present within the site boundary during the operation and maintenance phases of the Array, Tier 1 and Tier 2 projects and that the potential for cumulative effects is unlikely.

813. It should also be considered that during the operation and maintenance phase of the Array some of the Tier 2 projects may be decommissioned. There may be an increase in vessel numbers associated with the decommissioning phases of the Tier 2 projects outlined above. However, as outlined in paragraph 839, considering the vessel activity within the North Sea, it is anticipated that these will not add substantially to the number of vessels present within the site boundary during the operation and maintenance phases of the Array and will consist of considerably less vessels than the construction phases.

814. The cumulative impact (elevated underwater noise during vessel use and other noise producing activities) is predicted to be of local to regional spatial extent in the context of the geographic frame of reference, long term duration, intermittent and the effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after they moved from the impact zone). It is predicted that the impact will affect the receptor directly. Whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects. The magnitude was therefore considered to be low.

Sensitivity of the receptors

815. The sensitivities of marine mammals to cumulative disturbance from elevated underwater noise during vessel activity and other noise producing activities are as previously described for the assessment of the Array alone (paragraph 396) for the construction phase and therefore is not repeated here.

816. All marine mammals are deemed to have some resilience to cumulative behavioural disturbance from vessel noise, high recoverability and adaptability and high international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of effect

817. 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

818. No 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.

Decommissioning phase

Magnitude of impact

819. There was one Tier 2 project identified within the 50 km buffer considered for potential for cumulative effects associated with this impact:

- Morven BP-EnBW.

820. Decommissioning at Morven is likely to occur at a similar time to that of the Array. On the basis of a 35 year operational lifetime, decommissioning will not occur at the Array until 2074. There will therefore be no temporal overlap between construction activities at Tier 2 projects and decommissioning at the Array. Cumulative effects from underwater noise generated during vessel use and other noise producing activities are not anticipated.

821. The cumulative impact (elevated underwater noise during vessel use and other noise producing activities) is predicted to be of local to regional spatial extent, medium-term duration, intermittent and the effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after they moved from the impact zone). It is predicted that the impact will affect the receptor directly. Whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects. The magnitude was therefore considered to be low.

Sensitivity of the receptors

822. The sensitivities of marine mammals to cumulative disturbance from elevated underwater noise during vessel activity and other noise producing activities are as previously described for the assessment of the Array alone (paragraph 396) for the construction phase and therefore is not repeated here.

823. All marine mammals are deemed to have some resilience to cumulative behavioural disturbance from vessel noise, high recoverability and adaptability and high international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of effect

824. 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

825. No 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.

Tier 3

Construction phase

Magnitude of impact

826. There were three Tier 3 projects identified within the 50 km buffer considered for potential for cumulative effects associated with this impact:

- Bellrock Offshore Wind Farm;
- Bowdun Offshore Wind Farm;
- Campion Offshore Wind Farm; and
- Morven BP-EnBW Offshore Export Cable Corridor.

827. Tier 3 projects are in a pre-application phase and no EIA Scoping Report or EIA Report is available to inform a quantitative assessment. Therefore, a qualitative assessment is provided below.

828. The construction of the Array, together with construction phase of Tier 1, Tier 2 and Tier 3 projects (Table 10.52) may lead to cumulative underwater noise generated during vessel use and other noise producing activities. Bellrock Offshore Wind Farm, Bowdun Offshore Wind Farm, Campion Offshore Wind Farm and Morven BP-EnBW Offshore Export Cable Corridor are all located within 50 km of the Array, all other Tier 3 projects are located over 50 km away. The other Tier 3 projects which are located >50 km from the Array are considered to be located at a distance great enough that cumulative impacts are highly unlikely.

829. There is no information in the public domain on potential numbers of vessels associated with the construction phase of Bellrock Offshore Wind Farm. If any overlap of the construction phases were to occur, the uplift in vessels would be primarily restricted to within the relevant discrete project footprints, with the implementation of standard industry measures such as PAM and MMOs[2] the potential for cumulative effects is very low. Therefore, it is anticipated that these will not add substantially to the number of vessels present within the site boundary during the construction of the Array and that the potential for cumulative effects is unlikely.

830. There is no information in the public domain on potential numbers of vessels associated with the construction phase of Campion Offshore Wind Farm. If any overlap of the construction phases were to occur, the uplift in vessels would be primarily restricted to within the relevant discrete project footprints, with the implementation of standard industry measures such as PAM and MMOs[2] the potential for cumulative effects is very low. Therefore, it is anticipated that these will not add substantially to the number of vessels present within the site boundary during the construction of the Array and that the potential for cumulative effects is unlikely.

831. The construction phase of Bowdun Offshore Wind Farm may overlap with the construction phase of the Array. There is no information in the public domain on potential numbers of vessels associated with the

construction phase of Bowdun Offshore Wind Farm, however the uplift in vessels would be primarily restricted to within the relevant discrete project footprints, with the implementation of standard industry measures such as PAM and MMOs[2] the potential for cumulative effects is very low. Therefore, it is anticipated that these will not add substantially to the number of vessels present within the site boundary during the construction of the Array and that the potential for cumulative effects is unlikely.

832. There is no information in the public domain on potential numbers of vessels associated with the construction phase of Morven BP-EnBW Offshore Export Cable Corridor. If any overlap of the construction phases were to occur, the uplift in vessels would be primarily restricted to within the relevant discrete project footprints, with the implementation of standard industry measures such as PAM and MMOs[2] the potential for cumulative effects is very low. Therefore, it is anticipated that these will not add substantially to the number of vessels present within the site boundary during the construction of the Array and that the potential for cumulative effects is unlikely.

833. The cumulative impact (elevated underwater noise during vessel use and other noise producing activities) is predicted to be of local to regional spatial extent in the context of the geographic frame of reference, medium-term duration, intermittent and the effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after they moved from the impact zone). It is predicted that the impact will affect the receptor directly Whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects. The magnitude was therefore considered to be low.

Sensitivity of the receptors

834. The sensitivities of marine mammals to cumulative disturbance from elevated underwater noise during vessel activity and other noise producing activities are as previously described above for the assessment of the array alone (paragraph 396) for the construction phase and therefore is not repeated here.

835. All marine mammals are deemed to have some resilience to cumulative behavioural disturbance from vessel noise, high recoverability and adaptability and high international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of effect

836. 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

837. No 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.

Operation and maintenance phase

Magnitude of impact

838. There were three Tier 3 projects identified within the 50 km buffer considered for potential for cumulative effects associated with this impact:

- Bellrock Offshore Wind Farm;
- Bowdun Offshore Wind Farm;
- Campion Offshore Wind Farm, and
- Morven BP-EnBW Offshore Export Cable Corridor.

839. Tier 3 projects are in a pre-application phase and no EIA Scoping Report or EIA Report is available to inform a quantitative assessment. Therefore, a qualitative assessment is provided below.

840. As described in paragraph 786, maintenance of cables or turbines typically involves considerably smaller numbers of vessels and round trips compared to construction. Considering the vessel activity within the North Sea, it is anticipated that these will not add substantially to the number of vessels present during the operation and maintenance phases of the Array, Tier 1 and Tier 2 projects and that the potential for cumulative effects is unlikely.

841. It should also be considered that during the operation and maintenance phase of the Array some of the Tier 3 projects may be decommissioned. There may be an increase in vessel numbers associated with the decommissioning phases of the Tier 3 projects outlined above. However, as outlined in paragraph 839, considering the vessel activity within the North Sea, it is anticipated that these will not add substantially to the number of vessels present during the operation and maintenance phases of the Array.

842. The cumulative impact (elevated underwater noise during vessel use and other noise producing activities) is predicted to be of local to regional spatial extent in the context of the geographic frame of reference, long term duration, intermittent and the effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after they moved from the impact zone). It is predicted that the impact will affect the receptor directly. Whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects. The magnitude was therefore considered to be low.

Sensitivity of the receptors

843. The sensitivities of marine mammals to cumulative disturbance from elevated underwater noise during vessel activity and other noise producing activities are as previously described for the assessment of the Array alone (paragraph 396) for the construction phase and therefore is not repeated here.

844. All marine mammals are deemed to have some resilience to cumulative behavioural disturbance from vessel noise, high recoverability and adaptability and high international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of effect

845. 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.

Decommissioning phase

Magnitude of impact

846. There were three Tier 3 projects identified within the 50 km buffer considered for potential for cumulative effects associated with this impact:

- Bellrock Offshore Wind Farm;
- Bowdun Offshore Wind Farm;
- Campion Offshore Wind Farm; and
- Morven BP-EnBW Offshore Export Cable Corridor.

847. The decommissioning timescale for Tier 3 projects is currently unknown. On the basis of a 35 year operational lifetime, decommissioning will not occur at the Array until 2074. There is therefore unlikely to be temporal overlap between Tier 3 projects currently in pre-planning stage (i.e., not submitted a scoping report) and decommissioning at the Array. Cumulative effects from underwater noise generated during vessel use and other noise producing activities are not anticipated.

848. The cumulative impact (elevated underwater noise during vessel use and other noise producing activities) is predicted to be of local to regional spatial extent in the context of the geographic frame of reference, medium-term duration, intermittent and the effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after they moved from the impact zone). It is predicted that the impact will affect the receptor directly. Whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects. The magnitude was therefore considered to be low.

Sensitivity of the receptors

849. The sensitivities of marine mammals to cumulative disturbance from site-investigation surveys are as previously described above for the assessment of the array alone (paragraphs 395 to 411) for the construction phase and therefore is not repeated here.

850. All marine mammals are deemed to have some resilience to cumulative behavioural disturbance from vessel noise, high recoverability and adaptability and high international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of effect

851. 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.

INJURY DUE TO COLLISION WITH VESSELS

Tier 1

Construction phase

Magnitude of impact

852. One Tier 1 project was identified with potential for cumulative effects associated with this impact within the 50 km buffer, in the regional marine mammal study area:

- Proposed offshore export cable corridor(s) (construction and operation and maintenance phases).

853. As discussed in paragraph 590, there is uncertainty of the final design and location details of the Proposed offshore export cable corridor(s) and therefore it is not possible to provide a quantitative assessment but it can be reasonably assumed injury due to collision with vessels is scoped in and will be assessed in the Proposed offshore export cable corridor(s) EIA.

854. High volumes of vessel traffic during construction of the Array have the potential to increase interaction (such as collision or noise disturbance) with marine mammals (see paragraph 443), with the severity of resulting injury generally correlated with the vessel speed. As many as 7,902 return vessel movements may be made during the construction phase within the Array marine mammal study area. With all vessels adhering to the rules (e.g. maximum speeds, no abrupt changes in course etc.) proposed within the NSVMP, volume 4, appendix 24 the risk of collision is anticipated to be reduced, the risk would only be present for transiting vessels to/from and within the Array; with the sound emitted likely to deter animals from the potential zone of impact. The impact during the construction phase is predicted to be localised and intermittent for a medium term duration. It is predicted to affect sensitive receptors directly with medium to low reversibility. The magnitude is therefore considered to be low.

855. The number and types of vessels associated with construction of Array as well as construction and/or operation and maintenance of projects considered in the CEA is provided in paragraph 786 *et seq*. 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 CEA projects. The types of vessels involved in construction activities at the other offshore wind farms will be similar to those identified for construction of the Array (such as those described in paragraph 776). As previously described for the Array alone (see paragraph 446 *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 Array and respective projects are likely to be travelling considerably slower than this, and will be required to adhere to the NSVMP, volume 4, appendix 24 which includes not deliberately approaching marine mammals as a minimum, to avoid abrupt changes in course or speed should marine mammals approach the vessel to bow-ride and remain at safe speeds at all times (as detailed in Table 10.22). There is also a potential that the noise emissions from vessels will deter animals from the potential zone of impact.

856. The Array and respective projects are located in the area of relatively high vessel traffic, particularly cargo vessels (see paragraph 387 *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. Furthermore, the Array is located in proximity to oil and gas structures in the North Sea and as such the traffic of oil and gas vessels is substantial. Considering the baseline levels of vessel traffic, it can be anticipated that marine mammals present in the vicinity of the Array marine mammal study area are familiarised to passing ships in the area.

857. It is anticipated that the risk of collision at other CEA projects, such as the Proposed offshore export cable corridor(s) would be reduced through the adoption of factored-in measures similar to those for the Array, 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 much greater risk to marine mammals than baseline levels.

858. The cumulative impact is predicted to be of local spatial extent in the context of the geographic frame of reference, medium term duration, intermittent and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of the receptors

859. The sensitivity of marine mammals to collision risk is as described in section 10.11.2, paragraph 449 *et seq.* and is not repeated here.

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

Significance of effect

861. Overall, the magnitude of the cumulative impact is deemed to be low (particularly with the adoption of the NSVMP, volume 4, appendix 24 and similar measures for other projects) 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.

Further mitigation and residual effect

862. No 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.

Operation and maintenance phase

Magnitude of impact

863. One Tier 1 project was identified with potential for cumulative effects associated with this impact within the 50 km buffer, in the regional marine mammal study area:

- Proposed offshore export cable corridor(s) (construction and operation and maintenance phases).

864. Vessel use during operation and maintenance phase of Array may lead to injury to marine mammals due to collision with vessels (including CTVs, SOVs, jack-up vessels, cable repair vessels, CSVs and DSVs). 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 443 *et seq*. for the construction phase for the Array. The maximum scenario for the operation and maintenance phase of the Array is presented in Table 10.17 with up to 508 vessel round trips over the operational lifetime of the Array.

865. As discussed in paragraph 592 for the Proposed offshore export cable corridor(s), there is no information in the public domain to determine if injury due to collision with vessels is scoped in, but it can be reasonably assumed it will be assessed in the EIA. If a project has not presented quantified information, then it is not appropriate for the Applicant to generate hypothetical numbers on the project’s behalf, however it can be assumed the impact assessment will be comparable or less than the Array.

866. Given that vessel movements will be confined to the Array and Proposed offshore export cable corridor(s) 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. There is also a potential that the noise emissions from vessels will deter animals from the potential zone of impact.

867. The operation and maintenance phase of the Array will temporally overlap with the operation and maintenance phase and decommissioning phase of the Proposed offshore export cable corridor(s). The operational lifetime of the Proposed offshore export cable corridor(s) is expected to run from 2038 to 2062, with decommissioning beginning in 2063. Vessel numbers for decommissioning are likely to be at worst, similar to those for construction phases, and it is expected animals will have some degree of habituation to vessel traffic that has been present throughout the operation and maintenance phases of CEA projects. Additionally, it can be expected that after decades of construction and maintenance activities taking place in the wider vicinity of the Array (within the regional marine mammal study area), marine mammals may have further habituated to higher vessel numbers. Therefore, the cumulative magnitude of the impact of the decommissioning phase of Proposed offshore export cable corridor(s) 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 cumulative construction phase.

868. The cumulative impact is predicted to be of local spatial extent, long term duration, intermittent and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of the receptors

869. The sensitivity of marine mammals to collision risk is as described in section 10.11.2 for the Array alone assessment, paragraph 449 *et seq.* and is not repeated here.

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

Significance of effect

871. Overall, the magnitude of the cumulative impact is deemed to be low (particularly with the adoption of the NSVMP, volume 4, appendix 24 and similar measures for other projects) 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.

Further mitigation and residual effect

872. No 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.

Decommissioning phase

Magnitude of impact

873. One Tier 1 project was identified with potential for cumulative effects associated with this impact within the 50 km buffer, in the regional marine mammal study area:

- Proposed offshore export cable corridor(s) (operation and maintenance phases).

874. Vessel use during decommissioning phase of the Array may lead to injury to marine mammals due to collision with vessels. Vessels will be required for activities such as removal of foundation, cables and cable protection. Noise from vessels assumed to be as per vessel activity described for construction phase, with an overview of the potential impacts described in paragraph 443 *et seq*. for the construction phase.

875. As discussed in paragraph 590 for the Proposed offshore export cable corridor(s), there is no information in the public domain to determine if injury due to collision with vessels is scoped in, but it can be reasonably assumed it will be assessed in the EIA.

876. It is anticipated the Proposed offshore export cable corridor(s) will begin decommissioning before the Array and therefore there may be some overlap with the decommissioning phase of the Array, though decommissioning phases are a matter of years and much less than the operational phase of 35 years for the Array. As discussed in paraph 867, it is expected animals will have some degree of habituation to vessel traffic that has been present throughout the operation and maintenance phases of CEA projects. Additionally, it can be expected that after decades of construction and maintenance activities taking place in the wider vicinity of the Array (within the regional marine mammal study area), marine mammals may have further habituated to higher vessel numbers. Therefore, the cumulative magnitude of the impact of

the decommissioning phase of the Array and Proposed offshore export cable corridor(s) 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 cumulative construction phase.

877. The cumulative impact is predicted to be of local spatial extent in the context of the geographic frame of reference, medium term duration, intermittent and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of the receptors

878. The sensitivity of marine mammals to collision risk is as described for the construction phase in paragraph 859 *et seq*. (with detail given in section 10.11.2, paragraph 449) and is not repeated here.

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

Significance of effect

880. Overall, the magnitude of the cumulative impact is deemed to be low (particularly with the adoption of the NSVMP, volume 4, appendix 24 and similar measures for other projects) 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.

Tier 2

Construction phase

Magnitude of impact

881. There was one Tier 2 project identified within the 50 km buffer considered for potential for cumulative effects associated with this impact:

- Morven BP-EnBW .

882. The construction of the Array, together with construction phase of Tier 1 and Tier 2 projects (Table 10.52) may lead to cumulative injury due to collision risk with vessels. Morven BP-EnBW is located within 50 km of the Array, all other Tier 2 Projects are located over 50 km away. The other Tier 2 Projects which are located >50 km from the Array are considered to be located at a distance great enough that cumulative impacts are highly unlikely.

883. The Morven Offshore Scoping Report scopes in injury to marine mammals due to collision with vessels for the construction and decommissioning phase of the Morven Offshore Wind Project (Morven Offshore Wind Limited, 2023). Although there is no information on the numbers and types of vessels which will be associated with the construction phase of the Morven Offshore Wind Project, the types of vessels involved in construction activities at other offshore wind farms will be similar to those identified for the Array (such as those described in paragraph 864), and the number of vessel movements represents a slight increase in the risk of collision for marine mammals over the existing levels of vessel traffic.. As outlined in paragraph 856, the Array and respective projects are located in the area of relatively high vessel traffic, particularly cargo vessels (see paragraph 387 *et seq*.) and therefore it can be expected that marine mammals present in the area will demonstrate some degree of habituation to the presence of high number of vessels. Furthermore, the Array is located in proximity to oil and gas structures in the North Sea and as such the traffic of oil and gas vessels is substantial. Considering the baseline levels of vessel traffic, it can be anticipated that marine mammals present in the vicinity of the Array marine mammal study area are familiarised to passing ships in the area.

884. The cumulative impact (injury due to collision risk with vessels) is predicted to be of local spatial extent in the context of the geographic frame of reference, medium term duration, intermittent and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of the receptors

885. The sensitivity of marine mammals to collision risk is as described for the construction phase in paragraph 859 *et seq*. (with detail given in section 10.11.2, paragraph 449) and is not repeated here.

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

Significance of effect

887. Overall, the magnitude of the cumulative impact is deemed to be low (particularly with the adoption of the VMP and similar measures for other projects) 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.

Further mitigation and residual effect

888. No 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.

Operation and maintenance phase

Magnitude of impact

889. There was one Tier 2 project identified within the 50 km buffer considered for potential for cumulative effects associated with this impact:

- Morven BP-EnBW

890. The operation and maintenance phase of the Array, together with construction phase of Tier 1 and Tier 2 projects (Table 10.52) may lead to cumulative injury due to collision risk with vessels. Morven BP-EnBW is located within 50 km of the Array, all other Tier 2 Projects are located over 50 km away. The other Tier 2 Projects which are located >50 km from the Array are considered to be located at a distance great enough that cumulative impacts are highly unlikely.

891. There is the potential for the operation and maintenance phase of Morven BP-EnBW to overlap with the operation and maintenance phase of the Array. It should be noted that the Morven Offshore Scoping Report scoped out injury due to collision risk with vessels during the operation and maintenance phase on the basis that operation and maintenance vessels will transit slowly through the Morven Array, and the Morven

Array will adhere to the Scottish Marine Wildlife Watching Code. This approach was discussed and confirmed by NatureScot via the Morven BP-EnBW Scoping Workshop.

892. As described in paragraph 786, maintenance of cables or turbines typically involves considerably smaller numbers of vessels and round trips compared to construction. Considering the vessel activity within the North Sea, it is anticipated that these will not add substantially to the number of vessels present during the operation and maintenance phases of the Array, Tier 1 and Tier 2 projects and that the potential for cumulative effects is unlikely.

893. It should also be considered that during the operation and maintenance phase of the Array some of the Tier 2 projects may be decommissioned. There may be an increase in vessel numbers associated with the decommissioning phases of the Tier 2 projects outlined. However, as outlined in paragraph 839, considering the vessel activity within the North Sea, it is anticipated that these will not add substantially to the number of vessels present during the operation and maintenance phases of the Array.

894. The cumulative impact (injury due to collision risk with vessels) is predicted to be of local spatial extent in the context of the geographic frame of reference, long term duration, intermittent and is 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 receptors

895. The sensitivity of marine mammals to collision risk is as described for the construction phase in paragraph 859 *et seq*. (with detail given in section 10.11.2, paragraph 449) and is not repeated here.

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

Significance of effect

897. Overall, the magnitude of the cumulative impact is deemed to be low (particularly with the adoption of the NSVMP, volume 4, appendix 24 and similar measures for other projects) 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.

Further mitigation and residual effect

898. No 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.

Decommissioning phase

Magnitude of impact

899. There was one Tier 2 project identified within the 50 km buffer considered for potential for cumulative effects associated with this impact:

- Morven BP-EnBW.

900. Based on a 35-year operational lifetime, and the commencement of operation and maintenance phase in 2038, decommissioning at Morven is likely to occur from 2073 and potential overlap with decommissioning phase at the Array. Cumulative effects from underwater noise generated during vessel use and other noise producing activities are not anticipated.

901. The cumulative impact (injury due to collision risk with vessels) is predicted to be of local extent in the context of the geographic frame of reference, medium-term duration, intermittent and is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of the receptors

902. The sensitivity of marine mammals to collision risk is as described for the construction phase in paragraph 859 *et seq*. (with detail given in section 10.11.2, paragraph 449) and is not repeated here.

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

Significance of effect

904. Overall, the magnitude of the cumulative impact is deemed to be low (particularly with the adoption of the NSVMP, volume 4, appendix 24 and similar measures for other projects) 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.

Further mitigation and residual effect

905. No 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.

Tier 3

Construction phase

Magnitude of impact

906. There were three Tier 3 projects identified with potential for cumulative effects associated with this impact:

- Bellrock Offshore Wind Farm;
- Bowdun Offshore Wind Farm;
- Campion Offshore Wind Farm;
- Morven BP-EnBW Offshore Export Cable Corridor.

907. Tier 3 projects are in a pre-application phase and no EIA Scoping Report or EIA Report is available to inform a quantitative assessment. Therefore, a qualitative assessment is provided below.

908. Bellrock Offshore Wind Farm, Bowdun Offshore Wind Farm, Campion Offshore Wind Farm and Morven BP-EnBW Offshore Export Cable Corridor are all located within 50 km of the Array, all other Tier 3 projects are located over 50 km away. The other Tier 3 projects which are located >50 km from the Array are considered to be located at a distance great enough that cumulative impacts are highly unlikely.

909. There is no information in the public domain on potential numbers of vessels associated with the construction phase of Bellrock Offshore Wind Farm, Bowdun Offshore Wind Farm, Campion Offshore Wind

Farm and Morven BP-EnBW Offshore Export Cable Corridor, and construction timelines are unknown. If any overlap of the construction phases were to occur, the uplift in vessels would be primarily restricted to within the relevant discrete project footprints, with the implementation of standard industry measures such as PAM and MMOs[2] the potential for cumulative effects is very low. The operation and maintenance phase of offshore wind projects typically involves considerably fewer vessels and round trips compared to construction. Therefore, it is anticipated that these will not add substantially to the number of vessels present during the construction of the Array and that the potential for cumulative effects is unlikely.

910. The cumulative impact (injury due to collision risk with vessels) is predicted to be of local to regional spatial extent in the context of the geographic frame of reference, medium-term duration, intermittent and the effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after they moved from the impact zone). It is predicted that the impact will affect the receptor directly. Whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects. The magnitude was therefore considered to be low.

Sensitivity of the receptors

911. The sensitivity of marine mammals to collision risk is as described in paragraph 859 *et seq*. (with detail given in section 10.11.2, paragraph 449) for construction and is not repeated here.

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

Significance of effect

913. Overall, the magnitude of the cumulative impact is deemed to be low (particularly with the adoption of the NSVMP, volume 4, appendix 24 and similar measures for other projects) 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.

Further mitigation and residual effect

914. No 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.

Operation and maintenance phase

Magnitude of impact

915. There were three Tier 3 projects identified within the 50 km buffer considered for potential for cumulative effects associated with this impact:

- Bellrock Offshore Wind Farm;
- Bowdun Offshore Wind Farm;
- Campion Offshore Wind Farm; and
- Morven BP-EnBW Offshore Export Cable Corridor.

916. Tier 3 projects are in a pre-application phase and no EIA Scoping Report or EIA Report is available to inform a quantitative assessment. Therefore, a qualitative assessment is provided below.

917. As described in paragraph 786, maintenance of cables or turbines typically involves considerably smaller numbers of vessels and round trips compared to construction. Considering the vessel activity within the North Sea, it is anticipated that these will not add substantially to the number of vessels present during the operation and maintenance phases of the Array, Tier 1 and Tier 2 projects and that the potential for cumulative effects is unlikely.

918. It should also be considered that during the operation and maintenance phase of the Array some of the Tier 3 projects may be decommissioned. There may be an increase in vessel numbers associated with the decommissioning phases of the Tier 3 projects outlined above. However, as outlined in paragraph 839, considering the vessel activity within the North Sea, it is anticipated that these will not add substantially to the number of vessels present during the operation and maintenance phases of the Array.

919. The cumulative impact (injury due to collision risk with vessels) is predicted to be of local to regional spatial extent, long term duration, intermittent and the effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after they moved from the impact zone). It is predicted that the impact will affect the receptor directly. Whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects. The magnitude was therefore considered to be low.

Sensitivity of the receptors

920. The sensitivity of marine mammals to collision risk is as described in paragraph 859 *et seq*. (with detail given in section 10.11.2, paragraph 449) for construction and is not repeated here.

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

Significance of effect

922. Overall, the magnitude of the cumulative impact is deemed to be low (particularly with the adoption of the NSVMP, volume 4, appendix 24 and similar measures for other projects) 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.

Further mitigation and residual effect

923. No 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.

Decommissioning phase

Magnitude of impact

924. There were three Tier 3 projects identified within the 50 km buffer considered for potential for cumulative effects associated with this impact:

- Bellrock Offshore Wind Farm;
- Bowdun Offshore Wind Farm;
- Campion Offshore Wind Farm; and
- Morven BP-EnBW Offshore Export Cable Corridor.

925. Tier 3 projects are in a pre-application phase and no EIA Scoping Report or EIA Report is available to inform a quantitative assessment. Therefore, a qualitative assessment is provided below.

926. On the basis of a 35 year operational lifetime, decommissioning will not occur at the Array until 2074. There is unlikely to be a temporal overlap between Tier 3 projects and decommissioning at the Array. Cumulative effects from underwater noise generated during vessel use and other noise producing activities are not anticipated.

927. The cumulative impact (injury due to collision risk with vessels) is predicted to be of local to regional spatial extent, medium-term duration, intermittent and the effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after they moved from the impact zone). It is predicted that the impact will affect the receptor directly. Whilst there may be effects at an individual level, these are not predicted to be at a scale that would lead to any population-level effects. The magnitude was therefore considered to be low.

Sensitivity of the receptors

928. The sensitivity of marine mammals to collision risk is as described in for the construction phase in paragraph 859 *et seq*. (with detail given in section 10.11.2, paragraph 449) and is not repeated here.

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

Significance of effect

930. Overall, the magnitude of the cumulative impact is deemed to be low (particularly with the adoption of the NSVMP, volume 4, appendix 24 and similar measures for other projects) 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.

Further mitigation and residual effect

931. No 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.

EFFECTS ON MARINE MAMMALS DUE TO EMFS FROM SUBSEA ELECTRICAL CABLING IN THE WATER COLUMN

Tier 1

Operation and maintenance phase only

Magnitude of impact

932. One Tier 1 project was identified with potential for cumulative effects associated with this impact within the 10 km buffer, in the regional marine mammal study area:

- Proposed offshore export cable corridor(s) (construction and operation and maintenance phases).

933. As discussed in paragraph 590, there is no information in the public domain to determine if effects on marine mammals due to EMFs is scoped in for the Proposed offshore export cable corridor(s), but as a precautionary approach we have included it in the assessment given the potential effects of EMF from a cable project. However, given that the Proposed offshore export cable corridor(s) is a HVDC subsea power cable, they will not include dynamic cabling, and will likely be entirely buried and protected where burial is not practicable. Cable burial and cable protection are common industry practice measures, which can reduce EMF levels in the benthic environment (Chapman *et al.*, 2023, CSA Ocean Sciences Inc and Exponent, 2019, Gill *et al.*, 2005, Gill *et al.*, 2009, Hervé, 2021) and it is unlikely marine mammal receptors will spend any significant amount of time near the seabed (given their highly mobile nature, pelagic lifestyle and need to surface for air periodically) which would lead to any substantial cumulative effects beyond those for the Array alone.

934. As presented in paragraphs 469 *et seq*., EMF levels in the vicinity of subsea cables are influenced by a variety of design and installation factors, including distance between cables, cable sheathing, number of conductors, and internal cable configuration. Therefore, the cumulative magnitude of impact with the Tier 1 projects is likely to be highly localised to within metres to tens of metres from cables.

935. As discussed in paragraph 472, significant knowledge gaps around the estimates of cumulative EMF exist and the magnitude of repeated exposure through time and space (Ocean Science Consulting Ltd., 2022). Therefore, at this stage it is difficult to quantify the exact effects of EMF on marine mammals but it is anticipated the cumulative effect will not lead to any substantial further disturbance to marine mammals due to the factors described above.

936. The cumulative impact is predicted to be of local spatial extent, long term duration, continuous 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 receptors

937. The sensitivity of marine mammals to EMF is as described for the Array, with detail given in section 10.11.2, paragraph 476 *et seq.*) and is not repeated here.

938. All receptors, except humpback whale, are deemed to be of high resilience, high recoverability and adaptability and international value. The sensitivity of these receptors is therefore, considered to be low. Humpback whale is deemed to be of medium resilience and adaptability and high recoverability. The sensitivity of humpback whale is therefore, considered to be medium.

Significance of effect

939. Overall, for all marine mammal species, the magnitude of the impact is deemed to be low and the sensitivity is considered to be low for all species except humpback whale, which is assessed as medium. Due to the uncertainty associated with the magnitude, the effect for all species is assessed precautionarily as being of **minor** adverse significance, which is not significant in EIA terms.

Further mitigation and residual effect

940. No 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.

Tier 2

Operation and maintenance phase only

Magnitude of impact

941. There was one Tier 2 project identified within the 10 km buffer with potential for cumulative effects associated with this impact:

- Morven BP-EnBW

942. As outlined in paragraph 469 *et seq*., the impacts related to EMF are expected to be localised to within the close vicinity of the respective projects and transient for marine mammals and as such the assessment has focussed only on projects within a representative 10 km buffer of the Array as a proportionate approach.

943. Whilst there is the potential for the operation and maintenance phase of Morven BP-EnBW to overlap with the operation and maintenance phase of the Array, the Morven Offshore Scoping Report did not include EMF as an impact for assessment on the basis of no likely effect on marine mammals, since fixed-foundation wind turbines lack suspended cables in the water column (Morven Offshore Wind Limited, 2023) and therefore there is no additional potential for cumulative effects for Tier 2 projects.

Sensitivity of the receptors

944. The sensitivity of marine mammals to EMF is as describe for the Array, with detail given in section 10.11.2, paragraph 476 *et seq.*) and is not repeated here.

945. All receptors, except humpback whale, are deemed to be of high resilience, high adaptability and recoverability and international value. The sensitivity of these receptors is therefore, considered to be low. Humpback whale is deemed to be of medium resilience and adaptability and high recoverability. The sensitivity of humpback whale is therefore, considered to be medium.

Significance of effect

946. Overall, for all marine mammal species, the magnitude of the impact is deemed to be low and the sensitivity is considered to be low for all species except humpback whale, which is assessed as medium. Due to the uncertainty associated with the magnitude, the effect is assessed precautionarily as being of **minor** adverse significance, which is not significant in EIA terms.

Further mitigation and residual effect

947. No 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.

Tier 3

Operation and maintenance phase only

Magnitude of impact

948. There was Tier 3 project identified within 10 km buffer with potential for cumulative effects associated with this impact:

- Bellrock Offshore Wind Farm.

949. Tier 3 projects are in a pre-application phase and no EIA Scoping Report or EIA Report is available to inform a quantitative assessment. Therefore, a qualitative assessment is provided below.

950. As outlined in paragraph 599 *et seq.,* the impacts related to EMF are expected to be localised and transient for marine mammals, expected to be localised to within the close vicinity of the respective projects and as such the assessment has focused only on projects within a representative 10 km buffer of the Array as a proportionate approach. Bellrock Offshore Wind Farm is the only project located within 10 km of the Array that has subsea cabling in the water column (Morven BP-EnBW Offshore Export Cable Corridor is buried), all other Tier 3 projects are located over 10 km away. The other Tier 3 projects which are located >10 km from the Array are considered to be located at a distance great enough that cumulative impacts are highly unlikely.

951. At this point in time, Bellrock Offshore Wind Farm is anticipated to have impacts of EMF due to its floating design but no further information is currently available. Effects from EMF are expected to be highly localised to the projects, as described in paragraph 469 *et seq*. Moreover, the proposed capacity and spatial coverage of the Bellrock Offshore Wind Farm are both anticipated to be approximately one-third that of the Array (with Bellrock Offshore Wind Farm development area covering 280 km^2).

952. The cumulative impact is predicted to be of local spatial extent, long term duration, continuous 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 receptors

953. The sensitivity of marine mammals to EMF is as describe for the Array, with detail given in section 10.11.2, paragraph 476 *et seq.*) and is not repeated here.

954. All receptors, except humpback whale, are deemed to be of high resilience, high adaptability and recoverability and international value. The sensitivity of these receptors is therefore, considered to be low. Humpback whale is deemed to be of medium resilience and adaptability and high recoverability. The sensitivity of humpback whale is therefore, considered to be medium.

Significance of effect

955. Overall, for all marine mammal species, the magnitude of the impact is deemed to be low and the sensitivity is considered to be low for all species except humpback whale, which is assessed as medium. Due to the uncertainty associated with the magnitude, the effect is assessed precautionarily as being of **minor** adverse significance, which is not significant in EIA terms.

Further mitigation and residual effect

956. No 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.

INJURY AND DISTURBANCE FROM UNDERWATER NOISE GENERATED DURING THE OPERATION OF WIND TURBINES AND ANCHOR MOORING LINES (OPERATION PHASE)

957. No Tier 1 projects with turbines (and therefore the potential for any cumulative operational noise) were identified within the 50 km buffer of the Array, and therefore there is no cumulative effect predicted from additional Tier 1 projects.

Tier 2

Operation and maintenance phase only

Magnitude of impact

958. There was one Tier 2 project identified within 50 km buffer with potential for cumulative effects associated with this impact:

959. Morven BP-EnBW. As outlined in paragraph 492 *et seq*. the impacts related to operational noise from turbines and anchor mooring lines are expected to be localised to within the close vicinity of the respective projects and as such the assessment has focussed only on projects within a representative 50 km buffer of the Array as a proportionate approach.

960. Whilst there is the potential for the operation and maintenance phase of Morven BP-EnBW to overlap with the operation and maintenance phase of the Array, the Morven Offshore Scoping Report did not include operational noise as an impact for assessment (it has been scoped out in the Morven scoping report (Morven Offshore Wind Limited, 2023)) and therefore there is no additional potential for cumulative effects for Tier 2 projects.

Sensitivity of the receptors

961. The sensitivity of marine mammals to operational noise from wind turbines and mooring lines is as described for the Array, with detail given in section 10.11.2, paragraph 496 *et seq.*) and is not repeated here.

962. All receptors are deemed have limited resilience to auditory injury, low recoverability and adaptability and high international value. The sensitivity of the receptor to auditory injury is therefore, considered to be high.

Significance of effect

963. Overall, the magnitude of the cumulative effect (auditory injury) is deemed to be negligible and the sensitivity of the receptor is considered to be high. The cumulative effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

964. Overall, the magnitude of the effect (behavioural disturbance) is deemed to be negligible 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.

Further mitigation and residual effect

965. No 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.

Tier 3

Operation and maintenance phase

Magnitude of impact

966. There were two Tier 3 projects identified with potential for cumulative effects associated with this impact:

- Bellrock Offshore Wind Farm;
- Bowdun Offshore Wind Farm; and
- Campion.

967. Tier 3 projects are in a pre-application phase and no EIA Scoping Report or EIA Report is available to inform a quantitative assessment. Therefore, a qualitative assessment is provided below.

968. As described in paragraph 485 *et seq.*, operational noise from anchor mooring lines is likely to be considerably lower compared to underwater noise associated with piling and UXO clearance activities that occurred during the construction phase. Most Tier 3 projects are located in excess of 50 km from the Array. The exceptions are Bellrock Offshore Wind Farm, Bowdun Offshore Wind Farm and Campion. Of these, only Bellrock and Campion are floating projects and may contribute to cumulative effects with respect to operational noise from anchor mooring lines.

969. The Array alone assessment (see paragraph 485 *et seq.*), which draws on a study completed at a Hywind floating site in Scotland by Burns *et al.* (2022) concluded that the maximum distance at which the TTS could occur across all hearing groups was estimated for harbour porpoise at 50 m from a turbine assuming that the animal would remain stationary for the 24 hour period (Burns *et al.*, 2022). The study concluded that even at a wind speed of 25 knots, the noise footprint is negligible and in the relatively noisy soundscape of the North Sea, it does not present any realistic threat of auditory injury to marine species. Similarly, the impact from the Array alone was considered to be negligible. As discussed in paragraph 489, Risch *et al.* (2023a) found noise emissions from FOW turbines were similar to the operational noise of fixed offshore wind turbines, with biggest difference between fixed and FOW turbines in relation to underwater noise generation is mooring-related noise, rather the operational wind turbine noise.

970. Considering Bellrock Offshore Wind Farm, Bowdun Offshore Wind Farm and Campion are ~8 km, ~25 km~44 km from the Array, respectively and on the basis of the estimated TTS ranges associated with operational noise the potential for a cumulative impact is unlikely.

971. For auditory injury, the cumulative impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility (the elevation in underwater sound occurs only during the operation and maintenance phases). The injury, which is highly unlikely to occur, would be of medium (TTS) to low (PTS) reversibility. It is predicted that the impact will affect the receptor directly. Given that animals are highly unlikely to stay within the injury ranges continuously for 24 hours, injury and therefore population-level effects are highly unlikely to occur. The magnitude for injury is therefore considered to be negligible.

972. For behavioural disturbance, the impact (elevated underwater noise from floating wind turbines and mooring lines) is predicted to be of local spatial extent, long term duration and continuous. The impact as well as the effect of behavioural disturbance are of high reversibility. It is predicted that the impact will affect the receptor directly. Although noise levels are likely to be audible to marine mammals, animals are

unlikely to experience behavioural disturbance including displacement as a result of the increased underwater noise during operational phase. The magnitude is therefore considered to be negligible.

Sensitivity of the receptors

973. The sensitivity of marine mammals to operational noise from wind turbines and mooring lines is as described for the Array, with detail given in section 10.11.2, paragraph 496 *et seq.*) and is not repeated here.

974. All receptors are deemed have limited resilience to auditory injury, low recoverability and adaptability and high international value. The sensitivity of the receptor to auditory injury is therefore, considered to be high.

975. All receptors are deemed to have some resilience to behavioural disturbance, high recoverability and adaptability and high international value. The sensitivity of the receptor to behavioural disturbance is therefore, considered to be medium.

Significance of effect

976. Overall, the magnitude of the cumulative effect (auditory injury) is deemed to be negligible and the sensitivity of the receptor is considered to be high. The cumulative effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

977. Overall, the magnitude of the effect (behavioural disturbance) is deemed to be negligible 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.

Further mitigation and residual effect

978. No 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.

EFFECTS ON MARINE MAMMALS DUE TO ENTANGLEMENT

979. There are concerns regarding the hazards that mooring lines and dynamic cables may pose to marine mammals, which could inadvertently become entangled or entrapped (MD-LOT, 2023). The expansion in FOW means there is an increasing cumulative risk of entanglement.

980. However, no Tier 1 or Tier 2 projects were identified with the potential for entanglement risk (i.e. FOW projects) within the 50 km buffer region.

Tier 3

Operation and maintenance phase

Magnitude of impact

981. There were two Tier 3 FOW projects identified within the 50 km buffer region with potential for cumulative effects associated with this impact:

- Bellrock Offshore Wind Farm; and
- Campion.

982. Tier 3 projects are in a pre-application phase and no EIA Scoping Report or EIA Report is available to inform a quantitative assessment. Therefore, a qualitative assessment is provided below.

983. As described in paragraph 520, as a part of the designed in measures, mooring lines and dynamic inter-array cables will undergo regular inspections during the operation and maintenance phase, employing a risk-based adaptive management approach. All Tier 3 projects are located in excess of 50 km from the Array except for Bellrock, Bowdun and Campion Offshore Wind Farms. Of these projects only Bellrock and Campion are floating projects and may contribute to the cumulative impacts of entanglement.

984. The risks of entanglement are not fully understood but the commitment of the Array to monitor and manage the risks will reduce any potential contribution to cumulative effects with other projects. There are no published standard industry measures at the time of writing, but should other wind projects adopt a similar 'monitor and manage' approach, it is likely that the potential for cumulative effects would be further reduced. Considering the implementation of these designed in measures during the operation and maintenance phases of the Array, the potential for contribution of the Array to any cumulative effects resulting from entanglement is considered very unlikely.

985. The impact (risk of entanglement due to presence of mooring lines and inter-array cables in the water column) is predicted to be of very local spatial extent in the context of the geographic frame of reference, long term duration, continuous and the effect is irreversible when entanglement does occur. It is predicted that the impact will affect the receptor directly in the case of both (rare) primary entanglement and secondary entanglement, however the risk of secondary entanglement is sufficiently reduced with the application of the designed in measures (routine surveys and removal of marine debris as required following inspection) and any population-level effects are highly unlikely and the project will reduce any contribution to cumulative effects. Therefore, the magnitude of primary and secondary entanglement is considered to be low.

Sensitivity of the receptors

986. The sensitivity of marine mammals to entanglement is as described for the Array, with detail given in section 10.11.2, paragraph 524 to 530 for primary entanglement and 534 to 545 for secondary entanglement) and is not repeated here.

Primary entanglement

987. Mysticetes are deemed to have some resilience to primary entanglement (largely due to avoidance and design of mooring lines/cables), some adaptability, limited recoverability and are of international value. The sensitivity of the receptors (minke whale and humpback whale) is therefore, conservatively, considered to be medium.

988. Odontocetes and pinnipeds are deemed to have some resilience to primary entanglement (largely due to avoidance and design of mooring lines/cables), high adaptability, limited recoverability and are of international value. The sensitivity of the receptors (harbour porpoise, bottlenose dolphin, white-beaked dolphin and grey seal) is therefore, considered to be low.

Secondary entanglement

989. Marine mammals are deemed to have some resilience to secondary entanglement (largely via avoidance), medium adaptability, limited recoverability and are of international value. The designed in measures (routine inspections and removal of marine debris as required) will reduce the risks for secondary entanglement, but due to paucity of information on secondary entanglement and the irreversible nature if

entanglement does occur, the sensitivity of all marine mammals is conservatively considered to be medium.

Significance of effect

Primary entanglement

990. Overall, the magnitude of the cumulative impact (primary entanglement) is deemed to be low for all marine mammals and the sensitivity of the receptor is considered to be low for odontocetes and pinnipeds and medium for mysticetes. the cumulative effect therefore will be of **minor** adverse significance for all species, which is not significant in EIA terms.

Secondary entanglement

991. Overall, the magnitude of the cumulative impact (secondary entanglement) is deemed to be low for all marine mammals and the sensitivity of all receptors (odontocetes, pinnipeds and mysticetes) is considered to be low. The cumulative effect will, therefore, be of **minor** adverse significance for all marine mammals, which is not significant in EIA terms.

Further mitigation and residual effect

992. No 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.

EFFECTS ON MARINE MAMMALS DUE TO ALTERED PREY AVAILABILITY

Tier 1

<u>Construction phase</u>

Magnitude of impact

993. The construction of the Array together with the projects and plans identified in Table 10.52 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 MDSs for these receptors and therefore are carried forward here. Key impacts include temporary habitat loss/disturbance, long term habitat loss/disturbance and underwater noise from piling and UXO clearance impacting fish and shellfish receptors.

994. There is potential for cumulative temporary habitat loss and disturbance impacting fish and shellfish receptors because of construction activities associated with the Array and the other plans and projects, and volume 2, chapter 9 identified one Tier 1 project with potential for CEA effects for this impact: the Proposed offshore export cable corridor(s). The maximum duration of the offshore construction phase for the Array is up to seven years and therefore, there may be five years of overlap between the site preparation and construction activities of the Array and the Proposed offshore export cable corridor(s). Within this phase of development of the Array, site preparation and construction activities are anticipated to occur intermittently; activities will be spread across the phase with only a small proportion of the MDS footprint for this impact being affected at any one time. As the cumulative effect was predicted to be of local spatial extent, medium duration and high reversibility, the magnitude has been assessed as low (in volume 2, chapter 9). Sensitivity of the fish and shellfish receptors was considered low to medium and overall, cumulative effects were assessed as being of minor adverse significance fish and shellfish IEFs.

995. There is potential for cumulative long term habitat loss and disturbance impacting fish and shellfish receptors. Volume 2, chapter 9 identified two Tier 1 projects with potential for CEA effects for this impact: the Proposed offshore export cable corridor(s) and the Eastern Green Link (operation and maintenance phase). It likely that long term habitat loss will occur at the Tier 1 projects because of cable and/or pipeline protection and crossing protection, and presents some measurable, but minor, long term loss of and alteration to the affected areas of seabed within the Array fish and shellfish ecology study area and wider North Sea. As the cumulative effect was predicted to be of local spatial extent, the magnitude has been assessed as low (in volume 2, chapter 9). Sensitivity of the fish and shellfish receptors was considered low to medium and therefore overall, cumulative effects were assessed as being of minor adverse significance for all fish and shellfish IEFs.

996. There is potential for cumulative effects from underwater noise from piling and UXO clearance impacting fish and shellfish receptors. Volume 2, chapter 9 identified two Tier 1 projects with potential for CEA effects for this impact: the Proposed offshore export cable corridor(s) and Berwick Bank Offshore Wind Farm. As the cumulative effect was predicted to be of regional spatial extent, medium duration and high reversibility, the magnitude has been assessed as low (in volume 2, chapter 9). Sensitivity of the fish and shellfish receptors was considered low to medium (herring) and therefore overall, cumulative effects were assessed as being of minor adverse significance for all fish and shellfish IEFs.

997. With respect to indirect effects on marine mammals, no additional cumulative effects due to changes in prey availability are predicted (with no significant cumulative effects predicted for fish and shellfish IEFs). As discussed in paragraph 559, all marine mammals in this assessment are considered to be generalist opportunistic feeders and are thus not reliant on a single prey species. Given that marine mammals are wide-ranging in nature with the ability to exploit numerous food sources, there would be a variety of prey species available for marine mammal foraging.

998. The impact of altered prey availability 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. Therefore, cumulatively for marine mammals, the impact of effects on marine mammals due to altered prey availability is low.

Sensitivity of the receptors

999. The sensitivity of marine mammals altered prey availability is as described for the Array, with detail given in paragraph 560 to 565 and is not repeated here.

1000. All receptors are deemed to be of high resilience, high recoverability and adaptability and high international value. The sensitivity of the receptor is therefore, considered to be low.

Significance of effect

1001. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor** adverse (though could be minor beneficial for some species dependent on the reef effect) significance, which is not significant in EIA terms.

Further mitigation and residual effect

1002. No 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.

Operation and maintenance phase

Magnitude of impact

1003. Potential cumulative impacts on marine mammal prey species during the operation and maintenance phase have been assessed in volume 2, chapter 9 using the appropriate MDSs for these receptors and therefore are carried forward here.

1004. There is potential for cumulative temporary habitat loss and disturbance because of activities associated with the Array and the other plans and projects, and volume 2, chapter 9 identified two Tier 1 projects with potential for CEA effects for this impact: the Proposed offshore export cable corridor(s) and Eastern Green Link 2. The operation and maintenance phase of Eastern Green Link 2 and Proposed offshore export cable corridor(s) overlaps temporally with that of the Array. As the cumulative effect was predicted to be of local spatial extent, the magnitude for cumulative temporary habitat loss and disturbance has been assessed as negligible (in volume 2, chapter 9). Sensitivity of the fish and shellfish receptors was considered low to medium and overall, cumulative effects from temporary habitat loss and disturbance were assessed as being of minor adverse significance.

1005. Volume 2, chapter 9 combined the cumulative assessment for all phases for the impact of long term habitat loss and disturbance and therefore the magnitude of impact is as described in paragraph 995 and is not duplicated here.

1006. There is potential for cumulative effects to fish and shellfish receptors due to EMF from subsea electrical cabling, and volume 2, chapter 9 identified the Proposed offshore export cable corridor(s) and Eastern Green Link 2 for cumulative effects associated with EMF. EMF levels in the vicinity of subsea cables are influenced by a variety of design and installation factors, including distance between cables, cable sheathing, number of conductors, and internal cable configuration. Further, the intensity of EMF from subsea cables decreases at approximately the inverse square/power of the distance away from the cable (Hutchison *et al.*, 2021). This attenuation is the same for buried, unburied, and dynamic cables (Hutchison *et al.*, 2021). Therefore, the cumulative magnitude of impact with the Tier 1 projects is likely to be highly localised to within metres to tens of metres from cables. For all fish and shellfish IEF species, including those key prey species for marine mammals, the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of negligible to minor adverse significance, which is not significant in EIA terms.

1007. There is potential for cumulative effects to fish and shellfish receptors from colonisation of hard substrates. Volume 2, chapter 9 identified two Tier 1 projects with potential for CEA effects for this impact: the Proposed offshore export cable corridor(s) and the Eastern Green Link (operation and maintenance phase). A detailed CEA assessment is given in volume 2, chapter 9 which determined that the cumulative spatial extent of this impact in the operation and maintenance phase is likely to be small in relation to the whole Array fish and shellfish ecology study area. It is expected that these artificial hard substrates will be colonised by epifaunal species local to the Array fish and shellfish ecology study area, but this impact will represent a shift in the baseline seabed conditions from soft to hard substrate in the areas where the infrastructure is installed. This could result in beneficial effects for fish and shellfish IEFs (e.g. increased biodiversity, greater shelter/protection opportunities, greater prey availabilities and potential reef effects (Bender *et al*., 2020, Langhamer *et al*., 2016)), but could also reduce burial substrate for species like edible crab (which do not form a major prey species for marine mammal IEFs). As the cumulative effect was predicted to be of local spatial extent but long term duration, the magnitude has been assessed as low (in volume 2, chapter 9). Sensitivity of the fish and shellfish receptors was considered low to medium and therefore overall, cumulative effects were assessed as being of negligible (considering any potential beneficial effects) to minor adverse significance for all fish and shellfish IEFs.

1008. As discussed in paragraph 559 *et seq*. all marine mammals in this assessment are considered to be generalist opportunistic feeders and are thus not reliant on a single prey species. Given that marine mammals are wide-ranging in nature with the ability to exploit numerous food sources, there would be a variety of prey species available for marine mammal foraging.

1009. Therefore, cumulatively for marine mammals, the impact of effects on marine mammals due to altered prey availability is predicted to be of local spatial extent, long term duration, intermittent and the effect on marine mammals is of high reversibility. The magnitude for effects on marine mammals due to altered prey availability is therefore, considered to be low.

Sensitivity of the receptors

1010. The sensitivity of marine mammals altered prey availability is as described for the Array, with detail given in paragraph 560 to 565 and is not repeated here.

1011. All receptors are deemed to be of high resilience, high recoverability and adaptability and high international value. The sensitivity of the receptor is therefore, considered to be low.

Significance of effect

1012. Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor** adverse/beneficial significance, which is not significant in EIA terms.

Further mitigation and residual effect

1013. No 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.

Decommissioning phase

Magnitude of impact

1014. Volume 2, chapter 9 combined the cumulative assessment for all phases for the impact of long term habitat loss and disturbance and therefore the magnitude of impact is as described in paragraph 995.

1015. Volume 2, chapter 9 combined the cumulative assessment for all phases for the impact of colonisation of hard structures and therefore the magnitude of impact is as described in paragraph 1022.

1016. Volume 2, chapter 9 did not assess the impact of temporary habitat loss during the decommissioning phase as there is not sufficient information to determine the decommissioning programme of plans/projects screened into the CEA. However, the magnitude of impact is likely to be similar to, or less than, the cumulative effect of construction.

Sensitivity of the receptors

1017. The sensitivity of marine mammals altered prey availability is as described for the Array, with detail given in paragraph 560 to 565 and is not repeated here.

1018. All receptors are deemed to be of high resilience, high recoverability and adaptability and high international value. The sensitivity of the receptor is therefore, considered to be low.

Significance of effect

1019. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor** adverse (though could be minor beneficial for some species dependent on the reef effect) significance, which is not significant in EIA terms.

Further mitigation and residual effect

1020. No 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.

Tier 2

Construction phase

Magnitude of impact

1021. The construction of the Array together with the projects and plans identified in Table 10.52 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 MDSs for these receptors and therefore are carried forward here.

1022. In addition to the Tier 1 projects, there was one Tier 2 project identified in volume 2, chapter 9 with potential for cumulative LSE[1] associated with temporary habitat loss and disturbance in the construction phase: the operation and maintenance and decommissioning phases of Morven BP-EnBW. According to the Morven BP-EnBW Scoping Report (Morven Offshore Wind Limited, 2023), site preparation and construction activities applicable to this impact for Morven BP-EnBW are expected to be site preparation (sand wave clearance and boulder clearance and relocation) cable installation; and jack-up vessel use for infrastructure installation (Morven Offshore Wind Limited, 2023). Given the reversibility of temporary habitat loss and disturbance, and the fact that construction operations would only affect a small proportion of the total habitat loss and disturbance footprint at any one time any, the cumulative magnitude of impact is still not expected to represent additional material impact because it represents only a small proportion of the habitats within the fish and shellfish ecology study area and the wider North Sea area. For most marine and shellfish species, the cumulative magnitude of the impact is deemed to be low and the sensitivity of most fish IEFs (including herring) is considered to be low. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms. For sandeel, the cumulative magnitude of the impact is deemed to be low and the sensitivity is considered to be medium. The effect will, therefore, be of minor adverse significance which is not significant in EIA terms. This is largely due to the area of unsuitable habitat for sandeel, that sandeel spawning grounds within the fish and shellfish ecology area is of low intensity and because modelling shows the abundance of buried sandeel to be very low.

1023. In addition to the Tier 1 projects, there was one Tier 2 project identified in volume 2, chapter 9 with potential for cumulative effects associated with long term habitat loss and disturbance in the construction phase: the operation and maintenance and decommissioning phases of Morven BP-EnBW. According to the Morven BP-EnBW Scoping Report, infrastructure associated with long term habitat loss and disturbance is expected to include foundations, scour protection, cable protection, and cable crossing protection, although further detail on extents and footprints was not provided in the Scoping Report for Morven BP-EnBW (Morven Offshore Wind Limited, 2023). Volume 2, chapter 9 stated the cumulative magnitude of impact is still not expected to represent significant additional impact than that defined for the assessment of the Array alone because it represents only a small proportion of the habitats within the fish and shellfish ecology study area and the wider North Sea area. For most fish and shellfish IEF species (including herring), the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms. For sandeel (an important prey species for minke whale), the cumulative 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.

1024. As discussed in paragraph 559 *et seq*. all marine mammals in this assessment are considered to be generalist opportunistic feeders and are thus not reliant on a single prey species. Given that marine mammals are wide-ranging in nature with the ability to exploit numerous food sources, there would be a variety of prey species available for marine mammal foraging.

1025. Therefore, cumulatively for marine mammals, the impact of effects on marine mammals due to altered prey availability is predicted to be of local spatial extent, medium term duration, intermittent and the effect on marine mammals is of high reversibility. The magnitude for effects on marine mammals due to altered prey availability is therefore, considered to be low.

Sensitivity of the receptors

1026. The sensitivity of marine mammals altered prey availability is as described for the Array, with detail given in paragraph 560 to 565 and is not repeated here.

1027. All receptors are deemed to be of high resilience, high recoverability and adaptability and high international value. The sensitivity of the receptor is therefore, considered to be low.

Significance of effect

1028. Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor** adverse/beneficial significance, which is not significant in EIA terms.

Further mitigation and residual effect

1029. No 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.

Operation and maintenance phase

Magnitude of impact

1030. The construction of the Array together with the projects and plans identified in Table 10.52 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 operation and maintenance phase have been assessed in volume 2, chapter 9 using the appropriate MDSs for these receptors and therefore are carried forward here.

1031. In addition to the Tier 1 projects, there was one Tier 2 project identified in volume 2, chapter 9 with potential for cumulative effects during the operation and maintenance phase associated with temporary habitat loss and disturbance: the operation and maintenance phases of the Morven BP-EnBW. As with the Array, operation and maintenance activities applicable to this impact for the Morven BP-EnBW are expected to include cable repair and reburial and the use of jack-up vessels for operation and maintenance activities (Morven Offshore Wind Limited, 2023). Within the Scoping Report for Morven BP-EnBW, it is stated that the extent of these activities is expected to be lower than that of the site preparation and construction phase (Morven Offshore Wind Limited, 2023). The cumulative magnitude of impact of the Tier 2 assessment presented in volume 2, chapter 9 is not expected to represent additional material impact beyond that defined for the assessment of the Array alone. For marine and shellfish species, the cumulative magnitude of the impact is deemed to be low and the sensitivity of most fish IEFs (including herring) is considered to be low. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms. For sandeel, the cumulative magnitude of the impact is deemed to be low and the sensitivity is considered to be medium. The effect will, therefore, be of minor adverse significance which is not significant in EIA terms. This is largely due to the area of unsuitable habitat for sandeel, that sandeel spawning grounds within the fish and shellfish ecology area is of low intensity and because modelling shows the abundance of buried sandeel to be very low. For diadromous species, the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms.

1032. Volume 2, chapter 9 combined the cumulative assessment for construction and operation and maintenance phases for the impact of long term habitat loss and disturbance and therefore the magnitude of impact is as described in paragraph 1023.

1033. In addition to the Tier 1 projects, there was one Tier 2 project identified in volume 2, chapter 9 with potential for cumulative effects associated with colonisation of hard structures in the construction phase: the operation and maintenance and decommissioning phases of Morven Offshore Wind Farm. According to the Morven BP-EnBW Scoping Report, hard structures installed at the Morven BP-EnBW are expected to include foundations, scour protection, and cable protection (Morven Offshore Wind Limited, 2023). As per the Tier 1 assessment, it is expected that the hard structures will be colonised by local epifauna, but will still represent a shift in the baseline conditions from soft sediments to hard substrate, which could be beneficial for some fish and shellfish receptors (Bender *et al.*, 2020, Langhamer *et al.*, 2016). Some fish species may benefit from the colonisation of hard structures, whereas others (more likely to be less mobile, demersal species) may be adversely affected. Overall, for fish and shellfish, the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. At worst, the effect will, therefore, be of negligible to minor adverse significance, which is not significant in EIA terms, though could be minor beneficial for some species. This is likely to be a conservative prediction as there is some evidence (although with uncertainties) that some fish and shellfish populations are likely to benefit from introduction of hard structures. For diadromous fish, the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of negligible to minor adverse significance, which is not significant in EIA terms.

1034. In addition to the Tier 1 projects, there was one Tier 2 project identified in volume 2, chapter 9 with potential for cumulative effects associated with EMF: the operation and maintenance phase of Morven BP-EnBW. As for Tier 1 projects, EMF levels in the vicinity of subsea cables are influenced by a variety of design and installation factors, including distance between cables, cable sheathing, number of conductors, and internal cable configuration. Further, the intensity of EMF from subsea cables decreases at approximately the inverse square/power of the distance away from the cable (Hutchison *et al.*, 2021). This attenuation is the same for buried, unburied, and dynamic cables (Hutchison *et al.*, 2021). Therefore, volume 2, chapter 9 concluded the cumulative magnitude of impact with the Tier 2 projects is likely to be highly localised to within metres to tens of metres from cables. For all fish and shellfish IEF species, the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of negligible to minor adverse significance, which is not significant in EIA terms.

1035. As discussed in paragraph 559 *et seq*. all marine mammals in this assessment are considered to be generalist opportunistic feeders and are thus not reliant on a single prey species. Given that marine mammals are wide-ranging in nature with the ability to exploit numerous food sources, there would be a variety of prey species available for marine mammal foraging.

1036. Therefore, cumulatively for marine mammals, the impact of effects on marine mammals due to altered prey availability is predicted to be of local spatial extent, long term duration, intermittent and the effect on marine mammals is of high reversibility. The magnitude for effects on marine mammals due to altered prey availability is therefore, considered to be low.

Sensitivity of the receptors

1037. The sensitivity of marine mammals altered prey availability is as described for the Array, with detail given in paragraph 560 to 565 and is not repeated here.

1038. All receptors are deemed to be of high resilience, high recoverability and adaptability and high international value. The sensitivity of the receptor is therefore, considered to be low.

Significance of effect

1039. Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor** adverse/beneficial significance, which is not significant in EIA terms.

Further mitigation and residual effect

1040. No 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.

Decommissioning phase

1041. Volume 2, chapter 9 did not assess decommissioning cumulatively and therefore it is not considered further in this CEA assessment. However, it is likely that the cumulative effects will be less than those from the construction and operational phase, and it is likely that over the lifetime of relevant projects marine mammals will have adapted to available prey sources.

Tier 3

Construction phase

Magnitude of impact

1042. The construction of the Array together with the projects and plans identified in Table 10.52 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 MDSs for these receptors and therefore are carried forward here.

1043. Volume 2, chapter 9 identified six Tier 3 projects with potential for cumulative effects associated with this temporary habitat loss in the construction phase: Bellrock Offshore Wind Farm, Bowdun Offshore Wind Farm, Campion Offshore Wind Farm, Eastern Green Link 3, Eastern Green Link 4 and Morven Offshore Export Cable Corridor. As these are Tier 3 projects, there are no Scoping Reports or EIA documents in the public domain. Therefore, there is no information available on the impact that these Tier 3 projects will have on fish and shellfish ecology. Temporary habitat loss and disturbance impacts associated with the Bellrock Offshore Wind Farm, Bowdun Offshore Wind Farm and Campion Offshore Wind Farm are expected to be similar in nature and extent to the Array. Impacts associated with the Morven Offshore Export Cable Corridor and Eastern Green Link 3 and 4 are likely to be similar to those assessed in Tier 1 for the Proposed offshore export cable corridor(s) and Eastern Green Link 2. The maximum duration of the offshore construction phase for the Array is up to seven years (2031 to 2038). There are currently no dates available for the construction phase of Bowdun Offshore Wind farm, Campion Offshore Wind farm and various INTOG projects. Therefore, there may be minimal overlap between the site preparation and construction activities of the Array and that of the Tier 3 projects. Volume 2, chapter 9 concluded for marine and shellfish species, the cumulative magnitude of the impact is deemed to be low and the sensitivity of most fish IEFs (including herring) is considered to be low. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms. For sandeel, the cumulative magnitude of the impact is deemed to be low, and the sensitivity is considered to be medium. The effect will, therefore, be of minor adverse significance which is not significant in EIA terms. This is largely due to the area of unsuitable habitat for sandeel, that sandeel spawning grounds within the fish and shellfish ecology area is of low intensity and because modelling shows the abundance of buried sandeel to be very low. For diadromous species, the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms.

1044. Long term habitat loss and disturbance impacts associated with Bellrock Offshore Wind farm, Bowdun Offshore Wind farm and Campion Offshore Wind Farm are expected to be similar in nature and extent to the Array, with the exception of the fixed foundations at Bowdun Offshore Wind farm, of which the extent of habitat loss is not possible to quantify at this stage. The impacts of site preparation and construction and operation and maintenance activities are expected to be long term and reversible. Volume 2, chapter 9 concluded for most fish and shellfish IEF species (including herring), the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms. For sandeel, the cumulative 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. For diadromous species, the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms.

1045. Volume 2, chapter 9 identified addition to the Tier 1 and Tier 2 projects, seven Tier 3 projects with potential for cumulative effects associated with underwater noise impacting fish and shellfish receptors: Morven Offshore Export Cable Corridor(s), Bellrock Offshore Wind Farm, Bowdun Offshore Wind farm, Campion Offshore Wind Farm, unknown phases of INTOG 10, Flora Floating Wind Farm, and Aspen. As these are Tier 3 projects, there are no Scoping reports or EIA documents in the public domain. Therefore, there is no information available on the impact that these Tier 3 projects will have on fish and shellfish ecology, though piling activities during the construction phase are expected to be similar in nature as that of the Array. Although information on hammer energies and piling durations are not available for Bowdun Offshore Wind Farm and Campion Offshore Wind Farm, the impact is likely to be of medium term duration, with noise being intermittent during the construction phase. volume 2, chapter 9 identified there may be minimal overlap between the site preparation and construction activities of the Array and that of the Tier 3 projects. For most marine fish, diadromous fish, and shellfish, the cumulative magnitude of the impact is deemed to be low, and the sensitivity of most marine fish IEFs is considered low. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms. For herring, the cumulative magnitude of the impact is deemed to be low, and the sensitivity of herring is considered to be medium. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms.

1046. As discussed in paragraph 559 *et seq*. all marine mammals in this assessment are considered to be generalist opportunistic feeders and are thus not reliant on a single prey species. Given that marine mammals are wide-ranging in nature with the ability to exploit numerous food sources, there would be a variety of prey species available for marine mammal foraging.

1047. Therefore, cumulatively for marine mammals, the impact of effects on marine mammals due to altered prey availability is predicted to be of local spatial extent, medium term duration, intermittent and the effect on marine mammals is of high reversibility. The magnitude for effects on marine mammals due to altered prey availability is therefore, considered to be low.

Sensitivity of the receptors

1048. The sensitivity of marine mammals altered prey availability is as described for the Array, with detail given in paragraph 560 to 565 and is not repeated here.

1049. All receptors are deemed to be of high resilience, high recoverability and adaptability and high international value. The sensitivity of the receptor is therefore, considered to be low.

Significance of effect

1050. Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor** adverse/beneficial significance, which is not significant in EIA terms.

Further mitigation and residual effect

1051. No 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.

Operation and maintenance phase

Magnitude of impact

1052. The operation and maintenance of the Array together with the projects and plans identified in Table 10.52 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 operation and maintenance phase have been assessed in volume 2, chapter 9 using the appropriate MDSs for these receptors and therefore are carried forward here.

1053. In addition to the Tier 1 and Tier 2 projects, volume 2, chapter 9 identified six Tier 3 projects with potential for cumulative effects associated with temporary habitat loss and disturbance during the operation and maintenance phase: Morven Offshore Export Cable Corridor(s), Bellrock Offshore Wind Farm, Bowdun Offshore Wind Farm, Campion Offshore Wind Farm, Eastern Green Link 3 and Eastern Green Link 4. As these are Tier 3 projects, there are no scoping reports or EIA documents available in the public domain. Therefore, there is no information available on the impact that these Tier 3 projects will have on fish and shellfish ecology. The activities associated with Bellrock Offshore Wind Farm, Bowdun Offshore Wind Farm, and Campion Offshore Wind Farm are likely to be similar to those of the Array. These activities include cable repair and reburial and use of jack-up vessels for infrastructure maintenance. The cumulative spatial extent of this impact in the operation and maintenance phase likely to be small in relation to the whole Array fish and shellfish ecology study area, although there is the potential for repeated disturbance to the habitats in the immediate vicinity infrastructure and cables. Volume 2, chapter 9 concluded for marine and shellfish species, the cumulative magnitude of the impact is deemed to be low and the sensitivity of most fish IEFs (including herring) is considered to be low. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms. For sandeel, the cumulative magnitude of the impact is deemed to be low, and the sensitivity is considered to be medium. The effect will, therefore, be of minor adverse significance which is not significant in EIA terms. This is largely due to the area of unsuitable habitat for sandeel, that sandeel spawning grounds within the fish and shellfish ecology area is of low intensity and because modelling shows the abundance of buried sandeel to be very low. For diadromous species, the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms.

1054. Volume 2, chapter 9 combined the cumulative assessment for construction and operation and maintenance phases for the impact of long term habitat loss and disturbance and therefore the magnitude of impact is as described in paragraph 1044 and is not duplicated here.

1055. Colonisation of hard structures associated with the Bellrock Offshore Wind Farm, Bowdun Offshore Wind Farm and Campion Offshore Wind Farm are expected to be similar in nature and extent to the Array. Impacts associated with the Morven Offshore Export Cable Corridor(s) and Eastern Green Link 3 and 4 are likely to be similar to those assessed in Tier 1 for the Proposed offshore export cable corridor(s) and Eastern Green Link 2. The cumulative magnitude of impact of the Tier 3 projects is not expected to represent significant additional impact than that defined for the assessment of the Array alone. It is expected that the hard structures will be colonised by local epifauna but will still represent a shift in the baseline conditions from soft sediments to hard substrate, which could be beneficial for some fish and shellfish receptors. However, this is expected to have beneficial effects, such as increased biodiversity and reef effects (Bender *et al.*, 2020, De Mesel *et al.*, 2015, Karlsson *et al.*, 2022, Lindeboom *et al.*, 2011, Mavraki *et al.*, 2020). Although a shift from soft sediments to hard structures will constitute habitat loss for the offshore subtidal sands and gravels, which may provide suitable substrate for burying crabs and sandeel, for example, the localised nature of the footprints is likely to only result in a minor loss to the soft bottom substrates in the Array fish and shellfish ecology study area and wider North Sea as a whole. Some fish species may benefit from the colonisation of hard structures, whereas others (more likely to be less mobile, demersal species) may be adversely affected. Overall, volume 2, chapter 9 concluded for fish and shellfish, the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. At worst, the effect will, therefore, be of negligible to minor adverse significance, which is not significant in EIA terms, though could be minor beneficial for some species. This is likely to be a conservative prediction as there is some evidence (although with uncertainties) that some fish and shellfish populations are likely to benefit from introduction of hard structures. For diadromous fish, the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of negligible to minor adverse significance, which is not significant in EIA terms.

1056. In addition to the Tier 1 projects, there were six Tier 3 projects identified in volume 2, chapter 9 with potential for cumulative effects associated with EMF during the operation and maintenance phase: Morven Offshore Export Cable Corridor(s), Bellrock Offshore Wind Farm, Bowdun Offshore Wind Farm, Campion Offshore Wind Farm, Eastern Green Link 3 and Eastern Green Link 4. As there is no published Scoping Report or EIA, there is no project-specific information regarding cable lengths, dimension, and voltages currently available for the Tier 3 projects. However, given the scale of the projects, it is likely that EMF related impacts associated with the Bellrock, Bowdun, and Campion Offshore Wind Farms will be of a similar in nature and extent to those of the Array and Morven BP-EnBW. Volume 2, chapter 9 concluded for most fish and shellfish IEF species, the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of negligible to minor adverse significance, which is not significant in EIA terms. For European lobster, *Nephrops*, edible crab and elasmobranchs, the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms. For diadromous fish, the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of negligible to minor significance, which is not significant in EIA terms.

1057. As discussed in paragraph 559 *et seq*. all marine mammals in this assessment are considered to be generalist opportunistic feeders and are thus not reliant on a single prey species. Given that marine mammals are wide-ranging in nature with the ability to exploit numerous food sources, there would be a variety of prey species available for marine mammal foraging.

1058. Therefore, cumulatively for marine mammals, the impact of effects on marine mammals due to altered prey availability is predicted to be of local spatial extent, long term duration, intermittent and the effect on marine mammals is of high reversibility. The magnitude for effects on marine mammals due to altered prey availability is therefore, considered to be low.

Sensitivity of the receptors

1059. The sensitivity of marine mammals altered prey availability is as described for the Array, with detail given in paragraph 560 to 565 and is not repeated here.

1060. All receptors are deemed to be of high resilience, high recoverability and adaptability and high international value. The sensitivity of the receptor is therefore, considered to be low.

Significance of effect

1061. Overall, the magnitude of the cumulative impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of minor adverse/beneficial significance, which is not significant in EIA terms.

Further mitigation and residual effect

1062. No 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.

Decommissioning phase

1063. Volume 2, chapter 9 did not assess decommissioning cumulatively and therefore it is not considered further in this CEA assessment. However, it is likely that the cumulative effects will be less than those from the construction and operational phase, and it is likely that over the lifetime of relevant projects marine mammals will have adapted to available prey sources.

10.13. PROPOSED MONITORING

1064. This section outlines the proposed monitoring proposed for marine mammals. Proposed monitoring measures are outlined in Table 10.63.

1065. As a part of the designed in measures (Table 10.22), mooring lines and dynamic inter-array cables will undergo regular inspections during the operation and maintenance phase. The inspection frequency for mooring lines and dynamic inter-array cables is anticipated to be more frequent initially (e.g. years 1 and 2), and likely to decline in frequency after this, following a risk based approach. Any inspected or detected debris on the floating lines and cables will be recovered based on a risk assessment which considers impact on environment including risk to marine mammal, risk to asset integrity, and health & safety. In addition, Ossian OWFL will consider new technologies for monitoring of mooring lines/snagged gear and will agree approach to monitoring of mooring lines and associated removal of gear with NatureScot and MD-LOT prior to the operation and maintenance phase. This will reduce the risk of entanglement (largely secondary entanglement).

1066. The Applicant will engage with MD-LOT, NatureScot, and other relevant key stakeholders to identify and contribute to targeted and proportionate regional or strategic monitoring to better understand the environmental effects of offshore wind taking account of known evidence gaps. This may involve engaging and contributing to ongoing strategic initiatives from ScotMER forum (Scottish Government, 2024). (see Table 10.63).

Table 10.63: Proposed Monitoring and the Method of Implementation for Marine Mammals

Potential Environmental Effect	Monitoring Commitment	Means of Implementation
Effects on marine mammals due to entanglement associated with the Array	Mooring lines and dynamic inter-array cables will undergo regular inspections during the operation and maintenance phase. The inspection frequency for mooring lines and dynamic inter-array cables is anticipated to be more frequent initially (e.g. years 1 and 2), and likely to decline in frequency after this, following a risk based approach. Any inspected or detected debris on the floating lines and cables will be recovered based on a risk assessment which considers impact on environment including risk to marine mammal, risk to asset integrity, and health & safety. In addition, Ossian OWFL will consider new technologies for monitoring of mooring lines/snagged gear and will agree approach to monitoring of mooring lines and associated removal of gear with NatureScot and MD-LOT prior to the operation and maintenance phase.	Monitoring commitments will be submitted post-consent and included in the EMP (see volume 4, appendix 21).

1067. No monitoring as a result of the CEA is proposed.

10.14. TRANSBOUNDARY EFFECTS

1068. A screening of transboundary impacts has been carried out and has identified that there were no likely significant transboundary effects with regard to marine mammal receptors from the Array upon the interests of EEA states.

1069. Potential transboundary effects could occur where elevations in underwater sound, particularly during construction piling, could ensonify large areas causing wide-ranging disturbance of marine mammals. The closest transboundary state, Norway, is 151.8 km away and therefore would not overlap with the zone of influence predicted for the Array. In addition, the underwater sound modelling is highly precautionary, and it is considered highly unlikely that sound propagating at tens of kilometres from the Array would be detected above background levels. For example, considering the NMFS threshold of 160 dB re 1 µPa (rms) for strong disturbance, the disturbance range for all marine mammals is out to a maximum of ~11 km from the Array. Even for harbour porpoise, as the most sensitive species, the 143 re 1µPa^{2}s SEL$_{ss}$ threshold for significant disturbance extents out to ~46.5 km from the Array and therefore does not reach the nearest EEA border. Whilst marine mammals are highly mobile and there is potential for individual animals to cross into EEA states, it is considered unlikely that piling would lead to significant transboundary effects.

1070. For the assessment of injury and disturbance from UXO clearance a precautionary 100 km screening buffer area was used, whilst for site-investigation surveys, vessel use and other noise producing activities, collision, operational noise and entanglement a buffer of 50 km was used. For effects on marine mammals due to EMFs from subsea electrical cabling in the water column, given the localised effect and transient nature of marine mammals a 10 km buffer was used. Therefore, given the closest transboundary EEA state is 151.8 km away, these effects are unlikely to have any interactions with transboundary sites, and it is concluded that there would be no likely significant transboundary effects with regard to marine mammal receptors from the Array.

10.15. INTER-RELATED EFFECTS (AND ECOSYSTEM ASSESSMENT)

1071. A description of the likely significant inter-related effects arising from the Array on marine mammals is provided in volume 3, appendix 18.1 of the Array EIA Report.

1072. For marine mammals the following potential impacts have been considered within the inter-related assessment:

- injury and disturbance from underwater noise generated during piling;
- injury and disturbance from underwater noise generated during UXO clearance;
- injury and disturbance due to site-investigation surveys (including geophysical surveys);
- injury and disturbance from underwater noise generated during vessel use and other noise producing activities;
- injury due to collision with vessels;
- effects on marine mammals due to EMFs from subsea electrical cabling in the water column;
- injury and disturbance from underwater noise generated during the operation of floating wind turbines and anchor mooring lines;
- effects on marine mammals due to entanglement associated with the Array; and
- effects on marine mammals due to altered prey availability.

1073. Table 10.64 assesses the likely significant inter-related effects (project lifetime effects) that are predicted to arise during the construction, operation and maintenance phase, and decommissioning of the Array and also the inter-related effects (receptor-led effects) that are predicted to arise for marine mammal receptors.

1074. Marine mammals also have the potential to have a secondary effect on other receptors and these effects are fully considered in the topic-specific chapters. These receptors and effects are:

- fish and shellfish ecology:
  - changes in the marine mammal community could have indirect effects on fish and shellfish populations.

Table 10.64: 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 Array (Array Lifetime Effects) and from Multiple Effects Interacting Across all Phases (Receptor-led Effects)

Description of Impact	Phase[9]			Likely Significant Inter-Related Effects
	C	O	D	
Array Lifetime Effects				
Injury and disturbance from underwater noise generated during piling	✓	✗	✗	Increased underwater noise during piling activities associated with construction of the Array only, have the potential to interact with other sources of underwater noise associated with the construction of the Array. This has the potential to contribute to an increase in underwater noise which in turn could affect marine mammals. However, the underwater noise produced as a result of piling during construction of the Array is likely to reach over a larger area compared to other noise-producing activities associated with the Array and therefore during this time it is considered unlikely that piling would act additively with other noise-producing activities occurring at the same time, as the noise produced during piling is likely to 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 Array. Significance is considered to be minor adverse and therefore not significant in EIA terms.
Injury and disturbance from underwater noise generated during UXO clearance.	✓	✗	✗	Increased underwater noise during UXO clearance during pre-construction activities could interact with other sources of underwater noise. This has the potential to contribute to an increase in the underwater noise which in turn could affect marine mammals. UXO clearance is planned using low order techniques which has the potential to result in localised disturbance only (TTS fleeing) out to ~3.2 km. However, the MDS assumes that high-order clearance may occur, with potential for injury (PTS) out to 14.5 km for the maximum assumed UXO size (698 kg NEQ) and out to 10 km for the most realistic maximum UXO size (227 kg NEQ). Additional disturbance is possible due to use of ADDs and soft start charges. Additive effects are possible as more animals may be affected at any one time. It should be noted however, that for each UXO clearance, the duration of the impact – including mitigation techniques - will be very short (approximately 1.5 hour). It has however been concluded on a precautionary basis that temporally UXO clearance could add to the overall duration of elevated underwater noise from all other activities during pre-construction and will contribution to the overall duration of noise impacts throughout all phases of the Array. Significance is considered to be minor adverse and therefore not significant in EIA terms.
Injury and disturbance due to site-investigation surveys (including geophysical surveys).	✓	✓	✗	Elevated underwater noise during site-investigation surveys could be additive over the construction and operation and maintenance phases of the Array with sequential noise from site-investigation surveys leading to extended effect on marine mammals. However, this impact will occur during short term events with cessation of noise in between events and the impact is localised. Additive effects are possible (though unlikely given intermittency of surveys)and the duration of elevated underwater noise from all activities could be extended. Significance is considered to be **minor** adverse and therefore not significant in EIA terms.
Injury and disturbance from underwater noise generated during vessel use and other noise producing activities.	✓	✓	✓	Elevated underwater noise during vessel use and other non-piling construction activities could occur across all three phases of the project. Vessels will be used throughout all stages of the Array and could cause additional disturbance to marine mammals. Other construction activities include drilling (anchor installation) and could also lead to disturbance effects in this phase. Effects are likely to be localised for non-piling construction activities and during vessel movements (e.g. out to maximum of 3,259 km) with breaks in activity within phases, however, temporally these effects could occur over all phases of the Array and lead to additive effects. Overall, the magnitude of the impact was considered to be negligible for injury and low for disturbance, with all IEFS considered to have high sensitivity to injury and medium sensitivity to disturbance. Significance is therefore considered to be **minor** adverse and therefore not significant in EIA terms.
Injury due to collision with vessels	✓	✓	✓	Over the lifetime of the Array there will be an ongoing risk of collision associated with vessels throughout all phases. If injury to marine mammals from collisions did occur this could lead to losses of individuals although the risk of mortality is likely to be low due to vessels moving at low speeds. However, with designed in measures, the risk of collisions will be reduced further through adopting good practice code of conduct for vessel operators (NSVMP, volume 4, appendix 24) 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. Significance is considered to be minor adverse and therefore not significant in EIA terms.
Effects on marine mammals due to EMF from subsea electrical cabling in the water column.	✗	✓	✗	This impact occurs during the operation and maintenance phase only, therefore no likely significant inter-related effects across multiple phases of the Array are therefore predicted
Injury and disturbance from underwater noise generated during the operation of floating wind turbines and anchor mooring lines.	✗	✓	✗	This impact occurs during the operation and maintenance phase only, therefore no likely significant inter-related effects across multiple phases of the Array are therefore predicted.
Effects on marine mammals due to entanglement associated with the Array.	✗	✓	✗	This impact occurs during the operation and maintenance phase only, therefore no likely significant inter-related effects across multiple phases of the Array are therefore predicted.
Changes in fish and shellfish communities affecting prey availability.	✓	✓	✓	Fish and shellfish communities may be affected variously through all phases of the Array 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 Array the effects were, however, predicted to be very localised and unlikely to lead to significant effects on fish and shellfish communities and therefore unlikely to lead to significant effects on marine mammals. Even in the context of longer-term impacts there is unlikely to be an additive effect as marine mammals can exploit a suite of prey species and only a small area will be affected when compared to available foraging habitat in the northern North Sea. Significance is considered to be **minor** adverse.

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

Description of Impact	Phase[9]			Likely Significant Inter-Related Effects
	C	O	D	
Receptor-led effects				
A number of the impacts identified could potentially interact to cause an additive/synergistic/antagonistic effect on marine mammal receptors. There are five key stressors identified for marine mammals: • stressor 1: injury or disturbance from elevated underwater noise (from piling, UXO clearance, site-investigation surveys, vessels, operational noise from turbines/mooring lines); • stressor 2: injury due to collisions with vessels; • stressor 3: EMF, • stressor 4: entanglement, • stressor 5: changes in prey communities. These are discussed in detail in paragraphs 1075 *et seq.* below. 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 underwater noise) and in addition each stressor could interact to contribute to a different, or greater effect on marine mammal receptors than when the effects are considered in isolation. Receptor-led effects also consider potential inter-chapter effects, such as those effects from prey species detailed in volume 2, chapter 9, which are included in the main assessment.				

Stressor 1: injury or disturbance from elevated underwater noise (from piling, UXO clearance, site-investigation surveys, vessels, operational noise from turbines/mooring lines)

1075. During the construction phase activities resulting in elevated underwater noise include piling, UXO clearance, site investigation surveys and vessel movements could occur. These activities are likely to result in disturbance to marine mammals which may be additive in nature 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 within the construction phase. Prior to piling, for example, UXO clearance could result in no more than 15 single clearance events (Table 10.17), and 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 high order detonation). Site investigation surveys are likely to occur over a total duration of up to five months (over a three year period) whilst disturbance during vessel activity will occur intermittently throughout this phase with timings linked to the pre-construction activities (UXO and site-investigation surveys).

1076. During the construction phase, activities resulting in elevated underwater noise include piling, other construction activities and vessel movements could occur. Since injury to marine mammals will be mitigated through the outline MMMP (volume 4, appendix 22) (Table 10.22), the key focus is on disturbance effects. Disturbance could occur intermittently on a total of 602 days over the construction phase of 96 months. Other construction activities (e.g. drilling and cable laying) and vessel movements would occur intermittently within the eight year construction phase. When piling occurs the disturbance effects are likely to be greater than for any of the other activities contributing to elevated underwater 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 Array, or temporally due to ongoing disturbance from activities throughout the construction phase (e.g. if they occur consecutively).

1077. During the operation and maintenance phase, activities resulting in elevated underwater noise include vessel activity, geophysical surveys and operational noise from floating turbines and mooring lines. These activities have the potential to result in disturbance to marine mammals which may be additive if activities are synchronised, as it could lead to a larger area disturbed at any one time. Disturbance is likely to occur as short term, localised events for vessel activity and geophysical surveys and the disturbance from operational noise is expected to be minimal, but there may be an additive effect spatially where two or more noise-producing activities occur in different parts of the Array, or temporally due to ongoing disturbance from activities throughout the operation and maintenance phase (e.g. if they occur consecutively).

1078. During decommissioning, vessel movements associated with decommissioning activities, as well as underwater cutting and site investigation surveys, will result in elevated underwater 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 Array area, or temporally due to ongoing disturbance throughout the decommissioning phase.

1079. Therefore, marine mammal receptors have the potential to experience ongoing disturbance due to elevations in underwater noise from different sources at all phases of the Array. The sensitivity of key species will be linked to their ability to tolerate the stressor such that their ability to function normally (e.g. forage, reproduce, communicate, avoid predators) is not impeded. The assessment, which adopts a highly precautionary approach (see paragraph 108 *et seq*.), 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 or UXO) 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.

1080. There are, however, uncertainties as to how all activities interact to contribute to an additive effect from underwater 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) an eight to 17% decline in harbour porpoise occurrence in the impacted area during pile-driving and other construction activities was observed, with probability of detection negatively related to levels of vessel intensity and background noise.

1081. To some extent it is anticipated that animals will acclimatise to or compensate for such increases in underwater noise. Graham *et al.* (2019), for example, demonstrated acclimatisation in harbour porpoise. The study showed that the proportional response of harbour porpoise to piling noise decreased over the piling phase, with the proportion of animals disturbed at a received level of 160 dB re 1 µPa decreased from 91.5% to 49.2% from the first pile to the last pile. 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).

1082. Therefore, as detailed in paragraphs 1075 to 1081 above, significance is considered to be minor adverse and therefore not significant in EIA terms.

Stressor 2: injury due to collisions with vessels

1083. Injury due to collisions with vessels is associated with increased vessel movement, the impact of which was assessed from different types of vessels and at different phases of the Array. As described in paragraph 1075 *et seq*., over the lifetime of the Array there will be a longer term risk to marine mammal receptors however, with designed in measures in place (section 10.10) the potential of experiencing injury is likely to be reduced and therefore it is not anticipated that an additive effect will occur. Additionally, to some extent the noise from the vessels themselves (Stressor 2, paragraph 1075 *et seq.*) 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 (see paragraph 405 *et seq.)*. For example, 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. This increased whistle production may be a tactic to reduce signal degradation to ensure that information is being communicated in elevated noisy environment, but it also demonstrates that animals are aware of approaching vessel from a distance. This corroborates previous research of Nowacek *et al.* (2001) found that bottlenose dolphins swim in tighter aggregated groups during vessel approaches, therefore if a vessel is loud enough to be detected by an animal for which it adjusts its behaviour, the likelihood of collision decreases.

1084. Therefore, as detailed in paragraph 1083, significance is considered to be minor adverse and therefore not significant in EIA terms.

Stressor 3: EMF

1085. EMF is highly localised and there is limited information on the effect of EMF on marine mammal receptors. It is unlikely to be additive with other stressors, given it will be confined to very specific locations in close proximity to the cables. There may be some synergistic effects if animals moving away from other disturbance activities (such as vessels) dive down and therefore move closer to the inter-array cables. Therefore, significance is considered to be minor adverse and therefore not significant in EIA terms.

Stressor 4: entanglement

1086. The risk of entanglement is highly localised. The possibility of primary entanglement is very unlikely given design factors such as the taut mooring lines with high bending stiffness (Statoil, 2015) and low weight of the cable systems (SEER, 2022). It is noted there is limited information to assess entanglement of marine mammal receptors in offshore wind development to date. Injury from entanglement is very different to other types of injury (e.g. injuries from collision, PTS) and therefore there is not considered to be any additive effects. As is the case for stressor 2, to some extent the noise (pinging or snapping) from operational noise from turbines/mooring lines and any vessels utilised during the operation and maintenance phase themselves may act antagonistically with this impact by deterring animals away from the mooring lines. Therefore, significance is considered to be minor adverse and therefore not significant in EIA terms.

Stressor 5: changes in prey communities.

1087. The EIA considered overall effect on fish and shellfish communities from multiple stressors (i.e. habitat loss, SSC, underwater noise, EMF etc) (see volume 3, chapter 9) and therefore, in this respect, has taken an ecosystem-based approach. For some, stressors such as underwater noise 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 to those assessed for marine mammals (e.g. low mobility or sessile species may recover slowly). The assessment of effects, however, demonstrated that due to the high mobility of marine mammals, generalist feeding strategy and ability to exploit different prey species, combined with the small scale of potential changes in context of wider available habitat, the changes to fish and shellfish communities are unlikely to have an effect even from multiple stressors. Therefore, significance is considered to be minor adverse and therefore not significant in EIA terms.

Multiple stressors: inter-related effect of all stressors

1088. 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. Arrigo *et al.* (2020) suggests that large organisms at higher trophic levels, such as marine mammals, tend to be generally negatively impacted by increasing stressor interaction strength but the variability in the response to stressor is small and therefore reduces the probability of population collapse.

1089. For stressor 1 (elevated underwater noise), there is the potential for marine mammals to forage in different habitats and to compensate for reduced foraging time. As such the ability of displaced animals will depend on the availability of prey resources in the habitat to which the animals are displaced. Studies have shown that for small, localised marine mammal populations with high site fidelity, there may be biological risks posed by displacement (Forney *et al.*, 2017). For example, due to the importance of the areas for survival (i.e. areas of high resource availability), animals may be highly motivated to remain in an area despite adverse impacts which may increase stress (Rolland *et al.*, 2012). Thus, the inter-related effects of underwater noise and changes in fish and shellfish prey resources needs to be considered. Impacts on fish and shellfish prey resources (stressor 5) 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 Array. Within the boundaries of the Array however, there may be short term inter-related effects of noise disturbance and reduced fish and shellfish prey resources. For marine mammals remaining in proximity to the Array, a substantial 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. It has been suggested it may be possible that damaged or disoriented prey could attract marine mammals to an area of impact due to providing short term feeding opportunities but increasing levels of exposure (Gordon *et al.*, 2003) however, there is currently little evidence available to investigate such indirect effects on marine mammals.

1090. The assessment has largely described potential adverse effects but there is also potential for some beneficial effects on marine mammal receptors. Construction of offshore wind farms can lead to the introduction of hard substrates which can lead to the establishment of new species and new fauna communities, and this may in turn attract marine mammals (Fowler *et al.*, 2018, Lindeboom *et al.*, 2011, Raoux *et al.*, 2017). Consequently, even where there is potential for an inter-related effect between ongoing vessel noise during the operation and maintenance phase this may be compensated for, to some extent, by an increase in available prey resources. Russell *et al.* (2014) and Russell and McConnell (2014) demonstrated that harbour seals and grey seals moved between hard structures at two operational wind farms and used space-state models to predict where animals were remaining at these locations to actively forage and where they were travelling to the next foundation structure. Lindeboom *et al.* (2011) studied the ecological effects of the Egmond aan Zee Offshore Wind Farm and found that even though the fish community was highly dynamic in time and space, with only minor effects upon fish assemblages observed during the operation and maintenance phase, some fish species (e.g. cod) benefited from the ‘shelter’ within the wind farm, although this effect may be reduced for floating wind turbines. This is likely due to reduced fishing activity and the new hard substratum with associated fauna which attracts predator species. Lindeboom *et al.* (2011) suggested the observed increase in echolocation activity of harbour porpoise within the wind farm may be correlated with presence of additional increased food sources compared to reference areas (Lindeboom *et al.,* 2011).

1091. The potential inter-related effects between underwater noise and collision risk have been discussed previously (in paragraph 1083) 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). Animals could also become habituated to vessel noise and not move away from the vessel (McWhinnie *et al.*, 2018) which would result in a synergistic interaction (Weilgart, 2011). Therefore, the outcome will depend on the degree of habituation and prior-experience and a number of acoustical properties that allow an approaching vessel to be detected by a marine mammal species (Gerstein *et al.*, 2005). However, as described in the impact assessment, with measures adopted as part of the Array (e.g. the NSVMP, volume 4, appendix 24) in place it is likely that any risk of injury from collision with vessels will be negligible.

1092. Evidence for the potential long term effects of offshore wind farms on marine mammals (related to all potential stressors) comes from monitoring programmes which baseline levels of abundance to construction and post-construction (operation and maintenance) phases. Limited monitoring studies regarding impacts on marine mammals have been carried out to date.

1093. Aerial survey haul-out counts were conducted before, during and after the construction phases at Scroby Sands Offshore Wind Farm, off the coast of Norfolk, to monitor harbour and grey seal counts at haul-out site, located less than two kilometres away from the offshore wind farm array (Skeate *et al.*, 2012). The two 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). It was noted regional changes in patterns of haul-outs of harbour seal in the Wash coincided with the construction of the Scroby Sands Offshore Wind Farm, but such changes in harbour seal number could have been part of wider regional dynamics (Verfuss *et al.*, 2016). It should be noted that Scroby Sands Wind Farm is located 2.5 km off the coast of Great Yarmouth whereas the Array is located 80 km offshore and therefore a greater distance from haul-out sites. 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 (Canning *et al.*, 2013). The monitoring data suggested that harbour porpoise were displaced from the wind farm site during the construction phase and operation period when compared to the pre-construction numbers. However, because there was only one year of pre-construction survey, natural variation cannot be ruled out as the reason for the observed change, especially since control survey locations outside of the wind farm also appeared to experience declines in harbour porpoise density.

1094. With the rapid expansion of offshore wind farms, post-construction monitoring programmes are being implemented at various developments in Europe. Tougaard *et al.* (2003) studied short term effects of the construction of wind turbines on harbour porpoises at Horns Rev Offshore Wind Farm. The study 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). (Tougaard *et al.*, 2003) also showed that over the entire construction phase at Horns Reef there was no significant change in the abundance of harbour porpoise in the wind farm area compared to reference areas. Teilmann *et al.* (2008) also reported that during the operation and maintenance phase porpoise activity was higher in both the wind farm and reference area compared to baseline levels. As a result of monitoring at Nysted Offshore Wind Farm, it was demonstrated initially during construction and the first two years of operation that 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 (Teilmann *et al.*, 2006). Teilmann *et al.* (2006) suggested that animals were gradually habituating and returning to the wind farm area.(Teilmann *et al.*, 2006)

1095. Nabe-Nielsen *et al.* (2011) suggested, using simulations of the response of harbour porpoise to wind farm construction, that wind farms already existing off Danish coast do not have impact on harbour porpoise population dynamics and that the that construction of new wind farms is not expected to cause any changes in the long term dynamics of the population. Likewise, Edrén *et al.* (2010) and McConnell *et al.* (2012) investigated possible interactions between seals and Danish offshore wind farms (Nysted Wind Farm and Rødsand II) and found that although there was a temporary reduction in the number of seals hauled out during construction operations (i.e. piling), there was no long term effect on haul-out behaviour trends.(Edrén *et al.*, 2010)

1096. Therefore, the examples of monitoring studies given in paragraphs 1093 to 1095 suggest marine mammal receptors can quickly recover and return to the impacted area, despite the potential effects from multiple stressors associated with offshore wind farms. Therefore, as detailed in paragraphs 1088 to 1095, significance is considered to be minor adverse and therefore not significant in EIA terms.

10.16. SUMMARY OF IMPACTS, MITIGATION, LIKELY SIGNIFICANT EFFECTS AND MONITORING

1097. Information on marine mammals within the marine mammal study area was collected through desktop review, site-specific surveys, and consultation. This information is summarised in Table 10.10, Table 10.11, and Table 10.12.

1098. Table 10.65 presents a summary of the potential impacts, designed in measures and the conclusion of LSE[1] in respect to marine mammals. The impacts assessed include:

- Injury and disturbance from underwater noise generated during piling;
- Injury and disturbance from underwater noise generated during UXO clearance;
- Injury and disturbance due to site-investigation surveys (including geophysical surveys);
- Injury and disturbance from underwater noise generated during vessel use and other noise producing activities;
- Injury due to collision with vessels;
- Effects on marine mammals due to emfs from subsea electrical cabling in the water column;
- Injury and disturbance from underwater noise generated during the operation of floating wind turbines and anchor mooring lines;
- effects on marine mammals due to entanglement associated with the array; and
- Effects on marine mammals due to altered prey availability.

1099. Overall, it is concluded that there will be no LSE[1] (after implementation of measures adopted as part of the Array and secondary mitigation) arising from the Array during the construction, operation and maintenance or decommissioning phases.

1100. Table 10.66 presents a summary of the potential impacts, designed in measures and the conclusion of LSE[1] on marine mammals in EIA terms. The cumulative effects assessed include:

- injury and disturbance from underwater noise generated during piling;
- injury and disturbance from underwater noise generated during UXO clearance;
- injury and disturbance due to site-investigation surveys (including geophysical surveys);
- injury and disturbance from underwater noise generated during vessel use and other noise producing activities;
- injury due to collision with vessels;
- effects on marine mammals due to EMFs from subsea electrical cabling in the water column;
- injury and disturbance from underwater noise generated during the operation of floating wind turbines and anchor mooring lines;
- effects on marine mammals due to entanglement associated with the array; and
- effects on marine mammals due to altered prey availability.

1101. Overall, it is concluded that there will be no likely significant cumulative effects from the Array (after implementation of measures adopted as part of the Array and secondary mitigation) alongside other projects/plans.

1102. No likely significant transboundary effects have been identified in regard to effects of the Array.

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Table 10.65: Summary of Likely Significant Environmental Effects, Secondary Mitigation and Monitoring

Description of Impact	Phase	Magnitude of Impact		Sensitivity of Receptor	Significance of Effect	Additional Measures	Significance of Residual Effect	Proposed Monitoring
Injury and disturbance from underwater noise generated during piling	Construction phase	Injury	Harbour porpoise: Negligible	All IEFs: High	All IEFs: Minor	None	Minor adverse	None
			Bottlenose dolphin: Negligible					
			White-beaked dolphin: Negligible					
			Minke whale: Low					
			Humpback whale: Low					
			Grey seal: Negligible					
		Behaviour	Harbour porpoise: Low	All IEFs: Medium	All IEFs: Minor	None	Minor adverse	None
			Bottlenose dolphin: Low					
			White-beaked dolphin: Low					
			Minke whale: Low					
			Humpback whale: Low					
			Grey seal: Negligible					
Injury and disturbance from underwater noise generated during Unexploded Ordnance (UXO) clearance	Construction phase	Injury	Harbour porpoise: Medium	All IEFs: High	All IEFS: Moderate	Implementation of soft start charges and ADD deployment.	Minor adverse	None
			Bottlenose dolphin: Low		All IEFs: Minor	Implementation of soft start charges and ADD deployment (duration to be determined post-consent).	Minor adverse	None
			White-beaked dolphin: Low					
			Minke whale: Low					
			Humpback whale: Low					
			Grey seal: Low					
		Behaviour	All IEFs: Low	All IEFs: Low	All IEFs: Minor	Implementation of soft start charges and ADD deployment (duration to be determined post-consent).	Minor adverse	None
Injury and disturbance due to site-investigation surveys (including geophysical surveys)	Construction and Operation Maintenance phases	Injury	All IEFs: Negligible	All IEFs: High	All IEFs: Minor	None	Minor adverse	None
		Behaviour	All IEFs: Low	All IEFs: Medium	All IEFs: Minor		Minor adverse	

Description of Impact	Phase	Magnitude of Impact		Sensitivity of Receptor	Significance of Effect	Additional Measures	Significance of Residual Effect	Proposed Monitoring
Injury and disturbance from underwater noise generated during vessel use and other noise producing activities	Construction, Operation Maintenance and Decommissioning Phases	Injury	All IEFs: Negligible	All IEFs: High	All IEFs: Minor	None	Minor adverse	None
		Behaviour	All IEFs: Low	All IEFs: Medium	All IEFs: Minor	None	Minor adverse	
Injury due to collision with vessels	Construction, Operation Maintenance and Decommissioning phases	Injury	All IEFs: Low	All IEFs: Medium	Minor	None	Minor adverse	None
Effects on marine mammals due to EMFs from subsea electrical cabling in the water column	Operation and Maintenance phase	All IEFS: Low		All IEFS (except humpback whale): Low	Minor	None	N/A	None
				Humpback whale: Medium	Minor	None	N/A	
Injury and disturbance from underwater noise generated during the operation of floating wind turbines and anchor mooring lines	Operation and Maintenance phase	Injury	Injury all IEFS: Negligible	All IEFs: High	Minor	None	Minor adverse	None
		Behaviour	Behaviour all IEFS: Negligible	All IEFs: Medium	Negligible to minor	None	Minor adverse	None
Effects on marine mammals due to entanglement associated with the Array	Operation and Maintenance	Primary entanglement	All IEFS: Low	Primary Entanglement: Low for odontocetes/pinnipeds Medium for mysticetes	Minor	None	Minor adverse	Mooring lines and dynamic inter-array cables will undergo regular inspections during the operation and maintenance phase. Any inspected or detected debris on the floating lines and cables will be recovered based on a risk assessment
		Secondary Entanglement	All IEFS: Low	Secondary Entanglement: All IEFS: Medium	Minor	None	Minor adverse	Inspection and removal of debris. Mooring lines and dynamic inter-array cables will undergo regular inspections during the operation and maintenance phase. Any inspected or detected debris on the floating lines and cables will be recovered based on a risk assessment
Effects on marine mammals due to altered prey availability	Construction, Operation and Maintenance, Decommissioning	All IEFs: Low		All IEFs: Low	All IEFs: Minor	None	Minor	None

Table 10.66: Summary of Likely Significant Cumulative Environment Effects, Mitigation and Monitoring

Description of Impact	Phase	Cumulative Effects Assessment Tier	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Additional Measures (Secondary Mitigation)	Significance of Residual Effect	Proposed Monitoring
Injury and disturbance from underwater noise generated during piling	Construction phase	1	Injury: Harbour porpoise: Negligible	All IEFs: High	All IEFs: Minor	None	Minor adverse	*No project specific noise monitoring proposed due to absence of significant impact.* *The Applicant will seek to work with the other offshore wind projects and stakeholders in Scotland to develop a robust approach to regional and strategic monitoring as appropriate, including for any noise monitoring taking account of the final project design. They will seek to support strategic monitoring taking account of the evidence maps and ongoing work being progressed as part of the ScotMER programme to address data gaps.*
			Injury: Bottlenose dolphin: Negligible					
			Injury White-beaked dolphin: Negligible					
			Injury Minke whale: Negligible					
			Injury: Humpback whale: Low					
			Injury Grey seal: Negligible					
			Behaviour: Harbour porpoise: Low	All IEFs: Medium	All IEFs: Minor	None	Minor adverse	
			Behaviour: Bottlenose dolphin: Low					
			Behaviour White-beaked dolphin: Low					
			Behaviour Minke whale: Low					
			Behaviour: Humpback whale: Low					
			Behaviour Grey seal: Low					
		2	Injury: Harbour porpoise: Negligible	All IEFs: High	All IEFs: Minor	None	Minor adverse	*No project specific noise monitoring proposed due to absence of significant impact.* *The Applicant will seek to work with the other offshore wind projects and stakeholders in Scotland to develop a robust approach to regional and strategic monitoring as appropriate, including for any noise monitoring taking account of the final project design. They will seek to support strategic monitoring taking account of the evidence maps and ongoing work being progressed as part of the ScotMER programme to address data gaps .*
			Injury: Bottlenose dolphin: Negligible					
			Injury White-beaked dolphin: Negligible					
			Injury Minke whale: Negligible					
			Injury: Humpback whale: Low					
			Injury Grey seal: Negligible					
			Behaviour: Harbour porpoise: Low	All IEFs: Medium	All IEFs: Minor	None	Minor adverse	
			Behaviour: Bottlenose dolphin: Low					

Description of Impact	Phase	Cumulative Effects Assessment Tier	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Additional Measures (Secondary Mitigation)	Significance of Residual Effect	Proposed Monitoring
			Behaviour White-beaked dolphin: Low					
			Behaviour Minke whale: Low					
			Behaviour: Humpback whale: Low					
			Behaviour Grey seal: Low					
		3	Injury: Harbour porpoise: Negligible	All IEFs: High	All IEFs: Minor	None	Minor adverse	No project specific noise monitoring proposed due to absence of significant impact. The Applicant will seek to work with the other offshore wind projects and stakeholders in Scotland to develop a robust approach to regional and strategic monitoring as appropriate, including for any noise monitoring taking account of the final project design. They will seek to support strategic monitoring taking account of the evidence maps and ongoing work being progressed as part of the ScotMER programme to address data gaps
			Injury: Bottlenose dolphin: Negligible					
			Injury White-beaked dolphin: Negligible					
			Injury Minke whale: Negligible					
			Injury: Humpback whale: Low					
			Injury Grey seal: Negligible					
			Behaviour: Harbour porpoise: Low	All IEFs: Medium	All IEFs: Minor	None	Minor adverse	
			Behaviour: Bottlenose dolphin: Low					
			Behaviour White-beaked dolphin: Low					
			Behaviour Minke whale: Low					
			Behaviour: Humpback whale: Low					
			Behaviour Grey seal: Low					
Injury and disturbance from underwater noise generated during Unexploded Ordnance (UXO) clearance	Construction phase	1	Injury: Harbour porpoise: Low	All IEFs: High	All IEFS: Moderate	Implementation of soft start charges and ADD deployment (duration to be determined post-consent) Consideration of secondary measures post-consent.	Minor adverse	None

Description of Impact	Phase	Cumulative Effects Assessment Tier	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Additional Measures (Secondary Mitigation)	Significance of Residual Effect	Proposed Monitoring
			Injury: Bottlenose dolphin: Negligible		All IEFs: Minor	Implementation of soft start charges and ADD deployment (duration to be determined post-consent).	Minor adverse	None
			Injury: White-beaked dolphin: Negligible					
			Injury: Minke whale: Negligible					
			Injury: Humpback whale: Negligible					
			Injury: Grey seal: Negligible					
			Behaviour: All IEFs: Low	All IEFs: Low	All IEFs: Minor	Implementation of soft start charges and ADD deployment (duration to be determined post-consent).	Minor adverse	None
		2	Injury: Harbour porpoise: Low	All IEFs: High	All IEFS: Moderate	Implementation of soft start charges and ADD deployment (duration to be determined post-consent). Consideration of secondary measures post-consent.	Minor adverse	None
			Injury: Bottlenose dolphin: Negligible		All IEFs: Minor	Implementation of soft start charges and ADD deployment (duration to be determined post-consent).	Minor adverse	None
			Injury: White-beaked dolphin: Negligible					
			Injury: Minke whale: Negligible					
			Injury: Humpback whale: Negligible					
			Injury: Grey seal: Negligible					
			Behaviour: All IEFs: Low	All IEFs: Low	All IEFs: Minor	Implementation of soft start charges and ADD deployment	Minor adverse	None

Description of Impact	Phase	Cumulative Effects Assessment Tier	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Additional Measures (Secondary Mitigation)	Significance of Residual Effect	Proposed Monitoring
		3	Injury: Harbour porpoise: Low	All IEFs: High	All IEFS: Moderate	Implementation of soft start charges and ADD deployment (duration to be determined post-consent). Consideration of secondary measures post-consent.	Minor adverse	None
			Injury: Bottlenose dolphin: Negligible		All IEFs: Minor	Implementation of soft start charges and ADD deployment (duration to be determined post-consent).	Minor adverse	None
			Injury: White-beaked dolphin: Negligible					
			Injury: Minke whale: Negligible					
			Injury: Humpback whale: Negligible					
			Injury: Grey seal: Negligible					
			Behaviour: All IEFs: Low	All IEFs: Low	All IEFs: Minor	Implementation of soft start charges and ADD deployment (duration to be determined post-consent).	Minor adverse	None
Disturbance due to site-investigation surveys (including geophysical surveys)	Construction and Operation and maintenance phase	1	Behaviour: All IEFs: Low	All IEFs: Medium	All IEFs: Minor	None	Minor adverse	N/A
		2	Behaviour: All IEFs: Low	All IEFs: Medium	All IEFs: Minor	None	Minor adverse	N/A
		3	Behaviour: All IEFs: Low	All IEFs: Medium	All IEFs: Minor	Behaviour: All IEFs: Low	Minor adverse	N/A
Injury and disturbance from underwater noise generated during vessel use and other noise producing activities	Construction, Operation Maintenance and Decommissioning Phases	1	Injury: All IEFs: Negligible	All IEFs: High	All IEFs: Minor	None	Minor adverse	N/A
			Behaviour: All IEFs: Low	All IEFs: Medium	All IEFs: Minor	None	Minor adverse	
		2	Injury: All IEFs: Negligible	All IEFs: High	All IEFs: Minor	None	Minor adverse	N/A
			Behaviour: All IEFs: Low	All IEFs: Medium	All IEFs: Minor	None	Minor adverse	N/A
		3	Injury: All IEFs: Negligible	All IEFs: High	All IEFs: Minor	None	Minor adverse	N/A
			Behaviour: All IEFs: Low	All IEFs: Medium	All IEFs: Minor	None	Minor adverse	N/A
		1	All IEFs: Low	All IEFs: Medium	Minor	None	Minor adverse	N/A

Description of Impact	Phase	Cumulative Effects Assessment Tier	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Additional Measures (Secondary Mitigation)	Significance of Residual Effect	Proposed Monitoring
Injury due to collision with vessels	Construction, Operation Maintenance and Decommissioning phases	2	All IEFs: Low	All IEFs: Medium	Minor	None	Minor adverse	N/A
		3	All IEFs: Low	All IEFs: Medium	Minor	None	Minor adverse	N/A
Effects on marine mammals due to EMFs from subsea electrical cabling in the water column	Operation and Maintenance phase	1	All IEFS: Low	All IEFS (except humpback whale): Low	Minor	None	Minor adverse	N/A
				Humpback whale: Medium	Minor	None	Minor adverse	
		2	All IEFS: Low	All IEFS (except humpback whale): Low	Minor	None	Minor adverse	
				Humpback whale: Medium	Minor	None	Minor adverse	
		3	All IEFS: Low	All IEFS (except humpback whale): Low	Minor	None	Minor adverse	
				Humpback whale: Medium	Minor	None	Minor adverse	
Injury and disturbance from underwater noise generated during the operation of floating wind turbines and anchor mooring lines	Operation and Maintenance phase	3	Injury all IEFS: Negligible	All IEFS: High	Minor	None	Minor adverse	N/A
			Behaviour all IEFS: Negligible	All IEFs: Medium	Minor	None	Minor adverse	N/A
Effects on marine mammals due to entanglement associated with the Array	Operation and Maintenance	3	All IEFS: Primary Entanglement: Low	Primary Entanglement: Low for odontocetes/pinnipeds Medium for mysticetes	Minor	None	Minor adverse	Regular inspections of mooring lines and dynamic inter-array cables during the operation and maintenance phase and removal of debris on a risk based approach
			All IEFS: Secondary Entanglement: Low	Secondary Entanglement: All IEFS: Medium	Minor	None	Minor adverse	Regular inspections of mooring lines and dynamic inter-array cables during the operation and maintenance phase and removal of debris on a risk based approach
Effects on marine mammals due to altered prey availability	Construction, Operation and Maintenance, Decommissioning	1	All IEFs: Low	All IEFs: Low	All IEFs: Minor	None	Minor	N/A
		2	All IEFs: Low	All IEFs: Low	All IEFs: Minor	None	Minor	N/A
		3	All IEFs: Low	All IEFs: Low	All IEFs: Minor	None	Minor	N/A

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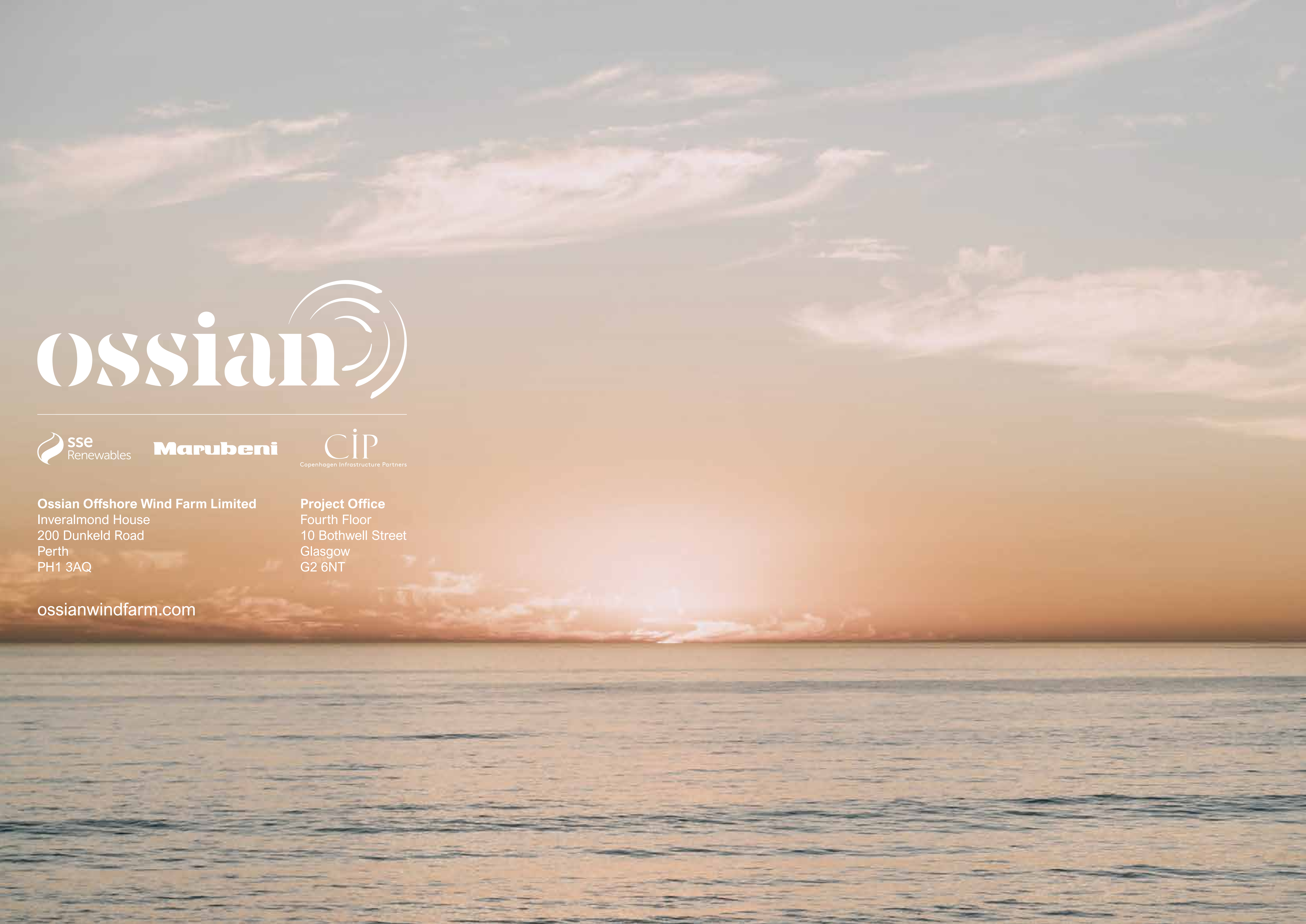

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