Offshore Wind Power Limited

West of Orkney Windfarm Offshore EIA Report

Volume 1, Chapter 12 - Marine Mammals and Megafauna

WO1-WOW-CON-EV-RP-0028: Approved by S.Kerr
Document Control 18/09/2023

ASSIGNMENT	L-100632-S05
DOCUMENT	L-100632-S05-A -ESIA-012

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West of Orkney Windfarm

REVISIONS & APPROVALS

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A01	08/09/2023	Issued for Use	HiDef	DB	DB	OWPL
R02	23/06/2023	Reissued for Review	HiDef	NB	DB	OWPL
R01	16/05/2023	Issued for review	HiDef	DB	DB	OWPL
REV	**DATE**	**DESCRIPTION**	**ISSUED**	**CHECKED**	**APPROVED**	**CLIENT**

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12 MARINE MAMMALS AND MEGAFAUNA

Chapter summary

This chapter of the Offshore Environmental Impact Assessment (EIA) Report assesses the potential effects from the offshore Project on marine mammals and megafauna receptors. This includes direct, indirect, whole Project assessment, cumulative, inter-related effects, inter-relationships and transboundary effects.

The baseline was characterised using a combination of desk-based studies, digital aerial surveys (July 2020 – September 2022) and sightings obtained from observers aboard survey vessels, and environmental DNA (eDNA) analysis. These showed that a range of marine mammals and megafauna may occur within the offshore Project and its vicinity. Ten marine mammal species, along with basking sharks are considered to use the offshore study area regularly and were taken forward for assessment. There are no designated sites with marine mammal and megafauna features, or seal haul out sites in the vicinity of the offshore Project. The following impacts were identified as requiring assessment:

- Construction (including pre-construction) and decommissioning:
  - Injury and disturbance from underwater noise-generating activities;
  - Disturbance due to physical presence and underwater noise from vessels;
  - Vessel collision;
  - Indirect effects related to changes in availability or distribution of prey species;
- Operation and maintenance:
  - Noise related impacts during operation;
  - Disturbance due to physical presence and underwater noise from vessels;
  - Vessel collision;
  - Displacement or barrier effects associated with physical presence of devices and infrastructure;
  - Habitat change, including foraging opportunities; and
  - Indirect effects related to changes in availability or distribution of prey species.

The assessment has taken account of embedded mitigation measures for the assessment of potential effects. No significant impacts to any species are predicted during any Project stage, either for the offshore Project alone, or cumulatively with other plans or developments. This includes from the highly precautionary assessment of underwater noise generating activities such as Unexploded Ordnance (UXO) clearance and pile installation. The development of a Piling Strategy ahead of construction will inform mitigation measures to be implemented once the offshore Project design is further refined. Through all stages of the Project there is the potential for impacts caused by vessel disturbance and collision; however, impacts are short-term, temporary, and localised with the implementation of embedded mitigation measures. Additionally, it is not anticipated that there will be any significant inter-related effects within or between each stage of the Project for any impacts. The majority of impacts are also fully contained within UK Exclusive Economic Zone (EEZ) waters and these impacts are not expected to cause significant effects outside of the EEZ. Therefore, there are no requirements for any secondary mitigation measures from the project-alone or cumulative EIA impact assessments.

It should be noted that whilst impacts to marine mammals are not considered to be significant in EIA terms, all cetaceans are protected as European Protected Species (EPS) under the Habitats Regulations. A separate EPS Licence application and risk assessment will be undertaken, once all the appropriate information is collated to inform the Piling Strategy. This information will also feed into the final Marine Mammal Mitigation Protocol.

A monitoring programme, including the potential for monitoring of marine mammals and megafauna, will be developed in consultation with relevant stakeholders and be presented within the Project Environmental Monitoring Programme (PEMP) that will be subject to approval as part of the discharge of consent conditions.

12.1 Introduction

This chapter of the Offshore Environmental Impact Assessment (EIA) Report presents the marine mammal and megafauna receptors of relevance to the offshore Project and assesses the potential impacts from the pre-construction, construction, operation and maintenance, and decommissioning of the offshore Project on these receptors. Where required, mitigation is proposed, and the residual impacts and their significance are assessed. Potential cumulative and transboundary impacts are also considered.

The receptors which have been considered within this chapter include marine mammals, which are comprised of cetaceans (whales, dolphins and porpoises) and pinnipeds (seals), as well as other marine megafauna which here includes basking sharks (*Cetorhinus maximus*) and marine turtles.

Table 12-1 below provides a list of all the supporting studies which relate to and should be read in conjunction with the marine mammal and megafauna impact assessment. All supporting studies are appended to this Offshore EIA Report and issued on the accompanying Universal Serial Bus (USB).

Table 12-1 Supporting studies for marine mammals and megafauna

DETAILS OF STUDY	LOCATIONS OF SUPPORTING STUDY
Marine Mammal and Megafauna Baseline Report	Offshore EIA Report, Supporting Study (SS) 9: Marine mammal and megafauna baseline report.
Marine Mammal Underwater Noise Impact Assessment	Offshore EIA Report, Supporting Study (SS) 10: Marine mammal underwater noise impact assessment.
Underwater Noise Modelling Report	Offshore EIA Report - Supporting Study (SS) 11: Underwater noise modelling report.
Digital Video Aerial Survey Methodology and Marine Mammal Survey Results	Offshore EIA Report, Supporting Study (SS) 8: Digital video aerial survey methodology and marine mammal survey results.

The impact assessment presented herein draws upon information presented within other impact assessments within this Offshore EIA Report, including:

- Offshore EIA Report, chapter 8: Marine physical and coastal processes – which assesses the impact of the offshore Project on aspects such as geology, bathymetry, seabed sediment and sediment transport, hydrodynamics, waves and coastal characteristics) which could indirectly affect the distribution of marine mammal and megafauna receptors;
- Offshore EIA Report, chapter 9: Water and sediment quality – which assesses the potential impacts of increased suspended sediment concentrations and disturbance and release of contaminated sediments or radioactive particles, which have the potential to affect marine mammal and megafauna prey species;

- Offshore EIA Report; chapter 10: Benthic subtidal and intertidal ecology – which assesses the potential impacts on benthic habitats and species, which may impact marine mammal and megafauna prey species, and outlines mitigation measures to reduce biofouling;
- Offshore EIA Report; chapter 11: Fish and shellfish ecology – which assesses the potential impacts on key marine mammal and megafauna prey species, such as herring, cod, whiting, sandeels and flatfish;
- Offshore EIA Report; chapter 14: Commercial fisheries – which assesses the potential impacts on commercial fishing effort, which may affect marine mammal and megafauna prey species; and
- Offshore EIA Report; chapter 15: Shipping and navigation – which characterises the baseline vessel traffic conditions and assesses the impact of additional vessels associated with the offshore Project, which has been used to inform the assessment of vessel collision for marine mammals and megafauna.

Where information is used to inform the impact assessment, reference to the relevant Offshore EIA Report chapter is given. Inter-relationships are defined as the interaction between the impacts assessed within different topic-specific chapters on a receptor; the other relevant chapters and impacts related to the assessment of potential effects on marine mammals and megafauna are provided in Table 12-2. It is important to understand impacts at an ecosystem scale, and thus in the assessment of marine mammals and megafauna as top predators, the impacts on benthic subtidal and intertidal ecology (chapter 10: Benthic subtidal and intertidal ecology) and on fish and shellfish (chapter 11: Fish and shellfish ecology) in the same marine food web have been considered when assessing indirect impacts on marine mammal and megafauna receptors.

Table 12-2 Marine mammals and megafauna inter-relationships

CHAPTER	IMPACT	DESCRIPTION
Water and sediment quality (chapter 9, Offshore EIA Report)	Indirect effects related to changes in availability or distribution of marine mammal and megafauna prey species resulting from decreased water quality.	There is potential for changes in water quality resulting from increased suspended sediment concentration or disruptions of contaminants or radioactive particles from the seabed to affect the availability or distribution of prey species and affect marine mammal and megafauna foraging success. Impacts to water quality are discussed in chapter 9: Water and sediment quality. The potential impacts that changes to water quality may have on the benthic ecology are assessed in chapter 10: Benthic subtidal and intertidal ecology. The potential impacts that changes to water quality may have on the fish and shellfish are considered in chapter 11: Fish and shellfish ecology, although there was deemed to be no potential for impact from temporary increases in Suspended Sediment Content (SSC) and associated sediment deposition on fish and shellfish receptors, and this pressure was scoped out. As described in sections 12.6.1.4 and 12.6.2.5, marine mammals and basking sharks were assessed to have negligible sensitivity to indirect effects related to changes in availability or distribution of prey species from the Project during all stages.
Benthic subtidal and intertidal ecology	Indirect impacts to marine mammal and megafauna	Change to benthic habitat quality can affect fish prey species which exploit benthic habitats, which can subsequently affect

CHAPTER	IMPACT	DESCRIPTION
(chapter 10, Offshore EIA Report)	through habitat change, including impacts to benthic habitat quality.	habitat use and foraging success of higher trophic level species, including marine mammals and megafauna, which rely on those fish species as prey. The potential impacts that habitat loss or disturbance may have on the benthic ecology are assessed in chapter 10: Benthic subtidal and intertidal ecology, whilst impacts on fish distributions are assessed in chapter 11: Fish and shellfish ecology. As described in sections 12.6.1.4 and 12.6.2.5, marine mammals and basking sharks were assessed to have negligible sensitivity to indirect effects related to changes in availability or distribution of prey species from the Project during all stages.
Fish and shellfish ecology (chapter 11, Offshore EIA Report)	Indirect effects related to changes in availability or distribution of fish and shellfish prey species	There is potential for direct effects on fish and shellfish prey species to impact the availability and distribution of food resources available for marine mammals and megafauna thus impacting their foraging success. This includes temporary and long-term habitat loss or disturbance, underwater noise, Introduction of new hard substrate and Wind Turbine Generator (WTG) infrastructure resulting in fish and predator aggregation effects, Electromagnetic Field (EMF) effects, barrier effects and indirect effects related to changes in fish and shellfish prey, which have been assessed in chapter 11: Fish and shellfish ecology. As described in sections 12.6.1.4 and 12.6.2.5, marine mammals and basking sharks were assessed to have negligible sensitivity to indirect effects related to changes in availability or distribution of prey species from the offshore Project during all stages.

Impacts relating to European otter (*Lutra lutra*) are discussed in the Onshore EIA Report chapter 10: Terrestrial non-avian ecology, as there is considered to be no potential for effect on this species as a result of the offshore works.

Effects on Annex I marine mammal receptors identified as a qualifying interest of Special Areas of Conservation (SACs) have been considered by the Habitats Regulation Appraisal (HRA) process which has been undertaken alongside this Offshore EIA Report. The HRA screening process, undertaken in consultation with NatureScot and Marine Directorate, concluded that there will be no potential for Likely Significant Effect (LSE) on any SACs with marine mammal qualifying interests, therefore no further assessment is required under Stage 2 of the HRA process within the Offshore Report to Inform the Appropriate Assessment (RIAA). For full details, please see the Offshore HRA Screening Report (OWPL, 2022) and the Offshore RIAA.

The following specialists have contributed to the assessment:

- HiDef Aerial Surveying Ltd (HiDef) – draft Offshore EIA Report Chapter and the Offshore EIA Report, SS9: Marine mammals and megafauna baseline report in addition to site-specific Digital Aerial Surveys (DAS);
- Sea Mammal Research Unit Consulting (SMRU Consulting) – SS10: Marine mammal underwater noise impact assessment; and

- Subacoustech Environmental Ltd (Subacoustech) – underwater noise propagation modelling (SS: Underwater noise modelling report).

12.2 Legislation, policy and guidance

Over and above the legislation presented in chapter 3: Planning policy and legislative context, the following legislation, policy and guidance are relevant to the assessment of impacts from the offshore Project on marine mammals and megafauna:

- Legislation:
  - The Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) which applies to Scottish inshore waters (within 12 nautical miles (nm)) and the Conservation of Offshore Marine Habitats and Species Regulations 2017 which applies to the area of sea beyond 12 nm. Collectively these are known as 'the Habitats Regulations'[1];
    - European Protected species (EPS) are species listed in Annex IV of the Habitat Directive (and afforded protection under the Habitats Regulations). All cetacean species found in Scottish waters are protected, as are turtle species present in Scottish waters.
    - There are subtle differences in the EPS inshore and offshore legislation. The inshore legislation makes it an offence to deliberately or recklessly capture, injure or kill a wild animal of an EPS. It is also an offence to deliberately or recklessly disturb any cetacean (dolphin, porpoise or whale). In terms of the disturbance offence, this is assessed at the individual level.
    - The offshore legislation makes it an offence to deliberately kill, injure or disturb. In relation to the disturbance offence, this is interpreted to prohibit disturbance at a level above 'trivial' disturbance. Non-trivial disturbance is considered to be disturbance that is likely to have a certain negative effect on EPS in terms of affecting their ability to forage, breed (fitness) or by significantly altering local abundance or distribution. Under this legislation it is not expected that that an activity which is predicted to disturb individual animals would amount to disturbance under the legislation.
    - Bottlenose dolphin (*Tursiops truncatus*), harbour porpoise (*Phocoena phocoena*), grey seal (*Halichoerus grypus*) and harbour seal (*Phoca vitulina*) are also protected under Annex II of the Habitats Directive, as implemented under the same UK regulations, which requires their designation of SACs. Where a plan or project is likely to have a significant impact on a SAC, there is the requirement under the Habitats Regulations for the competent authority to carry out an appropriate assessment. The information required to inform this assessment is provided in the Offshore RIAA, noting that marine mammals were screened out of further assessment (OWPL, 2022)).
    - Annex V of the Habitats Directive as transposed into Scottish and UK legislation, defines seals as species of community interest, meaning that any take of these species in the wild is subject to management measures.

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[1] *Following Brexit, these regulations, which transpose the requirements of the European Union (EU) Habitats Directive (Council Directive 92/43 /EEC) into Scottish Law, were amended in 2019 within the Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019 which ensures that the regulations are still in force and the strict protections for EPS remain.*

- The Marine (Scotland) Act 2010 in Scottish territorial waters and the Marine and Coastal Access Act 2009 beyond 12 nm;
    - The Nature Conservation Marine Protected Area (NCMPA) network, designated under the above legislation, includes several NCMPAs which protect marine mammal and megafauna features such as Risso's dolphin (*Grampus griseus*), minke whale (*Balaenoptera acutorostrata*) and basking shark.
- Protection of Seals (Designation of Haul-Out Sites) (Scotland) Order 2014 (as amended), made in exercise of the power conferred by section 117 of the Marine (Scotland) Act 2010;
    - This legislation designates seal haul-outs (coastal locations that seals use to breed, pup, moult and rest). At designated haul-out sites, it is an offence to intentionally or recklessly harass seals, and seals are protected from adverse anthropogenic impacts.
- Nature Conservation (Scotland) Act 2004 and Schedule 5 of the Wildlife and Countryside Act (1981);
    - Under these Acts, it is illegal to intentionally or recklessly, disturb or harass dolphins, whales, porpoise and basking sharks.
    - It is also an offence to deliberately kill, injure or take wild animals including cetaceans, pinnipeds (seals) and sea turtles under The Wildlife and Countryside Act (1981).
- Marine Strategy Framework Directive (MSFD) transposed into UK law under the Marine Strategy Regulations 2010;
    - The MSFD describes the good environmental status on the basis of eleven elements, including Descriptor 1: Biodiversity, Descriptor 4: Food web and Descriptor 11: Energy supply, including Underwater Noise.
- Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention);
- Convention on the Conservation of Migratory Species of Wild Animals;
- Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS) – amended in 2008 to the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas; and
- Convention for the Protection of the Marine Environment of the Northeast Atlantic (OSPAR Convention).

- Policy:
    - Scottish Biodiversity Strategy, including the documents: Scotland's Biodiversity: It's in Your Hands and the 2020 Challenge for Scotland's Biodiversity (Scottish Government, 2022a);
    - The European Commission's Guidance document on wind energy developments and European Union (EU) nature legislation (European Commission, 2021);
    - The following General Policies (referred to as 'GEN' policies) of Scotland's National Marine Plan (Marine Scotland, 2015), which was prepared in accordance with the UK Marine Policy Statement, apply to this marine mammal and megafauna assessment:
        - GEN 1: General planning principle: There is a presumption in favour of sustainable development and use of the marine environment when consistent with the policies and objectives of this Plan;
        - GEN 9: Natural heritage: Development and use of the marine environment must: (a) Comply with legal requirements for protected areas and protected species; (b) Not result in significant impact on the national status of PMFs; and (c) Protect and, where appropriate, enhance the health of the marine area;
        - GEN 11 Marine litter: Developers, users, and those accessing the marine environment must take measures to address marine litter where appropriate. Reduction of litter must be taken into account by decision-makers;
        - GEN 13 Noise: Development and use in the marine environment should avoid significant adverse effects of man-made noise and vibration, especially on species sensitive to such effects;

    - GEN 19 Sound evidence: Decision making in the marine environment will be based on sound scientific and socio-economic evidence;
    - GEN 20 Adaptive management: Adaptive management practices should take account of new data and information in decision-making, informing future decisions and future iterations of policy; and
    - GEN 21 Cumulative impacts: Cumulative impacts affecting the ecosystem of the marine plan area should be addressed in decision making and plan implementation.
  - Sectoral marine plan for offshore wind energy (Scottish Government, 2020);
  - National Island's Plan (Scottish Government, 2019);
  - A Blue Economy Vision for Scotland (Scottish Government, 2022b);
  - Priority Marine Features (PMFs);
    - Cetaceans, pinnipeds, and basking sharks are amongst the most regularly occurring marine mammal and megafauna species within Scottish waters designated as PMFs and are considered to be marine nature conservation priorities in Scottish waters (Tyler-Walters *et al.*, 2016; NatureScot, 2020); and
  - UK Biodiversity Action Plan (UK BAP);
    - Cetaceans, pinnipeds, and basking sharks, as well as leatherback turtle (*Dermochelys coriacea*) and loggerhead turtle (*Caretta caretta*) are listed as priority species under the UK BAP, which identified species which are most threatened and require conservation.
- Guidance:
  - Joint Nature Conservation Committee (JNCC) guidelines for minimising the risk of injury to marine mammals from geophysical surveys (seismic survey guidelines) (JNCC, 2017);
  - Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise (JNCC, 2010a);
  - JNCC guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC, 2010b);
  - The protection of Marine European Protected Species from injury and disturbance: Guidance for Inshore Waters (July 2020 Version) (Marine Scotland, 2020);
  - Guidance on the Offence of Harassment at Seal Haul-out Sites (Marine Scotland, 2014);
  - Scottish Marine Wildlife Watching Code (NatureScot, 2017); and
  - The Basking Shark Code of Conduct (Marine Conservation Society, n.d.).

All available relevant guidance at the time of the assessment has been utilised. It was agreed in writing with Marine Directorate – Licensing Operations Team (MS-LOT)[2] that any guidance published up to five months prior to the consent application would be considered within the Offshore EIA Report.

12.3 Scoping and consultation

Stakeholder consultation has been ongoing throughout the EIA and has played an important part in ensuring the scope of the baseline characterisation and impact assessment are appropriate with respect to the offshore Project and the requirements of the regulators and their advisors.

[2] *MS-LOT have since been renamed Marine Directorate – Licensing Operations Team (MD-LOT).*

The Scoping Report, which covered the onshore and offshore Project, was submitted to Scottish Ministers (via MS-LOT) and The Highland Council (THC) on 1st March 2022[3]. MS-LOT circulated the Scoping Report to consultees relevant to the offshore Project and a Scoping Opinion was received on 29th June 2022. Relevant comments from the Scoping Opinion and other consultation specific to marine mammals and megafauna are provided in Table 12-4, which provides a high-level response on how these comments have been addressed within the Offshore EIA Report.

Further consultation has been undertaken throughout the pre-application stage. Table 12-3 summarises the consultation activities carried out relevant to marine mammals and megafauna.

Table 12-3 Consultation activities for marine mammals and megafauna

CONSULTEE AND TYPE OF CONSULTATION	DATE	SUMMARY
NatureScot – meeting	23rd June 2022	To present and discuss data to be used for marine mammal and megafauna baseline characterisation, site-specific population modelling, spatial units to be used for assessment and scoping feedback.
NatureScot and OIC – meeting	29th June 2022	To introduce the Project, and to discuss data availability and Scoping Opinion feedback.
NatureScot – email response	7th July 2022	Email response to provide clarification on the following points raised during the meeting held on 23rd June 2022: • Confirmation that Bayesian Integrated Nested Laplace Approximation (INLA)-BRU could be used for population modelling; • Agreement that the UK portion of the species-specific Management Units (MUs) could be used to inform the species reference population; • Confirmation that, as the offshore Project overlaps with two SCANS areas, the worst case density estimate (density estimate for K, density estimate for S, or density surface covering K and S) should be used as the most precautionary approach; and Moray Firth SAC, which has bottlenose dolphin qualifying features, can be scoped out as there are very few of bottlenose dolphin on the north coast of Scotland and around Orkney, and no evidence of connectivity of individuals to the SAC.
NatureScot – written letter	22nd September 2022	An underwater noise modelling method statement was circulated to NatureScot and MS-LOT on 25th August 2022 to set out the proposed

[3] *The Scoping Report was also submitted to Orkney Islands Council (OIC), as the scoping exercise included consideration of power export to the Flotta Hydrogen Hub, however, this scope is not covered in this Offshore EIA Report and will be subject to separate Marine Licence and onshore planning applications.*

CONSULTEE AND TYPE OF CONSULTATION	DATE	SUMMARY
		approach for the underwater noise modelling. The methodology is also outlined within SS11: Underwater noise modelling report. Written response to the underwater noise modelling method statement (circulated 25th August 2022), including: • Agreement with the proposed underwater noise modelling methods; and Further consultation about the expected information which should be provided in the report.
NatureScot – meeting	3rd October 2022	To confirm the approaches for marine mammal and megafauna baseline characterisation and underwater noise modelling, including: • Presentation of further information about the site-specific abundance modelling methodology using HiDef DAS data and its suitability without the requirement for Passive Acoustic Monitoring (PAM); • Agreement from NatureScot on the HiDef note on Abundance Estimation of Cetaceans from Digital Aerial Survey (DAS) Data; and • Agreement on the approach for the underwater noise modelling.
NatureScot – email response	10th October 2022	Confirmation that, where the offshore Project overlaps with two MUs, the reference populations for marine mammals should be the sum of both MUs.
MS-LOT – written letter	16th November 2022	Clarifications were sought for topic-specific queries raised in the Scoping Opinion and consultation. The clarifications were sent in the form of a letter to MS-LOT on 7th October 2022. Written response to consultation letter was issued on 16th November 2022. The response included: • Agreement on the approach presented in the underwater noise modelling methods; and • Agreement and clarification on the approach for the marine mammal and megafauna impact assessment.
NatureScot – meeting	22nd March 2023	To present and discuss the results of the underwater noise modelling, the potential impacts on marine mammals and potential mitigation options.
NatureScot –post-meeting note	5th May 2023	Written response to confirm agreement on assumptions of baseline inputs. Confirmation of updated results following reanalysis of population level effects using iPCoD for grey seal, harbour seal, harbour porpoise.

Table 12-4 Comments from the Scoping Opinion relevant to marine mammals and megafauna

CONSULTEE	COMMENT	RESPONSE
Scottish Ministers (via MS-LOT)	As highlighted in the representations from NatureScot, and Orkney Marine Mammal Research Initiative (OMMRI), the Developer has provided only high-level information on impacts and assessment methods, including underwater noise impacts, within the Scoping Report. Due to the broad nature of the design envelope within the Scoping Report, the Scottish Ministers are also unable to comment on the realistic worst case scenario of the project.	Impact assessment methods, including for underwater noise, have been discussed during regular stakeholder consultation meetings throughout the EIA process (including the worst case scenario that has informed the assessment) and assessment results have been presented and discussed.
Scottish Ministers (via MS-LOT)	The Scottish Ministers are broadly content with the study area detailed in section 2.6.2 of the EIA Report. In line with the MSS advice, The Scottish Ministers advise that distances to protected sites should be measured from the site boundary, rather than the centre of the Proposed Development. In addition to digital aerial surveys, the Scottish Ministers advise that the Developer must also carry out passive acoustic monitoring to provide a more robust estimate of cetaceans present. Additionally, to ensure that SACs with grey and harbour seal qualifying features are fully considered within the EIA Report, 50 kilometre (km) and 20 km buffers should be used respectively. Designated seal haul-out sites within or adjacent to potential landfall sites of the Proposed Development must also be fully addressed within the EIA Report.	It has been agreed with NatureScot during the Marine Mammal Consultee Meeting held on 3rd October 2022 that PAM would not be required. A supporting document was sent to Marine Scotland outlining why PAM was not necessary for the Project, available in Appendix III of SS9: Marine mammal and megafauna baseline report. Letter received 7th October 2022 from the Scottish Ministers via MS-LOT confirmed this approach: "MS-LOT advise that MSS has no further comment to provide". To ensure SACs with grey and harbour seal qualifying features were fully considered, 20 km and 50 km buffers were used respectively; these were confirmed by Scottish Ministers (via MS-LOT) in a letter received 7th October 2022. Please see the Offshore HRA Screening Report (OWPL, 2022) for full details. Distances to designated sites were measured as the nearest at-sea distance from the boundary of the offshore Project. No SACs designated for harbour or grey seals were deemed to have connectivity with the offshore Project. All relevant guidance in relation to Section 117 of the Marine (Scotland) Act 2010 has been followed. There are no seal haul out sites within or immediately adjacent to the selected landfall site, therefore no further

CONSULTEE	COMMENT	RESPONSE
		assessment of impacts to seals at designated seal haul out sites was required (See section 12.4.4.4.3).
Scottish Ministers (via MS-LOT)	The Scottish Ministers are broadly content with the baseline data sources listed in Table 2-37 within section 2.6.3 of the Scoping Report. However, overall, the Scoping Report lacks information on marine mammal abundance and distribution within the development area and this must be addressed in the EIA Report, in line with the MSS advice. The EIA Report must also consider the Scottish Marine Wildlife Watching Code and available data on strandings from sources such as the Scottish Marine Stranding scheme. In line with the MSS advice, the Scottish Ministers advise that the Developer consider the use of Thompson *et al.* (2019) in considering local harbour seal population estimates.	Baseline data sources have been discussed and agreed with NatureScot during the Marine Mammal Consultee Meetings held on 3rd August 2022, 3rd October 2022 and 22nd March 2023. Thompson *et al.* (2019) was considered and is included in the list of data sources (section 12.4.2) and SS9: Marine mammal and megafauna baseline report. For harbour seal estimates Carter *et al.* (2022) at-sea habitat usage maps have been preferentially used instead of Thompson *et al.* (2019) as this provides more up-to date data from which densities can be extracted for the offshore Project; this approach has been agreed and confirmed. The Scottish Marine Wildlife Watching Code (SMWWC) and Scottish Marine Stranding scheme have been considered, please refer to section 12.4.2 for the full list of data sources.
Scottish Ministers (via MS-LOT)	In regard to key species, in addition to list of species identified in section 2.6.4 of the Scoping Report, the Scottish Ministers advise that the Developer must take a precautionary approach and include killer whale (orca), white-sided dolphin and humpback whale in the assessment. This is a view supported by NatureScot and MSS. In addition, and in line with the NatureScot representation, the most recent Inter-Agency Marine Mammal Working Group ("IAMMWG") (2021) management until estimates should be used for each species in the impact assessment.	Killer whale (*Orcinus orca*), white-sided dolphin (*Lagenorhynchus acutus*) and humpback whale (*Megaptera novaeangliae*) have been included in assessment and are assessed qualitatively within this chapter and SS9: Marine mammal and megafauna baseline report (see section 12.6). The most recent cetacean MU reference populations have been used IAMMWG (2022) (revised March 2022).
Scottish Ministers (via MS-LOT)	In Table 2.40 of the Scoping Report, the Developer summarises the potential impacts to marine mammals and megafauna 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 during the operation phase, the potential for vessel collisions and, disturbance due to physical presence and noise from vessels, and impacts due to prey availability for all	In addition to the proposed impact pathways in the Scoping Report the additional requested impact pathways have also been scoped in and been brought forward into the EIA, presented in sections 12.6.1, 12.6.2 and 12.6.3. 'Indirect effects of construction noise on marine mammal prey species' and 'Impacts to prey availability' are now considered under the impact pathway 'Indirect effects related to changes in availability or distribution of prey

CONSULTEE	COMMENT	RESPONSE
	phases must be scoped into the EIA Report. In this regard, the NatureScot representation and MSS advice must be addressed in full in the EIA Report. The Scottish Ministers also advise that potential noise impacts from pre-construction activities, including the removal of unexploded ordnance and geophysical surveys must be scoped into the EIA Report. In addition landfall and export cable works at Scapa Flow, and the potential interaction with seal haul out sites, must be scoped into the EIA Report for further assessment, in line with the NatureScot representation.	species' for all Project stages. Disturbance due to physical presence and underwater noise of vessels, vessel collision and noise impacts from pre-construction activities have also been scoped into the Offshore EIA Report. Floating WTGs are no longer being considered as part of the current consent application, therefore 'Entanglement with moorings' and 'Underwater noise from floating turbines' have not been relevant to consider for this current application. Landfall and export cable works at Scapa Flow are no longer included as part of the current consent application therefore potential interaction with seal haul out sites are no longer considered.
Scottish Ministers (via MS-LOT)	The Scottish Ministers advise that due to the broad nature of the project design envelope it is difficult at this stage to scope out many impact pathways. In line with the MSS advice, the Scottish Ministers advise that there is insufficient evidence to exclude potential impacts of operational noise. Therefore, the impact from floating and fixed foundation types must be scoped into the EIA Report. However, the operational noise impact from fixed foundation types need only be assessed in respect of minke whale. In addition, potential pollutants have not been specified, nor have the mechanisms and likelihood of any accidental releases. Therefore, this impact pathway must also be scoped into the EIA Report for further assessment.	Floating WTGs are no longer part of the Project Design Envelope for this application; therefore only underwater noise from fixed WTGs has been scoped in for impact assessment. Noise related impacts to minke whale and humpback whale (both in the same functional hearing group from Southall *et al.*, (2019)) during operation has been assessed in section 12.6.2.1. Additional information has been added about potential pollutants and mechanisms by which pollutants may be released. This is now consistent with the information provided in chapter 10: Benthic subtidal and intertidal ecology, and chapter 11: Fish and shellfish ecology, where this impact was also scoped out.
Scottish Ministers (via MS-LOT)	In regards assessment methodologies, the metrics for underwater noise modelling and assessment of cumulative effect require further discussion with NatureScot. The Scottish Ministers advise that the Developer must consider and fully implement the NatureScot advice in relation to its approach to the assessment of marine mammal densities and population consequence and cumulative impacts.	The proposed approach to underwater noise modelling was provided in the underwater noise modelling method statement (circulated 25th August 2022), discussed with NatureScot during the Marine Mammal Consultee Meeting held on 3rd October 2022 and agreed with MS-LOT via letter on 16th November 2022. Following advice from MS-LOT, the approach to cumulative impact assessment was discussed with NatureScot during the Marine Mammal

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		Consultee Meeting held on 22nd March 2023 and additional developments which were suggested to be added to the list of developments have now been included in the cumulative impact assessment. See sections 12.7 and SS10: Marine mammal underwater noise impact assessment.
Scottish Ministers (via MS-LOT)	In line with the NatureScot representation, the Scottish Ministers advise that where impact pathways have been identified, a full range of mitigation techniques and published guidance must be included in the EIA Report. This should include development of and adherence to a marine mammal mitigation protocol. If pile driving is to be used, the Scottish Ministers expect that the approach to noise mitigation will be informed by the best available evidence and advise the Developer to refer to the NatureScot advice on noise abatement and entanglement.	Offshore EIA Report, Outline Plan (OP) 2: Marine Mammal Mitigation Protocol (MMMP) has been provided alongside this application and will be developed further and agreed in consultation with NatureScot and the Scottish Ministers via MS-LOT ahead of construction. To ensure adherence to the MMMP, this will be a condition of the Section 36 Consent and/or Marine Licence. Once the Piling Strategy (PS) is finalised post consent, final mitigation and monitoring requirements can be confirmed.
Scottish Ministers (via MS-LOT)	In regards to the cumulative and transboundary impacts from the Proposed Development included in section 2.6.8, little detail is provided in the Scoping Report on how these effects will be assessed and therefore this should be further informed though discussion with NatureScot.	Following this advice, the approach to cumulative impact assessment was discussed with NatureScot during the Marine Mammal Consultee Meeting held on 22nd March 2023 and additional developments which were suggested to be added to the list of developments have been included during cumulative impact assessment. See sections 12.7 and SS10: Marine mammal underwater noise impact assessment. Transboundary impacts have been considered in section 12.10.
Scottish Ministers (via MS-LOT)	Section 2.6.1 of the Scoping Report states that pre-construction surveys and unexploded ordnance ("UXO") clearance will be considered and assessed as part of the European Protected Species licence application and Marine Licence application. The Scottish Ministers advise that the EIA Report must include assessment of the in-combination effects of pre-construction activities such as geophysical surveys and UXO clearance. The EIA Report must also include considerations of noise abatement methods for detonation of UXO and must include a worst case scenario of high order	Assessment of underwater noise impacts from both pre-construction geophysical surveys (section 12.6.1.1.2) and Unexploded Ordnance (UXO) clearance (section 12.6.1.1.3) assuming a worst case scenario of high-order detonation have been considered in this chapter. The potential for cumulative effects from disturbance relating to UXO clearance has also been assessed in section 12.7.2.1.

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	detonation in terms of impact and mitigation, unless there is robust supporting evidence that can be presented to show consistent performance of the preferred low order or deflagration method. The Scottish Ministers refer to the Joint SNCB/DEFRA/MS statement – Marine environment: unexploded ordnance clearance in this regard. Additionally, clearance of UXO must also be considered within a cumulative impact assessment in the EIA Report. Further to this, the potential presence of UXO and disposal sites should also be assessed within the EIA Report with regards to the installation of cables and any other works that result in disturbance to the seabed.	Considerations of noise abatement methods for detonation of UXO are considered within the OP2: Outline Marine Mammal Mitigation Protocol. This has included consideration of the Joint SNCB/DEFRA/MS statement – Marine environment: UXO clearance.
Marine Scotland Science (MSS)	Study area MSS agree with the study area encompassing the OAA and the associated offshore export cable search area, though we advise that any abundance estimates to be used in assessments need to be derived from an area at least as large as the area of potential impact. The applicant should ensure that impact pathways with a large spatial extent (e.g. impulsive underwater noise) are adequately covered by the study area and buffer. Without further details on piling strategy, MSS cannot confirm that the area covered by site-specific surveys is sufficient.	The offshore study area has been defined as the site-specific DAS area, as outlined in section 12.4.1. Underwater noise impacts for marine mammals have been assessed against reference populations derived from regional study areas (detailed in section 12.4.1 and SS9: Marine mammal and megafauna baseline report) which consider the wider abundance and distribution of animals beyond the immediate study area. The use of these abundance estimates within this EIA was confirmed by NatureScot during the Marine Mammal Consultee Meeting held on 22nd March 2023.
MSS	MSS broadly agree with the list of species to be included in the assessment: harbour porpoise; white beaked dolphin; Risso's dolphin; minke whale; grey seal; harbour seal. However, killer whales should be included in this list. As indicated in Section 2.6.4.1.1 of the Scoping Report, sightings data suggests killer whales regularly occur in the region. A new data stream being collected in the Pentland Firth and Orkney waters through ECOPredS (www.ecopreds.com) incorporates sightings reports, visual surveys and passive acoustic monitoring data to study killer whale foraging ecology. This project has already demonstrated killer whale presence in the area, and may be a useful additional source of information on this species in Orkney waters. MSS agree with NatureScot that common dolphin, Atlantic white-sided dolphin and humpback whale should also be included.	In addition to the species originally proposed in the Scoping Report, killer whale, Atlantic white-sided dolphin, common dolphin and humpback whale have been included in the impact assessment, although due to data limitations these species are assessed qualitatively. More detail on available data sources for these species can be found in section 12.4.4 and SS9: Marine mammal and megafauna baseline report. At the time of Scoping, the DAS survey programme had not yet been fully completed; however, all available data are presented in SS8: Digital video aerial survey methodology and marine mammal survey results.

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		ECOPredS has been considered. However, ECOPredS have not yet published reports or data which could be incorporated into baseline characterisation or impact assessment for the offshore Project.
MSS	Baseline characterisation MSS broadly agree with the data sources listed, noting the additional sources highlighted in our advice and the advice of NatureScot. The extremely broad nature of the Scoping Report restricts our ability to comment on the realistic worst case scenario of the project. There may be additional sources of information that may be useful as the project design envelope is refined.	As requested, additional sources highlighted by MSS and NatureScot have been considered. The SMWWC and Thompson *et al*. (2019) are included in the list of data sources and their applicability discussed in SS9: Marine mammal and megafauna baseline report. ECOPredS has been considered however, ECOPredS have not yet published reports or data which could be incorporated into baseline characterisation or impact assessment for the offshore Project. As the Project Design Envelope has been refined, the relevant data sources have also been adjusted and refined following an extensive review of relevant guidance and literature.
MSS	MSS note that information on marine mammal abundance and distribution within and surrounding the development area is lacking. Site-specific surveys should ensure that the data collected are of a suitable quality to both characterise the site and inform quantitative impact assessments.	Site-specific DAS were able to provide estimates of density and abundance which could be used during quantitative impact assessment for harbour porpoise, white-beaked dolphin (*Lagenorhynchus albirostris*) and common dolphin (*Delphinus delphis*); more detail is provided in section 12.4.4 and SS8: Digital video aerial survey methodology and marine mammal survey results and SS9: Marine mammal and megafauna baseline report. Where there were insufficient data available from site-specific DAS to provide estimates which may be used in impact assessment, additional data sources were preferentially used, e.g. from Special Committee on Seals (SCOS), Carter *et al.* (2022) and Small Cetaceans in the European Atlantic and North Sea (SCANS), to ensure suitable quality data were used to inform quantitative impact assessment.

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MSS	Data sources Thompson *et al*. (2019) may be useful for considering local harbour seal population estimates, which are particularly important for this management unit given the declining trajectories of the North Coast and Orkney Seal Management Area (SMA).	Thompson *et al*. (2019) has been considered in SS9: Marine mammal and megafauna baseline report, and in section 12.4.5. Thompson *et al.* (2019) could be useful to inform harbour seal population estimates but has since been superseded by the production of at-sea density estimates by Carter *et al.* (2020) (which has been used to inform applications for other, similar offshore developments, and more recently, Carter *et al.* (2022). Site-specific estimates of density could be extracted for harbour seal using Carter *et al.* (2022). More detail can be found in SS9: Marine mammal and megafauna baseline report and section 12.4.5.
MSS	Embedded mitigation measures MSS note the applicants have committed to embedded mitigation measures for the wind farm construction such as a Piling Strategy (PS), an Environmental Management Plan (EMP) and a Vessel Management Plan (VMP). While we welcome the commitment to these to aid mitigation planning, we advise that such plans do not rule out the potential requirement for additional mitigation measures, depending upon the results of the impact assessment. We expect the list of embedded mitigation measures (Table 2-39), along with any additional mitigation that may be required following the assessment, will be refined once the project design envelope is finalised. At present, the design envelope is too broad to evaluate if the mitigation proposed is sufficient, but MSS recommend that a Marine Mammal Mitigation Plan is developed and adhered to. This should include both the offshore and Scapa Flow study areas as the impact pathways, and therefore the mitigation required, will potentially be very different for these two areas.	Embedded mitigation measures have been outlined in section 12.5.4. An Outline MMMP (OP2: Outline Marine Mammal Mitigation Protocol) has been provided alongside this application and will be developed and agreed in consultation with NatureScot and Scottish Ministers via MS-LOT. To ensure adherence to the MMMP, this will be a condition of the Section 36 Consent and/or Marine Licence (section 12.12). The landfall and export cable works which were proposed at Scapa Flow are no longer considered as part of the current application and therefore has not been included.
MSS	In the Scoping Report there is no mention of additional underwater noise abatement methods and technologies e.g. bubble curtains. MSS recommend that noise abatement methods for noisy activities, such as impact piling and detonation of UXO, should be considered where practicable and discussed in the EIA report.	Potential noise abatement systems were discussed during the Marine Mammal Consultee Meeting held on 22nd March 2023. The underwater noise impact assessment concluded there will be no significant impacts (in EIA terms) to marine mammal and megafauna receptors from underwater noise during any Project stages. Mitigation considered as part of the

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		consent application have been discussed in OP2: Outline Marine Mammal Mitigation Protocol. Further mitigation measures will be considered, as required, in relation to future EPS Licence applications, once all the appropriate information is collated to inform the PS.
MSS	Potential impacts identified MSS agree with the following relevant impact pathways that have been identified to be brought forward into the EIA: Injury and disturbance from underwater noise-generating activities (construction and decommissioning phases); Indirect effects of construction noise on marine mammal prey species (construction and decommissioning phases); Habitat change, including foraging opportunities (all phases); Displacement or barrier effects associated with physical presence of devices and infrastructure (operation phase); Entanglement with moorings (if floating WTG) (operation phase). MSS agree with NatureScot that the following impact pathways should also be scoped in: Underwater noise from floating turbines (operation phase); Vessel collision (all phases); Disturbance due to physical presence of vessels (all phases); Disturbance due to underwater noise from vessels (all phases); Impacts to prey availability (all phases)	In addition to the proposed impact pathways in the Scoping Report the additional requested impact pathways have also been scoped in and been brought forward into the EIA, presented in sections 12.6.1, 12.6.2 and 12.6.3. 'Indirect effects of construction noise on marine mammal prey species' and 'Impacts to prey availability' are now considered under the impact pathway 'Indirect effects related to changes in availability or distribution of prey species' for all Project stages. Floating WTGs are no longer being considered as part of the Project Design Envelope for this current application, therefore 'Entanglement with moorings' and 'Underwater noise from floating turbines' have not been relevant to consider for this current application. Vessel collision, disturbance due to physical presence and underwater noise from vessels and indirect effects related to changes in availability or distribution of prey species have been assessed for all Project stages. Additionally, the cumulative effect of disturbance due to physical presence and underwater noise from vessels has been assessed. These impact pathways are presented in sections 12.6.1, 12.6.2, 12.6.3 and 12.7.
MSS	We note the applicant states potential effects of pre-construction surveys or UXO clearance to marine mammals will be fully considered and assessed as part of the EPS Licence and Marine Licence applications. This Scoping Report covers construction,	Pre-construction surveys and UXO clearance have been fully considered. Injury and disturbance from underwater noise generating activities have been assessed in section 12.6.1.1.2 for pre-construction surveys, and in

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	operation and decommissioning phases. However, MSS advise that the EIA should also include pre-construction activities that are integral to the construction going ahead, such as geophysical surveys and UXO clearance. MSS recommends that clearance of UXO is also considered within a cumulative impact assessment for this project.	section 12.6.1.1.3 for UXO clearance. These have also been considered in the cumulative impact assessment in section 12.7.
MSS	Approach to assessment Site-specific density and abundance estimates beyond the standard aerial surveys will be required, however more detail is expected on how will this be collected for all species of interest. MSS advise that absolute densities will be required for quantitative assessments for activities producing impulsive noise (e.g. piling), and that the spatial extent across which marine mammal densities are estimated should cover the area of potential impact, as a minimum.	DAS data were corrected to get absolute estimates of abundance for harbour porpoise and white-beaked dolphin, which were used during quantitative assessment. Absolute abundance estimates could not be calculated for common dolphin from DAS data due to the limited available data on species-specific diving rates. However, the relative abundance estimates are still considered to be the most appropriate density estimates for the offshore Project compared with other data sources (as outlined in SS9: Marine mammal and megafauna baseline report and section 12.4.4.1). For example, no common dolphin were recorded within the relevant SCANS-III survey blocks (K and S; Hammond *et al*., 2021), and IAMMWG (2022) reference populations calculated for the CGNS are likely to be inflated by areas of known high abundance in other regions, such as the southwest UK. Other data sources were also used during quantitative assessment where site-specific data were not deemed as the most preferential data source; discussion around this can be found in section 12.4.4 and SS9: Marine mammal and megafauna baseline report. All density and abundance estimates used during impact assessment have been agreed with NatureScot and confirmed during the Marine Mammal Consultee Meeting held on 22nd March 2023.
MSS	In agreement with NatureScot, given the early stages of surveying we recommend the use of PAM to augment aerial survey data (e.g. Thompson *et al*. 2015). While aerial surveys provide good spatial coverage of a site, they provide poor temporal coverage.	As discussed in the Marine Mammal Consultee Meeting held on 3rd October 2022, PAM will not provide absolute estimates of density and abundance for cetaceans. Whilst the Project acknowledges that the

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	Static PAM is complementary to this as it generally provides less spatial coverage, but much greater temporal coverage of presence/absence of small cetaceans (harbour porpoise and dolphin species). MSS would encourage the use of PAM to monitor baselines to ensure that abundance and distribution estimates can be more accurately assessed. Further, if monitoring stations are carefully located throughout the site, these data could provide the distribution and abundance models from HiDef with scalars for temporal changes in cetacean density, allowing proportion of missed animals during a survey to be estimated. There may be potential to use PAM to detect minke whales using broadband recorders (Risch *et al.* 2019). Minke whales are known to occur in this area and aerial surveys have been shown to be ineffective at detecting this species (Webb *et al.*, 2018), possibly due to their long dives.	temporal coverage of PAM is high, it is limited in spatial coverage. Therefore, it was agreed that PAM would not be required. A separate letter outlining this and the preferred approach using DAS data is submitted as part of within Appendix III of SS9: Marine mammal and megafauna baseline report. This approach has been agreed with NatureScot (Marine Mammal Consultee Meeting held on 3rd October 2022) and the Scottish Ministers via MS-LOT (letter dated 7th October 2022).
MSS	Scoped out impacts MSS broadly agree that relevant impact pathways have been identified to be brought forward into the EIA, however we note that due to the extremely broad nature of the project design envelope it is difficult at this stage to scope out many impact pathways. The applicant states in Table 2-38 that minke whales may be sensitive to the low frequency sounds emitted during operation, but have then scoped out disturbance to marine mammals from operational noise. There is insufficient evidence to exclude potential impacts of operational noise, therefore MSS advise this is addressed in the EIA. Offshore wind farms are sources of low frequency noise and cumulative effects from turbines may be considerable (Tougaard *et al.*, 2020).	Noted. Noise related impacts to minke whale and humpback whale during operation have been assessed in section 12.6.2.1. Humpback whale was also included as it is in the same functional hearing group as minke whale from Southall *et al.* (2019).
MSS	MSS note that potential pollutants have not been specified, nor the mechanism and likelihood of any accidental releases. Therefore, at present there is insufficient information to scope this impact pathway out.	Additional detail has been added about potential pollutants and mechanisms by which pollutants may be released. This is now consistent with the information provided in chapter 10: Benthic subtidal and intertidal ecology, and in chapter 11: Fish and shellfish ecology where this impact was also scoped out.

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MSS	MSS agree that the following impact pathways can be scoped out of the marine mammal assessments: Associated impacts with decreasing marine water quality including increased turbidity (construction and decommissioning).; Electromagnetic Field (EMF) (operations and maintenance phase)	Noted and justifications for impacts scoped out of the assessment are provided in Table 12-14.
MSS	Cumulative effects assessment and for transboundary effects The Scoping Report states that cumulative and transboundary effects will be considered, but aside from considering the timings of construction activities little detail is available on how effects will be assessed. Therefore, we cannot state that we agree with this approach, given the paucity of details.	Cumulative effects have been considered in section 12.7. The list of developments for inclusion in cumulative assessment has been agreed with NatureScot following discussion during the Marine Mammal Consultee Meeting held on 22nd March 2023. Transboundary effects have been considered in section 12.10.
MSS	The inner Pentland Firth is not explicitly considered for additional surveying however, depending on installation method, animals in this region may be affected. The area has high usage for harbour seals (Carter *et al*. 2020) and the population in this region is in decline. MSS recommend this area should be included in impact assessments for installation periods.	Quantitative noise impact assessment includes animals within the Zone of Influence (ZoI) which is likely to be impacted during pre-construction and construction, as determined through noise modelling (see sections 12.6.1, 12.6.2.1 and SS10: Marine mammal underwater noise impact assessment). The zone of impact is used in conjunction with the Carter *et al.* (2022) at-sea usage density surface to determine the number of animals likely to be impacted (see SS9: Marine mammal and megafauna baseline report; SS10: Marine mammal underwater noise impact assessment). Animals within the Pentland Firth are included when necessary (see sections 12.6.1, 12.6.2.1 and SS10: Marine mammal underwater noise impact assessment).
MSS	MSS note that distances to protected sites have been estimated from the centre of the development. We recommend these distances are revised and estimated from the site boundary, rather than the centre. MSS note that a Habitats Regulations Appraisal screening report has not accompanied this scoping request.	Distances to designated sites have been measured as the nearest at-sea distance from the boundary of the offshore Project. Please refer to the Offshore HRA Screening Report (OWPL, 2022) which was submitted on the 8th September 2022. The HRA Screening Response has been taken into account in the Offshore RIAA, noting that marine mammals have been screened out of further assessment in the Offshore RIAA (OWPL, 2022).

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MSS	MSS request clarification on what cetacean Management Units (MU) and corresponding population sizes will be used in the [Environmental Impact Assessment Report (EIAR)], in addition to which absolute density estimates are suitable for assessment. MSS agree with NatureScot that the population estimates from the most recent IAMMWG report (2021) should be used.	NatureScot have provided advice via email (received 7th July 2022) that the reference population should be the UK portion of the relevant cetacean MU. Following this advice from NatureScot, the reference population from the UK portion of the MU was used throughout impact assessment. For harbour porpoise, where the offshore Project straddles the boundary of the North Sea and West Scotland Mus, NatureScot advised via email (received 10th October 2022) that the reference population would be derived from the sum of both abundance estimates from each MU (UK portion). As requested, reference population abundance estimates have been taken from the most recent IAMMWG report, which was IAMMWG (2022). Following this advice, the MU for harbour porpoise has been derived using the UK portion of North Sea and West Scotland Mus.
MSS	MSS note that whilst in the past operational noise has been scoped out of further assessment, the scale of developments planned as part of the ScotWind leasing round mean that we do now consider that cumulative impacts warrant further assessment, for both floating and fixed-foundation developments. We advise that the low frequency sound produced by operational wind turbines is more likely to be of concern to baleen whales. For this reason, we are content that only minke whale are scoped in for this impact pathway.	Floating WTGs are no longer part of the PDE for this current application therefore only underwater noise from fixed WTGs has been scoped in for impact assessment. Noise related impacts to minke whale and humpback whale during operation have been assessed in section 12.6.2.1.humpback whale was also included as it is in the same functional hearing group as minke whale from Southall *et al*. (2019).
NatureScot	Study area As detailed in Section 2.6.2, the study area encompasses the OAA and ECC search area, with site-specific Digital Aerial Surveys (DAS) being undertaken over the OAA plus a 4 km buffer to collect baseline characterisation data on marine mammals.	Noted. The offshore study area has been defined as the site-specific DAS area (OAA plus 4 km buffer), as outlined in section 12.4.1. Reference populations and baseline characterisation data are presented for the marine mammal and megafauna species of interest for the offshore study area and regional study area and are outlined in section 12.4.4. Full results from the DAS are presented in SS8: Digital aerial survey methodology and marine mammal survey results and SS9: Marine mammal and megafauna baseline report.

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NatureScot	We would also recommend that static passive acoustic monitoring (PAM) is carried out. A combination of PAM with visual survey data could be used to better estimate density or abundance of cetaceans.	At the point of the Project receiving Scoping Opinion, two years of DAS had been completed. There is no agreed approach for methods integrating DAS and PAM data to estimate absolute abundance and density of cetaceans. Whilst the Project acknowledges that the temporal coverage of PAM is high, it is limited in spatial coverage. Agreement with NatureScot during the Marine Mammal Consultee Meeting held on 3rd October 2022 that PAM would not be required. A supporting document was sent to Marine Scotland outlining why PAM was not necessary for the Project, available in Appendix III of SS9: Marine mammal and megafauna baseline report. This was approach was agreed by the Scottish Ministers via MS-LOT and MSS through written correspondence (letter dated 7th October 2022) "…MS-LOT advice that MSS has no further comment to provide".
NatureScot	We would expect to see the wider Management Units (MU) specific to each species being used for the impact assessment and recommend use of the most recent IAMMWG (2021) MU population estimates.	As requested, the most recent Inter-Agency Marine Mammal Working Group (IAMMWG) (2022) (updated March 2022) Mus have been used for cetacean species, where Mus have been defined (see section 12.4.1). Following advice from NatureScot received 7th July 2022, the reference population from the UK portion of the MU was used throughout impact assessment.
NatureScot	In the absence of the HRA screening report, we advise that buffers of 50 km and 20 km respectively should be used to screen in SACs with seal qualifying features.	As requested, a buffer of 50 km for harbour seal, and 20 km for grey seal was used to screen for SACs with seal qualifying features. As there were no SACs identified within these buffers, no LSE was concluded for all SACs with harbour seal and grey seal qualifying features (see Offshore HRA Screening Report; OWPL, 2022).

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NatureScot	There are a number of designated seal-haul out sites within or immediately adjacent to the potential landfall sites identified in the Scoping Report. Seal haul-outs are designated under Section 117 of the Marine (Scotland) Act 2010, whereby the intentional or reckless harassment of seals at designated haul-outs may be an offence. The potential impacts should be assessed in reference to the Marine Scotland Guidance.	All relevant guidance in relation to Section 117 of the Marine (Scotland) Act 2010 has been followed. There are no seal haul out sites within or immediately adjacent to the selected landfall site (at the time of scoping, some of the retained landfall options were adjacent to seal haul out sites), therefore no further assessment of impacts to seals at designated seal haul out sites was deemed necessary (see section 12.4.4.4.3).
NatureScot	Baseline characterisation We are content that Table 2-37, Section 2.6.3 captures relevant baseline datasets, but we recommend also including the Scottish Marine Wildlife Watching Code.	The SMWWC has also been reviewed and considered in this current application where relevant (see section 12.4.2).
NatureScot	Cetacean species proposed to be included in the baseline characterisation are: harbour porpoise, white-beaked dolphin, Risso's dolphin and minke whale. These were identified in the Regional Baselines report as being either present year-round or seasonally. Other species identified as rare or as sighted within the region but not within the Draft Plan Option (DPO) area are not included. However, there is very little existing data from this area and in the absence of any results from the DAS, we recommend inclusion of killer whale (orca), white-sided dolphin, common dolphin and humpback whale in addition to those detailed above. Once survey results are available we recommend further consultation to ensure that the key species list is appropriate to inform the impact assessments.	Noted. Harbour porpoise, white-beaked dolphin, Risso's dolphin and minke whale have been included in assessment. Upon receiving Scoping comments, the following additional species have been included in baseline characterisation: killer whale, Atlantic white-sided dolphin, common dolphin and humpback whale (section 12.4.4 and SS9: Marine mammal and megafauna baseline report) and have been assessed in this chapter. This has been discussed and agreed in the Marine Mammal Consultee Meetings held on 26th June 2022 and 3rd October 2022.
NatureScot	Table 2-41 (Section 2.6.9.2) lists specific legislation that will be considered in relation to the marine mammal and megafauna EIA. Just to note that several key pieces of Scottish legislation has been omitted from the list including: • Cetaceans (removed from the Wildlife & Countryside Act in Scotland) are protected by the Conservation (Natural Habitats, &c.) Regulations 1994 (as	The highlighted legislation has now been included in the list of legislation (section 12.2) and has been considered where relevant in the assessment process.

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	amended) in Scottish territorial waters, and the Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2017 in offshore waters; • Seals are protected under the Marine Conservation (Natural Habitats, &c.) Regulations 2017 in offshore waters; and • Basking sharks are protected by the Wildlife & Countryside Act 1981 (as amended).	
NatureScot	Pre-construction noise impacts There are a range of activities likely to be undertaken during the pre-construction period which can emit significant underwater noise e.g. UXO clearance and some geophysical surveys. It is noted in Section 2.6.1 that UXO clearance will be fully considered as part of a separate European Protected Species (EPS) Licence application and Marine Licence application. Just for clarity these should also be considered in the EIA Report rather than solely post-consent.	Both pre-construction geophysical surveys (section 12.6.1.1.2) and UXO clearance (section 12.6.1.1.3) have been considered in this chapter and within SS10: Marine mammal underwater noise impact assessment, through assessment of noise-related impacts to marine mammal and megafauna receptors. UXO clearance will also be considered as part of the EPS licence application and Marine Licence application.
NatureScot	We support the joint SNCB/DEFRA/MS statement – Marine environment: unexploded ordnance clearance joint interim position statement. Therefore, we would require the risk assessment to consider a high order detonation in terms of impact and mitigation as the worst case scenario, unless the preferred low order/deflagration method has robust supporting evidence than can be presented.	Within assessment of UXO clearance, high-order detonation was used as the worst case scenario in terms of impact and mitigation during the pre-construction underwater noise assessment (section 12.6.1.1.3). It should be noted that high order detonation methods are considered to be a last resort, however, they have been included within the Project Design Envelope at the request of NatureScot to ensure the worst case is being considered if it is required and the potential impacts have been assessed.
NatureScot	Disturbance due to physical presence of vessels We recommend that both vessel collision and vessel disturbance are scoped in for all stages (construction, operation and maintenance, and decommissioning) of the development. A qualitative assessment should be undertaken based on best available literature, with potential impacts to both cetaceans and basking shark considered.	'Vessel collision' and 'Disturbance due to physical presence and underwater noise from vessels' have been scoped in for all stages of the Project, and have been assessed in section 12.6.1.2 (construction (including pre-construction) and decommissioning) and section 12.6.2.2 (operation and maintenance) for marine mammal and megafauna receptors.

CONSULTEE	COMMENT	RESPONSE
NatureScot	In addition, we wish to see separation of the effects from vessel noise and presence (given the differing sizes, types and number of vessels needed for the differing stages of development) and these other activities, and how the influence of such may change depending on the marine mammal species being considered. Cumulatively it will be important to understand the likely level and effect of such disturbance and whether it could result in population level effects on marine mammals.	The effects of vessel noise and presence are linked and occur simultaneously, unless the vessel is idle. There is insufficient evidence to support the assessment of physical presence separately, and vessel underwater noise studies are often subject to observer bias from the presence of the research vessel and cannot differentiate between the effects of vessel presence and vessel noise (Erbe *et al*., 2019). Additionally, the magnitude of impact from underwater noise and physical presence of vessels will both increase with vessel size and number of vessels. Therefore, the assessment has considered the underwater noise and physical presence of vessels as a single impact pathway for construction (including pre-construction; section 12.6.1.2) and operation and maintenance (section 12.6.2.2). The cumulative effect of underwater noise and physical presence of vessels on harbour porpoise during construction (including pre-construction) and operation and maintenance is discussed in section 12.7.
NatureScot	Changes in prey species availability Section 2.6.6 doesn't capture changes in prey availability as a result of habitat loss or disturbance in adequate detail. More consideration is required in the EIA Report to ensure that impacts to key prey species (such as sandeel, herring, mackerel and sprat) and their habitats are considered. We recognise most EIA Reports concentrate on receptor specific impacts, however increasingly we need to understand the impacts at an ecosystem scale. Consideration across key trophic levels will enable better understanding of the consequences (positive or negative) of any potential changes in prey distribution and abundance on marine mammal (and other top predator) interests and how this may influence population level impacts.	In order to capture a broader range of indirect impacts, the following potential impacts which were presented in the Scoping Report have now been considered under the following impact 'Indirect effects related to changes in availability or distribution of prey species': • Injury and disturbance from decommissioning activities generating noise; and • Habitat change, including foraging opportunities, with decommissioning. The impact of changes in prey availability and distribution are assessed during all offshore Project stages, in sections 12.6.1.4 and 12.6.2.5. Inter-related impacts assessed in chapter 10: Benthic subtidal and intertidal ecology and chapter 11: Fish and shellfish ecology (outlined in Table 12-2) has also been considered to determine potential effects of the offshore

CONSULTEE	COMMENT	RESPONSE
		Project across multiple trophic levels, as part of a wider ecosystem. A summary of Ecosystem effects is detailed in section 12.10.
NatureScot	Approach to assessment The methodology and metrics for underwater noise modelling and assessment of cumulative effects require discussion and agreement with NatureScot and Marine Scotland.	An underwater noise modelling method statement was prepared by Subacoustech and submitted to NatureScot and Marine Scotland via email on 25th August 2022. A written response was received 22nd September 2022. The approach was further discussed and agreed with NatureScot during the Marine Mammal Consultee Meetings held on 3rd October 2022 and 22nd March 2023. The Scottish Ministers via MS-LOT and MSS had no further comments (letter received 7th October 2022).
NatureScot	Marine mammal densities Marine mammal densities within the zone of impact are required in order to predict the number of individuals which might be impacted by underwater noise. Information should be available from SCANS for cetaceans and from SCOS/Marine Scotland for seals (Carter *et al*. 2020). Data is constantly being gathered, so the most up to date information should be checked and agreed in advance of the application submission.	Marine mammal densities within the marine mammal and megafauna study area (section 12.4.1) have been collated to inform the underwater noise impact assessments and are presented in section 12.4.4.1. SCANS and SCOS data have been included as part of the assessment and are presented in SS9: Marine mammal and megafauna baseline report and SS10: Marine mammal underwater noise impact assessment alongside densities derived from DAS data. Carter *et al.* (2022) has been preferentially used rather than Carter *et al.* (2020).
NatureScot	Population consequences and cumulative impacts In order to consider the significance of underwater noise disturbance to marine mammals and the consequences of this on relevant populations we advise the application of the iPCoD approach (interim population consequences of disturbance model).	iPCoD has been applied by SMRU C within this impact assessment to assess the significance of underwater noise disturbance to marine mammals. Detail on the approach can be found in section 12.6.1.1.4 and SS10: Marine mammal underwater noise impact assessment.

CONSULTEE	COMMENT	RESPONSE
NatureScot	Any requirements for population modelling will be determined by the outputs from underwater noise modelling and will only apply to key species. Therefore, at the appropriate time, any requirements for population modelling should be discussed and agreed with NatureScot and Marine Scotland.	The approach to underwater noise modelling was circulated via email on 25th August 2022 with written confirmation received from NatureScot (email received 22nd September 2022) the Scottish Ministers via MS-LOT and MSS (letter dated 7th October 2022). Further clarification on the proposed population modelling approach and preliminary results were discussed with NatureScot during the Marine Mammal Consultee Meeting held on 22nd March 2023. NatureScot had no objections to the approach.
NatureScot	It is noted in Section 2.9.6.1 that the risk of injury will be assessed using agreed dual criteria. We advise that consideration of both instantaneous and accumulated Permanent Threshold Shift (PTS) is required, and that this is addressed using thresholds for impulsive and/or non-impulsive (relevant for the sound in question) as per Southall *et al*. (2019) and NMFS (2018). Instantaneous PTS should be provided as unweighted zero-to-peak SPL and will inform the choice of pre-piling mitigation methods. While accumulated PTS should be provided as weighted cumulative SEL and will inform any required assessment of population consequences.	Instantaneous and accumulated Permanent Threshold Shift (PTS) was considered for impulsive and non-impulsive noise sources, following Southall *et al*. (2019) and NMFS (2018). Instantaneous PTS was provided as unweighted zero-to-peak Sound Pressure Level (SPL) and accumulated PTS was provided as weighted cumulative SEL. See sections 12.6.1.1.1 and SS10: Marine mammal underwater noise impact assessment for more detail.
NatureScot	Cumulative impacts The approach to cumulative impacts assessment for marine mammal interests for HRA, EIA and EPS licensing requirements will also require agreement in advance of submission of the application.	The approach to cumulative impact assessment was discussed during the Marine Mammal Consultee Meeting held on 22nd March 2023 and additional developments which were suggested to be added to the list of developments has now been included during cumulative impact assessment. See section 12.7 and SS10: Marine mammal underwater noise impact assessment. Two additional projects suggested to be considered in the cumulative impact list were the Scapa Deepwater Quay (SDWQ) and the Meygen tidal project. A cumulative assessment for SDWQ is included in section 12.7. The Meygen tidal project is operational and has not been included. Details of

CONSULTEE	COMMENT	RESPONSE
		the Projects included for the cumulative impact assessment is detailed in SS9: Marine mammals underwater noise impact assessment.
NatureScot	Mitigation and monitoring Where impact pathways have been identified, we advise that the full range of mitigation techniques and published guidance is considered and discussed in the EIA Report. This should include the development of, and adherence to, a Marine Mammal Mitigation Protocol (MMMP).	An Outline MMMP (OP2: Outline Marine Mammal Mitigation Protocol) has been provided alongside this application and will be developed further and agreed in consultation with NatureScot and the Scottish Ministers via MS-LOT ahead of construction (including pre-construction). To ensure adherence to the MMMP, this will be a condition of the Section 36 Consent and/or Marine Licence.
NatureScot	Extensive discussions have been held by the [Forth & Tay Regional Advisory Group (FTRAG)] and [Moray Firth Regional Advisory Group (MFRAG)] marine mammal sub-groups regarding potential mitigation and monitoring methods in relation to underwater noise disturbance particularly as a result of pile-driving activity. We anticipate that the approach to noise mitigation will be informed by best available evidence. In addition, we recommend referring to our commissioned reports on noise abatement and entanglement, which may be helpful.	In assessing underwater noise impacts and any required noise mitigation, the best available evidence has been considered. This includes consideration of the suggested commissioned reports on noise abatement (Verfuss *et al.*, 2019). The report on entanglement (Benjamins *et al.*, 2014) was not required to be considered as floating WTGs have no longer been considered as part of the current consent application. For this current application, potential mitigation options and noise abatement were discussed during the Marine Mammal Consultee Meeting held on 22nd March 2023 and are detailed in OP2: Outline Marine Mammal Mitigation Protocol submitted with the application.
NatureScot	Transboundary impacts We agree transboundary impacts should be considered further.	Transboundary impacts have been considered in section 12.10.
Orkney Island Council (OIC)	The EIA will have to assess and address the likely effects on seals. Seals are vulnerable to disturbance when on land, and especially during the pupping season when pups risk becoming separated from their mothers. The search area includes a number of designated seal haulouts and grey sea pupping areas which can be viewed on the	The effects of the offshore Project on seals has been considered in this chapter.

CONSULTEE	COMMENT	RESPONSE
	National Marine Plan interactive map at https://marinescotland.atkinsgeospatial.com/nmpi/ Please note that some of these coincide with potential cable landfall sites, e.g., Murra and Green Head in Hoy and the north and east coast of Fara.	
Orkney Marine Mammal Research Initiative (OMMRI)	We broadly agree with the study area, but recommend two modifications: 1) Extend the study area boundary to 6 km around the OAA rather than 4km. This would aid the understanding of species within the range likely to cause a temporary threshold shift in harbour porpoise hearing (although it is noted this threshold varies by species).	Increasing area boundary by 2 km is unlikely to change the fundamental conclusions of the EIA when assessing marine mammal and megafauna species. Additionally, underwater noise impacts for marine mammals have been assessed against reference populations derived from regional study areas (detailed in section 12.4.1) which considers the wider densities and distributions of animals beyond the immediate study area.
OMMRI	We believe that the SCANS (I, II and III) data whilst providing a broadscale overview, is more limited in its usefulness at smaller scales, such as those being considered within this report. We therefore welcome the inclusion of fine scale data for informing the baseline.	We acknowledge the limitations of using SCANS data at smaller scales. Where there were sufficient data, density estimates have been calculated using site-specific DAS data, as summarised in Table 12-7 and SS9: Marine mammal and megafauna baseline report.
OMMRI	We do note that a number of the data sources cited could be considered out-of-date (although they are the most recent available) and may not provide the most reliable baseline. This is particularly true of harbour seals where abundance and presence is varying each year within the region.	Every effort has been made to use the most up to date data sources within assessment (section 12.4.2 and SS9: Marine mammal and megafauna baseline report). Baseline data sources have been discussed and agreed with NatureScot during the Marine Mammal Consultee Meetings held on 3rd August 2022, 3rd October 2022 and 22nd March 2023. IAMMWG (2022) have been used to provide reference populations for cetacean species, with SCOS (2021) providing the same for harbour and grey seals. Site-specific DAS data collected between 2020 and 2022 have also been used, in addition to Carter *et al.* (2022). SCOS (2021) and Carter *et al.* (2022) provide the most up-to-date data for harbour seals of relevance to the Project.

CONSULTEE	COMMENT	RESPONSE
OMMRI	More broadly, there is a general lack of verified historical data regarding the presence, distribution and abundance of cetaceans in Orkney waters – especially within the OAA. We therefore welcome the commencement of aerial surveys over the OAA to improve the level of data regarding presence and abundance. The comprehensiveness of this data would be improved by further incorporating the cable corridors, aiding the identification of appropriate mitigation measures.	Site-specific DAS were commissioned covering the OAA but not the offshore Export Cable Corridor (ECC), as pointed out. To characterise the baseline environment, other sources of data were additionally used which covered the offshore ECC to inform assessment, including Project specific environmental DNA (eDNA) analysis. A letter outlining the limited spatial coverage of PAM and the preferred approach using DAS data is submitted as part of within Appendix III of SS9: Marine mammal and megafauna baseline report. This approach has been agreed with NatureScot (Marine Mammal Consultee Meeting held on 3rd October 2022) and the Scottish Ministers via MS-LOT (letter dated 7th October 2022).
OMMRI	Strandings data, such as that held by the Scottish Marine Animal Stranding scheme can provide current (and historical) additional information regarding seasonality and species and presence. This is of particular relevance to cetaceans with climate change seeing species range extending northward.	This data are accessible and were considered, but did not provide any additional baseline information to what was already known regarding species at-sea distribution and abundance information for the offshore Project.
OMMRI	We note that the lack of specific details at this stage makes it difficult to comment [on suggested embedded mitigation measures]. For example, the piling strategy (Table 2-39, ref 2) gives examples of soft-start and ramp-up as mitigation but it is unclear as to which other mitigations, such as bubble curtains will be included in this strategy.	An Outline MMMP (OP2: Outline Marine Mammal Mitigation Protocol) has been provided alongside this application which further considers potential mitigation measures for marine mammals. This will be developed further and agreed in consultation with NatureScot and the Scottish Ministers via MS-LOT ahead of construction (including pre-construction). To ensure adherence to the MMMP, this will be a condition of the Section 36 Consent and/or Marine Licence.
OMMRI	As a general point of note, we feel strongly that the West of Orkney Windfarm should lead the way in upholding the highest standards in terms of sustainable development. We would therefore seek that the EIA identify and recommend appropriate current best	Consideration of mitigation methods utilised internationally have been considered and are presented within OP2: Outline Marine Mammal Mitigation Protocol.

CONSULTEE	COMMENT	RESPONSE
	practice in terms of mitigation – not simply the minimum required by law. This includes consideration of research undertaken outwith UK waters.	
OMMRI	We would also note that the identified mitigation should include measures to avoid impact as an initial starting point (for example, avoiding proximity to seal haul outs of cable landing) as well as including recommendations for ecological enhancements and funding for local NGOs that undertake marine biodiversity work within Orkney waters.	Consideration of mitigation methods utilised internationally have been considered and are presented within OP2: Outline Marine Mammal Mitigation Protocol and section 12.12. Proximity to seal haul outs is also presented in section 12.4.4.4.3. Recommendations for ecological enhancements and funding for local NGOs are not within the remit of a MMMP. Such considerations are strategic, and are covered broadly under the Scottish Biodiversity Action Plan, and locally by local Biodiversity Action Plans, for which there is one in place for Orkney (Local Biodiversity Action Plan (orkney.gov.uk)).
OMMRI	The associated impact of increased water turbidity during operation should also be considered, as there is evidence to suggest that increased vertical mixing increases phytoplankton production through the water column to greater depth.	As detailed in chapter 9: Water and sediment quality, the short-term and localised changes to turbidity associated with operational activities will not ultimately alter the water quality across the offshore Project area. Therefore the potential for impact on marine mammals from decreased marine water quality including increased turbidity during the operation and maintenance stage is not assessed within this chapter.
OMMRI	For the included impacts, the methods described are sufficient to inform the impact assessment if sufficiently detailed and comprehensive.	A detailed and comprehensive assessment has now been undertaken within this chapter.
OMMRI	We generally agree with the reasoning behind scoping out specific impacts. The only exception to this is 'noise related impacts during operation'. The potential impact of this type of noise should be quantified and assessed, specifically with reference to common minke whale and other baleen species. Habitat models of species distribution and peer reviewed literature should inform the assessment.	Noise related impacts to minke whales and humpback whales (as the baleen whale species scoped in for assessment, is in the same functional hearing group from Southall *et al.* (2019)) during operation has been assessed in section 12.6.2.1. Underwater noise modelling for operational

CONSULTEE	COMMENT	RESPONSE
		noise has been included in SS11: Underwater noise modelling report and has been considered in this assessment.
OMMRI	With regards to our area of knowledge, the general comments and procedures outlined in the Scoping Report are largely welcomed as both thorough and considered. We look forward to the data from the marine mammal survey programme being made publicly available in due course. Specifically, we would note that our own organisation is planning to survey and study the harbour porpoise aggregation off Flotta, once funding has been secured.	Noted.
OMMRI	As a general principle, we believe that sustainable development requires local voices to be heard and respected. We therefore welcome the inclusion of OMMRI as a key consultee for the marine mammals and megafauna impact assessment, as well as the inclusion of other locally based specialist organisations for other elements of the EIA.	Noted.

12.4 Baseline characterisation

This section outlines the current baseline for marine mammals and megafauna within the relevant offshore study area and the wider species-specific regional study areas (as defined below) to provide wider context. To understand the usage of marine mammals and megafauna within these areas, a desk-based review of available data has been undertaken. This review has been supplemented by site-specific DAS and visual and acoustic marine megafauna data collected during site-specific environmental and geophysical surveys. This review is presented in the following sections and detailed in SS9: Marine mammal and megafauna baseline report.

12.4.1 Study area

The marine mammal and megafauna offshore study area for marine mammal and megafauna receptors is defined as the Option Agreement Area (OAA) and 4 km buffer, in addition to a slight extension to the southeast, which also comprised the survey area for the most recent site-specific DAS (detailed in SS8: Digital video aerial survey methodology and marine mammal survey results, SS9: Marine mammal and megafauna baseline report and section 12.4.3.1); Figure 12-1. This area has been refined and reduced in size for the OAA as described in chapter 4: Site selection and consideration of alternatives. There is also potential for impact within the offshore ECC from construction and pre-construction activities.

As marine mammals and megafauna are highly mobile, it is also important to consider the wider area in which these animals range. Therefore, this assessment has also considered the ecology, distribution, and density/abundance of animals within a wider region for each species to understand the species on a broader regional scale. These species-specific 'regional study areas' are defined in the following paragraphs. This is also used to support the impact assessments where the expected ZoI extends beyond the offshore study area, such as for underwater noise.

For the most common cetacean species in UK waters, the IAMMWG have defined MUs which are based on the use of the area on a broad, regional-seas scale (IAMMWG, 2022; Figure 12-2). As advised by NatureScot (email communication 7th July 2023), the UK portion of the MU overlapping the offshore Project has been used to define the reference populations to inform the quantitative impact assessments for each cetacean species, where available (Figure 12-2; Table 12-5). For harbour porpoise, as the offshore Project lies on the boundary of two MUs, the regional study area for this species includes both of these MUs. Species-specific MUs have not been defined for humpback whales or killer whales, as these species range over wide areas across the North Atlantic and globally (Reid *et al.*, 2003), the regional study area has been limited to the distribution of these species within the United Kingdom Continental Shelf (UKCS).

For seals, the SCOS proposed Seal Management Units (SMUs) considers current biological knowledge, distance between major haul-outs, environmental conditions, the spatial structure of existing data, practical constraints on future data collection and management requirements (SCOS, 2021; Figure 12-3). The offshore Project is located within the North Coast and Orkney SMU for both harbour and grey seals, which has been used to define the seal regional study area and to inform density and abundance estimates. Telemetry data from harbour seal and grey seal from several studies (e.g. Graham *et al.*, 2017a; Russell *et al.*, 2017; Carter *et al.*, 2022) suggest there may be some connectivity with the wider area, as detailed in the marine mammal and megafauna baseline report (SS9: Marine mammal and megafauna baseline report).

There are no MUs defined for basking sharks, and individuals within UK waters are thought to belong to a single global population (Rigby *et al.*, 2021); the regional study area for basking sharks has been limited to the distribution of these species within the UKCS.

Seven Regional Management Units (RMUs) have been defined for leatherback turtle globally. The offshore Project is located within the Northwest Atlantic RMU, which extends from North and Central America to northern Europe and northern Africa (IUCN, 2010), and has been used to define the regional study area for this species. However, given the wide extent of this RMU, the regional study area for leatherback turtle has been limited to the distribution of these species within the UKCS.

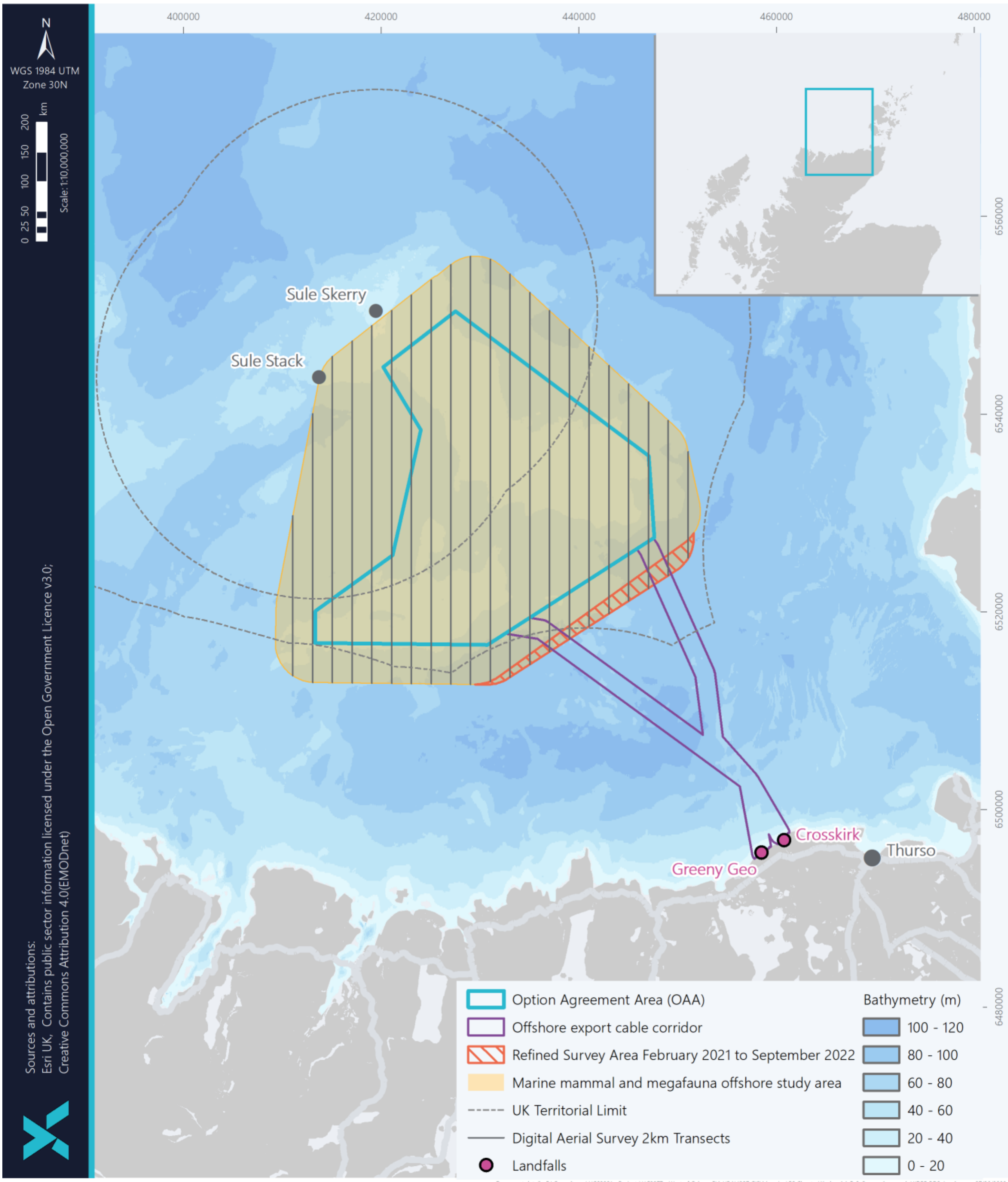

Figure 12-1 Marine mammal and megafauna offshore study area

Table 12-5 Summary of the species-specific regional study areas for each marine mammal and megafauna species

SPECIES	SPECIES-SPECIFIC REGIONAL STUDY AREAS	SOURCE
Cetaceans		
Harbour porpoise	West Scotland and North Sea MU	IAMMWG, 2022
White-beaked dolphin	Celtic and Greater North Seas (CGNS) MU	IAMMWG, 2022
Common dolphin	CGNS MU	IAMMWG, 2022
Risso's dolphin	CGNS MU	IAMMWG, 2022
Minke whale	CGNS MU	IAMMWG, 2022
Atlantic white-sided dolphin	CGNS MU	IAMMWG, 2022
Killer whale	UKCS	Reid *et al.*, 2003
Humpback whale	UKCS	Reid *et al.*, 2003
Pinnipeds		
Harbour seal	North Coast and Orkney Seal SMU	SCOS, 2021
Grey seal	North Coast and Orkney SMU	SCOS, 2021
Other megafauna		
Basking shark	UKCS	n/a*
Leatherback turtle	UKCS	n/a*

** Basking sharks are considered to be part of a global population, and leatherback turtle are part of the Northwest Atlantic RMU (IUCN, 2010), which extends from North and Central America to northern Europe and northern Africa. Therefore, the regional study area has been limited to the distribution of these species within the UKCS for this assessment.*

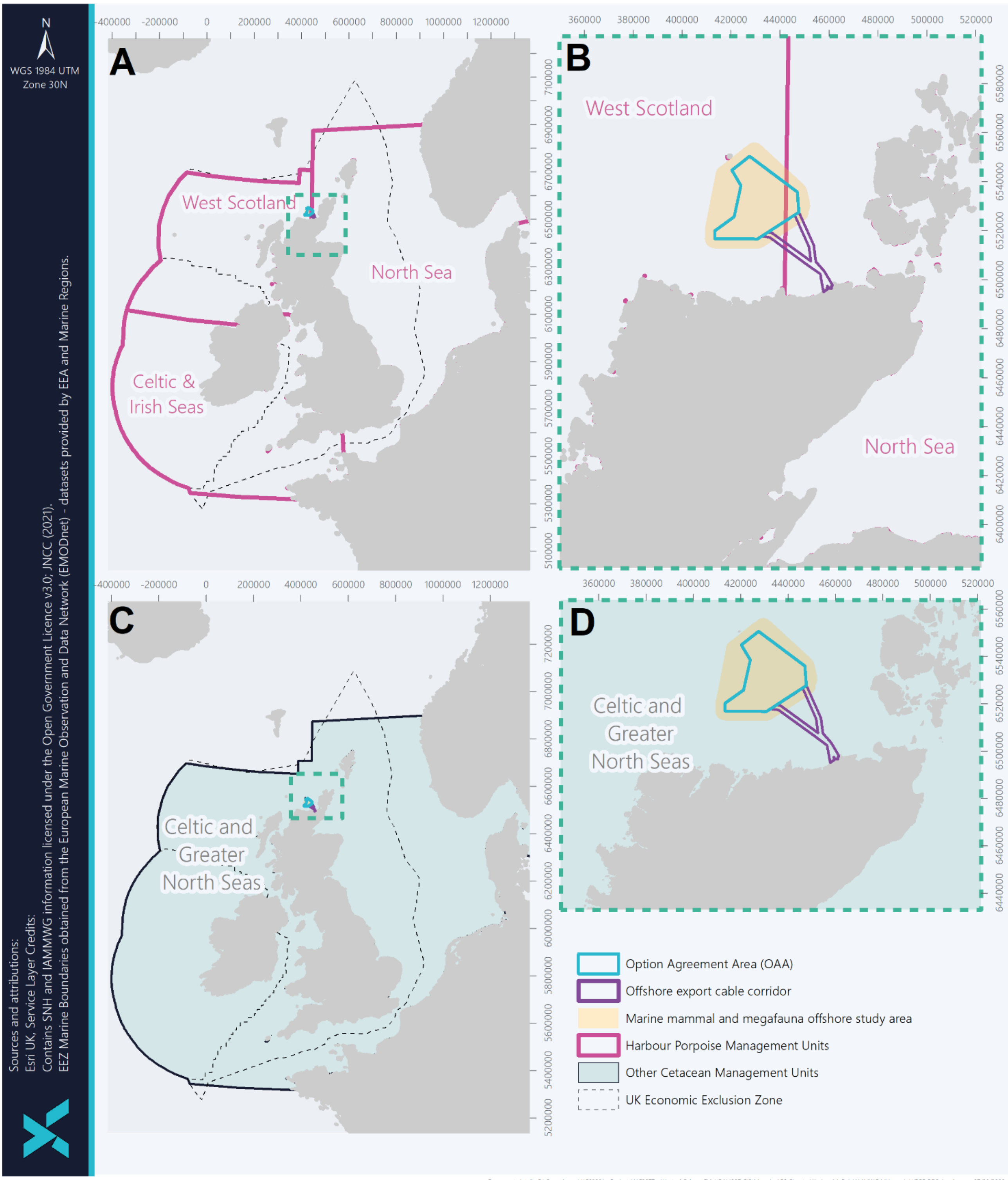

Figure 12-2 Species-specific regional study areas for harbour porpoise (A and B) and white-beaked dolphin, common dolphin, Risso's dolphin, minke whale and white-sided dolphin (C and D) using the IAMMWG (2022) marine mammal MUs

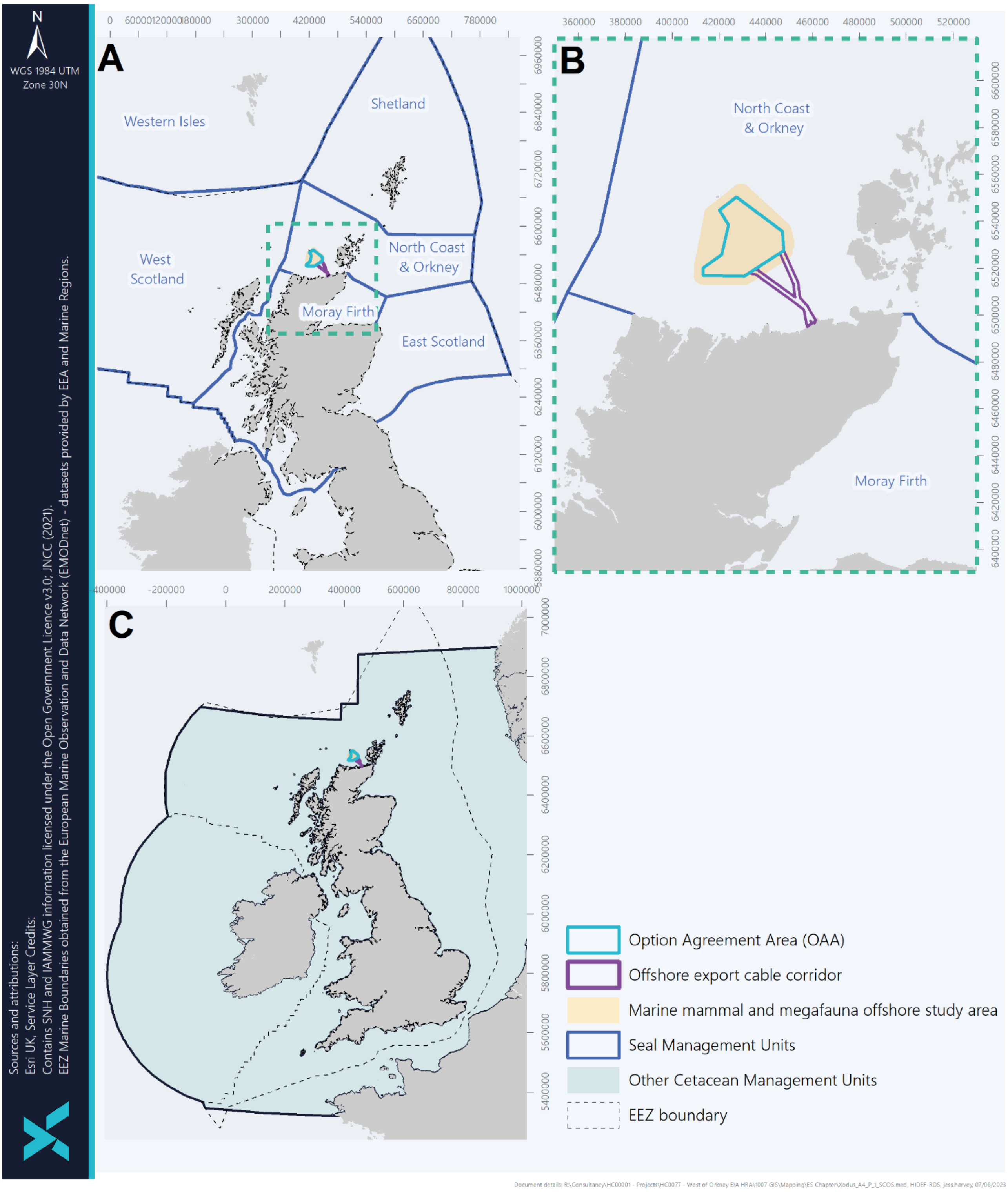

Figure 12-3 Species-specific regional study areas for harbour seal and grey seal (A and B; SCOS, 2021) and the UKCS I which has been used as the regional study area for killer whale, humpback whale, basking shark and leatherback turtle

12.4.2 Data sources

The existing data sets and literature relevant to the offshore Project and which have been used to inform the baseline characterisation for marine mammals and megafauna are outlined in Table 12-6.

Table 12-6 Summary of key datasets and reports

TITLE	SOURCE	YEAR	AUTHOR
Site-specific Digital Video Aerial Surveys of Seabirds and Marine Mammals at West of Orkney Windfarm from 2020 to 2022	OWPL	2022	HiDef (see SS8: Digital video aerial survey methodology and marine mammal survey results)
Digital Video Aerial Surveys of Seabirds and Marine Mammals at the Hexicon Dounreay Tri Project: Final Report / Pentland Floating Offshore Windfarm	Hexicon AB / Pentland Floating Offshore Windfarm Environmental Impact Assessment (EIAR)	2015 / 2020 – 2021	HiDef as cited in Smith *et al.* (2022)
Digital Video Aerial Surveys of Seabirds and Marine Mammals at the Highlands and Islands Dounreay Demonstration Centre Project	Highlands and Islands Enterprise (HIE)	2015 – 2016	HiDef as cited in Smith *et al.* (2022)
Abundance of Harbour Porpoise and Other Cetaceans in the North Sea and Adjacent Waters	https://besjournals.onlinelibrary.wiley.com/doi/full/10.1046/j.1365-2664.2002.00713.x	2002	Hammond *et al.*
Cetacean Abundance and Distribution in European Atlantic shelf Waters to Inform Conservation and Management	https://www.sciencedirect.com/science/article/pii/S0006320713001055	2013	Hammond *et al.*
Estimates of Cetacean Abundance in European Atlantic waters in Summer 2016 from the SCANS-III Aerial and Shipboard surveys	https://scans3.wp.st-andrews.ac.uk/files/2021/06/SCANS-III_design-based_estimates_final_report_revised_June_2021.pdf	2021	Hammond *et al.*
Modelled Density Surfaces of Cetaceans in European Atlantic waters in Summer 2016 from the SCANS-III Aerial and Shipboard Surveys	https://scans3.wp.st-andrews.ac.uk/files/2022/08/SCANS-III_density_surface_modelling_report_final_20220815.pdf	2022	Lacey *et al.*

TITLE	SOURCE	YEAR	AUTHOR
Abundance and Behaviour of Cetaceans and Basking Sharks in the Pentland Firth and Orkney Waters	https://www.nature.scot/doc/naturescot-research-report-419-abundance-and-behaviour-cetaceans-and-basking-sharks-pentland-firth	2011	Evans *et al.*
Distribution Maps of Cetacean and Seabird Populations in the North-East Atlantic	https://besjournals.onlinelibrary.wiley.com/doi/abs/10.1111/1365-2664.13525	2019	Waggitt *et al.*
Revised Phase III Data Analysis of Joint Cetacean Protocol Data Resources	https://data.jncc.gov.uk/data/01adfabd-e75f-48ba-9643-2d594983201e/JNCC-Report-517-FINAL-WEB.pdf	2016	Paxton *et al.*
Statistical Approaches to Aid the Identification of Marine Protected Areas for Minke whale, Risso's dolphin, White-beaked dolphin and Basking shark	https://www.nature.scot/sites/default/files/2017-11/Publication%202014%20-%20SNH%20Commissioned%20Report%20594%20-%20Statistical%20approaches%20to%20aid%20identification%20of%20Marine%20Protected%20Areas%20for%20Minke%20whale%2C%20Risso%27s%20dolphin%2C%20White-beaked%20dolphin%20and%20Basking%20shark.pdf	2014	Paxton *et al.*
JNCC Report 544: The Identification of Discrete and Persistent Areas of Relatively High Harbour Porpoise Density in the Wider UK Marine Area	https://hub.jncc.gov.uk/assets/f7450390-9a89-4986-8389-9bff5ea1978a	2015	Heinänen and Skov
Regional Baselines for Marine Mammal Knowledge Across the North Sea and Atlantic areas of Scottish Waters	https://data.marine.gov.scot/sites/default/files/Scottish%20Marine%20and%20Freshwater%20Science%20%28SMFS%29%20Vol%2011%20No%2012%20Regional%20baselines%20for%20marine%20mammal%	2020	Hague *et al.*

TITLE	SOURCE	YEAR	AUTHOR
	20knowledge%20across%20the%20North%20Sea%20and%20Atlantic%20areas%20of%20Scottish%20waters.pdf		
Updated Abundance Estimates for Cetacean Management Units in UK waters (Revised March 2022)	https://hub.jncc.gov.uk/assets/3a401204-aa46-43c8-85b8-5ae42cdd7ff3	2022	IAMMWG
Atlas of Cetacean Distribution in North-west European Waters	https://data.jncc.gov.uk/data/a5a51895-50a1-4cd8-8f9d-8e2512345adf/atlas-cetacean-distribution-web.pdf	2003	Reid *et al.*
Updated Seal Usage Maps: The Estimated at-sea Distribution of Grey and Harbour Seals	https://data.marine.gov.scot/sites/default/files/SMFS%200825.pdf	2017	Russell *et al.*
Aerial Surveys of Seals in Scotland During the Harbour Seal Moult, 2016–2019	https://www.nature.scot/doc/naturescot-research-report-1256-aerial-surveys-seals-scotland-during-harbour-seal-moult-2016-2019#:~:text=The%20total%20number%20of%20harbour%20seals%20counted%20in%20Scotland%20was,total%20overall%20(Table%202).	2021	Morris *et al.*
Habitat-based Predictions of At Sea Distribution for Grey and Harbour Seals in the British Isles	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/959723/SMRU_2020_Habitat-based_predictions_of_at-sea_distribution_for_grey_and_harbour_seals_in_the_British_Isles.pdf	2020	Carter *et al.*
Sympatric Seals, Satellite Tracking and Protected Areas: Habitat-Based Distribution Estimates for Conservation and Management	https://www.frontiersin.org/articles/10.3389/fmars.2022.875869/full	2022	Carter *et al.*

TITLE	SOURCE	YEAR	AUTHOR
Scientific Advice on Matters Related to the Management of Seal Populations: 2021 (as the most recent available report at the time of assessment)	http://www.smru.st-andrews.ac.uk/scos/scos-reports/	2021	SCOS
Basking Sharks in the Northeast Atlantic: Spatio-temporal Trends from Sightings in UK Waters	https://www.int-res.com/articles/meps2012/459/m459p121.pdf	2012	Witt *et al.*
Sectoral Marine Plan for Offshore Wind Energy – regional locational guidance	https://www.gov.scot/publications/sectoral-marine-plan-regional-locational-guidance/	2020	Scottish Government
Draft Orkney Islands Regional Marine Plan (consultation draft)	https://www.orkney.gov.uk/Files/Committees-and-Agendas/Development%20and%20Infrastructure/DI2022/DI08-11-2022/Item%2012%20%20Orkney%20Islands%20Regional%20Marine%20Plan%20Consultation%20Draft.pdf	2022	Orkney Islands Regional Marine Plan
Designated Sites	https://sitelink.nature.scot/home	Various	NatureScot
Scottish Marine Wildlife Watching Code (SMWWC)	https://www.nature.scot/doc/scottish-marine-wildlife-watching-code-smwwc	2017	NatureScot

12.4.3 Project site-specific surveys

12.4.3.1 Site-specific Digital Aerial Surveys (DAS)

HiDef undertook high-resolution video DAS on behalf of OWPL to inform baseline characterisation for seabirds, marine mammals and other megafauna in the offshore study area. Monthly surveys were undertaken between July 2020 and September 2022. The survey design comprised 2 km-spaced transects across the OAA and 4 km buffer, orientated approximately north to south and across depth gradients to reduce variation in animals associated with depth between transects (Figure 12-1). For surveys conducted from July 2020 to January 2021, the survey area was 1,290 km^2. As result of refinement of the OAA, from February 2021 to September 2022, the area was extended slightly to the southeast, resulting in a larger survey area of 1,321 km^2, as illustrated in Figure 12-1 and detailed in SS8: Digital video aerial survey methodology and marine mammal survey results.

It should be noted that, as density calculations (animals/km^2) account for the area surveyed, they are standardised and comparable between months for both density- and model-based estimates, despite the small extension of the surveyed area. Additionally for the model-based estimates, the model was fit to the larger, refined survey area (surveyed from February 2021 to September 2022) for all months, with the model able to extrapolate to the new boundary by predicting over the updated survey area and using observations recorded in the new boundary. Thus, the change in the surveyed area will not affect the validity of the density estimates used (Table 12-7).

12.4.3.2 Visual and acoustic data from environmental and geophysical surveys

Environmental and geophysical surveys were undertaken between 9th April and 24th September 2022 across the offshore Project. Throughout these surveys, Marine Mammal Observers (MMOs) (during environmental and geophysical surveys) and PAM operators (during geophysical surveys only) conducted visual and acoustic opportunistic surveys for marine mammals and megafauna as part of the survey mitigation plan. These opportunistic observations have been reported in the marine mammal and megafauna baseline, with encounter rates produced for each species, to indicate marine mammal and megafauna presence within the offshore Project and surrounding area (SS9: Marine mammal and megafauna baseline report). All cetacean species assessed within this Offshore EIA Report were recorded intermittently during environmental and geophysical surveys, supporting other data sources suggesting their presence in and around the offshore Project; see SS9: Marine mammal and megafauna baseline report for more information.

12.4.3.3 Mammal environmental DNA (eDNA) metabarcoding

Mammal eDNA metabarcoding was performed from water samples collected in the OAA and offshore ECC between 15th August and 13th September 2022 as part of the environmental survey scope. Two water samples, one near the sea surface and one near the seabed, were collected at 20 locations across the offshore Project area, giving a total of 40 samples. All 40 samples were analysed for the presence of vertebrates, nine of which yielded usable high-quality marine mammal data, while ten of the 40 samples yielded high quality vertebrate data. eDNA signals can be influenced by several factors such as the quantity and condition of sample, distance from sample origin and quality of the reference database. Therefore, this information has been used only to indicate species presence in the offshore Project and surrounding area. The results of the eDNA metabarcoding which are relevant to marine mammals and megafauna are presented in SS9: Marine mammal and megafauna baseline report.

12.4.3.4 Benthic and environmental surveys

The offshore benthic ecology survey included the use of grab sampling (primarily using 0.1 m^2 dual van Veen grabs, and 0.1 m^2 hamon grabs in areas of coarse sediment)), Drop Down Video (DDV) and video transects. These data have been reviewed to understand the macrofauna present within the area and to understand the potential suitability for spawning habitat for sandeel (*Ammodytes* spp.), herring (*Clupea harengus*), and flapper skate (*Dipturus intermedius*). This has been used in understanding the potential for indirect impacts to marine mammals through effects to their prey, with sandeel and herring being prey species for some marine mammal species.

12.4.4 Existing baseline

This section summarises the baseline environment in relation to marine mammal and megafauna receptors which may be found within the offshore Project. A review of literature and available data sources, augmented by consultation and offshore Project site-specific surveys has been undertaken to describe the current baseline environment for marine mammals and megafauna. Detailed characterisation of the baseline environment for marine mammals and megafauna is presented in SS9: Marine mammal and megafauna baseline report, which should be read in conjunction with this chapter. The baseline supporting study also provides further explanation behind density and abundance estimates which have been used in the impact assessment, possible caveats associated with the presented data sources and detailed information on density and abundance across the UKCS.

12.4.4.1 Marine mammals

Based on the available literature and site-specific surveys (SS9: Marine mammal and megafauna baseline report), harbour porpoise, white-beaked dolphin, common dolphin, Risso's dolphin, minke whale, grey seal, and harbour seal are likely to be present within and around the offshore Project. Density estimates which have been taken forward for these species in the quantitative impact assessment are presented in Table 12-7. Atlantic white-sided dolphin (hereafter white-sided dolphin), killer whale and humpback whale may also be present within the offshore Project. There are insufficient data to inform reference populations or densities within the offshore Project area for these species, so they have been assessed qualitatively. A summary of the methods used to obtain the site-specific DAS estimates, in addition to a summary of the available data taken forward for quantitative impact assessment is given for each species below.

Table 12-7 Species MUs, reference populations (UK MU abundance) and baseline density estimates for use in quantitative impact assessment

SPECIES	MANAGEMENT UNIT (MU)	MU ABUNDANCE (No. OF ANIMALS)	DENSITY ESTIMATE (ANIMALS/KM^2)	DENSITY ESTIMATE SOURCE
Harbour porpoise	UK portion of North Sea and West Scotland MUs	183,937 (IAMMWG, 2022)	0.15 (95% Confidence Interval (CI) 0.11 – 0.19)	Site-specific DAS (absolute model-based; overall average)
White-beaked dolphin	UK portion of CGNS MU	34,025 (IAMMWG, 2022)	0.19 (95% CI 0.09 – 0.32)	Site-specific DAS (absolute model-based; summer average)
Common dolphin	UK portion of CGNS MU	57,417 (IAMMWG, 2022)	0.01 (95% CI 0.00 – 0.02)	Site-specific DAS (relative design-based; overall average)

SPECIES	MANAGEMENT UNIT (MU)	MU ABUNDANCE (No. OF ANIMALS)	DENSITY ESTIMATE (ANIMALS/KM^2)	DENSITY ESTIMATE SOURCE
Risso's dolphin	UK portion of CGNS MU	8,687 (IAMMWG, 2022)	0.0135 (0.763 CV)	SCANS-III survey block K (Hammond *et al.*, 2021)
Minke whale	UK portion of CGNS MU	10,288 (IAMMWG, 2022)	0.01 (0.26 CV)	SCANS-III survey block S (Hammond *et al.*, 2021)
Harbour seal	North Coast and Orkney SMU	1,951 (SCOS, 2021)	0.009 (95% CI 0.003 – 0.023)*	Carter *et al.* (2022)
Grey seal	North Coast and Orkney SMU	34,191 (SCOS, 2021)	0.581 (95% CI 0.162 – 1.227)*	Carter *et al.* (2022)

***Represents extracted density for OAA + ECC. Actual mean density in the impacted area will vary depending on the grid cells that are extracted from the density surface within the impact area boundary (Carter *et al.*, 2022).**

Harbour porpoise are the most abundant cetacean in UK waters and are widely distributed on the UKCS and occur year-round (Hammond *et al.*, 2021). They occur as single animals or in small groups and feed on a variety of fish including gadoids and clupeoids (Leopold, 2015). There are two MUs for harbour porpoise of relevance to the offshore Project: the North Sea MU and West Scotland MU (IAMMWG, 2022). Since the offshore Project lies on the boundary of these two MUs, NatureScot advised (advice received 10th October 2022) that the reference population would be derived from the sum of both abundance estimates from each MU (UK portion). Harbour porpoise was the most frequently recorded species during site-specific DAS (125 total records), with an average absolute density for the full survey period of 0.15 animals/km^2 (95% CI 0.11 – 0.19). Seasonal variation in abundance from DAS was observed. The average density estimate from SCANS-III surveys for blocks K and S (the SCANS blocks of relevance to the offshore Project) was 0.230 animals/km^2 (Hammond *et al.*, 2021). Although these are slightly higher than from DAS, SCANS surveys are only performed during summer months, so site-specific estimates are expected to be more representative and have been used during quantitative impact assessment.

White-beaked dolphins are one of the more common cetacean species recorded around the UK (IAMMWG, 2022), and typically favour shallow (e.g. <200 m) continental shelf waters (Northridge *et al.*, 1997). Feeding on a variety of fish species including mackerel (*Scombrini scombrus*) and herring (Reeves *et al.*, 1999), they generally occur in small groups although larger aggregations of animals have been recorded, predominately further offshore. White-beaked dolphins are managed within a single MU (CGNS); the abundance for the UK portion of the MU is 34,025 (0.28 CV) animals. Recorded relatively frequently during DAS (100 total records; particularly during winter months), the average absolute density was estimated at 0.39 animals/km^2. Observed differences in derived estimates between seasons and survey years suggest high seasonal and interannual variation in abundance (SS9: Marine mammal and megafauna baseline report). It is anticipated that construction of the offshore Project (the Project stage which is most likely to adversely affect white-beaked dolphins), and in particular, piling of WTG foundations, will occur over the summer period, when environmental conditions will generally be more favourable. Considering this and the observed seasonal variation in abundance, the average model-based density for the summer period (0.19 animals/km^2) has been taken forward for use during quantitative impact assessment.

Found both coastally and in deeper offshore waters (Murphy *et al.*, 2013), common dolphins feed on a variety of prey including sardine (*Sardina* spp.) and anchovy (*Engraulis* spp.). The UK population is primarily concentrated in the southwest; however, in recent years, sightings in the north and east of Scotland have been increasing (Evans, 2008; Robinson *et al.*, 2010). The estimated abundance for common dolphins in the UK portion of the CGNS MU is 57,417 (0.32 CV) animals (IAMMWG, 2022). The species was not recorded in the relevant survey blocks during SCANS-III surveys and were recorded infrequently during DAS. Although IAMMWG (2022) provide estimates of abundance it is likely these are not representative of the offshore Project, as the entire UK is considered, and estimates will likely be predominately driven by high common dolphin abundance off the southwest UK. Considering high temporal coverage of seasons from DAS and no estimates of relevance from SCANS-III, relative density estimates from DAS (0.01 animals/km^2) have been used in quantitative impact assessment. No correction for animals submerged at the time of the survey could be applied, due to the lack of data on species-specific diving rates, so these are likely to be underestimating abundance to some extent.

Risso's dolphins generally occur in relatively deep offshore waters around the continental shelf edge, such as off the Hebrides and in the Irish Sea (Jefferson *et al.*, 2013). They occur in small groups of up to ten individuals and typically prey on cephalopod species (Cockroft *et al.*, 1993; Hartman *et al.*, 2008). Risso's dolphins were rarely recorded during site-specific DAS, although seasonal variation in abundance was observed, supported by Paxton *et al.* (2016); SCANS-III surveys of block K gave a density estimate of 0.0135 animals/km^2 (Hammond *et al.*, 2021). The species is managed within the CGNS MU, with the UK portion estimated to support 8,687 (0.63 CV) animals, equating to a density of 0.01 animals/km^2 (IAMMWG, 2022), although this estimate is derived from densities throughout the entire MU. The SCANS-III density estimate (0.0135 animals/km^2) is likely to be more relevant to the offshore Project and therefore has been used during quantitative impact assessment.

The most common whale species in UK waters, minke whales (Reid *et al.*, 2003), are found throughout the UK, typically in relatively shallow and coastal areas (Anderwald *et al.*, 2012). Feeding on small shoaling species and euphasiids, they are generally sighted alone or in pairs. Similar to the latter three species, minke whales are also managed within the CGNS MU; abundance for the UK portion of the MU is estimated at 10,288 (0.26 CV) animals (IAMMWG, 2022). Density estimates from the CGNS MU and summer estimates from DAS and SCANS-III were similar (0.01, 0.01, 0.0095 animals/km^2 respectively). Considering this, the SCANS-III density estimate has been used during quantitative impact assessment, as these estimates are corrected for animals submerged at the time of the survey and are spatially relevant to the offshore Project.

There are two resident seal species found in the UK. Harbour seals, which feed on a range of prey including crustacean and fish species, are mainly concentrated in Scotland while grey seals are more widespread (SCOS, 2021). Grey seals feed throughout continental shelf waters and will travel large distances in search of prey. Abundance of harbour and grey seals was considered within the North Coast and Orkney SMU (SCOS, 2021). No harbour seals were recorded during site-specific DAS, although an abundance of 1,951 seals was estimated from haul-out data within the North Coast and Orkney SMU (SCOS, 2021). At-sea density from tagged harbour seals was estimated for the offshore Project at 0.009 animals/km^2 (95% CI 0.003 – 0.023; Carter *et al.*, 2022); these data have been used during quantitative impact assessment, with predicted percentage at-sea distribution maps from Carter *et al.* (2022) presented in SS9: Marine mammal and megafauna baseline report. Grey seals were more abundant than harbour seals. Site-specific DAS recorded a maximum density estimate of 0.07 animals/km^2 (October 2021) while SCOS estimate 34,191 individuals are likely to be present within the North Coast and Orkney SMU. The at-sea density calculated for the offshore Project was estimated at 0.581 animals/km^2 (95% CI 0.162 – 1.227; Carter *et al.*, 2022), which have been used during quantitative impact assessment, with predicted percentage at-sea distribution maps from Carter *et al.* (2022) presented in SS9: Marine mammal and megafauna baseline report.

Commonly seen in small groups of up to ten individuals in the UK, white-sided dolphins are generally found in deeper waters (Evans *et al.*, 2011), feeding on pelagic prey such as herring and mackerel (Reeves *et al.*, 1999). White-sided dolphins may be present intermittently within the offshore Project. However, no individuals were recorded during site-specific DAS or SCANS-III surveys of the relevant SCANS blocks and the only available estimate of density was derived from the entire UK portion of the CGNS MU (0.02 animals/km; IAMMWG, 2022). Considering the relatively low absolute density of white-sided dolphins estimated from IAMMWG (2022) and lack of spatially relevant estimates for this species in other presented data sources, white-sided dolphin will not be included in quantitative impact assessment and will instead be considered qualitatively.

There are no recognised reference populations for killer whales or humpback whales in the UK, and no estimates of density and abundance of relevance to the offshore Project which could be used to inform a quantitative impact assessment. Therefore, any potential impacts have also been assessed qualitatively. More detail is provided in SS9: Marine mammal and megafauna baseline report.

12.4.4.2 Sharks and sea turtles

Generally distributed along the west coast of the UK, basking sharks migrate to Scottish waters for the summer and early autumn. Basking sharks are the only shark species recorded within the offshore Project area. Five individuals were recorded during site-specific DAS, recorded in spring, summer and autumn (peak relative density September 2022, 0.01 animals/km^2). Peak sightings in Pentland Firth and Orkney waters were recorded in summer and early autumn by Evans *et al.* (2011), although compared to other parts of Scotland (e.g., west coast), density is likely to be relatively low in the vicinity of the offshore Project. Due to insufficient data, the species will not be considered during quantitative impact assessment and will instead be assessed qualitatively.

Of the five species of sea turtle which have been recorded in the UK, leatherback turtles are the most frequently recorded in UK waters. However, as highlighted in SS9: Marine mammal and megafauna baseline report, they are likely to be rare within the offshore Project, with most sightings and strandings occurring on the west coast of the UK (Botterell *et al.*, 2020). No sea turtles were recorded during the site-specific DAS, and less than ten leatherback turtles were sighted, stranded or incidentally captured off the north coast of mainland Scotland between 1910 and 2018 (Botterell *et al.*, 2020).

12.4.4.3 Conservation importance

The importance of ecological features is dependent upon their biodiversity, social, and economic value within a geographic framework of appropriate reference (CIEEM, 2019). The biodiversity and conservation importance of marine mammals and megafauna is recognised through international and/or national legislation. As detailed in section 12.2, marine mammals and megafauna are protected through legislation in Scotland and the UK throughout their range and within designated sites, such as SACs, NCMPAs and designated seal haul-outs. Relevant legislation/conservation plans for marine mammals and megafauna identified through the baseline study (SS9: Marine mammal and megafauna baseline report) are summarised in Table 12-8.

Table 12-8 Summary of legislation and conservation relevant to the protection of marine mammals and megafauna considered in this chapter

SPECIES	VALUE	ANNEX II SPECIES	EUROPEAN PROTECTED SPECIES	ANNEX V SPECIES	OSPAR LISTED SPECIES	SCOTTISH PMF	IUCN* RED LIST
Harbour porpoise	International	✓	✓		✓	✓	Least concern
White-beaked dolphin	International		✓			✓	Least concern
Common dolphin	International		✓			✓	Least concern
Risso's dolphin	International		✓			✓	Least concern
Minke whale	International		✓			✓	Least concern
Harbour seal	International	✓		✓		✓	Least concern
Grey seal	International	✓		✓		✓	Least concern
Basking sharks	National					✓	Endangered
Leatherback turtle	International	✓	✓				Vulnerable
*International Union for Conservation of Nature							

The most recent assessment of conservation status, undertaken by JNCC in 2019 under the requirements of Article 17 of the Habitats Directive, concluded that the conservation status was 'unknown' for all assessed cetacean species, due to a lack of data to inform an assessment of population trends (Table 12-9; JNCC, 2019). Grey seals were the only marine mammal and megafauna species of interest listed as having a 'favourable' conservation status, with harbour seals listed as 'Unfavourable – Inadequate'.

Table 12-9 Conservation status of key marine mammal species of interest to the offshore Project (JNCC, 2019)

SPECIES	RANGE	POPULATION	HABITAT	FUTURE PROSPECTS	CONSERVATION STATUS	OVERALL TREND
Harbour porpoise	Favourable	Unknown	Unknown	Favourable	Unknown	Unknown
White-beaked dolphin	Favourable	Unknown	Unknown	Unknown	Unknown	Unknown
Common dolphin	Favourable	Unknown	Unknown	Unknown	Unknown	Unknown
Risso's dolphin	Favourable	Unknown	Unknown	Unknown	Unknown	Unknown
Minke whale	Favourable	Unknown	Unknown	Unknown	Unknown	Unknown
White-sided dolphin	Favourable	Unknown	Unknown	Unknown	Unknown	Unknown
Killer whale	Favourable	Unknown	Unknown	Unknown	Unknown	Unknown
Humpback whale	Favourable	Unknown	Unknown	Unknown	Unknown	Unknown
Harbour seal	Favourable	Unfavourable – Inadequate	Unknown	Unfavourable – Inadequate	Unfavourable – Inadequate	Unknown
Grey seal	Favourable	Favourable	Favourable	Favourable	Favourable	Improving

12.4.4.4 Designated sites with marine mammal and megafauna features

12.4.4.4.1 Special Areas of Conservation (SACs)

There are three SACs in the UK national site network which are within the UK portion of North Sea and West Scotland MUs and have harbour porpoise as a qualifying feature (Table 12-10; Figure 12-4). An additional 27 transboundary SACs designated for harbour porpoise were identified within the species-specific regional study area (a full list of these sites is available in Figure 12-4 and in the Offshore HRA Screening Report; OWPL, 2022). Whilst harbour porpoise within the MUs may use these sites, their distance from the offshore Project reduces the potential for negative effects to the conservation objectives of each of the sites. Additionally, given the distance of these SACs from the offshore Project, it is unlikely the offshore Project will constitute a particularly important area or foraging ground for harbour porpoise using these SACs. Therefore, all SACs with harbour porpoise as a qualifying feature were screened out of further assessment during the HRA screening process (as is consistent with the feedback on the HRA Screening Report; MS-LOT, 2022a).

Bottlenose dolphin were scoped out of the assessment following advice from NatureScot, based on there being very few sightings of the species on the north coast of Scotland or around Orkney, and no evidence of connectivity of individuals to Moray Firth SAC (NatureScot *pers comm*, email received 7th July 2022). Therefore, no SACs designated for bottlenose dolphin have been considered.

As per the Scoping Opinion received on 29th June 2022, only SACs designated for harbour seal within 50 km, and grey seal within 20 km of the offshore Project were screened in for consideration in the HRA assessment. All SACs with harbour seal or grey seal qualifying interest features are outside of this range, with the closest site for grey seal at 70.1 km (Faray and Holm of Faray SAC) and for harbour seal at 85.5 km (Sanday SAC) from the offshore Project. Therefore, all SACs designated for harbour seal and grey seal were screened out of further assessment during the HRA process (as is consistent with the feedback on the HRA Screening Report; MS-LOT, 2022a).

Full details of the HRA process for all Annex II marine mammal species are available in the Offshore HRA Screening Report (OWPL, 2022). Noting that marine mammals were screened out of further assessment within the Offshore RIAA.

Table 12-10 Summary of the designated sites designated for marine mammals within the UK national site network

SITE NAME	NEAREST DISTANCE TO OFFSHORE PROJECT (KM)	SITE DETAILS	CORRESPONDING NUMBER IN FIGURE 12-4
Inner Hebrides and the Minches SAC	93.9	• Highest densities of harbour porpoise in Scotland, occurring in the summer months; and • Only harbour porpoise Marine Protected Area (MPA) in Scotland, estimated to support approximately 32% of the Scottish west coast harbour porpoise population (NatureScot, 2020a).	1
Skerries and Causeway SAC	453.3	• Supports a local population of harbour porpoise which are resident throughout the year (DAERA, 2017).	2
Southern North Sea SAC	491.3	• Supports approximately 17.5% of the UK harbour porpoise population (JNCC, 2021).	3

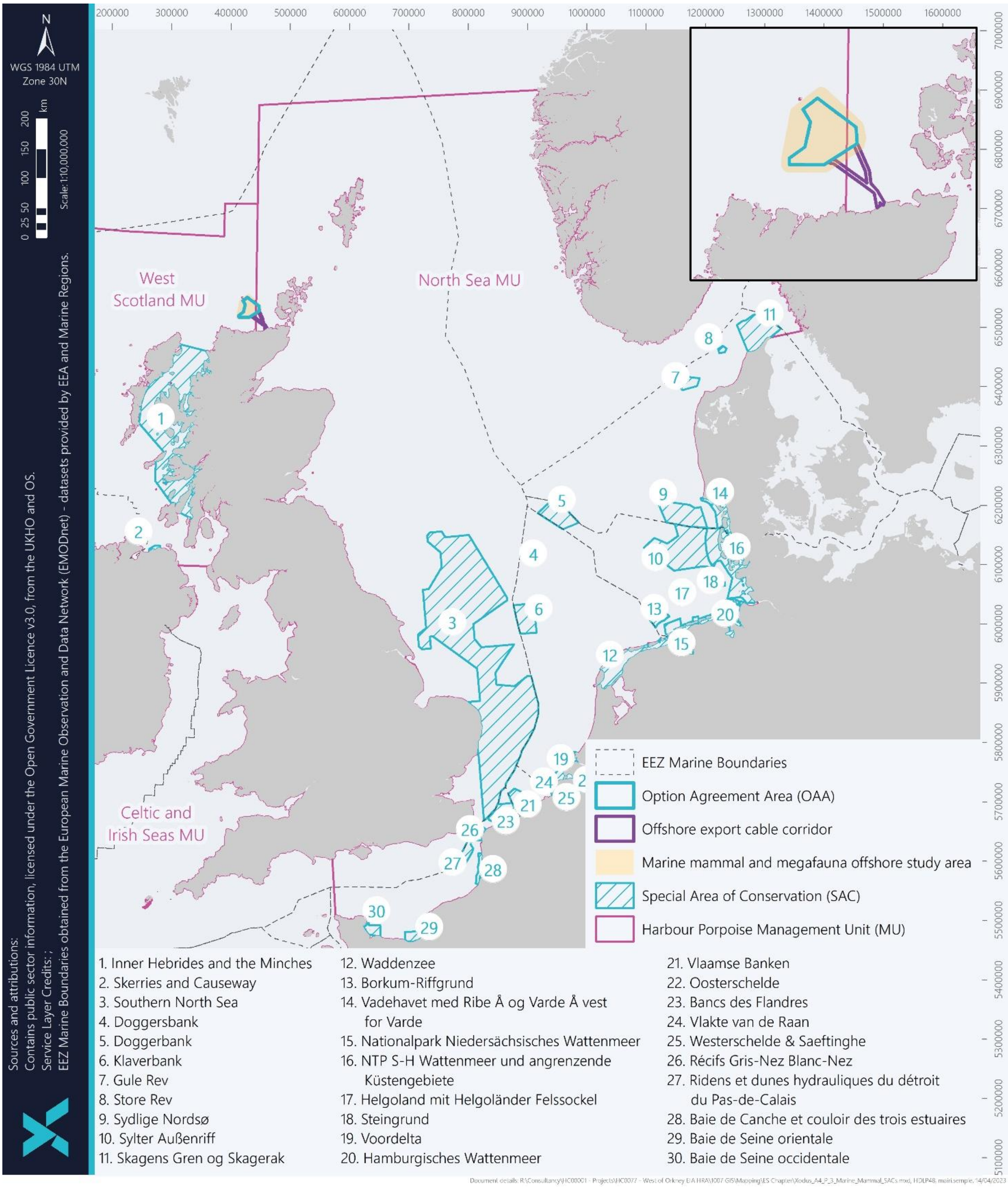

Figure 12-4 Location of SACs designated for harbour porpoise with potential connectivity to the offshore Project

12.4.4.4.2 Nature Conservation Marine Protected Areas (NCMPAs)

There are three NCMPAs designated for marine mammal and megafauna features located in Scottish waters which are within the relevant species-specific regional study areas (Table 12-11; Figure 12-5). None of these NCMPAs are directly overlapping the offshore Project or are within the worst case ZoI (determined by the underwater noise modelling; SS11: Underwater noise modelling report) from the offshore Project. Therefore, whilst these NCMPAs are within the species-specific regional study areas, further assessment is not required as there is no direct overlap between the ZoI and the offshore Project and they have not been considered further in this report.

Table 12-11 NCMPAs with marine mammal and/or megafauna protected features within Scottish waters

NCMPA	RELEVANT PROTECTED FEATURES	APPROXIMATE AT-SEA DISTANCE TO OFFSHORE PROJECT (KM)	SITE DETAILS
North-East Lewis NCMPA	• Risso's dolphin	88	• One of two locations in the UK where Risso's dolphin of all age classes are recorded in high densities (NatureScot, 2020b); and • Recorded across the site throughout the year, with increased numbers between May and October (Weir *et al.*, 2019).
Southern Trench NCMPA	• Minke whale	200	• Summer feeding hotspot for minke whale with highest densities from June to October, although present throughout the year (Robinson *et al.*, 2009); and • Oceanic fronts also protected by the NCMPA enhance primary productivity and prey availability for minke whale (NatureScot, 2020c).
Sea of the Hebrides NCMPA	• Minke whale; and • Basking shark	132	• Summer feeding hotspot for minke whale with highest densities in late summer months, although present throughout the year (Anderwald and Evans 2007, Paxton *et al.*, 2014); • Basking shark observed in high densities between June and October during feeding, courtship and potentially breeding (Speedie *et al.*, 2009, Doherty *et al.*, 2017); and • Oceanic fronts also protected by the NCMPA enhance primary productivity and prey availability for minke whale and basking shark (NatureScot, 2020d).

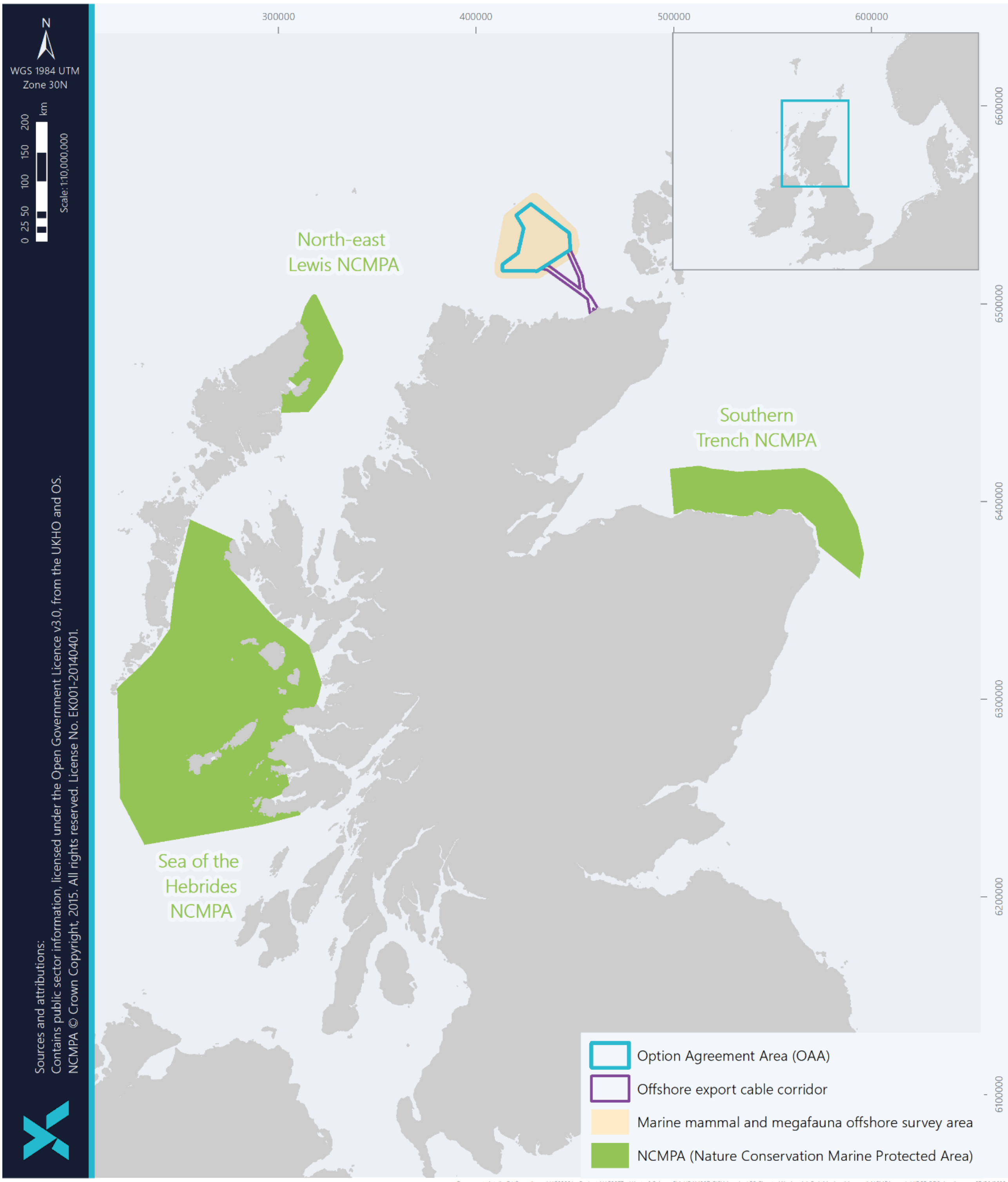

Figure 12-5 NCMPAs with marine mammal and/or megafauna protected features in relation to the offshore Project

12.4.4.4.3 Designated seal haul-out sites

Under Section 117 of the Marine (Scotland) Act 2010, the Scottish Government has identified and designated haul-out sites for harbour seals and grey seals, where seals come ashore to rest, moult or breed. This legislation provides additional protection for seals from intentional or reckless harassment at these sites. There are 195 designated haul-out sites, 45 of which are specified as breeding colony haul-out sites for grey seal.

The closest seal haul-out sites to the offshore Project are Sule Skerry grey seal breeding colony (4.6 km northwest of the boundary of the OAA), Loch Eriboll and Whiten Head (20.2 km southwest of the OAA), Eilean nan Ron grey seal breeding colony (24.3 km south of the OAA), Eilean Hoan (24.4 km southwest of the OAA) and Gills Bay (27.8 km east of the landfall) (Figure 12-6). There are no seal haul-out sites within 20 km of the proposed landfall site, where the greatest risk of disturbance or harassment to hauled out seals from the offshore Project would exist. Whilst Sule Skerry haul-out site is closer, there is unlikely to be any significant adverse impacts from the offshore Project to hauled-out seals at this distance. Therefore, there is a negligible risk of a reckless harassment offence being committed under Section 117, from the offshore construction (including pre-construction) and decommissioning or operation and maintenance activities at these haul-out sites, and hauled-out seals, including designated seal haul-out sites, have been screened out of further assessment.

Several Sites of Special Scientific Interest (SSSIs) also overlap with the larger designated haul-outs in Orkney: Selwick, Eynhallow, Switha, Muckle Green Holm, and Little Green Holm. However, all of these SSSIs are located more than 30 km from the offshore Project, which limits the potential for interaction with seals associated with these sites, as the at-sea density of seals declines with increasing distance from their haul-out (Jones *et al*., 2013, Russell *et al*., 2017). Therefore, given the distance of the offshore Project to these SSSIs, they have been screened out of further assessment.

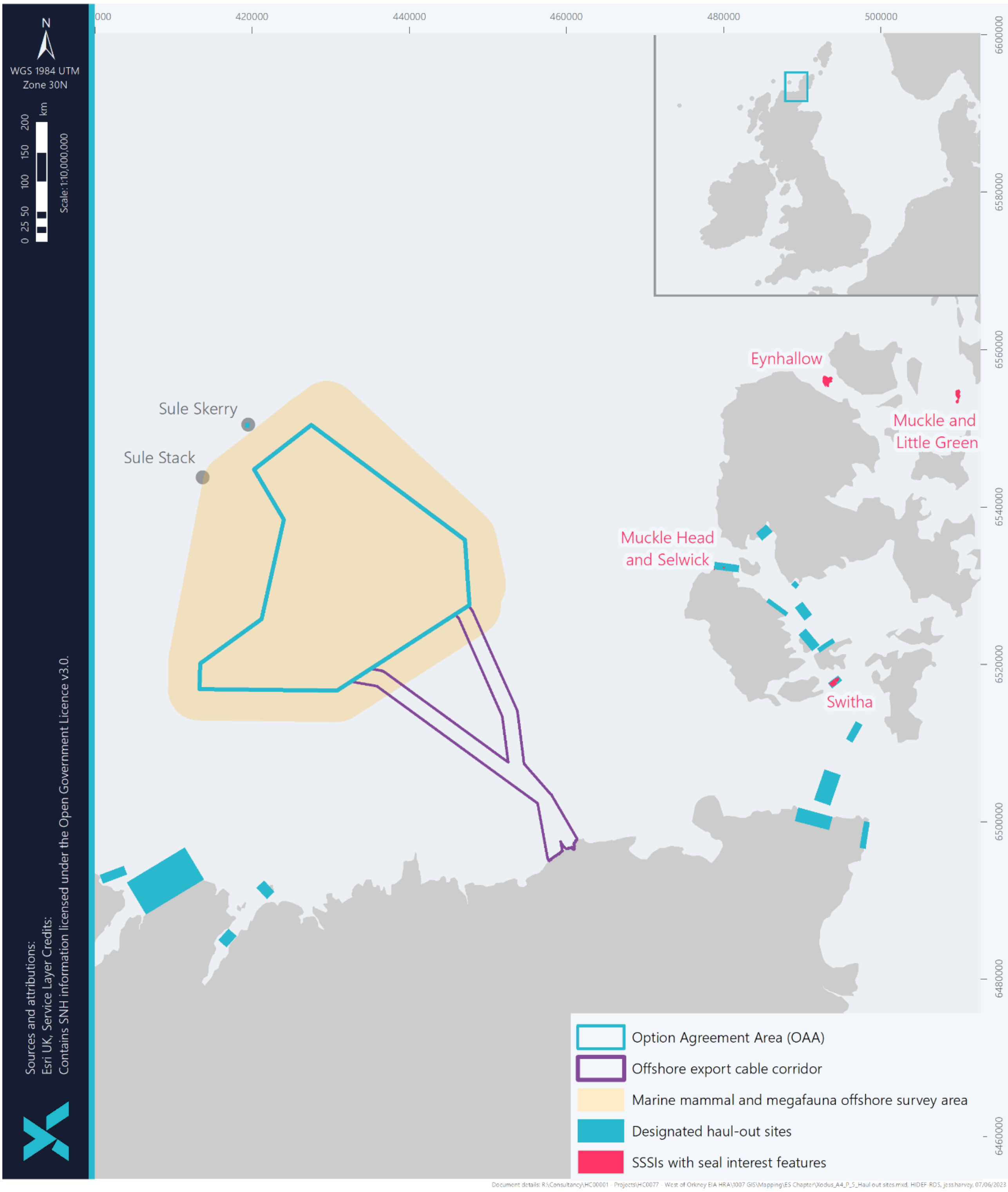

Figure 12-6 Seal designated haul-out sites and SSSIs with seal interest features in relation to the offshore Project

12.4.5 Future baseline

The abundance and distribution of marine mammals and megafauna changes in response to small scale and larger scale environmental and anthropogenic pressures (Avila *et al.*, 2018). These include competition for resource, between species and with commercial fisheries, direct mortality through incidental take in commercial fisheries, broad-scale habitat change, coastal development, and climate change.

Wide-scale changes in marine mammal and megafauna distribution and abundance are often correlated with influences on their prey, with prey availability likely to continue being a significant factor in the future baseline of these species. For example, regional shifts in fish to deeper and colder waters which may result from increasing sea surface temperature, or changes in commercial fishing patterns, may result in changed availability of prey for marine mammal and megafauna species (BEIS, 2022). The baseline and future baseline for a number of prey species is further described in chapter 11: Fish and shellfish ecology.

Ocean temperatures are anticipated to continue increasing across Scotland and the wider UKCS in response to climate change (Hughes *et al*., 2018; Tinker and Howes, 2020). Albouy *et al*. (2020) carried out an assessment of the vulnerability of all marine mammal species to global warming based on traits such as range and habitat and diet specialisation and produced a ranked list of species by vulnerability to climate change effects. White beaked dolphin (14), grey seal (16), harbour porpoise (18) and harbour seal (20) were ranked within the top twenty most vulnerable species of marine mammals to climate change extinction risk.

The Orkney region has seen increases in fish that are typically found in warmer waters, as well as changes in the timing of zooplankton and fish spawning, all of which may have significant effects on resource competition, the presence of, and foraging success of marine mammals and megafauna within the species-specific regional study areas (Mitchell *et al*., 2018). The ranges of some species may change as a result, with northward shifts seen in several warm-water species like short-beaked common dolphins (Evans and Waggitt, 2020). Renewable energy developments such as the offshore Project aim to mitigate the effects of climate change by reducing the greenhouse gas emissions that affect sea surface temperature and the resultant faunal communities present in the region.

Monitoring of marine mammal and megafauna species, with the exception of seals, is insufficient to inform population trends at the scale of each species-specific regional study area. Across the UK, SCANS-III estimated a slight decline in harbour porpoise (1.8%; CV 0.18), white-beaked dolphin (5%; CV 0.36) and minke whale (0.5%; CV 0.3) between 1994 and 2016, whereas comparison of the abundance between the 2005/07 and 2016 surveys suggests that common dolphin populations have increased (Hammond *et al.*, 2021). There is limited information about the trends of Risso's dolphin, killer whale, white-sided dolphin, humpback whale, basking shark and turtles due to their relatively low occurrence. However, as they are relatively rare within their respective study areas, it is not expected that their populations will increase significantly throughout the lifetime of the Project.

For harbour and grey seals, it is likely that the current population trends observed over the last 20 years will continue for the immediate future. Significant declines in harbour seal populations within the North Coast and Orkney SMU have been almost consistently observed since 2001 (Thompson *et al*., 2019). The declining trend is not significant across all of the UK; for example, in 1996-1997 the West Scotland SMU and Orkney and North Coast SMU had 27% of the UK population, whereas now those numbers sit at 50% and 4% respectively. It is likely that ingestion of toxins is contributing to the decline of harbour seals as well as prey quality and availability, competition for food and predation resulting in reduced survival for adults and possibly pups (SCOS, 2021). Grey seal pup production has remained stable since 2000 in the same area, and populations are estimated to be increasing overall across the UK, although estimates indicate that some SAC colonies close to the offshore Project (e.g. Faray and Holm of Faray SAC) may be in decline (SCOS, 2021).

Future research, for example into evidence gaps identified through the Scottish Marine Energy Research (ScotMER) Evidence Map for the marine mammals receptor group (Scottish Government, 2023), may improve our understanding of how marine mammal populations will change and respond to environmental changes in the future. However, at this time, due to the complexity of both environmental and anthropogenic pressures on marine mammals and megafauna, and the interactions between them, it is not possible to predict accurately how the distribution and abundance of these species will change over the lifecycle of the Project. However, observed trends to date may continue during this timeframe.

12.4.6 Summary and key issues

Through the SS9: Marine mammal and megafauna baseline report, site-specific DAS and the Scoping Opinion, the following key sensitive receptors have been identified which may occur within the offshore Project, and have been taken forward for assessment:

- Harbour porpoise;
- White beaked dolphin;
- Common dolphin;
- Risso's dolphin;
- Minke whale;
- White-sided dolphin;
- Killer whale;
- Humpback whale;
- Harbour seal;
- Grey seal; and
- Basking shark.

Due to the rare occurrence of sea turtles, including leatherback turtles, within the offshore Project (as described in section 12.4.4.2), these species have been scoped out and are not considered further within this assessment. Therefore, from hereon we refer to basking sharks as the only megafauna species to be assessed.

Table 12-12 Summary and key issues for marine mammals and megafauna

	OFFSHORE PROJECT AREA
Summary and Key Issues	• Several cetacean species may be present within the offshore Project area, all of which are protected as EPS, amongst other national legislation (section 12.2); • Harbour seals and grey seals may be present within the offshore Project area, which are protected under Annex V of the Habitats Directive as transposed into Scottish and UK legislation as well as various national legislation within Scottish and UK waters (section 12.2); • Basking sharks may be present within the offshore Project area, which are protected under various national legislation (section 12.2); • All SACs or NCMPAs designated for the protection of marine mammal or megafauna receptors have been scoped out for assessment (section 12.4.4.4); • There are no designated seal-haul out sites in the vicinity of the landfall sites. The closest designated haul-out site is Sule Skerry, however there is not anticipated to be a negligible risk of a reckless harassment offence being committed under Section 117 and this site has been scoped out for further assessment (section 12.4.4.4.3); and • Sea turtles, including leatherback turtles, are rare within the offshore Project (as described in section 12.4.4.2), so these species have been scoped out from further assessment.

12.4.7 Data limitations and uncertainties

To inform the baseline, an extensive desktop review was undertaken to define marine mammal and megafauna distribution, abundance and density within the offshore Project and wider region. Combined with two years of site-specific DAS, a robust baseline (as per section 12.4.4 and SS9: Marine mammal and megafauna baseline report) is available to assess potential impacts to marine mammal and megafauna receptors.

A total of 27 surveys were flown between July 2020 and September 2022. A survey was flown in every month except for January 2021 and consequently two surveys were flown in February 2021. The survey programme provides good temporal snapshots of the marine mammal and megafauna species present and an indication of seasonality. Currently, abundance estimates for three cetacean species derived from DAS surveys are corrected for availability bias. For harbour porpoise, the correction is based on dive data collected from tagged harbour porpoise in the North Sea (Teilmann *et al.*, 2013). Due to a lack of comparable data from which diving behaviours could be ascertained, the only other cetacean species for which corrections could be applied was white-beaked dolphins; the approach here followed that in Paxton *et al.* (2016). For these species, the model-based estimates of abundance were preferentially used as generally these produced estimates with smaller estimates of uncertainty i.e. tighter CIs. For seals, the proportion of unidentified seals in the DAS data was relatively high and therefore, could not be used to generate reliable density estimates for the two species.

It should also be noted that relatively little abundance data is available regarding the occurrence of common dolphin within the offshore Project and the surrounding area. The species was not recorded during SCANS-III surveys of block K or S. However, the species was recorded intermittently during site-specific DAS, with an average relative density for the full survey period of 0.01 animals/km^2. During the site-specific environmental and benthic survey, nine sightings of common dolphin were recorded by MMOs, equating to 233 individuals, although there were no sightings during the geophysical survey. Generally, this species is recorded to the west and south of the UK in deeper water (Lacey *et al.*, 2022); however, since common dolphin were recorded during the surveys mentioned above, they have been included in quantitative impact assessment. There are no available absolute density estimates for common dolphin within the offshore Project or surrounding area; therefore, relative densities from site-specific DAS have been used (overall average 0.01 animals/km^2). It is likely that the species occurs intermittently or sporadically within the Pentland Firth and Orkney waters (Evans *et al.*, 2011). Paxton *et al.* (2016) suggested relatively high seasonal variation in occurrence north of Sutherland and Caithness (including the region to the west of Orkney) with peak densities recorded in the summer and autumn.

As described in section 12.4.4, there are also no robust density estimates available for white-sided dolphin, killer whale or humpback whale within the offshore Project due to their low occurrence, which makes collection of sufficient data to inform density estimation challenging. However, ongoing and planned research, such as ECOPredS and evidence gaps identified through the ScotMER Evidence Map for the marine mammals receptor group (Scottish Government, 2023) are likely to improve our understanding of the baseline conditions of these species, as well as other marine mammals and other megafauna species, and the potential impacts on these receptors from offshore developments.

There are also uncertainties and limitations associated with the underwater noise modelling and subsequent impact assessments, which have been detailed in SS10: Marine mammal underwater noise impact assessment and summarised here. Predominantly these are associated with how to predict the exposure to and response of animals to underwater noise and quantifying resultant population consequences:

- The level of noise that animals are exposed to, particularly over long periods of time:
  - Fundamentally, there are uncertainties around the behaviour of impulsive sounds with distance from the source and how the position and response of the receptor affects levels of received sound. This has considerable implications for the assessment of the onset of cumulative PTS, which is based on assumptions that are unlikely to be upheld and therefore lead to a conservative determination of impact ranges. Similarly, assuming the equal-energy hypothesis will also overestimate PTS impact ranges, because it does not account for the recovery that occurs between pulses (Finneran, 2015, Kastelein *et al.*, 2013); and
  - The underwater noise assessment assumes the amount of energy an animal is exposed to over 24 hours will have the same effect whether it occurs over multiple small doses or all at once and that the impulsive nature of the sound will remain constant regardless of distance to the sound source. This is not true, there is likely to be a slight recovery of threshold shift between noise pulses which will lead to PTS occurring at a higher threshold. Additionally, the impulsive character of pulsed sound decreases with distance from the sound source, giving a slower occurrence of threshold shift than is modelled.
- The number and proportion of animals affected:
  - Despite the programme of DAS and existence of other sources of baseline data for the offshore Project, the ability to predict the likely number of animals that will be affected is inherently problematic because the receptors are highly mobile and there is high natural variation in their distribution and abundance.
- The individual and ultimately population consequences of disturbance due to noise:
  - Population consequences of disturbance for some species are modelled using iPCoD. However, there are insufficient data to parameterise the model and instead this was achieved through a process of expert elicitation (Donovan *et al*. 2016). Other assumptions within the model, including that a minke whale will not forage for 24 hours after disturbance, the absence of density dependence and environmental and demographic stochasticity, all result in likely over-estimation of population consequences.

- Density of animals:
  - All methods to quantify the distribution and abundance of marine mammals are inherently biased and have associated uncertainties. Some surveys are performed on a decadal scale, and only occur in the summer months, therefore by applying predicted densities from summer surveys to the winter period, there is an increased likelihood that data will be unrepresentative. Generally, the majority of survey methodologies are biased towards the summer due to better weather conditions. For surveys which occur on a higher temporal scale but smaller spatial scale there may be the introduction of uncertainty when considering highly mobile and transient species such as marine mammals.
- Predicting animal response:
  - Currently, animal response is based on received sound levels but it is likely that other factors will be affecting individuals such as behavioural and physiological differences, proximity to the source or previous experience. A limitation of current models is that it is not currently possible to account for these individual-level factors.

Following this, the thresholds for onset of injury and disturbance which have been used to assess the potential impact of underwater noise during all stages of the Project on marine mammals are highly precautionary and should be considered as such when reading the following sections. More detail can be found in section 4 and appendix 1 of SS10: Marine mammal underwater noise impact assessment.

12.5 Impact assessment methodology

12.5.1 Impacts requiring assessment

The impacts identified as requiring consideration for marine mammals and basking sharks are listed in Table 12-13. Information on the nature of impact (i.e. direct or indirect) is also described. In the absence of detailed information regarding decommissioning works, the impacts during the decommissioning of the offshore Project are considered analogous with, or less than, those of the construction (including pre-construction) stage.

In the Scoping Opinion (received 29th June 2022), it was requested that the impact pathway covering impacts to prey availability was added ("Indirect effects related to changes in availability or distribution of prey species"). Due to the overlap between this impact and the impact "Habitat change, including foraging opportunities" (which was included in the Scoping Report and Offshore HRA Screening Report (OWPL, 2022), habitat change has now been removed as a separate impact and included within the assessment of "Indirect effects related to changes in availability or distribution of prey species".

In the Scoping Opinion, it was also recommended that disturbance due to physical presence of vessels and disturbance due to underwater noise from vessels should be considered separately given the differing sizes, types and number of vessels needed for the differing stages of development. However, these pressures are linked and occur simultaneously, unless the vessel is idle. There is insufficient evidence to support the assessment of physical presence separately, and vessel underwater noise studies are often subject to observer bias from the presence of the research vessel and cannot differentiate between the effects of vessel presence and vessel noise (Erbe *et al.*, 2019). Additionally, the magnitude of impact from underwater noise and physical presence of vessels will both increase with vessel size and number of vessels. Therefore, the assessment has considered the underwater noise and physical presence of vessels as a single impact pathway for construction (including pre-constriction; section 12.6.1.2) and operation and maintenance (section 12.6.2.2).

As requested in the Scoping Opinion, vessel collision has also been scoped in for assessment for all stages of development, and operational noise has been scoped in for species which may be sensitive to Low Frequency (LF) noise (minke whale and humpback whale, as detailed in section 12.6.2.1). As floating WTGs are no longer part of the Project Design Envelope for this application, entanglement with moorings has not been considered for assessment.

Table 12-13 Impacts requiring assessment for marine mammals and megafauna

POTENTIAL IMPACT	NATURE OF IMPACT
Construction (including pre-construction) and decommissioning*	
Injury and disturbance from underwater noise-generating activities	Direct
Disturbance due to physical presence and underwater noise from vessels	Direct
Vessel collision	Direct
Indirect effects related to changes in availability or distribution of prey species	Indirect
Operation and maintenance	
Noise related impacts during operation	Direct
Disturbance due to physical presence and underwater noise from vessels	Direct
Vessel collision	Direct
Displacement or barrier effects associated with physical presence of devices and infrastructure	Direct
Indirect effects related to changes in availability or distribution of prey species	Indirect

** In the absence of detailed information regarding decommissioning works, and unless otherwise stated, the impacts during the decommissioning of the offshore Project considered analogous with, or likely less than, those of the construction stage. Where this is not the case, decommissioning impacts have been listed separately and have been assessed in section 12.6.3.*

12.5.2 Impacts scoped out of the assessment

The impacts scoped out of the assessment during EIA scoping, and the justification for this, are listed in Table 12-14.

Table 12-14 Impacts scoped out for marine mammals and megafauna

IMPACT SCOPED OUT	JUSTIFICATION
Construction (including pre-construction) and decommissioning	
Impacts associated with decreased marine water quality including increased turbidity	Increased turbidity associated with installation and decommissioning activities (e.g. ploughing, trenching, mass flow excavation) will be temporary and localised to the works, and sediments are expected to be rapidly dispersed (see chapter 9: Water and sediment quality). Marine mammals and basking sharks are adapted to, and are tolerant of, turbid environments, and there are no known negative impacts to overall health associated with highly turbid waters (Todd *et al*., 2014). Many species have adapted additional sense organs such as vibrissae (whiskers), and sensory modalities such as echolocation and electro-sensory organs (basking sharks) to navigate during periods of low light or reduced visibility, so are unlikely to be hindered during a temporary increase in turbidity (e.g. Kempster and Collin, 2011; Murphy *et al*., 2015). Additionally, cetaceans and basking sharks predominantly use the water column so are unlikely to interact with temporary increases in turbidity which will occur near the seabed. Therefore, this impact has been scoped out for marine mammals and basking sharks.
Accidental pollution	Accidental releases of pollutants may arise as a result of accidental spill, such as oils or other fluids from vessels or other equipment and machinery which could have detrimental effects on marine mammals and basking sharks. There is also potential for small volumes of grout to be used at the connection jacket-piles. However, the risk and impact of accidental releases of hazardous substances will be reduced through the implementation of the Environmental Management Plan (EMP), including measures for compliance with international requirements of the International Convention for the Prevention of Pollution from Ships (MARPOL) convention, as well as best practice for works in the marine environment (e.g. preparation of Shipboard Oil Pollution Emergency Plans (SOPEP)). In this manner, accidental release of potential contaminants from vessels are highly unlikely and if a release of pollutants was to occur it will be strictly controlled and procedures will be in place to minimise the scale and impact of any accidental release if it occurs, and hence the impact has been scoped out of the EIA.
Operation and maintenance	
Impacts from any thermal load or EMF arising from the cable during operation	Subsea electrical cabling will emit localised EMFs and thermal energy. The results of the Project-specific EMF modelling by a cable manufacturing contractor (currently confidential) showed that the magnetic fields rapidly dissipate when assuming 1 – 3 m burial or cable protection. Magnetic fields at

IMPACT SCOPED OUT	JUSTIFICATION
	1 m burial or protection depth resulted in magnetic fields of lower strength than the approximate natural geomagnetic field at the offshore Project (see chapter 11: Fish and shellfish ecology). When cables are buried, the thermal energy may slightly increase surrounding sediment temperatures, However, thermal energy remains localised as water movement causes it to dissipate quickly (Taormina *et al.*, 2018) Therefore, this impact has been scoped out for marine mammals and basking sharks. Some species of cetaceans may be able to detect variations in magnetic fields (Normandeau *et al.*, 2011), although marine mammals are considered to be less sensitive to EMFs than elasmobranchs which may utilise EMFs during migration, orientation and prey location (Copping and Hemery, 2020). There is no evidence that EMFs related to marine renewable devices or subsea cables have any adverse impact on marine mammals. EMFs are only likely to be detectable in close proximity to the offshore export cables, and therefore it is not expected that highly mobile marine mammals and basking sharks would be negatively affected on an individual or population basis (Copping and Hemery, 2020). Therefore, this impact has been scoped out for marine mammals and basking sharks.
Accidental pollution	Accidental release of pollutants is limited to oils and fluids contained within the WTGs or emissions from any associated Project vessels. The only reasonably predictable scenario for release of pollutants from offshore infrastructure would be a slow leak of fluids, however the volume would be undetectable, would be rapidly dispersed and remedied immediately. However, through regular maintenance activities this is highly unlikely to occur. Embedded mitigation measures will be adopted to ensure that the potential for release of contaminants is minimised. In this manner, accidental release of potential contaminants from vessels will be strictly controlled and procedures will be in place to minimum the impact of any accidental release if it occurs

12.5.3 Assessment methodology

An assessment of potential impacts is provided separately for the construction (including pre-construction), operation and maintenance and decommissioning stages.

The assessment for marine mammals and basking sharks is undertaken following the principles set out in chapter 7: EIA methodology. The sensitivity of the receptor is combined with the magnitude to determine the impact significance. Topic-specific sensitivity and magnitude criteria are assigned based on professional judgement, as described in Table 12-15 and Table 12-16

Table 12-15 Sensitivity criteria

SENSITIVITY OF RECEPTOR	DEFINITION
High	• Receptor has no ability to tolerate a particular effect causing a significant change in individual vital rates (survival and reproduction); • Receptor has no ability to recover from any effect on vital rate (survival and reproduction); and/or • Receptor has no ability to adapt behaviour so that individual vital rates (survival and reproduction) are highly likely to be significantly affected.
Medium	• Receptor has a limited ability to tolerate a particular effect which may cause a significant change in individual vital rates (survival and reproduction); • Receptor has a limited ability to recover from any effect on vital rates (survival and reproduction); and/or • Receptor has a limited ability to adapt behaviour so that individual vital rates (survival and reproduction) may be significantly affected.
Low	• Receptor has some tolerance to a particular effect with no significant change in individual vital rates (survival and reproduction); • Receptor is able to recover from any effect on vital rates (survival and reproduction); and/or • Receptor has a limited ability to adapt behaviour so that individual vital rates (survival and reproduction) may be affected, but not at a significant level.
Negligible	• Receptor is able to tolerate a particular effect without any impact on individual vital rates (survival and reproduction); • Receptor is able to return to previous behavioural states / activities once the impact has ceased; and/or • Receptor is able to adapt behaviour so that individual vital rates (survival and reproduction) are not affected.

Table 12-16 Magnitude criteria

MAGNITUDE CRITERIA	DEFINITION
High	• Total change or major alteration to the conservation status or integrity of the receptor or key elements / features of the baseline conditions; • Impact occurs over a large scale or spatial geographical extent and/or is long-term (i.e. 15 years or more) or permanent in nature; and/or

MAGNITUDE CRITERIA	DEFINITION
	• High frequency (occurring repeatedly or continuously for a long period of time) and/or at high intensity.
Medium	• Partial change or alteration to the conservation status or integrity of the receptor or one or more key elements / features of the baseline conditions; • Impact occurs over a medium scale / spatial extent and/or has a medium-term duration (i.e. 6 to 15 years); and/or • Medium to high frequency (occurring repeatedly or continuously for a moderate length of time) and/or at moderate intensity or occurring occasionally / intermittently for short periods of time but at a moderate to high intensity.
Low	• Minor shift away from the baseline conditions but unlikely to have a significant effect on the conservation status or integrity of the receptor; • Impact occurs over a local to medium scale / spatial extent and/or has a short (i.e. 1 to 5 years) to medium-term duration; and/or • Impact is unlikely to occur or at a low frequency (occurring occasionally / intermittently for short periods of time at a low intensity).
Negligible	• Very slight change from baseline condition that will not affect the conservation status or integrity of the receptor; • Impact is highly localised and short term with full rapid recovery expected to result in very slight or imperceptible changes to baseline conditions or receptor population; and/or • The impact is very unlikely to occur and if it does will occur at very low frequency or intensity.

12.5.4 Embedded mitigation

As described in chapter 7: EIA methodology, certain measures have been adopted as part of the Project development process in order to reduce the potential for impacts to the environment, including those on marine mammals and basking sharks as presented in Table 12-17. These have been accounted for in the assessment presented below. The requirement for additional mitigation measures (secondary mitigation) is dependent on the significance of the effects on marine mammal and basking shark receptors.

Table 12-17 Embedded mitigation measures relevant to marine mammals and megafauna

MITIGATION MEASURE	FORM (PRIMARY OR TERTIARY)	DESCRIPTION	HOW MITIGATION WILL BE SECURED
Piling Strategy (PS)	Tertiary	Development and adherence to a PS which delineates the requirement for and nature of noise mitigation measures (documented in the MMMP) that will be implemented during piling activities (e.g. soft-start and ramp-up procedures) to reduce potential underwater noise effects during construction.	The production and approval of the PS and MMMP will be required under Section 36 Consent and/or Marine Licence conditions. An outline MMMP (with input from an installation contractor) as part of the offshore application in OP2: Outline Marine Mammal Mitigation Protocol.
Marine Mammal Mitigation Protocol (MMMP)	Tertiary	The development of, and adherence to, an appropriate MMMP. The MMMP will outline (either separately or in the same document), protocols to reduce underwater noise impacts on marine mammals in relation to geophysical surveys, UXO clearance and piling such as: • MMOs; • PAM; • Soft-start procedure; and • Acoustic Deterrent Devices (ADD), as required. The MMMP also provides consideration to mitigation that will be considered as part of future EPS licences.	The production and approval of an MMMP will be required under Section 36 Consent and/or Marine Licence conditions. An outline MMMP (with input from an installation contractor) is provided as part of the offshore application in OP2: Marine Mammal Mitigation Protocol.
Detonation of UXO using low order techniques	Primary	Low order techniques for UXO detonation will be utilised wherever practicable to reduce underwater noise effects.	The production and approval of the PS and MMMP will be required under Section 36 Consent and/or Marine Licence conditions. An outline MMMP (with input from an installation contractor) is provided as part of the offshore application in OP2: Outline Marine Mammal Mitigation Protocol.
Cable protection	Primary	Suitable implementation and monitoring of cable protection (via burial or external protection).	Final cable design will be informed by the CBRA and detailed within the Cable Plan (CaP), required under

MITIGATION MEASURE	FORM (PRIMARY OR TERTIARY)	DESCRIPTION	HOW MITIGATION WILL BE SECURED
		Cables will be buried as the first choice of protection. External cable protection will be used where adequate burial cannot be achieved and this will be minimised as far as is practicable. This will be informed by a Cable Burial Risk Assessment (CBRA), undertaken post-consent following results of the geotechnical survey. Burial or protection of cables increases the distances between cables and marine mammal and megafauna, reducing EMF and barrier effects.	Section 36 Consent and/or Marine Licence conditions.
Environmental Management Plan (EMP)	Tertiary	The development of, and adherence to, an EMP covering pollution prevention, biosecurity and waste management. A Marine Pollution Contingency Plan (MPCP) and invasive non-native species (INNS) management plan will be included within the EMP. The EMP also includes measures to protect wildlife such as adherence to guidance and protocols supplied in the SMWWC (SNH, 2017a) and the Guide to Best Practice for Watching Marine Wildlife (SNH, 2017b).	The production and approval of an EMP, including the MPCP and INNS management plan, will be required under Section 36 Consent and/or Marine Licence conditions. An outline EMP is provided as part of the offshore application in OP1: Outline Environmental Management Plan.
Decommissioning Programme	Tertiary	The development of, and adherence to, a Decommissioning Programme approved by Scottish Ministers prior to construction and updated throughout the Project lifespan.	The production and approval of a Decommissioning Programme will be required under Section 105 of the Energy Act 2004 (as amended).

12.5.5 Worst case scenario

As detailed in chapter 7: EIA methodology, this assessment considers the worst case scenario for the offshore Project parameters which are predicted to result in the greatest environmental impact, known as the 'worst case scenario'. The worst case scenario represents, for any given receptor and potential impact, the design option (or combination of options) that would result in the greatest potential for change.

Given that the worst case scenario is based on the design option (or combination of options) that represents the greatest potential for change, the development of any alternative options within the design parameters will give rise to no worse effects than assessed in this impact assessment. Table 12-18 presents the worst case scenario for potential impacts on marine mammals and megafauna during construction (including pre-construction), operation and maintenance and decommissioning.

Table 12-18 Worst case scenario specific to marine mammals and megafauna receptor impact assessment

POTENTIAL IMPACT	WORST CASE SCENARIO	JUSTIFICATION
Construction (including pre-construction)		
Injury and disturbance from underwater noise-generating activities	• Pre-construction geophysical surveys: – Multibeam echosounder (MBES) and Side Scan Sonar (SSS) with piggybacked magnetometer, ultra-short baseline (USBL); and – 435 km^2 covered within the OAA and 105 km^2 over the offshore ECC over three-year period. Per year up to 180 km^2 total will be covered. • UXO clearance: – Detonation of up to 22 UXO; – High-order clearance (it should be noted that high order detonation methods are considered to be a last resort, however, they have been included within the Project Design Envelope to ensure the worst case is being considered if it is required) of a maximum charge of 247 kg + 5 kg donor charge; and – 1 detonation per day using high-order clearance up to a maximum of 22 days. • WTG impact piling: – Spatial worst case scenario: piling of up to 125 WTGs with monopile foundations with a maximum of one pile per day and up to 16 hours of piling per day (125 piling days), at 5,000 kJ hammer energy (in hard sediment); – Temporal worst case scenario: piling of up to 125 WTGs with piled jacket foundations (up to 500 piles) with two piles per day and up to eight hours of piling per day (250 piling days), at 3,000 kJ hammer energy (in hard or soft sediment); and	Monopile WTG foundations will require the maximum hammer energy of 5,000 kJ (for installation in hard sediments) and represent the worst case scenario in terms of the spatial extent of any underwater noise propagation (SS11: Underwater noise modelling report). Whilst the installation of jacket foundations involves a greater number of piles being installed over a longer period, the maximum hammer energy required is lower than for monopile foundations. Up to four piles may be installed per day (over 125 piling days). However, the installation of jacket foundations at two piles per day represents the longest duration of piling activities, in piling days, and can be considered the temporal worst case scenario. For OSP foundations, in terms of injury ranges, the spatial worst case scenario is a maximum of four piles per day. The temporal worst case scenario is up to two piles installed per day. It should be noted that the sound propagation modelling assumptions are highly precautionary (as described in SS10: Marine mammal underwater noise impact assessment and SS11: Underwater noise modelling report). For instance, the maximum hammer energy of 5,000 kJ

POTENTIAL IMPACT	WORST CASE SCENARIO	JUSTIFICATION
	– Intermittent piling over six-month piling window each year in a three-year period (83.5 piling days per year). • Offshore Substation Platform (OSP) impact piling: – Spatial worst case scenario: piling of up to five OSP pin-pile jacket foundations, each with 16 piles required (total of 80 piles) with a maximum of four piles per day and up to 16 hours of piling per day (20 piling days), at 3,000 kJ hammer energy (in hard or soft sediment); – Temporal worst case scenario: piling of up to five OSP pin-pile jacket foundations, each with 16 piles required (total of 80 piles) with a maximum of two piles per day and up to eight hours of piling per day (40 piling days), at 3,000 kJ hammer energy (in hard or soft sediment); and – Intermittent piling over a six-month piling window each year in a three-year period (13.5 piling days per year). • Concurrent piling: – Two concurrent piling locations with up to two piles installed in a 24-hour period at each location. • Non-piling construction activities: – Cable laying, dredging, drilling, rock placement, trenching and suction bucket installation. As a highly precautionary approach, SEL_{cum} has been calculated on the assumption that all sources will operate constantly for 24 hours to give a worst case assessment. Although, these activities are likely to be intermittent during daylight hours across the construction period and are unlikely to all occur simultaneously.	and 3,000 kJ is unlikely to be required for all WTG and OSP pile locations (dependent on sediment conditions). UXO clearance will be undertaken during the one-year pre-construction period[4], whilst piling will be undertaken during the four-year construction period, with no overlap between these activities. Pre-construction geophysical surveys will take place over up to 3 years across the pre-construction and / or construction period. For pre-construction geophysical surveys it is assumed that all marine mammals in the area required to be surveyed could be disturbed. Pre-construction geophysical surveys will be conducted over a period of three years, rather than the total area being surveyed in one year.

[4] *Although pre-construction activities may not all take place within the 1-year preceding construction, a single year is assumed as worst case – i.e. all pre-construction activities may take place concurrently in the year ahead of construction.*

POTENTIAL IMPACT	WORST CASE SCENARIO	JUSTIFICATION
Disturbance due to physical presence and underwater noise from vessels	• Construction stage (up to four years with seasonal construction periods) in addition to the pre-construction stage (additional one year e.g. UXO clearance and boulder clearance[3]); • Continuous noise generated by large vessels (>100 m); • Source level (SL): 161-168 SEL_{cum} dB re 1 µPa@1m (RMS); • Up to 101 vessels making a total of 1,772 transits (across the four-year construction stage and one year pre-construction stage combined[3]); and • Maximum of 30 vessels at the site simultaneously.	These parameters represent the expected maximum worst case scenario with regards to vessel movement during construction and are based on the following assumptions: • Based on jacket foundations, as other foundations are expected to be less conservative; • Where possible vessels which may be shared across packages have been included in the vessel numbers; and • It is optimistically assumed installation of 60 WTGs per year. However, this is realistically likely to be less which will reduce the total number of vessels, transit and/or vessel days.
Vessel collision	• Construction stage (up to four years with seasonal construction periods) in addition to the pre-construction stage (additional one year e.g. UXO clearance and boulder clearance[3]); • Up to 101 vessels making a total of 1,772 transits (across the four-year construction stage and one year pre-construction stage combined[3]); and • Maximum of 30 vessels at the site simultaneously.	
Indirect effects related to changes in availability or distribution of prey species	The worst case scenarios for marine mammal and basking sharks are also considered to represent the worst case scenario for prey related impacts, where the impacts which have been scoped into assessment are the same. As further detailed in the assessment (section 12.6.1.4), many relevant prey species to marine mammals have been assessed within chapter 11: Fish and shellfish ecology. Therefore, the worst case scenario for impacts which are specific to fish and shellfish, and which may therefore have an indirect effect on marine mammals, are presented within chapter 11: Fish and shellfish ecology.	
Operation and maintenance		
Underwater noise from fixed WTGs	• Low level continuous noise generated by the rotating machinery and transmitted into the water column through the WTG foundations; • Operational life of up to 30 years; and	The expected worst case scenario for operational noise is related to the size of the WTGs and wind speed (Tougaard *et al.*, 2020). Tougaard *et al.* (2020) presents the WTG size as a power output in MW, but as this has not been finalised

POTENTIAL IMPACT	WORST CASE SCENARIO	JUSTIFICATION
	• Maximum up to 125 WTGs, up to 330 m rotor diameters.	at West of Orkney, an equivalent figure in terms of rotor diameter has been used instead (SS11: Underwater noise modelling report).
Disturbance due to physical presence and underwater noise from vessels	• Operational life of up to 30 years; • Continuous noise generated by large vessels (>100 m); • SL: 161 - 168 SELcum dB re 1 µPa@1m (RMS); • Up to 12,695 transits from operation and maintenance vessels estimated throughout the operational life of the Project; and • Maximum of 19 vessels at the site simultaneously.	These parameters represent the expected maximum worst case scenario with regards to vessel movement during operation. The assumptions about vessel numbers and transits outlined above for 'disturbance due to physical presence and underwater noise from vessels' and 'vessel collision' during construction also apply here.
Vessel collision	• Operational life of up to 30 years; • Up to 12,695 transits from operation and maintenance vessels estimated throughout the operational life of the Project; and • Maximum of 19 vessels at the site simultaneously.	These parameters represent the expected maximum worst case scenario with regards to vessel movement during operation. The assumptions about vessel numbers and transits outlined above for 'disturbance due to physical presence and underwater noise from vessels' and 'vessel collision' during construction also apply here.
Displacement or barrier effects associated with physical presence of devices and infrastructure	• Up to 125 WTGs built out across the OAA; • Up to five OSPs built out across the OAA; • Minimum spacing of 944 m; and • Operational life of 30 years.	The maximum number of WTGs and OSPs built out across the OAA is considered to represent the greatest spatial extent of any displacement or barrier effect to marine mammals and basking sharks during the operation and maintenance stage.

POTENTIAL IMPACT	WORST CASE SCENARIO	JUSTIFICATION
Indirect effects related to changes in availability or distribution of prey species	The worst case scenarios for marine mammal and basking sharks are also considered to represent the worst case scenario for prey related impacts, where the impacts which have been scoped into assessment are the same. As further detailed in the assessment (section 12.6.2.5), many relevant prey species to marine mammals have been assessed within chapter 11: Fish and shellfish ecology. Therefore, the worst case scenario for impacts which are specific to fish and shellfish, and which may therefore have an indirect effect on marine mammals, are presented within chapter 11: Fish and shellfish ecology.	
Decommissioning		
In the absence of detailed information regarding decommissioning works, the impacts during the decommissioning of the offshore Project considered analogous with, or likely less than, those of the construction stage (including pre-construction). Therefore, the worst case parameters defined during the construction stage and pre-construction stage also apply to the decommissioning stage.		

12.6 Assessment of potential effects

12.6.1 Potential effects during construction (including pre-construction)

12.6.1.1 Injury and disturbance from underwater noise-generating activities

During the pre-construction and construction stages, there is potential for underwater noise generated to impact marine mammals and basking sharks on an individual and population basis through physiological effects, which can result in injury or mortality, and through disturbance effects, which can cause a barrier effect and/or displacement which may result in energetic consequences.

SS10: Marine mammal underwater noise impact assessment assesses the risk of injury and disturbance to marine mammals from underwater noise and the potential effects such impacts may have on the receptors in the vicinity of the offshore Project for minke whale, white-beaked dolphin, Risso's dolphin, common dolphin, harbour porpoise, harbour seal and grey seal, whilst white-sided dolphin, killer whale and humpback whale have been assessed qualitatively within this chapter. This supporting study uses the results of the underwater noise propagation modelling undertaken by Subacoustech (2023) (as detailed in SS11: Underwater noise modelling report). A detailed assessment, including the methodologies used to identify impact significance and explanation of the assumptions and limitations of this assessment can be found in SS10: Marine mammal underwater noise impact assessment and SS11: Underwater noise modelling report. This section summarises the results of the underwater noise impact assessment.

The following activities have been identified as having potential to cause injury and/or disturbance to marine mammals and basking sharks, and have been taken forward for quantitative underwater noise assessment (SS11: Underwater noise modelling report; SS10: Marine mammal underwater noise impact assessment):

- Pre-construction geophysical surveys (section 12.6.1.1.2);
- UXO clearance (section 12.6.1.1.3);
- Pile installation (section 12.6.1.1.4); and
- Other non-piling construction activities associated with installation, such as cable laying, trenching and rock placement (section 12.6.1.1.5).

As basking sharks do not possess a swim bladder, they do not have hearing capabilities like marine mammals and are less vulnerable to injury or behavioural effects from underwater noise (Popper *et al.*, 2014). Therefore, the potential for injury and disturbance to basking sharks from underwater noise generating activities has been assessed separately to marine mammals, at the end of this section.

12.6.1.1.1 Approach to underwater noise assessments

There is considered to be potential for underwater noise to impact marine mammals where the frequency of the sound is within their hearing range and where the sound levels produced exceed the threshold for injury or disturbance for that species. The hearing range of marine mammals varies depending on the species; however, there is a lack of species-specific hearing range and sensitivity for many species. Therefore, marine mammals have been grouped into functional hearing groups (Southall *et al.* 2019), based on available evidence such as audiogram data, anatomy, phylogenetic relationships, and the frequencies they generally vocalise, which are presented in Table 12-19.

For each group, Southall *et al.* (2019) also gives a predicted hearing range, sensitivity range and peak sensitivities for each group (Table 12-19).

Table 12-19 Marine mammal hearing groups, estimated hearing range and sensitivity and injury criteria and corresponding species relevant to this assessment (Southall et al., 2019)

HEARING GROUP	SPECIES	ESTIMATED HEARING RANGE	ESTIMATED REGION OF GREATEST SENSITIVITY**	ESTIMATED PEAK SENSITIVITY**
Low-frequency (LF) cetaceans	• Minke whale; and • Humpback whale*	7 Hz –35 kHz	200 Hz –19 kHz	-
High-frequency (HF) cetaceans	• White-beaked dolphin; • Risso's dolphin; • Common dolphin; • White-sided dolphin*; and • Killer whale*	150 Hz –160 kHz	8.8 –110 kHz	58 kHz
Very high-frequency (VHF) cetacean	• Harbour porpoise	275 Hz –160 kHz	12 –140 kHz	105 kHz
Phocid carnivores in water (PCW)	• Harbour seal; and • Grey seal	50 Hz –86 kHz	1.9 –30 kHz	13 kHz

**** Qualitative assessment only.***

*****Region of greatest sensitivity represents low-frequency(F1) and high-frequency (F2) inflection points, while peak sensitivity is the frequency at which the lowest threshold was measured (T0) (Southall et al., 2019).***

Loud sounds can result in auditory injury to marine mammals, whereby there is a reduction in the hearing sensitivity, generally at certain frequencies. PTS is the threshold above which a permanent shift in hearing occurs and is assumed to be irreversible. Underpinning the assessment of auditory injury are the thresholds defined for marine mammal functional hearing groups in Southall *et al.* (2019) (Table 12-20). PTS-onset impact ranges are calculated for both 'instantaneous' PTS (SPL_{peak}) as a measure of sound energy from a single pulse, and 'cumulative' PTS (SEL_{cum}) which is a metric of the cumulative sound energy an animal is exposed to over a standard time period (here, 24-hours; Southall *et al.*, 2019). The method used to calculate are detailed in (SS11: Underwater noise modelling report).

Table 12-20 PTS-onset thresholds for impulsive noise (from Southall et al., 2019)

HEARING GROUP	SPECIES	CUMULATIVE PTS (SEL_{CUM} DB RE 1 µPA2S WEIGHTED)	INSTANTANEOUS PTS (SPL_{PEAK} DB RE 1 µPA UNWEIGHTED)
Very High Frequency (VHF) Cetacean	• Harbour porpoise	155	202
High Frequency (HF) Cetacean	• White-beaked dolphin; • Common dolphin; • Risso's dolphin; • White-sided dolphin*; and • Killer whale*	185	230
Low Frequency (LF) Cetacean	• Minke whale; and • Humpback whale*	183	219
Phocid (PCW)	• Harbour seal; and • Grey seal	185	218
****Qualitative assessment only.***			

Underwater noise can also result in behavioural responses, which may vary by a range of factors such as species, individual, location, season as well as per construction and pre-construction activity. To determine the extent of disturbance from underwater noise associated with various construction and pre-construction activities, a range of approaches have been applied to quantify injury based on the best available evidence and guidance (e.g. PTS-onset ranges using Southall *et al.* (2019) for piling and UXO clearance) and disturbance (e.g. dose-response functions for piling and Temporary Threshold Shift (TTS)-onset for UXO clearance).

The approach to each of the underwater noise assessments for injury and disturbance from underwater noise generating activities has been summarised in Table 12-21. Additional details of the INSPIRE model, used for modelling of impact piling, are summarised below from SS11: Underwater noise modelling report. Full details and justification for the methods which have been used are provided in SS10: Marine mammal underwater noise impact assessment.

Table 12-21 Approach to the assessment of injury and disturbance to marine mammals from underwater noise generating activities

ACTIVITY	INJURY	DISTURBANCE
Pre-construction geophysical surveys	SPL_{peak} and SEL_{cum} continuous thresholds for PTS-onset from Southall *et al*. (2019) for MBES and SSS.	USBL compared to sub-bottom profilers (SBPs) as a proxy for the extent of disturbance. Disturbance has been assessed both for a static and moving sound source.
UXO clearance	SPL_{peak} and SEL_{cum} impact thresholds for PTS-onset from Southall *et al*. (2019).	SPL_{peak} and SEL_{ss} (for a single strike) impact ranges for TTS-onset from Southall *et al*. (2019), as a proxy for the extent of behavioural disturbance (in the absence of a robust scientific understanding and methodology to assess the effect of disturbance from UXO clearance).
Pile driving	SPL_{peak} and SEL_{cum} impact thresholds for PTS-onset from Southall *et al*. (2019), using estimated noise propagation from pile driving modelled using the INSPIRE model (SS11: Underwater noise modelling report).	Dose-response functions* based on harbour porpoise responses (as a proxy for all cetacean species) to impact piling during the first stage of construction at the Beatrice Offshore Wind Farm, Moray Firth (Graham *et al*., 2017a), and harbour seal responses (also as a proxy for grey seal) to impact piling at the Lincs Wind Farm, Greater Wash area (Whyte *et al*., 2020). This is combined with estimated noise propagation from pile driving modelled using the INSPIRE model (SS11: Underwater noise modelling report).
Non-piling construction activities	Simple propagation noise modelling using the Southall *et al*. (2019) continuous noise thresholds (non-impulsive) (SS11: Underwater noise modelling report).	Qualitative assessment based on available evidence in the literature on disturbance responses and ranges, using species in the same hearing group (Southall *et al*., 2019) as a proxy, where insufficient species-specific information exists.

Dose-response functions account for the variability in response by animals to underwater noise stimuli (Southall et al., 2019; Tyack and Thomas, 2019), by estimating the proportion of animals which will respond (from 1 to 0) at different noise levels, and thus are considered to be disturbed.

Underwater noise modelling has been undertaken to determine the extent of underwater sound propagation from impact piling of the WTGs and OSPs from three representative locations at the north-west (NW), south-east (SE) and south-west (SW) extremities of the OAA (SS11: Underwater noise modelling report). The INSPIRE underwater noise model (version 5.1) was used for all impact piling modelling (i.e. impulsive noise source), which uses numerical modelling and measured source-level data to calculate noise propagation in shallow (less than 100 m), mixed water (typical of that around the offshore Project, and the UK in general). This model has been developed using over 80 data sources of underwater noise propagation from piling activities. To ensure results are specific to the offshore Project, other project-specific inputs such as hammer energy, piling duration and swim-speeds of the assessed receptors, have been included (as detailed in SS11: Underwater noise modelling report). Both unweighted peak criteria (SPL_{peak}) and cumulative sound exposure level (SEL_{cum}) criteria have been used to determine the distances at which receptors are likely to experience sound levels above the thresholds for auditory injury. The SPL_{peak} criteria is a measure of sound energy from a single pulse, whereas SEL_{cum} is a metric of the cumulative sound energy an animal is exposed to over a standard time period, with 24-hours being used in these assessments (Southall *et al.*, 2019).

It should be reiterated that there is a considerable amount of precaution in assessing the impact of underwater noise on marine mammals. Predominantly these are associated with how to predict the exposure to and response of animals to underwater noise and quantifying resultant population consequences. There are uncertainties around the level of noise exposure, the number and proportion of animals affected, the individual and population level consequences of disturbance due to underwater noise, quantifying the density of animals and predicting individual animals response. Realistically, any impacts to marine mammals from underwater noise are likely to be less than are presented here. See section 12.4.7 and SS10: Marine mammal underwater noise impact assessment for more detail.

12.6.1.1.2 Injury and disturbance to marine mammals from pre-construction geophysical surveys

Pre-construction surveys using MBES, SSS and USBL will be required, for example for high resolution seafloor mapping and for accurate equipment positioning. The SPLs produced by some geophysical survey equipment has the potential to cause injury and disturbance to marine mammals. This section summarises the assessment for injury and disturbance to marine mammals presented in SS10: Marine mammal underwater noise impact assessment. Whilst white-sided dolphin, killer whale and humpback whale were not quantitatively assessed in SS10: Marine mammal underwater noise impact assessment, assessments were conducted for marine mammal hearing groups as described in Southall *et al*. (2019). The assessments for LF hearing group cetaceans (which includes humpback whales) and HF hearing group cetaceans (which includes white-sided dolphin and killer whale) are also expected to be applicable for these species for which no dedicated quantitative assessment was performed.

A comparison of the overlap between the expected sound characteristics for each survey equipment and marine mammal functional hearing capability was undertaken by SS10: Marine mammal underwater noise impact assessment and is summarised in Table 12-22. Where there is no overlap in the noise produced by the survey equipment, and the functional hearing capability of an animal, there is considered to be no potential for disturbance effects to occur. However, injury may still occur if animals are exposed to sound pressure of sufficient magnitude.

Table 12-22 Comparison of typical noise emitting survey equipment operating characteristics and overlap with the most sensitive region of marine mammal hearing capabilities (SS10: Marine mammal underwater noise impact assessment)

EQUIPMENT	ESTIMATED SOURCE PRESSURE LEVEL1	EXPECTED SOUND FREQUENCY*	FUNCTIONAL HEARING GROUP			
			LF	HF	VHF	PCW
Multibeam echosounder (MBES)	218 (peak), 213 dB rms	200 – 400 kHz	Above all hearing ranges			
Side scan sonar (SSS)	210 (peak), 242 dB rms	300 kHz & 900 kHz	Above all hearing ranges			

EQUIPMENT	ESTIMATED SOURCE PRESSURE LEVEL1	EXPECTED SOUND FREQUENCY*	FUNCTIONAL HEARING GROUP			
			LF	HF	VHF	PCW
Ultra-short baseline (USBL)	194 (peak), 188 (rms)	20 – 35 kHz	No	Yes	Yes	Yes
***These are typical values for geophysical surveys for large offshore windfarms, but equipment specific values will vary between different survey contractors.**						

Injury from pre-construction geophysical surveys

The indicative source pressure levels presented for MBES and SSS exceed the unweighted injury threshold for the VHF and PCW hearing groups, which includes harbour porpoise and seals. However, the peak energy from these equipment types is much higher than the hearing sensitivities for these species. It is also expected that, as the source frequencies are high, SPLs would rapidly diminish to below thresholds for PTS-onset for harbour porpoise (VHF hearing group) within a few metres of the source, further reducing the risk of injury. There are also likely to be individual-level effects which will determine the actual perceived level of impact (for more limitations and uncertainties see section 12.4.7). For the PWC hearing group, the source pressure levels do not exceed the unweighted injury threshold. Whilst there is an overlap in the expected sound frequency from USBL with several marine mammal species, the SLs are below the PTS-onset thresholds for all assessed marine mammals. Therefore, all marine mammals are assessed to be of low sensitivity.

The *JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys* (JNCC, 2017) do not advise that mitigation to avoid injury from the use of high-frequency MBES (which are proposed for the offshore Project) is necessary in shallow waters (<200 m). For SSS, EPS Guidance from JNCC *et al*. 2010 SSS states that "*this type of survey is of a short-term nature and results in a negligible risk of an injury or disturbance offence (under the Regulations[5])*.", which is consistent with advice given by DECC (2011). As the USBL SLs are below the thresholds for PTS-onset for all hearing groups, it was also concluded that this survey equipment does not pose any risk of injury (PTS-onset) to any marine mammal receptors. Therefore, the risk of injury from all geophysical equipment is defined as being of negligible magnitude.

[5] *Here referring to both The Conservation of Habitats and Species Regulations 2010 and The Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (amended in 2009 and 2010), the latter of which has since been superseded by The Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended).*

Evaluation of significance

Taking the low sensitivity and the negligible magnitude of the impact, the overall effect on marine mammals from injury caused by pre-construction geophysical surveys is considered to be **negligible** and **not significant** in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Low	Negligible	Negligible
Impact significance – NOT SIGNIFICANT		

Disturbance from pre-construction geophysical surveys

Given that the frequency of MBES and SSS equipment is beyond the hearing frequency range of all marine mammal receptors, there is no scope to cause impacts. Use of USBL is also highly unlikely to cause disturbance effects to the LF hearing group (which includes minke and humpback whales) as the sound levels emitted, whilst within the hearing frequency range, are above the expected hearing frequency range of greatest sensitivity. However, the expected sound frequency for the USBL is within the hearing range for all other assessed marine mammal hearing groups (Southall *et al.*, 2019; Table 12-20), and therefore there is potential for USBL to result in disturbance effects for these species.

The risk of disturbance from USBL is thought to be lower than that from sub-bottom profilers when considering the characteristics of the noise emitted. JNCC *et al.* (2010) EPS guidance concludes that sub-bottom profilers, *"Could, in a few cases, cause localised short-term impacts on behaviour such as avoidance. However, it is unlikely that this would be considered as disturbance in the terms of the Regulations*[6]*. It is unlikely that injury would occur as an animal would need to locate in the very small zone of ensonification and stay in that zone associated with the vessel for a period of time, which is also unlikely."* Therefore, considering that marine mammals are unlikely to be impacted beyond short-term, localised avoidance, there would be no significant change in the ability of an individual to survive or reproduce and it is expected they can adapt to and recover from disturbance from USBL.

Additionally, as summarised in SS10: Marine mammal underwater noise impact assessment, Thompson *et al.* (2013) suggests that there are no long-term displacement effects to harbour porpoise from short term disturbance caused by a commercial two-dimensional seismic survey, which is a much louder noise source than USBL. Additionally, by comparing the expected USBL noise to the anticipated broadband SLs and frequency from survey vessels (OSPAR, 2009; Rutenko and Ushchipovskii, 2015), SS10: Marine mammal underwater noise impact assessment also concluded that noise generated by the survey vessel whilst using dynamic positioning thrusters is likely to be similar in amplitude to that from the USBL equipment (although the dominant energy would be at a lower frequency), meaning that the

[6] *Here referring to both The Conservation of Habitats and Species Regulations 2010 and The Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (amended in 2009 and 2010), the latter of which has since been superseded by. The Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended).*

impact is unlikely to be much greater than the temporary avoidance caused by the associated survey vessel. Therefore, it is expected that marine mammals would be able to quickly recover from any short-term disturbance from geophysical equipment such as USBL and there would be no significant change in the ability of an individual to survive or reproduce. Marine mammals are therefore assessed to be of low sensitivity.

As described in SS9: Marine mammal underwater noise impact assessment, disturbance from the USBL is likely to be highly localised, temporary and short-lived. SS10: Marine mammal underwater noise impact assessment considers two scenarios in the assessment of magnitude for USBL: assessment of disturbance at any one time (static source) and assessment of disturbance over a survey day (moving source), to account for the moving survey vessel. The moving source assessment considers the impact area to be 240.8 km^2 per survey day (calculated from an impact radius of 1.08 km^2 over 109.8 km as the average distance travelled by the 2022 geophysical survey vessel). The results of this assessment are summarised in Table 12-23.

Table 12-23 A summary of the number of animals predicted to experience disturbance by USBL (SS10: Marine mammal underwater noise impact assessment)

SPECIES	METRIC	DISTURBANCE AT ANY ONE TIME (STATIC SOURCE)	DISTURBANCE OVER SURVEY DAY (MOVING SOURCE)	MAGNITUDE OF IMPACT
Harbour porpoise	Area impacted (km^2)	3.66	240.8	Negligible
	No. of animals	<1	36	
	% UK MU	0.00%	0.02%	
	% MU	0.00%	0.01%	
White-beaked dolphin	Area impacted (km^2)	3.66	240.8	Negligible
	No. of animals	<1	46	
	% UK MU	0.00%	0.13%	
	% MU	0.00%	0.10%	
Common dolphin	Area impacted (km^2)	3.66	240.8	Negligible
	No. of animals	<1	2	
	% UK MU	0.00%	0.00%	
	% MU	0.00%	0.00%	
Risso's dolphin	Area impacted (km^2)	3.66	240.8	Negligible

SPECIES	METRIC	DISTURBANCE AT ANY ONE TIME (STATIC SOURCE)	DISTURBANCE OVER SURVEY DAY (MOVING SOURCE)	MAGNITUDE OF IMPACT
	No. of animals	<1	3	
	% UK MU	<0.01%	0.04%	
	% MU	<0.01%	0.03%	
Minke whale	Area impacted (km^2)	3.66	240.8	Negligible
	No. of animals	<1	2	
	% UK MU	<0.01%	0.02%	
	% MU	0.00%	0.01%	
Harbour seal	Area impacted (km^2)	3.66	240.8	Negligible
	No. of animals	<1	2	
	% MU	<0.05%	0.11%	
Grey seal	Area impacted (km^2)	3.66	240.8	Negligible
	No. of animals	2	140	
	% MU	0.01%	0.41%	

As geophysical surveys are mobile, assessment of a moving sound source is likely to be a more accurate reflection of the true impacted area and subsequent number of animals impacted. However, the actual area over which geophysical surveys will be required is currently unknown and consequently this has been assessed using a precautionary worst case area of impact. It should be noted that both the static and moving source assessments determined that less than 1% of the UK MU and SMUs respectively, would be affected. In this assessment, it was therefore concluded that disturbance effects to marine mammals are expected to be isolated, temporary and short-lived, and affecting relatively low numbers of individuals. White-sided dolphins and killer whales are expected to occur in considerably lower densities than other marine mammal species which have been quantitatively assessed (see section 12.4.2 and SS9: Marine mammal and megafauna baseline report), therefore there are not expected to be any population-level impacts to these species.

For any marine mammal present during the use of USBL, any disturbance would be isolated, short-term and temporary, without any anticipated impact to the conservation status or integrity of the receptor, and the directionality of the sound. Underwater noise generated by the USBL is also not expected to add significantly to cumulative underwater noise in the region and is expected to be similar in amplitude to the associated pre-construction vessels. Therefore, due to the short-term and temporary nature of USBL surveys, and the low number of marine mammals which may be affected in the worst case, the risk of disturbance from USBL is defined as being of **negligible magnitude**. As the sound levels are outside the hearing range for marine mammals, the risk of disturbance from MBES and SSS is also defined as being of **negligible magnitude.**

Evaluation of significance

Taking the low sensitivity and the negligible magnitude of the impact, the overall effect on marine mammals from disturbance caused by pre-construction geophysical surveys is considered to be **negligible** and **not significant** in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Low	Negligible	Negligible
Impact significance – NOT SIGNIFICANT		

12.6.1.1.3 Injury and disturbance to marine mammals from UXO clearance

UXO clearance may be required prior to construction of the offshore Project. The underwater explosions associated with UXO clearance generate a broadband acoustic pulse of very high peak pressure, which can result in auditory injury (assessed here as PTS-onset), or behavioural disturbance. In the absence of other factors, generated noise levels from UXO clearance are assumed to be proportional to the total size of explosive material being detonated, which is indicated by the charge weight.

Initial investigation estimated that 222 potential UXO will require further investigation, and that between 3-10% of those may require clearance, equating to 6 to 22 UXO across the offshore Project (6 Alpha Associates Limited, 2022a; 2022b). These may be avoided, removed, or detonated *in situ*, as determined by a risk assessment. One UXO is anticipated to be cleared per day (during daylight hours only), resulting in an estimated 6 to 22 days for all UXOs to be removed. The estimated maximum worst case charge weight for potential UXO items which may be present within the offshore Project is 247 kg, in addition to a 5 kg donor charge which would be required to initiate the detonation, based on the predicted charge weights in the UXO risk assessment from 6 Alpha Associates Limited (2022a; 2022b).

This section summarises the assessment for injury and disturbance to marine mammals from UXO clearance presented in SS10: Marine mammal underwater noise impact assessment. Whilst white-sided dolphin, killer whale and humpback whale were not assessed in SS11: Underwater noise modelling report and SS10: Marine mammal underwater noise impact assessment, as the assessments were conducted for the hearing groups from Southall *et al.* (2019). Therefore, the assessments for LF cetaceans (which includes humpback whales) and HF hearing group cetaceans (which includes white-sided dolphin and killer whale) are also expected to be applicable for these species.

It is expected that if any UXO clearance is required, it would be undertaken using low-order clearance and all efforts will be made to avoid high-order clearance where possible. However, the potential impact associated with high-order detonation is given here to provide a worst case assessment, in line with advice from Department for Environment, Food and Rural Affairs (DEFRA *et al.*, 2021) and consultation advice received from NatureScot on 22nd September 2022 and MS-LOT on 7th November 2022. The potential for PTS-onset and TTS-onset (as a proxy for disturbance) from UXO clearance has been assessed for several scenarios (more detail can be found in SS11: Underwater noise modelling report):

- High-order clearance: this method aims to completely detonate of all explosive material in the UXO. The worst case high-order detonation of a large 247 kg UXO has been assessed, in addition to smaller potential charge weights of 3.1, 25 and 130kg plus a 5 kg donor charge which is used to initiate the detonation;
- Low-order deflagration: clearance of any size of UXO using a small specialist donor charge (up to 0.05 kg) which causes a very high temperature rapid burning event to vaporise the explosive material in the UXO without an explosion (called deflagration). Noise levels are proportional to the donor charge only and is typically 85% less than high-order clearance; and
- Low-order burning: The UXO case is penetrated by an Explosively Formed Magnesium Projectile (or similar) which aims to immediately burn-out its main high explosive charge, requiring significantly less explosive to initiate the shape charge (typically up to 90% less) than that for higher-order clearance.

However, it should be noted that when attempting to employ a low-order clearance, including deflagration and burning, there is a potential risk (albeit low) that a high-order event will be initiated.

Injury from UXO clearance

Relatively LF sound is produced by controlled explosions, with most of the energy below a few hundred Hz, (von Benda-Beckmann *et al*., 2015; Salomons *et al*., 2021) which is below the area of greatest sensitivity for the majority of marine mammal species considered, with the exception of minke whale and humpback whale, which are in the LF hearing group (Southall *et al*., 2019). Therefore, a PTS at this frequency is expected to result in a minor reduction in hearing sensitivity outside of the frequency of peak sensitivity, and thus have little impact on vital rates for these species. Therefore, dolphins, porpoise and seal receptors, including white-sided dolphin and killer whale, are assessed to be of **low sensitivity** to PTS from UXO clearance.

Due to their sensitivity to lower frequencies, and recent studies suggesting there is more acoustic energy at these low frequencies (<100 Hz) (Robinson *et al*., 2022), it is more precautionary to assess minke whale as having **medium sensitivity** to PTS from UXO clearance. Humpback whale are also most sensitive to lower frequencies between 15 to 200 Hz and 3 to 9 kHz (depending on which simulation is used) with peak sensitivity estimated to be around 1 kHz (Tubelli *et al*., 2018); therefore, humpback whale have also been assessed to have **medium sensitivity**.

Table 12-24, below, summarises the underwater noise modelling results and impact assessment for the high-order clearance of a large 247 kg UXO as the worst case, and the low order deflagration methods, with full details provided in SS10: Marine mammal underwater noise impact assessment. Underwater noise generated by low-order burning is expected to be less in magnitude than low-order deflagration methods, and therefore this has not been assessed separately and the assessment for low-order deflagration is also expected to apply to low-order burning. Underwater noise modelling assumes that no mitigation has been used, which includes that there has been no prior deterrence of animals from the impact area. However, as part of the MMMP which is an embedded mitigation measure (see section 12.5.4 and OMP2), measures such as soft-starts to deter animals from the area prior to works commencing has been proposed, to reduce the potential risk of injury to marine mammals. Therefore, the number of animals which are predicted to experience PTS from UXO clearance is likely to be highly conservative, as mitigation measures to safely displace animals beyond the PTS-onset range may be employed.

For the worst case high-order UXO clearance (247 kg UXO plus a 5 kg donor charge), the underwater noise modelling (Table 12-24) indicated that the greatest impact would occur for harbour porpoise and grey seals, with potential for PTS-onset for 46 harbour porpoise and six grey seals, equating to 0.01% and 0.22% of the relevant MU population for those species, respectively. For all other species, injury was predicted to affect less than one individual per species. For low-order deflagration, auditory injury was predicted to affect less than one individual, for all assessed species.

White-sided dolphins and killer whales are expected to have similar impact ranges to the HF hearing group species (Southall *et al.*, 2019), which have been grouped into 'dolphin species' in the quantitative assessment. Humpback whales are expected to have similar impact ranges as minke whales, as both species are within the LF hearing group (Southall *et al.*, 2019). White-sided dolphin, killer whales and humpback whales are expected to occur in lower densities than other species which have been included in the quantitative impact assessment (SS9: Marine mammal and megafauna baseline report) and therefore it would be less likely that these species would be in the vicinity of the offshore Project in significant numbers during UXO clearance. Impacts to these species and subsequent assessment of magnitude are therefore expected to be analogous with, or less than, that assessed for dolphin species and minke whales.

Whilst injury from UXO clearance is a permanent change in the hearing threshold and affected animals will not recover, a very low number of animals are predicted to be affected, which will be further reduced using embedded mitigation measures. Additionally, the impact is expected to be intermittent (maximum 22 days) over a 9-month period in the year prior to piling activities. Therefore, considering the embedded mitigation measures, injury resulting from UXO clearance is defined as being of negligible magnitude for all marine mammal species.

Table 12-24 A summary of the number of animals predicted to experience injury (PTS-onset; in the absence of any mitigation measures) and summary of the impact assessment for low-order deflagration (0.05 donor only) and high-order (247 kg + donor) UXO clearance (SS10: Marine mammal underwater noise impact assessment)

SPECIES	METRIC	LOW-ORDER DEFLAGRATION (0.05 KG DONOR) RESULT	HIGH ORDER (247 + 5 KG DONOR) RESULT	SENSITIVITY	MAGNITUDE OF IMPACT	CONSEQUENCE
Harbour porpoise	Range (km)	0.58	9.9	Low	Negligible	Negligible
	No. of animals	<1	46			
	% UK MU	<0.01	0.03			
	% MU	<0.01	0.01			
Dolphins (all species)	Range (km)	0.03	0.57	Low	Negligible	Negligible
	No. of animals	<1	<1			
	% UK MU	<0.01	<0.01			

SPECIES	METRIC	LOW-ORDER DEFLAGRATION (0.05 KG DONOR) RESULT	HIGH ORDER (247 + 5 KG DONOR) RESULT	SENSITIVITY	MAGNITUDE OF IMPACT	CONSEQUENCE
	% MU	<0.01	<0.01			
Minke whale	Range (km)	0.10	1.7	Medium	Negligible	Negligible
	No. of animals	<1	<1			
	% UK MU	<0.01	<0.01			
	% MU	<0.01	<0.01			
Harbour seal	Range (km)	0.11	1.9	Low	Negligible	Negligible
	No. of animals	<1	<1			
	% MU	<0.05	<0.05			
Grey seal	Range (km)	0.11	1.9	Low	Negligible	Negligible
	No. of animals	<1	6			
	% MU	0.00	0.022			

Evaluation of significance

Taking the low to medium sensitivity and the negligible magnitude of the impact, the overall effect on marine mammals from injury caused by UXO clearance during pre-construction is considered to be **negligible** and **not significant** in EIA terms.

Receptor	Sensitivity	Magnitude of impact	Consequence
• All other marine mammal receptors	Low	Negligible	Negligible
• Minke whale; and • Humpback whale	Medium	Negligible	Negligible

Impact significance – NOT SIGNIFICANT

Disturbance from UXO clearance

Due to the lack of empirical studies, there is limited understanding of the effect of disturbance from UXO detonation on marine mammals, meaning that assessments can only provide an indication of the number of animals at risk based on limited evidence.

Any disturbance from UXO clearance would be highly short-term, and intermittent. As per the JNCC guidance (2020), *"…a one-off explosion would probably only elicit a startle response and would not cause widespread and prolonged displacement…"*. Therefore, it is not expected that disturbance from UXO detonation would result in any significant impacts or result in any changes to the vital rates of individuals. Therefore, all marine mammals are assessed to be of negligible sensitivity.

Table 12-25 summarises the underwater noise modelling results and impact assessment for the high-order clearance of a large 247 kg UXO as the worst case, and the low order deflagration methods, with full details provided in SS10: Marine mammal underwater noise impact assessment.

Table 12-25 A summary of the number of animals predicted to experience disturbance (using TTS-onset as a proxy) and summary of the impact assessment for low-order (0.05 donor only) and high-order (247 kg + donor) UXO clearance (SS10: Marine mammal underwater noise impact assessment)

SPECIES	METRIC	LOW-ORDER (0.05 KG DONOR) RESULT	HIGH ORDER (247 + 5 KG DONOR) RESULT	SENSITIVITY	MAGNITUDE OF IMPACT	CONSEQUENCE
Harbour porpoise	Range (km)	0.42	3.6	Negligible	Negligible	Negligible
	No. of animals	<1	6			
	% UK MU	<0.01	<0.01			
	% MU	<0.01	<0.01			
Dolphins (all species)	Range (km)	0.05	0.40	Negligible	Negligible	Negligible
	No. of animals	<1	<1			
	% UK MU	<0.01	<0.01			
	% MU	<0.01	<0.01			
Minke whale	Range (km)	1.4	77	Negligible	Negligible	Negligible
	No. of animals	<1	186			

SPECIES	METRIC	LOW-ORDER (0.05 KG DONOR) RESULT	HIGH ORDER (247 + 5 KG DONOR) RESULT	SENSITIVITY	MAGNITUDE OF IMPACT	CONSEQUENCE
	% UK MU	<0.01	1.81			
	% MU	<0.01	0.92			
Harbour seal	Range (km)	0.26	14	Negligible	Negligible	Negligible
	No. of animals	<1	6			
	% MU	<0.05	0.28			
Grey seal	Range (km)	0.26	14	Negligible	Negligible	Negligible
	No. of animals	<1	343			
	% MU	0.00	1.00			

For the worst case high-order UXO clearance (247 kg UXO plus a 5 kg donor charge), the underwater noise modelling predicted that minke whale (186 individuals) and grey seal (343 individuals) would be subject to the greatest disturbance impact from UXO clearance, which is equivalent to 0.92% and 1.00% of the MU population for those species, respectively. For all other species, the maximum TTS-onset range equated to less than 0.1% of the MU population being impacted. The impact range and the number of animals predicted to be disturbed by low-order clearance, which is the preferred method where possible, is very low for all species (maximum of two animals, and <0.01% MU for each species).

As for the assessment of injury from UXO clearance, white-sided dolphin, killer whale and humpback whale are expected to have similar impact ranges to other species in the same hearing groups. These species are also expected to occur in lower densities than those which have been included in the quantitative assessment. Therefore, they would be less likely to be within the vicinity of the offshore Project in significant numbers during UXO clearance and so impacts to these species and subsequent assessment of magnitude are also expected to be analogous with, or less than, that assessed for dolphin species and minke whale.

Overall, whilst there may be some disturbance to marine mammals, a low proportion of the reference population is expected to be affected by UXO clearance and so there is unlikely to be significant shift away from baseline conditions. UXO clearance is also expected to be intermittent (maximum 22 days) in the year prior to piling activities. Therefore, the potential for disturbance resulting from UXO clearance is defined as being of negligible magnitude for all marine mammal species.

Evaluation of significance

Taking the negligible sensitivity and the negligible magnitude of the impact, the overall effect on marine mammals from disturbance caused by UXO clearance during pre-construction is considered to be **negligible** and **not significant** in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Negligible	Negligible	Negligible
Impact significance – NOT SIGNIFICANT		

12.6.1.1.4 Injury and disturbance to marine mammals from pile installation

Pile installation has the potential to generate underwater noise which could result in injury or disturbance to marine mammals during the construction stage. Underwater noise modelling has been undertaken to determine the extent of underwater sound propagation from impact piling of WTGs and OSPs from three representative locations in the north-west, south-east and south-west of the OAA (Figure 12-7, SS11: Underwater noise modelling report), which informed a detailed underwater noise impact assessment (SS10: Marine mammal underwater noise impact assessment). These locations on the boundary of the OAA were considered to represent a worst case from a spatial perspective. This section summarises the results of this impact assessment, with full technical details of the underwater noise modelling and impact assessment available in the supporting studies as shown in Table 12-1.

The worst case WTG installation method for marine mammals is pile driving due to the underwater noise levels it will produce. Quantitative assessment of injury from pile driving used the worst case scenario design parameters presented in Table 12-18, which are likely to result in the greatest injury or disturbance ranges.

Full information about piling parameters which have been used to assess auditory injury and disturbance is available in SS10: Marine mammal underwater noise impact assessment and SS11: Underwater noise modelling report. These two supporting studies both outline the precautionary nature of the underwater noise modelling and subsequent impact assessment.

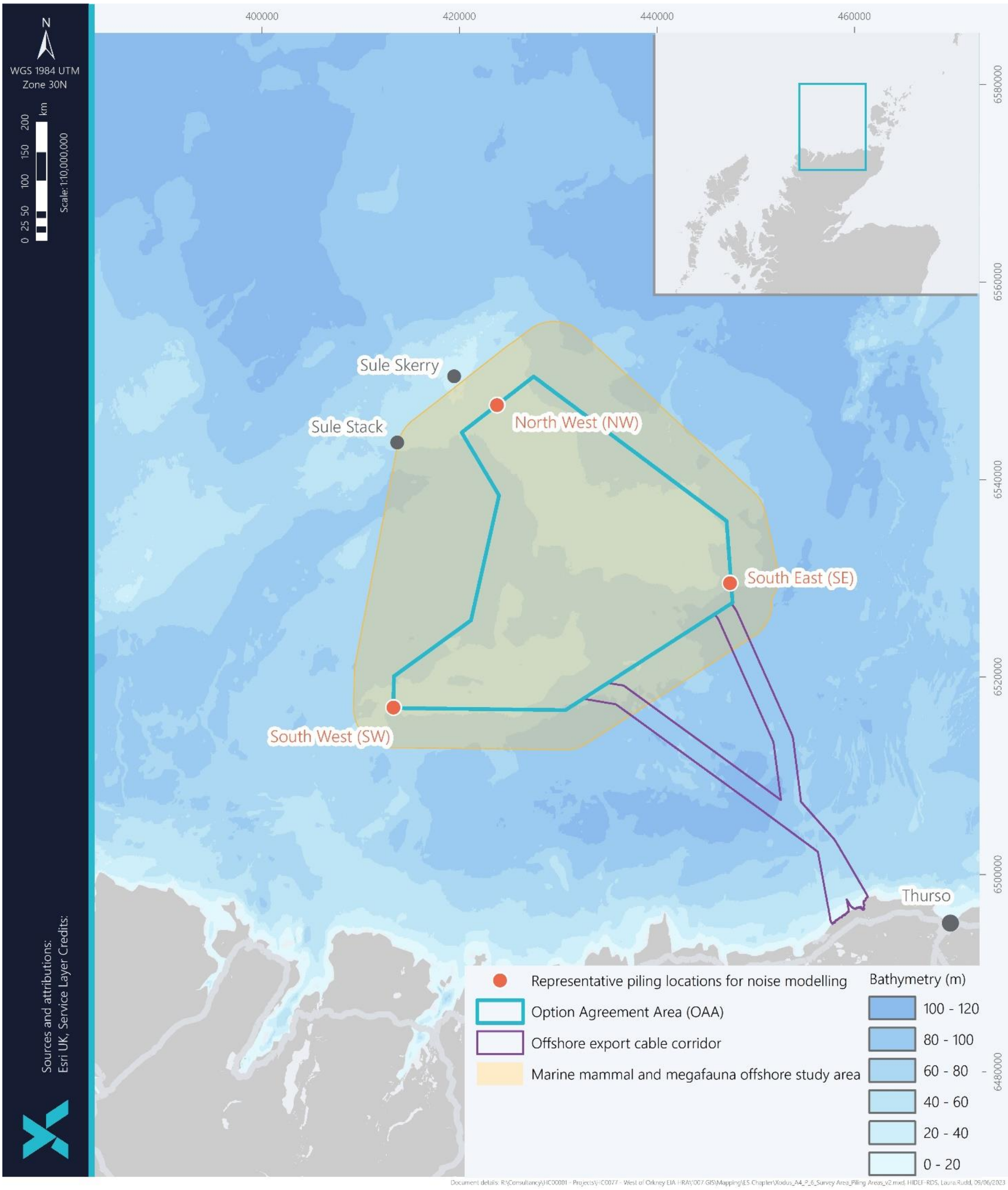

Figure 12-7 Representative worst case piling locations used in the underwater noise modelling

Injury from pile installation

Booth and Heinis (2018) describe the outcomes of an expert elicitation workshop that discussed the nature, extent and potential consequences of PTS on UK marine mammal species, in the absence of empirical studies. The magnitude and frequency band in which PTS is likely to occur is critical to potential impacts on affected individuals' survival and fecundity. Kastelein *et al*. (2017) concluded that threshold shifts resulting from pile driving would likely occur in the 2-10 kHz band. The expert elicitation workshop concluded that:

- "… the effects of a 6 dB PTS in the 2-10 kHz band was unlikely to have a large effect on survival or fertility of the species of interest";
- "… for all species experts indicated that the most likely predicted effect on survival or fertility as a result of 6 dB PTS was likely to be very small (i.e. <5 % reduction in survival or fertility)"; and
- "… the defined PTS was likely to have a slightly larger effect on calves/pups and juveniles than on mature females survival or fertility".

Probability distributions of the expert responses were used to conclude on likely declines in vital rates of assessed marine mammal species, with the 50% percentile of the elicited probability distribution (on which the assessments are based) summarised in Table 12-26. A full range of percentiles and the associated probability distribution graphs are presented in SS10: Marine mammal underwater noise impact assessment. Modelling was undertaken for harbour porpoise and seals, with bottlenose dolphin used as a proxy for white beaked dolphins, common dolphins and Risso's dolphins since they are expected to have similar hearing sensitivities and there are insufficient species-specific data available to be used during quantitative assessment.

PTS is a permanent effect with no potential for recovery; however, the probability distributions do not suggest that PTS from piling will impact either survival or reproductive rates significantly. Additionally, it is expected that disturbance from other construction related activities and vessels will act as a local scale deterrent for harbour porpoise (Brandt *et al*., 2018, Graham *et al*., 2019, Benhemma-Le Gall *et al*., 2021), thus reducing the likelihood of this species being present at the start of the pile driving activities and soft-starts and reducing the risk of auditory injury. Therefore, the assumption that harbour porpoise are present prior to pile driving in the probability distribution modelling is anticipated to be overly conservative. Given the very low (<1%) predicted median decline across age classes for harbour porpoise, harbour seal and grey seal, these species were assessed as having **low sensitivity** to injury from pile driving.

For white-beaked dolphin, common dolphin and Risso's dolphin (using bottlenose dolphin as a proxy), the predicted median decline was slightly higher for some groups (up to 2.96% for dependent calves; presented in Table 12-26). However, this would still be unlikely to cause a significant impact on either survival or reproductive rates. White-sided dolphin and killer whales are expected to occur in lower densities than other marine mammal species which have been quantitatively assessed in SS10: Marine mammal underwater noise impact assessment, and therefore there are also not expected to be any population-level impacts to these species. As a precaution, given that the estimated likely effect from pile driving is considerably less for these species than harbour porpoise, dolphin species were assessed as having **medium sensitivity** to injury from pile driving.

Table 12-26 Summary of the predicted decline in marine mammal vital rates as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band

SPECIES	MODELLED AGE CLASS / VITAL RATE	PREDICTED MEDIAN DECLINE (%)	SENSITIVITY
Harbour porpoise	Mature female survival	0.01	Low
	Mature female fertility	0.09	
	Juvenile or dependent calf	0.18	
White-beaked dolphin, common dolphin and Risso's dolphin (using bottlenose dolphin as a proxy)	Mature female	1.60	Medium
	Mature female fertility	0.43	
	Juvenile	1.32	
	Dependent calf	2.96	
Harbour seal and grey seal	Mature female survival	0.39	Low
	Mature female fertility	0.27	
	Seal pup/juvenile survival	0.52	

LF hearing group marine mammals may be more likely to have an overlap in hearing range with the low frequencies produced during pile driving. As summarised in SS10: Marine mammal underwater noise impact assessment, minke whale have been shown to communicate at frequencies below 2 kHz (Edds-Walton, 2000; Mellinger *et al.*, 2000; Gedamke *et al.*, 2001; Risch *et al.*, 2013; Risch *et al.*, 2014), with the most sensitive hearing range extending between 30 to 100 Hz and 7.5 to 25 kHz (depending on which model is considered; Tubelli *et al.*, 2012). Humpback whales were predicted to have a slightly lower and narrower range between 15 to 200 Hz and 3 to 9 kHz (depending on which simulation is used; Tubelli *et al.*, 2018).

Whilst there may be potential for permanent auditory injury to LF marine mammals, a 2-10kHz notch of 6 dB would only impact a small proportion of the hearing range for these species. Therefore, this is unlikely to significantly impact an animals reproductive or survival rates. Whilst minke whales are the only species assessed in SS10: Marine mammal underwater noise impact assessment, in the absence of detailed species-specific studies, this assessment is considered to apply to the sensitivity of humpback whale to pile driving injury, as they are in the same hearing group (Southall *et al.*, 2019). Therefore, acknowledging the LF hearing capabilities for this species, and also the lack of data and uncertainty surrounding the impact for these species, minke whale and humpback whale are conservatively assessed as having medium sensitivity to injury from pile driving.

To determine the magnitude of impact on marine mammals, underwater noise modelling has been undertaken to determine the instantaneous (SPL_{peak}) and cumulative (SEL_{cum}) PTS impact ranges (detailed in SS11: Underwater noise modelling report). The cumulative PTS impact range has been calculated for impact piling at each representative noise modelling location, in addition to concurrent piling of pin-pile jackets in the southwest and southeast locations, which were selected as they were furthest away from each other and the nearest points to the coast.

The worst case results from this noise modelling and the subsequent worst case magnitude assessment have been presented in Table 12-27. Further results from different configurations, including different foundation types (monopile and jacket), sediment conditions (hard and soft sediments) and underwater noise sampling locations for each species are also available in SS10: Marine mammal underwater noise impact assessment.

Whilst there is potential for permanent injury to occur as a result of pile driving to harbour porpoise (up to 255 animals from the concurrent pile driving scenario) and minke whale (up to 25 animals also from the concurrent pile driving scenario), there are no significant population-scale effects predicted (up to 0.14% and 0.44% of these species' MU, respectively. For dolphin and seal species, less than one animal was estimated to experience auditory injury, equating to 0% of the UK MU's and SMU's, respectively.

Quantitative assessment could not be undertaken for white-sided dolphin, killer whales and humpback whales. However, these species are expected to occur in lower densities than those which have been included in the quantitative assessment in the same hearing groups. Therefore, it is not expected that the impact to these species would exceed the magnitude of those species which have been assessed here. Given that no significant population effects are predicted, for all marine mammals the potential for injury resulting from pile driving is defined as being of negligible magnitude.

Table 12-27 Summary of the worst case pile driving underwater noise modelling results for injury of marine mammals, and the subsequent assessment of magnitude (SS10: Marine mammal underwater noise impact assessment)

SPECIES	METRIC	SINGLE LOCATION PILE DRIVING			CONCURRENT PILE DRIVING* CUMULATIVE PTS (SEL_{CUM})		MAGNITUDE
		WORST CASE SCENARIO	INSTANTANEOUS PTS (SPL_{PEAK}) RESULT	CUMULATIVE PTS (SEL_{CUM}) RESULT	WORST CASE SCENARIO	CUMULATIVE PTS (SEL_{CUM}) RESULT	
Harbour porpoise	Area (km^2)	• Monopile foundation; • Hard sediment; and • SE representative location.	1.6	620	Results from hard and soft sediment scenarios are the same.	1,700	Negligible
	Range (km)		0.72	17		-	
	No. of animals		<1	93		255	
	% UK MU		0.00	0.02		0.14	
Dolphin species	Area (km^2)	Results from all scenarios are the same.	<0.1	<0.1	N/A – no in-combination effect when piles are installed concurrently.		Negligible
	Range (km)		<0.1	<0.1			
	No. of animals		<1	<1			
	% UK MU		0.00	0.00			

<table>
<tr><th rowspan="2">SPECIES</th><th rowspan="2">METRIC</th><th colspan="3">SINGLE LOCATION PILE DRIVING</th><th colspan="2">CONCURRENT PILE DRIVING* CUMULATIVE PTS (SEL_{CUM})</th><th rowspan="2">MAGNITUDE</th></tr>
<tr><th>WORST CASE SCENARIO</th><th>INSTANTANEOUS PTS (SPL_{PEAK}) RESULT</th><th>CUMULATIVE PTS (SEL_{CUM}) RESULT</th><th>WORST CASE SCENARIO</th><th>CUMULATIVE PTS (SEL_{CUM}) RESULT</th></tr>
<tr><td rowspan="4">Minke whale</td><td>Area (km^2)</td><td rowspan="4">• Jacket foundation;
• Soft sediment; and
• SE representative location.</td><td>0.01</td><td>2,200</td><td rowspan="4">Results from hard and soft sediment scenarios are the same.</td><td>4,500</td><td rowspan="4">Negligible</td></tr>
<tr><td>Range (km)</td><td><0.05</td><td>40</td><td>-</td></tr>
<tr><td>No. of animals</td><td><1</td><td>22</td><td>45</td></tr>
<tr><td>% UK MU</td><td>0.00</td><td>0.21</td><td>0.44</td></tr>
<tr><td rowspan="4">Seal species</td><td>Area (km^2))</td><td rowspan="4">• Monopile foundation;
• Hard sediment; and
• SE representative location.</td><td>0.01</td><td>0.2</td><td colspan="2" rowspan="4">N/A – no in-combination effect when piles are installed concurrently.</td><td rowspan="4">Negligible</td></tr>
<tr><td>Range (km)</td><td><0.05</td><td>0.35</td></tr>
<tr><td>No. of animals</td><td><1</td><td><1</td></tr>
<tr><td>% SMU</td><td>0.00</td><td>0.00</td></tr>
</table>

**There is potential within the PDE for concurrent piling for jacket foundations only. Therefore, concurrent pile driving has only been considered in the underwater noise modelling and impact assessment for this foundation type.*

Evaluation of significance

Taking the low to medium sensitivity and the negligible magnitude of the impact, the overall effect on marine mammals from injury caused by pile driving during construction is considered to be **negligible** and **not significant** in EIA terms.

Receptor	Sensitivity	Magnitude of impact	Consequence
• Harbour porpoise	Low	Negligible	Negligible
• White beaked dolphin • Common dolphin • Risso's dolphin • White-sided dolphin; • Killer whale	Medium	Negligible	Negligible
• Minke whale • Humpback whale	Medium	Negligible	Negligible
• Harbour seal • Grey seal	Low	Negligible	Negligible

Impact significance – NOT SIGNIFICANT

Disturbance from pile installation

Disturbance from pile driving has been assessed in SS10: Marine mammal underwater noise impact assessment, using the latest guidance in Southall *et al.* (2019), based on the work of Tyack and Thomas (2019), who recommend a dose-response function is used to account for the high variability in response of marine mammals to a stimulus as opposed to all-or-nothing 'thresholds' (such as Effective Deterrent Range (EDR) or fixed noise threshold approaches). This allows for more realistic assumptions about the response of animals at different doses to be incorporated.

The sensitivity of species to pile installation was determined from an extensive literature review in SS10: Marine mammal underwater noise impact assessment and supported by expert elicitation in Booth *et al.* (2019). Key parts of this assessment have been summarised below, with full details of the assessment and the supporting literature in SS10: Marine mammal underwater noise impact assessment.

For harbour porpoise, previous studies have shown that harbour porpoises experienced short term displacement from the vicinity of piling events, such as at windfarms in the German North Sea ((Brandt *et al.*, 2011, Dähne *et al.*, 2013, Brandt *et al.*, 2016, Brandt *et al.*, 2018) and Beatrice Offshore Wind Farm (Graham *et al.*, 2019). Whilst harbour porpoise may exhibit effects to foraging efficiency from disturbance, it is also suggested they are resilient to short-term reductions in food intake (Wisniewska *et al.*, 2016). Benhemma-Le Gall *et al.* (2021) also suggests that harbour porpoise may not be completely displaced from an area during piling, and that displaced animals may resume foraging at a greater distance from the piling location with increased foraging activities to compensate. In an expert elicitation workshop funded by Department for Business, Energy & Industrial Strategy (BEIS), it was concluded that high levels of repeated exposure was unlikely to impact harbour porpoise fertility (Booth *et al*., 2019). Additionally, whilst repeated exposure may have the potential to impact calf survival it would be highly unlikely for a mother and calf to repeatedly return to an area in order to experience such levels of disturbance (Booth *et al*., 2019). Therefore, due to observed responsiveness to piling and the low numbers of days of disturbance expected to affect calf survival, harbour porpoise are assessed as having low sensitivity to disturbance from pile driving.

There is limited species-specific evidence to support assessment of white-beaked dolphins and Risso's dolphins and so bottlenose dolphin were used as a proxy (SS10: Marine mammal underwater noise impact assessment). This assessment is also thought to provide an appropriate proxy for white-sided dolphin and killer whale where there is also a lack of species-specific evidence. Small effects from piling activities have been observed in bottlenose dolphins, such as a short-term reduction in presence (but not complete displacement) at Nigg Energy Park in the Moray Firth (Graham *et al*., 2017b). During expert elicitation, it was concluded that bottlenose dolphin calf survival could be affected by disturbance over 30-50 days, where calves may be separated from their mothers thus impacting the amount of milk received (Harwood *et al*., 2014a). Whilst bottlenose dolphin may be sensitive to disturbance, studies of their response to increased vessel presence suggested that they are able to compensate for such disturbance with no overall impact to individual energy budgets (New *et al*., 2013). Therefore, no change to vital rates is expected and, using this assessment of bottlenose dolphin as a proxy, Risso's dolphins, white-beaked dolphins, white-sided dolphins and killer whales are assessed as having low sensitivity to disturbance from pile driving.

There is limited evidence for common dolphin sensitivity to piling. At Broadhaven Bay, Ireland, there was no significant reduction in common dolphin observed during piling activities (Culloch *et al*., 2016). Several studies of common dolphin in response to seismic activities (with a similar frequency range to pile driving) indicate no change to the presence or density of common dolphins (Stone *et al*., 2017, Kavanagh *et al*., 2019) whilst Goold (1996) found a reduction in common dolphin presence within 1 km of seismic activities in Pembrokeshire. Considering this information, and the evidence presented for bottlenose dolphin as another HF hearing group cetacean to support the assessment, common dolphins are assessed as having low sensitivity to disturbance from pile driving.

There are limited studies which consider the behavioural response of minke whales to underwater noise. They may alter their behaviour, such as diving patterns, in response to whale-watching vessels (Christiansen *et al*., 2013), and may avoid the sound source during emission of sonar signals (Sivle *et al*., 2015) and ADD (McGarry *et al*., 2017). Whilst there is potential for displacement of minke whales, which could affect foraging and reproductive rates, due to their large size and capacity for energy storage it is considered likely that they will be able to tolerate any short-term displacement better than harbour porpoise and other smaller animals. Therefore, there is unlikely to be any impact to vital rates. In the absence of species-specific evidence, this assessment is considered to be appropriate for humpback whales as another large size whale in the same hearing group. Therefore, minke whales and humpback whales are assessed as having low sensitivity to disturbance from pile driving.

During piling at the Wash, tagged harbour seals were shown to experience short-term (several hours) displacement from the vicinity of the piling, with a reduction in abundance up to 25 km from the area (Russel *et al*., 2016a). However, harbour seals often go through periods of fasting whilst hauled out between foraging trips and are sustained by energy stored in their thick layer of blubber, making them tolerant to short-term displacement from foraging. During expert elicitation, it was agreed that given their fat stores, mobility and generalist diet adults were likely to be able to compensate for short periods of lost foraging opportunity, although 'weaned of the year' animals may be more sensitive (Booth *et al*., 2019). Overall, it was determined that there may be potential for disturbance which could affect foraging opportunities, it is unlikely that animals would repeatedly return to the piling area. Given the responsiveness of harbour seals to piling activities, they were overall assessed as having **medium sensitivity** to disturbance from pile driving.

Twenty tagged grey seals in the Wadden Sea showed varied responses to pile driving activities, from no response to change in swimming/diving behaviour with responses evident from between 12 and 45 km, although seals returned to the area once the activity was ceased (Aarts *et al.*, 2018). This varied response may be related to a range of individual sensitivity or environmental factors. Hastie *et al*, (2021) suggests that seal avoidance rates to piling were dependent on the quality of the prey patch. During expert elicitation (Booth *et al*., 2019), it was concluded that grey seals have a reasonable ability to compensate for lost foraging opportunities given their fat stores, mobility and generalist diets. Like harbour seals, 'weaned of the year' animals are thought to be most vulnerable. However, grey seals were agreed to be much more robust to harbour seal due to their larger energy stores and adaptable foraging strategies (Beck *et al*., 2003, Sparling *et al*., 2006; Russel *et al*., 2013). Overall, grey seals were assessed as having **negligible sensitivity** to disturbance from pile driving.

The magnitude of impact has been determined using dose-response functions, supported by iPCoD modelling. As per SS10: Marine mammal underwater noise impact assessment, "*A dose-response function is used to quantify the probability of a response from an animal to a dose of a certain stimulus or stressor (Dunlop et al., 2017) and is based on the assumption that not all animals in an impact zone will respond. The dose can either be determined using the distance from the sound source or the received weighted or unweighted sound level at the receiver (Sinclair et al., 2021).*"

Following this guidance, 5 m dB interval noise contours have been generated using noise modelling. These have been overlaid on species density surfaces to predict the number of animals that will potentially be disturbed during pile driving. Species-specific approaches are summarised in the following paragraphs, with full details given in SS10: Marine mammal underwater noise impact assessment.

For harbour porpoise, the dose-response function presented in Graham *et al*. (2017a; Figure 12-8), based on data from the first six weeks of piling at Beatrice Offshore Windfarm, has been used. In this study, a behavioural response defined as when there was a proportional decrease in occurrence greater than 0.5. Whilst an updated dose-response function is presented in Graham *et al*., (2019) incorporating additional data from Beatrice Offshore Windfarm, the function presented in Graham *et al*. (2017a) has been used. The response of harbour porpoise is likely to reduce over the construction period as animals acclimatise to the stimuli (Graham *et al*., 2019). Therefore, using data from the initial piling period only, as presented in Graham *et al*., (2017a) is likely to represent a more precautionary approach.

For white-beaked dolphins, common dolphins, Risso's dolphins and minke whales, there are no species-specific dose-response functions currently available. Therefore, the harbour porpoise dose-response function from Graham *et al.* (2017a) has also been used for these species. Although, as harbour porpoise are thought to be more responsive to anthropogenic noise compared with other cetaceans such as bottlenose dolphins (Fernandez-Betelu *et al*., 2021; Stone *et al*., 2017), striped dolphins and common dolphins (e.g. Kastelein *et al*., 2006, Culloch *et al*., 2016) and other dolphin species (Stone *et al*., 2017), as further detailed in SS10: Marine mammal underwater noise impact assessment. In the absence of species-specific data, this is also thought to apply to white-sided dolphins, killer whales and humpback whales.

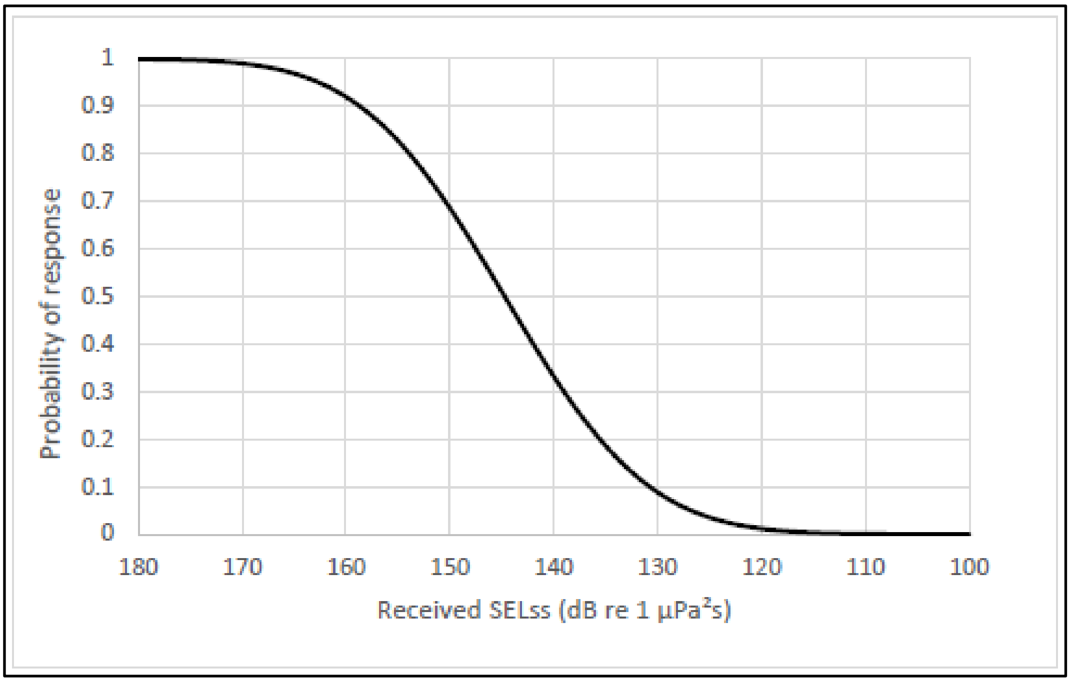

Figure 12-8 Relationship between the proportion of harbour porpoise responding and the received single strike SEL (SELss) (Graham et al. 2017a).

For harbour seals, the dose-response function in Whyte *et al*. (2020) has been used, which is based on telemetry data presented in Russell *et al*. (2016b) and Russell and Hastie (2017). There are no established dose-response functions for grey seals; therefore, the dose-response function from harbour seal is also applied for this species. Although, the dose response function for harbour seal is likely to overestimate the impact to grey seals, as grey seals are considered to be less sensitive to behavioural disturbance (Booth *et al*., 2019; Aarts *et al*., 2018), or may not exhibit any response for example if they are foraging in a high-quality area (Hastie *et al*., 2021), as detailed in SS10: Marine mammal underwater noise impact assessment.

Population modelling was then undertaken using the iPCoD framework (Harwood *et al*., 2014b, King *et al*., 2015) to predict the potential population-level consequence of PTS and disturbance from impact piling for harbour porpoise, harbour seal and grey seal. The model runs simulations to predict the population trajectory both with and without the predicted level of impact from impact piling, using information about the population dynamics including calf/pup, juvenile and adult survival, fertility, age at independence and age at first birth. A full description of the method and parameters used in the modelling are presented in SS10: Marine mammal underwater noise impact assessment.

The worst case results from this noise modelling have been presented in Table 12-28. For harbour porpoise, and harbour seal and grey seal, these assessments of magnitude are also supported by iPCoD modelling which are summarised in Table 12-29, with worst case disturbance contours generated from the underwater noise modelling for each species presented in Figure 12-10 to Figure 12-12, below. Full details of the assessment methodology and results, along with predicted population trajectories are fully detailed in SS10: Marine mammal underwater noise impact assessment. Further results from different configurations, including different foundation types (monopile and jacket), sediment conditions (hard and soft sediments) and underwater noise sampling locations for each species are also available in SS10: Marine mammal underwater noise impact assessment.

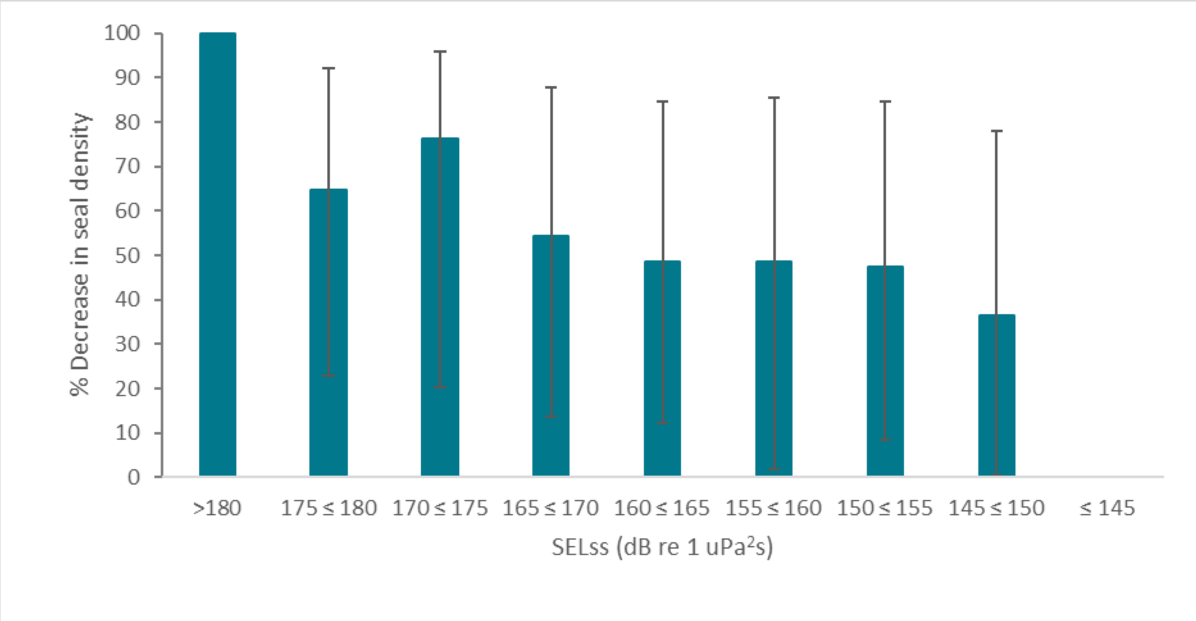

Figure 12-9 Predicted decrease in seal density as a function of estimated sound exposure level, error bars show 95% CI (from Whyte et al. (2020), as presented in SS10: Marine mammal underwater noise impact assessment)

Table 12-28 Summary of the worst case pile driving underwater noise modelling results for disturbance of marine mammals, and the subsequent assessment of magnitude (SS10: Marine mammal underwater noise impact assessment)

SPECIES	PREDICTED IMPACT FROM PILE DRIVING FROM DOSE-RESPONSE FUNCTION			MAGNITUDE
	METRIC	WORST CASE SCENARIO	RESULT	
Harbour porpoise	No. of animals	• Monopile foundation; • Hard sediment; and • NW representative location.	1,349	Negligible*
	% UK MU		0.73	
	% MU		0.36	
White-beaked dolphin	No. of animals	• Monopile foundation; • Hard sediment; and • NW representative location.	1,709	Medium
	% UK MU		5.02	
	% MU		3.89	
	No. of animals	• Monopile foundation;	90	Low

SPECIES	PREDICTED IMPACT FROM PILE DRIVING FROM DOSE-RESPONSE FUNCTION			MAGNITUDE
	METRIC	WORST CASE SCENARIO	RESULT	
Common dolphin	% UK MU	• Hard sediment; and • NW representative location.	0.16	
	% MU		0.09	
Risso's dolphin	No. of animals	• Monopile foundation; • Hard sediment; and • NW representative location.	121	Low
	% UK MU		1.4	
	% MU		1.0	
Minke whale	No. of animals	• Monopile foundation; • Hard sediment; and • NW representative location.	90	Low
	% UK MU		0.87	
	% MU		0.45	
Harbour seal	No. of animals	• Monopile foundation; • Hard sediment; and • SE representative location.	176 (18 – 328)**	Negligible[1]
	% SMU		9.0 (0.9 – 16.8) **	
Grey seal	No. of animals	• Monopile foundation; • Hard sediment; and • SE representative location.	2,887 (328 – 5,318)**	Negligible
	% SMU		8.4 (1.0 – 15.6)**	

** Magnitude reflects the magnitude informed by iPCoD, summarised in Table 12-29 and detailed in SS10: Marine mammal underwater noise impact assessment.*

*** 95% CIs presented for context, as presented in SS10: Marine mammal underwater noise impact assessment.*

Table 12-29 Summary of the results of iPCoD modelling

SPECIES	SIMULATION YEAR	UN-IMPACTED MEAN POPULATION SIZE	IMPACTED MEAN POPULATION SIZE	IMPACTED AS % OF UN-IMPACTED POPULATION SIZE	MEDIAN RATIO IMPACTED UN-IMPACTED GROWTH RATE
Harbour porpoise	End 2027 (before piling commences)	184,351	184,346	100	1.00
	End 2030 (after piling stops)	183,567	183,504	100	1.00
	End 2036 (6 years after piling stops)	183,241	183,191	100	1.00
	End 2042 (12 years after piling stops)	182,892	182,842	100	1.00
Harbour seal	End 2027 (before piling commences)	791	791	100	1.00
	End 2030 (after piling stops)	570	570	100	1.00
	End 2036 (6 years after piling stops)	293	293	100	1.00
	End 2042 (12 years after piling stops)	151	151	100	1.00
Grey seal	End 2027 (before piling commences)	36,060	36,060	100	1.00
	End 2030 (after piling stops)	36,902	36,902	100	1.00
	End 2036 (6 years after piling stops)	38,441	38,441	100	1.00
	End 2042 (12 years after piling stops)	39,998	39,998	100	1.00

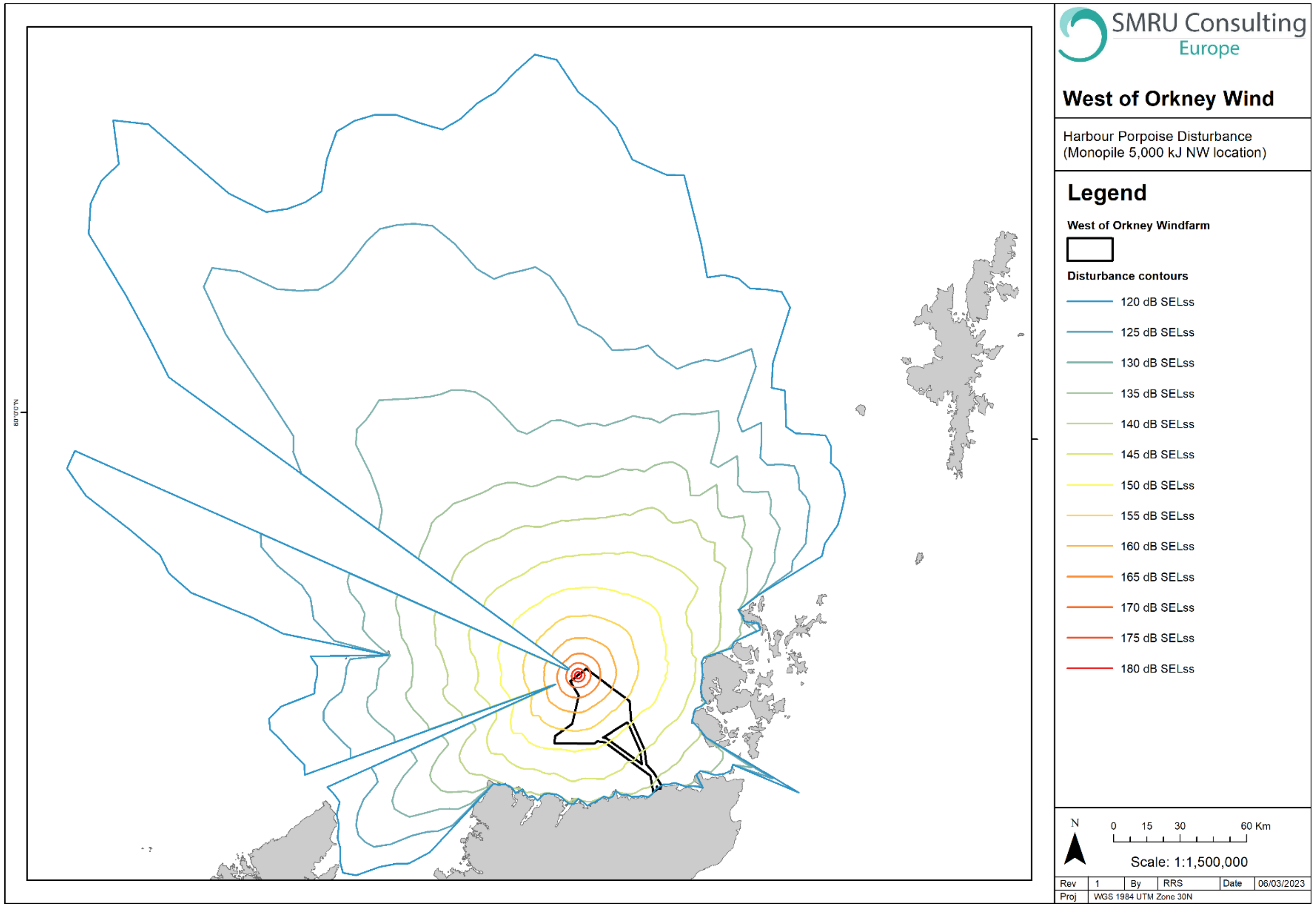

Figure 12-10 Harbour porpoise disturbance contours for the installation of a monopile at 5,000 kJ at the NW location (SS10: Marine mammal underwater noise impact assessment)

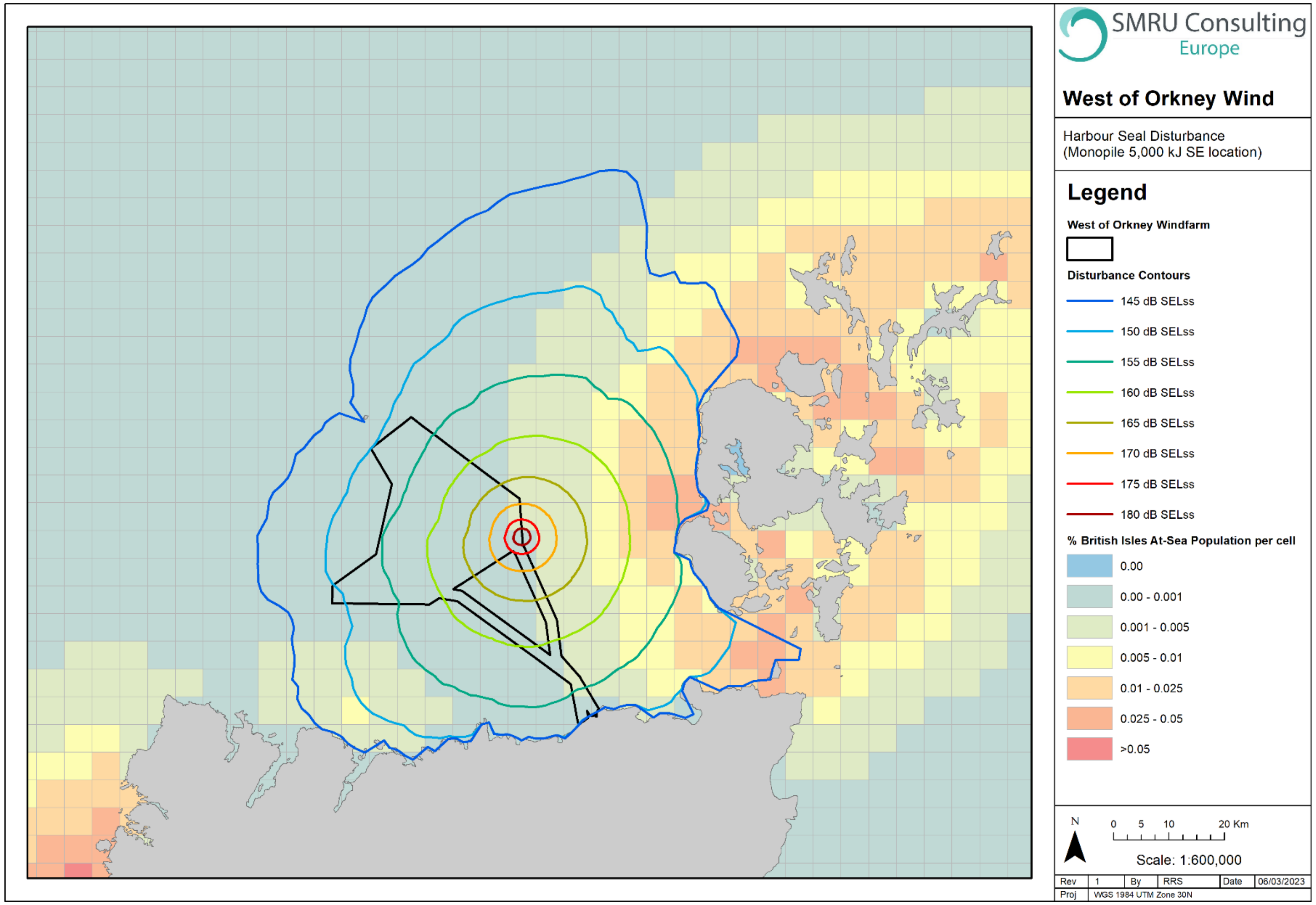

Figure 12-11 Harbour seal disturbance contours for the installation of a monopile at 5,000 kJ at the SW location (SS10: Marine mammal underwater noise impact assessment)

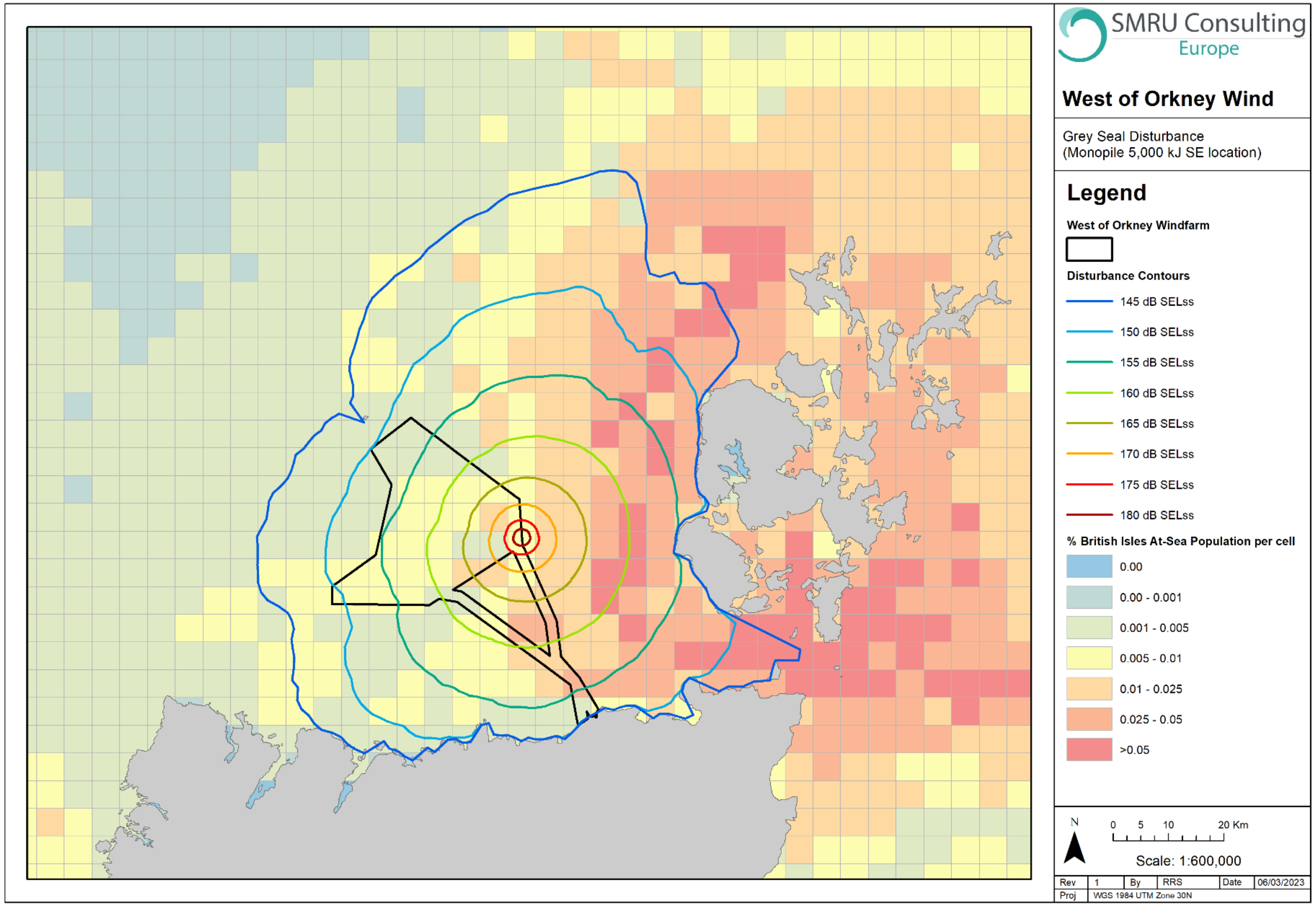

Figure 12-12 Grey seal disturbance contours for the installation of a monopile at 5,000 kJ at the SW location (SS10: Marine mammal underwater noise impact assessment)

Evaluation of significance

Taking the negligible to medium sensitivity and the negligible to medium magnitude of the impact, the overall effect on marine mammals from disturbance caused by pile driving during construction is considered to be **minor** or **negligible** and **not significant** in EIA terms.

Receptor	Sensitivity	Magnitude of impact	Consequence
• Harbour porpoise	Low	Negligible	Negligible
• White beaked dolphin	Low	Medium	Minor
• Common dolphin; • Risso's dolphin; • Minke whale; • White-sided dolphin; • Killer whale; and • Humpback whale	Low	Low	Negligible
• Harbour seal	Medium	Negligible	Negligible
• Grey seal	Negligible	Negligible	Negligible
Impact significance – NOT SIGNIFICANT			

12.6.1.1.5 Non-piling construction activities

Underwater noise may also be generated by a range of other non-piling construction activities, such as cable laying, dredging, drilling, rock placement and trenching, which have the potential to cause injury or disturbance to marine mammals. For each construction activity, a brief description in addition to the estimated SLs has been given in Table 12-30 from SS10: Marine mammal underwater noise impact assessment, with further information about these activities available in chapter 5: Project description. The potential impact from these activities has been assessed in detail in the marine mammal underwater noise impact assessment (SS10: Marine mammal underwater noise impact assessment), which has been summarised here.

Table 12-30 Underwater noise generated by non-piling construction activities (from SS10: Marine mammal underwater noise impact assessment)

ACTIVITY	DESCRIPTION	ESTIMATED UNWEIGHTED SOURCE LEVEL (SL) (DB RE 1 µPA @ 1 M (RMS))
Cable laying	Noise from the cable laying vessel and any other associated noise during the offshore cable installation.	171
Dredging	Dredging will be required at the Horizontal Directional Drilling (HDD) exit pit at the landfall. Dredging techniques may be required in the OAA for seabed preparation work for certain foundation options, and there is potential that dredging may be required for the export cable, array cables and interconnector cable installation. Suction dredging has been assumed as a worst case.	Backhoe: 165 Suction: 186
Drilling	There is the potential for WTG foundations to be installed using drilling depending on seabed type or if a pile refuses during impact piling operations. In addition, drilling will be required at the HDD exit pit at the landfall.	169
Rock placement	Potentially required on site for protection of offshore cables (cable crossings and where burial depth is not achieved) and scour protection around foundation structures.	172
Trenching	Trenching may be required during offshore cable installation.	172

Injury from non-piling construction activities

The sensitivity of marine mammals to injury from non-piling construction activities is dependent on both the activity and the marine mammal species. A literature review has been undertaken in SS10: Marine mammal underwater noise impact assessment to evaluate the sensitivity of marine mammals to these activities based on the expected overlap in the noise generated by each activity and the hearing range/sensitivities of the animals. The key conclusions from this review and assessment have been summarised below, with full details of the assessment and supporting literature given in SS10: Marine mammal underwater noise impact assessment.

Table 12-31 A summary of the assessment of sensitivity, and the impact significance assessment for injury from non-piling construction activities in marine mammal receptors

ACTIVITY	SPECIES	ASSESSMENT OF SENSITIVITY	SENSITIVITY
Dredging and drilling	Harbour porpoise, dolphins	Dredging and drilling produce continuous LF (main energy <1 kHz) noise (Evans, 1990; Thompson *et al.*, 2009; Todd *et al.*, 2015; Verboom, 2014). The hearing sensitivity for these receptors below 1 kHz is relatively poor, therefore a	Low

ACTIVITY	SPECIES	ASSESSMENT OF SENSITIVITY	SENSITIVITY
	and pinnipeds	PTS at this frequency would have little impact to vital rates and so these receptors are assessed to be of low sensitivity.	
	Minke whale and, humpback whale	LF noise generated from dredging and drilling may overlap with the hearing range of minke whale and mask LF communication (e.g. Risch *et al.*, 2013, Risch *et al.*, 2014; Tubelli *et al.*, 2012). Therefore, minke whale are assessed to be of medium sensitivity.	Medium
Cable laying	Harbour porpoise, dolphins and pinnipeds	Noise generated through cable laying has a low potential for impact as it is non-impulsive and is likely to be dominated by LF (<1 kHz) installation vessel noise (Genesis, 2011). Therefore, as the hearing sensitivity for these receptors below 1 kHz is relatively poor, they are assessed to be of low sensitivity.	Low
	Minke whale and humpback whale	LF noise generated from cable lay vessels may overlap with the hearing range of minke whale and mask LF communication (e.g. Risch *et al.*, 2013, Risch *et al.*, 2014; Tubelli *et al.*, 2012). Therefore, minke whale are assessed to be of medium sensitivity.	Medium
Trenching	Harbour porpoise, dolphins and pinnipeds	Noise generated from trenching is variable and dependent on the properties of the seabed being cut. North Hoyle Offshore Windfarm, which has similar benthic conditions to the offshore Project, recorded peak energy of LF (100 Hz – 1 kHz) (Nedwell *et al.*, 2003). Therefore, as the hearing sensitivity for these receptors below 1 kHz is relatively poor, they are assessed to be of low sensitivity.	Low
	Minke whale and, humpback whale	LF noise generated from trenching may overlap with the hearing range of minke whale and mask LF communication (e.g. Risch *et al.*, 2013, Risch *et al.*, 2014; Tubelli *et al.*, 2012). Therefore, minke whale are assessed to be of medium sensitivity.	Medium
Rock placement	Harbour porpoise, dolphins and pinnipeds	Little is known about noise generated from rock placement. Rock placement sound levels in the Yell Sound fell within background noise levels (Nedwell and Howell, 2004). Therefore, these receptors are assessed to be of low sensitivity.	Low
	Minke whale and humpback whale	LF noise generated from rock placement may overlap with the hearing range of minke whale (Nedwell and Howell, 2004). Therefore, minke whale are assessed to be of medium sensitivity.	Medium

Subacoustech (2023) (see SS11: Underwater noise modelling report) undertook underwater noise modelling to determine impact ranges from non-piling construction activities. Whilst both a fleeing animal and stationary animal model were run, the fleeing animal model is considered to be more accurate given the high mobility of marine mammals, and therefore this model has been summarised here. The full details and results are available in SS11: Underwater noise modelling report and summarised in SS10: Marine mammal underwater noise impact assessment. These models also assumed for the cumulative PTS worst case scenario that all sources were operating for the entirety of each 24-hour period, which in reality will not be the worst case. For all other non-piling construction activities assessed, the impact ranges for injury (PTS-onset) from the fleeing animal model were calculated to be <100 m, meaning that individuals would need to remain within 100 m of the construction activities for 24 hours before they would experience injury. This is highly unlikely, due to the transient and intermittent nature of the noise produced through these activities, and the ability of the animals to move away from the activity outside of the impact area. Therefore, the injury resulting from these construction activities is defined as being of negligible magnitude.

Evaluation of significance

Taking the low to medium sensitivity and the low magnitude of impact of marine mammals, the overall effect on marine mammals from injury caused by non-piling construction activities is considered to be negligible and not significant in EIA terms.

Receptor	Sensitivity	Magnitude of impact	Consequence
• Harbour porpoise; • White-beaked dolphin; • Common dolphin; • Risso's dolphin; • White-sided dolphin; • Killer whale; • Harbour seal; and • Grey seal	Low	Negligible	Negligible
• Minke whale; and • Humpback whale	Medium	Negligible	Negligible

Impact significance – NOT SIGNIFICANT

Disturbance from non-piling construction activities

There is limited literature available on the impacts of disturbance from other non-piling construction activities on marine mammals and basking sharks. Many studies which consider disturbance from activities such as dredging and trenching are confounded by the presence of vessels which makes it difficult to determine the sensitivity of marine species from non-piling construction activities in isolation (Anderwald *et al.*, 2013; Todd *et al.*, 2015).

SS10: Marine mammal underwater noise impact assessment presents a literature review to inform the sensitivity assessment of harbour porpoise, dolphin species (using bottlenose dolphin as a proxy), minke whales and seals, based primarily on behavioural studies during similar construction activities at other windfarms and Oil and Gas (O&G) platforms, the results of which are summarised here. In the absence of detailed studies to inform species-specific assessments, bottlenose dolphin are also expected to provide a suitable proxy for white-sided dolphin and killer whale; minke whale are expected to provide a suitable proxy for humpback whales, as they are within the same hearing group (Southall *et al.*, 2019).

For harbour porpoise at Beatrice and Moray East offshore windfarms, whilst there was a decrease of 17% in the detections of harbour porpoise during non-piling construction activities, they did continue to regularly use the area throughout the construction period (Benhemma-Le Gall *et al.*, 2021). At these developments, it was also found that once animals moved away from the noise source, they resumed normal behavioural activities, so they are thought to be able to compensate for any short-term, local disturbance. Therefore, it is not expected that individual survival or reproduction would be affected and harbour porpoise were assessed as having negligible sensitivity.

Dolphin species have been found to have varied responses to non-piling construction activities. An increase in dredging resulted in the absence of bottlenose dolphin (as a proxy for other cetacean species in this assessment) for five weeks at Aberdeen harbour (Pirotta *et al.* 2013), whereas during construction activities (including dredging, trenching and rock placement) for a gas pipeline off northwest Ireland, there was found to be no adverse effects to common dolphins (Culloch *et al.*, 2016). Although, it is expected that animals will be able to compensate for any short-term, local disturbance and there will be no significant effect on individual vital rates. Therefore, dolphin species were assessed as having low sensitivity.

For minke whale, Culloch *et al*. (2016) estimated fewer observations of minke whales on days where construction activities took place. Migrating humpback whales showed no significant response to construction activities at a desalination plant in Australia, although dive durations may have been shorter during the construction period (Pirotta *et al.*, 2014). However, both minke whale and humpback whale are expected to tolerate any temporary disturbance or displacement resulting from the construction activities, given their large size and subsequent high capacity for energy storage. Therefore, minke whales and humpback whales were assessed as having low sensitivity.

Monitoring of seal disturbance and site usage during the construction stage at the Lincs windfarm suggest that there were no displacement effects from construction activities, and seals would quickly return to the area following disturbance (Russell *et al.*, 2016a). The offshore Project is also in an area of relatively low densities for both harbour and grey seals, and thus it is not expected that any short term-local displacement caused by construction related activities would result in any changes to individual vital rates. Therefore, seals were assessed as having negligible sensitivity.

Disturbance of marine mammals from construction activities such as drilling, may occur at distances of between 10 – 20 km, and will vary depending on the species (Greene Jr, 1986, LGL and Greeneridge, 1986, Richardson and Wursig, 1990). Drilling may alter their foraging behaviour, dive patterns and mask vocalisations (Richardson and Wursig, 1990; Blackwell *et al.*, 2017; Malme *et al.*, 1984). There is a lack of information for non-piling construction activities, although for an underwater pipeline installation in northwest Ireland (which included activities such as dredging, trenching, pipe laying), a decline in harbour porpoise detections was initially observed, although there was considerable increase in detections after construction activities ended, suggesting impacts may be localised and temporary (Todd *et al.*, 2020).

It is expected that any disturbance impact will be primarily driven by the underwater noise generated by vessels during other construction-related activities, and, as such, it is expected that any impact of disturbance will be highly localised (within 5 km). The impacts will also be of short-term duration (<5 years) and will occur intermittently at low intensity and not all taking place at one time. Therefore, for all marine mammal species, disturbance resulting from these construction activities is defined as being of low magnitude.

Evaluation of significance

Taking the negligible to low sensitivity and the low magnitude of impact of on marine mammals from disturbance caused by non-piling construction activities is considered to be **negligible** and **not significant** in EIA terms.

Receptor	Sensitivity	Magnitude of impact	Consequence
• Harbour porpoise; • White-beaked dolphin; • Common dolphin; • Risso's dolphin; • Minke whale; • White-sided dolphin; • Killer whale; and • Humpback whale.	Low	Low	Negligible
• Harbour seal; and • Grey seal.	Negligible	Low	Negligible
Impact significance – NOT SIGNIFICANT			

12.6.1.1.6 Injury or disturbance to basking sharks from underwater noise generating activities

Underwater noise generating activities may also impact basking sharks; however, the hearing physiology and auditory capabilities of this species are poorly understood. Conclusions about basking shark hearing are therefore typically inferred using knowledge of hearing in other species with similar physiology as a proxy (Corwin, 1981; Casper and Mann, 2010; Popper *et al*., 2014).

Popper *et al*. (2014) set sound exposure guidelines and criteria for the potential impacts on fish from underwater noise, and group fish into hearing sensitivity categories defined by physiological (hearing anatomy, presence/absence of a swim bladder) and behavioural (the use of sound during navigation or mating) factors. As basking sharks lack swim bladders, they are within Group 1, as defined by Popper *et al*. (2014), meaning they are likely unable to detect sound pressure but may detect particle motion and are therefore only considered to be sensitive to a narrow band of frequencies. Particle motion is the kinetic component of sound and attenuates differently in the marine environment than sound pressure. Therefore, in the absence of species-specific physiology and sensitivity to sound, this assessment considers that impact on basking sharks to be consistent with the impact on other Group 1 species (flatfish, shark, skates and rays).

Studies on other elasmobranch species, such as lemon shark (*Negaprion brevirostris*), scalloped hammerhead (*Sphyrna lewini*) and sharpnosed shark (*Rhisoprionodon terranovae*) have been demonstrated to have increased sensitivity to LF sound and vibrational frequencies of up to 800 Hz (Corwin, 1981; Casper and Mann, 2010). Therefore, construction (including pre-construction) activities which generate noise energy at low frequencies may fall within the hearing sensitivity range for shark species, including basking sharks, meaning the noise may be detectable by the species and cause disturbance. The expected noise frequencies for pre-construction geophysical surveys are outside of the estimated hearing range for elasmobranchs, so they are unlikely to have any effect on basking sharks and have not been considered further. In Popper *et al*. (2014), there is a minimal risk of any injury or TTS to fish from continuous noise sources, such as other non-piling construction activities included within section 12.6.1.1.5. Therefore, these activities have also not been considered further for basking sharks.

Considering the limited hearing capabilities predicted for Group 1 fish and other elasmobranch species, basking sharks are assessed to have a low vulnerability to underwater noise, and overall, are assessed to have a low sensitivity.

Using the criteria set in Popper *et al*. (2014), Subacoustech (2023) has modelled the potential for injury and disturbance from impact piling and UXO clearance to fish, including those in Group 1 such as basking sharks (SS11: Underwater noise modelling report). This modelling is based on the same worst case design parameters as for marine mammals, presented in sections 12.6.1.1.3 and 12.6.1.1.4. Detailed modelling and results are presented in Subacoustech (2023), which has been summarised here and is analogous with the assessment presented for underwater noise in chapter 11: Fish and shellfish ecology. The modelling for fish was undertaken with the assumptions that the animal can flee from the area, and that it can also remain stationary, with the stationary model included to account for varied reactions of fish to underwater noise stimuli. For stationary animals, the impact ranges are larger. Basking sharks are highly mobile and would be likely to move away from the noise source. Therefore, the stationary model from this modelling would be overly conservative for this species and only the results from the fleeing animal model are considered.

For Group 1 fish and assuming the animal will flee from the area, the mean impact ranges for mortality, potential mortal injury and recoverable injury were all estimated to be within 130 m for WTG and OSP pile driving and 630 m for UXO clearance. The mean impact range for TTS was up to 33,000 m for single pile driving and 5,400 m for concurrent piling. The Popper *et al.* (2014) qualitative guidelines values for Group 1 fish for risk of recoverable injury and TTS associated with explosions (such as UXO clearance) suggests that high risk of recoverable injury and TTS is only expected to occur within tens of metres from the source, reducing to low at far distances from the source (i.e. thousands of metres). The same guidelines suggest that there is a high and moderate risk of masking and behavioural effects, respectively, up to hundreds of metres, reducing to moderate and low risk at far distances from the source.

The piling activities and UXO clearance will be short-term across the five-year construction and pre-construction period (up to 250 days under the temporal worst case scenario for impact piling) and not continuous (i.e. there would be periods of quiet between piling and UXO clearance events). Therefore, the impact ranges for mortality and injury are low, and whilst TTS and behavioural effects may occur over a wider range the effect will be temporary and short term. Overall, the impact is considered to be temporary, of medium spatial extent, and of a low frequency. Therefore, the Impact from underwater noise on basking sharks is defined as being of low magnitude.

Evaluation of significance

Taking the low sensitivity and the low magnitude of impact of Group 1 fish and other elasmobranchs as a proxy, the overall effect of underwater noise during construction (including pre-construction) for basking sharks is considered to be negligible and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Low	Low	Negligible
Impact significance – NOT SIGNIFICANT		

12.6.1.2 Disturbance due to physical presence and underwater noise from vessels

The physical presence of vessels and associated underwater noise may result in an increase in disturbance to marine mammals and megafauna, such as through avoidance and displacement as well as behavioural and vocalisation changes. Disturbance due to physical presence of and underwater noise generated by vessels are linked and occur simultaneously, unless the vessel is idle. There is insufficient evidence to support the assessment of physical presence separately, and vessel underwater noise studies are often subject to observer bias from the presence of the research vessel and cannot differentiate between the effects of vessel presence and vessel noise (Erbe *et al.*, 2019). Additionally, the magnitude of impact from underwater noise and physical presence of vessels will both increase with vessel size and number of vessels. Therefore, this impact assessment considers the underwater noise and physical presence of vessels as a single pressure.

The area surrounding the offshore Project already experiences high levels of vessel traffic (see chapter 15: Shipping and navigation). For the 14 days of vessel traffic analysed, there was an average of 23 unique vessels per day in the summer and 18 unique vessels in the winter recorded in the shipping and navigation offshore study area (the OAA plus a 10 nm buffer). The highest levels of existing shipping for both seasons were observed to the south of the OAA between the OAA and the north Scotland coastline, largely comprised of cargo vessels (51%), fishing vessels (21%), and tankers (8%), with vessel length ranging from 10 m to 332 m. Therefore, introduction of additional vessels of various sizes during the pre-construction and construction stage is not considered to be a novel impact for marine mammals and megafauna which are present in the area.

Up to 1,772 additional transits are anticipated to be made by construction and pre-construction vessels for the offshore Project over the four-year construction stage and one year pre-construction stage (see Table 12-18). It is estimated that there will be a maximum of 30 vessels consecutively on the site during the construction stage, although it is likely that a proportion of vessels would be stationary or slow moving for significant periods during the construction and pre-construction and would therefore pose a low risk of disturbance. Vessels from the offshore Project may include jack-up barges for piling substructures (if piled foundation design is selected) and WTG installation, other large and medium sized vessels to carry out other tasks and anchor handling as well as other small vessels such as for crew transport.

The additional vessels required during the construction and pre-construction stages are likely to increase the noise level around the offshore Project. These vessels will primarily produce non-impulsive, continuous, LF sounds (below

1 kHz), with SLs ranging from 165-180 dB re 1µPa (OSPAR, 2009; as detailed in SS10: Marine mammal underwater noise impact assessment). SS10: Marine mammal underwater noise impact assessment assesses the impact of vessel noise for harbour porpoise, common dolphin, minke whale, grey seal and harbour seal. Bottlenose dolphins and common dolphins were used as proxies for white-beaked dolphin and Risso's dolphin during quantitative assessment due to a lack of species-specific information (SS10: Marine mammal underwater noise impact assessment) and white-sided dolphin and killer whale in qualitative assessment. Minke whales were used as a proxy for humpback whales during qualitative assessment, with basking sharks considered qualitatively using best-available published information.

Vessel presence can alter behavioural budgets of cetaceans and interrupt important behaviours such as feeding and resting (Constantine *et al*., 2004; Christiansen *et al*., 2013; Christiansen *et al*., 2015; Christiansen and Lusseau, 2015; Meissner *et al*., 2015; Pirotta *et al*., 2015; Marley *et al*., 2017; Piwetz, 2019; Neumann and Orams, 2023; as referenced in SS10: Marine mammal underwater noise impact assessment). It can also impact swim speed, vocalisation, energy balance and cause displacement due to avoidance behaviour and has the potential to impact population recovery (La Manna *et al*., 2013; Marley *et al*., 2017; as referenced in SS10: Marine mammal underwater noise impact assessment; Palka and Hammond, 2001; Ayres *et al*., 2012; Stamation *et al*., 2010). However, susceptibility to vessel disturbance varies depending on a number of variables including location, habitat, water depth, time of year, calf presence, disturbance persistency and individual tolerance (Pirotta *et al*., 2015; Marley *et al*., 2017; as referenced in SS10: Marine mammal underwater noise impact assessment; Bauer, 1986; Corkeron, 1995; Stamation *et al*., 2010). In addition to their individual baseline tolerance, there is evidence that cetaceans have the ability to compensate any immediate behavioural changes, reducing the impact and biological significance of vessel disturbance on populations (Christiansen *et al*., 2015; Christiansen and Lusseau, 2015). It is worth noting that many existing studies are based on cetacean watching vessels which specifically target cetaceans while pre-construction and construction vessels are unlikely to follow cetaceans for any prolonged period of time and therefore are expected to result in less disturbance (Meissner *et al*., 2015; as referenced in SS10: Marine mammal underwater noise impact assessment). Therefore, all cetacean species, bar harbour porpoise, have been assessed to be of low sensitivity to disturbance from vessels.

Windfarm specific vessels have proven to displace harbour porpoise, resulting in reduced numbers around Offshore Windfarm sites (Brandt *et al*., 2018; Benhemma-Le Gall *et al*., 2021; as referenced in SS10: Marine mammal underwater noise impact assessment). This behaviour is consistent with other vessel types, which can also provoke behavioural changes (Dyndo *et al*.,2015; Oakley *et al*., 2017; Wisniewska *et al*., 2018). It is the HF noise that is most disruptive for harbour porpoise and so overall impacts will vary with vessel type. However, while disturbance from vessels can result in short term changes to porpoise behaviour, it is unlikely to result in alterations in vital rates in the longer term. Therefore, no population level impacts are. Harbour porpoise is therefore assessed as having low sensitivity to vessel disturbance.

For seals, vessels may cause disturbance both in the water and while they are hauled out, with impacts ranging from avoidance and stress reactions to TTS (using Southall *et al*., 2019 thresholds; Anderwald *et al*., 2013; Bishop *et al*., 2015; Karpovich *et al*., 2015; Jones *et al*., 2017; as referenced in SS10: Marine mammal underwater noise impact assessment). For both harbour seals and grey seals increases in stress and heart rate may occur when in proximity to vessels, which could result in significant energy expenditure over time. However, both species are classified as having low sensitivity to vessel disturbance.

Basking sharks are unlikely to be affected by vessel noise due to their limited hearing capabilities (outlined in section 11.6.1.2.5). The physical presence of the vessel is likely to have a greater impact on basking sharks with the potential of impacting courtship and feeding behaviour (Bloomfield and Solandt, 2008; Speedie, Johnson and Witt, 2009). However, it is likely that basking sharks will be able to tolerate disturbance from any construction and pre-construction vessels and return to previous behavioural states or activities once the vessel has passed. Therefore, basking sharks are assessed to be of low sensitivity.

The EMP, which has been adopted as part of the offshore Project as standard embedded mitigation (see section 12.5.4), includes safety measures to protect and reduce the risk of direct interactions and disturbance to marine wildlife using protocols supplied in the SMWWC (SNH, 2017a), the Codes of Conduct provided by the WiSe (Wildlife-Safe) Scheme (The WiSe Scheme, 2023) and Guide to Best Practice for Watching Marine Wildlife (SNH, 2017b) (see OP1: Outline Environmental Management Plan). For example, vessels should maintain a steady speed and direction if passing marine mammals, make sure any movements are steady and predictable and avoid cutting off an animal or group. This will reduce the severity and frequency of disturbance from vessels to marine mammals. The Navigational Safety and Vessel Management Plan (NSVMP) will also include indicative transit corridors to ensure vessel traffic moves along predictable routes which will reduce the area through which vessels are transiting, and thus the risk of disturbance to marine mammals and basking sharks (see OP4: Outline Navigational Safety and Vessel Management Plan).

With the adoption of best practice guidance and protocols, and the implementation of an EMP, any disturbance due to the physical presence and underwater noise from vessels are deemed to be short-term and temporary, with no potential for significant effect on animal vital rates. Therefore, the risk of disturbance from vessel activity for all marine mammals and basking sharks is assessed as being of low magnitude.

Evaluation of significance

Taking the low sensitivity of marine mammals and basking sharks, and the low magnitude of the impact, the overall effect of disturbance due to physical presence and underwater noise from vessels during construction (including pre-construction) is considered to be negligible and not significant in EIA terms.

Species	Sensitivity	Magnitude of impact	Consequence
• Harbour porpoise; • White-beaked dolphin; • Common dolphin; • Risso's dolphin; • Minke whale; • White-sided dolphin; • Killer whale; • Humpback whale; • Harbour seal; • Grey seal; and • Basking shark.	Low	Low	Negligible

Impact significance – NOT SIGNIFICANT

12.6.1.3 Vessel collision

During the construction stage (including pre-construction), there will be a small increase in localised vessel activity within the offshore Project area and along routes to ports being used by the Project, compared with baseline levels. This may result in an increased risk of injury or mortality to marine mammals and basking sharks within these areas, through collision with vessels and propeller strikes. These injuries include blunt trauma to the body or injuries consistent with propeller strikes. The severity of injuries associated with collision can range from minor, whereby the animal can recover, to mortality (Vanderlaan and Taggart, 2007; Schoeman *et al*., 2020).

As described in section 12.6.1.3, the area surrounding the offshore Project already experiences high levels of vessel traffic (detailed in chapter 15: Shipping and navigation). Up to 1,772 additional transits are anticipated to be made by construction and pre-construction vessels for the offshore Project over the four-year construction stage and one year pre-construction stage, with a maximum of 30 vessels consecutively at the site (see Table 12-18). However, a proportion of vessels would be stationary or slow moving for significant periods and would therefore pose a low collision risk. The increase in vessels present may increase the number of interactions between marine mammals and basking sharks and vessels, thus increasing the risk of collision.

The sensitivity of marine mammals and basking sharks to vessel collisions will be species dependent.

Harbour porpoise, white beaked dolphin, Risso's dolphin, grey seal, harbour seal, common dolphin, white-sided dolphin and killer whale are highly mobile and agile and have been observed to respond to vessel noise (e.g. propellors, thrusters, geophysical survey equipment) (Erbe *et al*., 2019). These species are therefore likely to be able to detect nearby vessels and move out of the ZoI and the path of the vessel, thus avoiding collision, although this is dependent on the vessel movement being predictable (Nowacek *et al*., 2001, Lusseau 2003). Additionally, in a study in the Moray Firth seals were shown to utilise the same areas as vessels when moving between foraging sites and haul-outs but tended to remain beyond 20 m from vessels with only three instances of seals coming within 20 m of vessels over 2,241 days (Onoufriou *et al*., 2016). Therefore, harbour porpoise, dolphin species and seal species are assessed to be of low sensitivity.

As larger and less agile species, minke whales, humpback whales and basking sharks may be less able to avoid moving vessels, but also may be more easily detected by vessels which are then able to take evasive action. Being less able to avoid moving vessels particularly applies to basking sharks, which forage by slowly moving through the water with their mouth open to feed on zooplankton and may be more abundant and vulnerable near the water surface during feeding and courtship (Speedie, Johnson and Witt, 2009). Therefore, minke whales, humpback whales and basking sharks are assessed to be of high sensitivity.

Vessel collision occurrence is challenging to estimate, as such events often occur far offshore and may go unnoticed or unreported (Cates *et al*., 2017; Peltier *et al*., 2019). The UK Cetacean Strandings Investigation Programme (CSIP) documents reported strandings and the cause of death where a post-mortem was undertaken for marine mammals, marine turtles and basking sharks. The CSIP data shows that very few marine mammal and basking shark strandings have been attributed to vessel collisions (CSIP, 2017). For example, the most recent report for strandings in 2017 attributes only two out of 148 animal strandings to boat or ship strikes, and a further three to physical trauma of unidentified cause, which could include vessel strikes, by-catch or bottlenose dolphin attack (CSIP, 2017). Therefore, mortality associated with vessel collisions may not be a key cause of mortality in the UK, as highlighted by these post-mortem examinations, relative to other causes.

The most important influences on severity of any potential impact are vessel size and speed (Peltier *et al.*, 2019; Schoeman *et al.*, 2020). The majority of the vessels during the construction (including pre-construction) stage are relatively small in size (e.g. tugs, vessels carrying ROVs, CTVs, barges and RIBs), which may have higher speeds than larger vessels but are also highly manoeuvrable so can more easily stop or move to avoid animals, when detected. Larger vessels, whilst less manoeuvrable, will be travelling at lower speeds meaning they have more time to detect and avoid animals, and for any animals themselves to take evasive action (Schoeman *et al.*, 2020).

As outlined in section 12.6.1.2, vessel activity will be managed under the EMP as part of the Projects standard embedded mitigation (see section 12.5.4) and includes adherence to wildlife best practice guidance and protocols such as the SMWWC (SNH, 2017a), the Codes of Conduct provided by the WiSe (Wildlife-Safe) Scheme (The WiSe Scheme, 2023) and Guide to Best Practice for Watching Marine Wildlife (SNH, 2017b). This includes measures that will reduce the risk of collision with marine mammals and basking sharks, such as to maintain a steady speed and direction in the presence of marine mammals and basking sharks and to try not to present the propellers to approaching animals. This will allow marine mammals and basking sharks to take evasive action and minimise the likelihood and severity of collision. Indicative transit corridors proposed within the NSVMP, will ensure vessel traffic moves along predictable routes and reduce vessel overlaps; further reducing the risk of vessel collision to marine mammals and basking sharks see OP4: Navigational Safety and Vessel Management Plan). Therefore, when considering these measures, there is only anticipated to be a highly localised impact with potential for a slight change from baseline conditions that will not affect the conservation status or integrity of the receptors.

Considering that vessel collision is not a dominant cause of mortality in stranded animals and the EMP and NSVMP embedded mitigation will reduce the likelihood and severity of vessel collisions, the impact is likely to occur at a low frequency over the construction and pre-construction period. Therefore, the impact for all receptors is defined as being of negligible magnitude.

Evaluation of significance

Taking the medium to high sensitivity of marine mammals and basking shark and the negligible magnitude of impact, the overall effect of vessel collision is considered to be negligible and not significant in EIA terms.

Receptor	Sensitivity	Magnitude of impact	Consequence
• Harbour porpoise; • White beaked dolphin; • Common dolphin; • Risso's dolphin; • White-sided dolphin; • Killer whale; • Grey seal; and • Harbour seal.	Low	Negligible	Negligible
• Minke whale; • Humpback whale; and • Basking shark.	High	Negligible	Negligible

Impact significance – NOT SIGNIFICANT

12.6.1.4 Indirect effects related to changes in availability or distribution of prey species

There is potential for changes in the availability and/or distribution of marine mammal and basking shark prey as a result of construction (including pre-construction) activities which physically disturb the seabed and generate underwater noise. This could affect the foraging ability and success of marine mammals and basking shark within the offshore Project.

Key prey species for many of the marine mammals considered in this assessment include clupeids (e.g. herring and sprat), gadoids (e.g. cod and whiting), sandeels and flatfish (Pierce *et al.*, 2004; Canning *et al.*, 2008; Tetley *et al.*, 2008; Jansen *et al.*, 2010; Evans and Hintner, 2013; Leopold *et al.*, 2018). Exceptions to this are humpback whales, which also consume small crustaceans such as calanoid copepods (e.g. Gavrilchuk *et al.*, 2014), Risso's dolphins which predominantly feed on cephalopods (e.g. squid and octopus; Evans and Hintner, 2013), grey seals which have also been observed to predate harbour porpoise, harbour seals and other grey seals (Leopold *et al.*, 2015; Stringell *et al.*, 2015; van Neer *et al.*, 2015; Brownlow *et al.*, 2016), and killer whales which also hunt seals off Scotland (Bolt *et al.*, 2009; Beck *et al.*, 2012; Ransijn, 2022). As filter feeders, basking sharks feed predominantly on zooplankton and around Scottish waters; the species is generally observed feeding on calanoid copepods (Sims, 2008).

A total of four key prey species are present within the vicinity of the offshore Project (sandeel, herring, sprat, and mackerel; see chapter 11: Fish and shellfish ecology). The offshore Project also potentially hosts migrating diadromous fish species (Atlantic salmon, sea trout, lamprey species, European eel), with the two former species identified as potential secondary prey for some key marine megafauna species in the area, such as bottlenose dolphins and grey and harbour seals (Santos *et al.*, 2001; Middlemas *et al.*, 2003; 2005). Furthermore, the presence of sandeel, herring, mackerel, cod, haddock and brown crab spawning and/or nursery habitat/grounds and flapper skate egg laying habitat were recorded within and around the fish and shellfish ecology offshore study area.

As marine mammals and basking sharks are highly mobile and wide-ranging, it is expected that individuals can forage in alternative areas, if required. However, they may also be required to forage different prey, or increase the time spent foraging which could have adverse energetic consequences and reduce the time available for other activities such as resting or reproduction (Ransijn *et al.*, 2022). Whilst their prey may be dominated by a few species, all marine mammals in this assessment, other than Risso's dolphin, are considered to be generalist feeders, and thus are not dependent on a single prey species (Evans and Hintner, 2013). Therefore, it is likely that marine mammals can supplement their diet with other available species if required, making them resilient to changes in prey availability. It has also been suggested that blooms of jellyfish may be related to the presence of offshore anthropogenic structures such as windfarms (Purcell, 2012; Duarte *et al.*, 2012; Janßen *et al.*, 2013; van Walraven *et al.*, 2016; Vodopivec *et al.*, 2017), meaning that whilst Risso's dolphin are more specialist in their prey selection, their preferred prey may not be adversely affected by the presence of the offshore Project. Therefore, given the expected adaptability of marine mammal and basking sharks to find alternative prey species or locations, marine mammals and basking sharks are assessed to be of low sensitivity.

Like marine mammals and basking sharks, there is potential for disturbance, injury and mortality to fish resulting from underwater noise (see chapter 11: Fish and shellfish ecology). Sensitivity of all fish species recorded in the area ranged from low to medium. For all species, the magnitude of impact was estimated low, resulting in overall significance of effect ranging from negligible to minor. Construction (including pre-construction) activities may also disturb benthic habitats which may support prey species exploited by marine mammal and basking sharks. Sensitivity of Atlantic salmon, sea trout, European eel and flapper skate to indirect effects related to changes in prey availability and distribution was assessed to be medium, while all other fish and shellfish ecology receptors were considered to present a low sensitivity. With a low magnitude of impact assessed for both groups, negligible consequences were concluded for all species during construction activities (chapter 11: Fish and shellfish ecology). As stated in chapter 11: Fish and shellfish ecology, there is not considered to be any scope for effect on fish and shellfish resulting from 'Temporary increases in suspended sediment concentrations and associated sediment deposition' during the construction and decommissioning stage.

Overall, no significant impacts to any fish and shellfish ecology receptors, including the identified prey species, are predicted, either for the offshore Project alone, or cumulatively with other plans or developments. There may be a localised reduction in fishing pressure on some commercially important prey species due to the safety distance and exclusion zones required around the construction operations. However, fishing effort which would have occurred within this area may instead be displaced to the surrounding area. These changes will occur on a relatively small scale; therefore, it is not expected that the change in fishing activity in the area would result in any significant changes to populations of these prey species.

Given that impacts to fish and shellfish from the offshore Project were determined to be not significant in EIA terms, and the scale of these impacts relative to the range of highly mobile marine mammals and basking sharks is likely to be small and highly localised, this impact is defined as being of negligible magnitude.

Evaluation of significance

Taking the high sensitivity of marine mammals and basking sharks and the negligible magnitude of the impact, the overall effect of indirect effects related to changes in availability and distribution of prey species during construction (including pre-construction) is considered to be negligible and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Low	Negligible	Negligible

Impact significance – NOT SIGNIFICANT

12.6.2 Potential effects during operation and maintenance

12.6.2.1 Noise related impacts during operation

12.6.2.1.1 Underwater noise from fixed WTGs

During operation, mechanical noise and vibration is generated by the machinery in the nacelle of the WTG, such as the gearbox and generator, which travels through the WTG foundation and propagates to the surrounding water (Nedwell *et al.*, 2003; Tougaard *et al*, 2020). This generates a LF, continuous underwater noise which may be detected by marine mammals and basking sharks, and lead to masking of communications or an alteration of their behaviour or distribution (Marmo *et al.*, 2013).

The expected maximum worst case scenario for operational noise is related to the maximum number and size of the WTGs. The worst case scenario for this assessment is up to 125 WTGs, each with a maximum 330 m rotor diameter (see Table 12-18).

As outlined in section 12.6.1.1, minke whales and humpback whales are able to detect sound at low frequencies. As the noise generated is of LF (up to 2 kHz), it is likely to only be within the sound detection frequency range for species in the LF hearing group, as defined in Southall *et al*. (2019), which includes baleen whales such as minke whales and humpback whales (Marmo *et al*., 2013). Therefore, there is only considered to be a potential for impact from WTG operational noise on minke whales (as requested by NatureScot and MSS) and humpback whales also in the LF hearing group. All other marine mammal species and basking sharks have been scoped out from further assessment for this impact pathway.

Using noise models, Marmo *et al*. (2013) predicted that minke whales may be able to detect sound from operational fixed-foundation WTGs up to 18 km away. However, any avoidance is likely to be more localised and would only affect a small portion of the animals, and thus there was not considered to be a displacement risk to these species (Marmo *et al*., 2013; Nedwell *et al*., 2007). Therefore, minke whales and humpback whales are assessed to be of low sensitivity.

Tougaard *et al*. (2020) investigated the underwater noise generated by 17 operational WTGs in Europe and the United States and proposed a method to estimate the broadband noise level, depending on the wind speed, WTG size and distance from the WTG. Based on this, Subacoustech (2023) (see SS11: Underwater noise modelling report) used this method to evaluate the potential risk of injury to marine mammals within the offshore Project OAA. This modelling predicted that the sound levels from the WTGs would decrease to ambient noise levels within a 100 m of each WTG. This was consistent with underwater noise modelling undertaken for marine mammals by Subacoustech for Hornsea Project Three (GoBe, 2018).

In a review of the post-consent monitoring at offshore windfarms both in the UK and abroad, the Marine Management Organisation also generally showed that noise levels radiated from operational WTGs are low and the spatial extent small, with marine mammal behavioural response only likely at close ranges to the WTGs (Marine Management Organisation, 2014). The broadband noise generated is generally comparable to ambient noise at distances of a few hundred metres. Nedwell *et al*. (2007) found that the noise from WTGs only dominated over the background noise in a few limited frequency bands and within these ranges, the noise was usually only a few dB above the background noise as akin to distant shipping. This is consistent with several other reviews which concluded that operational windfarm noise has negligible displacement or barrier effects (Madsen *et al*., 2006, Teilmann *et al*., 2006a; Teilmann *et al*., 2006b; CEFAS 2010; Brasseur *et al*., 2012).

Stöber and Thomsen (2021) considers the potential for behavioural disturbance caused by larger WTGs. Despite increasing WTG sizes the authors conclude that these might only have limited impacts related to behavioural response on marine mammals and fish. There is considerable uncertainty in the criteria available to assess this effect; however, based on highly precautionary thresholds it is estimated that disturbance may only occur up to approximately 200 m from the WTGs. As the distance between WTGs is considerably greater than 400 m, (over twice this distance), this would indicate that any array effect from the WTGs is not expected.

Considering the very limited impact ranges for injury and disturbance from WTG noise (<200 m) and the mobile nature of minke whales, the risk of injury or disturbance is likely to be highly localised, short term and highly unlikely to occur. Therefore, underwater noise from fixed WTGs is defined as being of negligible magnitude.

Evaluation of significance

Taking the low sensitivity of minke whale and humpback whale, and the negligible magnitude of the impact, the overall effect of underwater noise from fixed WTGs is considered to be negligible and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Low	Negligible	Negligible

Impact significance – NOT SIGNIFICANT

12.6.2.2 Disturbance due to physical presence and underwater noise from vessels

During the operation and maintenance of the offshore Project, there will be a small increase in localised vessel activity within the offshore Project and along routes to local ports, compared with baseline levels. The physical presence of vessels and associated underwater noise may result in an increase in disturbance to marine mammals and basking sharks through avoidance and displacement as well as behavioural and vocalisation changes.

As described in section 12.6.1.2, the area surrounding the offshore Project already experiences high levels of vessel traffic (further detailed in chapter 15: Shipping and navigation). Therefore, the introduction of additional vessels is not a novel impact for marine mammals and basking sharks which are present in the area.

Up to 12,695 transits are anticipated to be made by operation and maintenance vessels over the 30 year operational period (approximately 360 vessel transits per year- i.e. an average of approximately one transit per day; (see Table 12-18). It is estimated that there will be a maximum of 19 vessels simultaneously on the site, although it is likely that a proportion of vessels would be stationary or slow moving for significant periods during the operation or maintenance activities and would therefore pose a low risk of disturbance.

Given the lower number of vessels and vessel passes estimated during the operation and maintenance stage, the potential impact to marine mammals and basking sharks from vessel noise disturbance during operation and maintenance is predicted to be analogous with or less than that of the construction (including pre-construction) stage. Therefore, the assessment of the sensitivity of each receptor, and the magnitude of the potential impacts due to collision risk during construction (including pre-construction) in section 12.6.1.2 also applies during the operation and maintenance stage and is not repeated here. All marine mammals and basking sharks have been assessed as having low sensitivity to disturbance from vessels.

With the adoption of best practice guidance and protocols, such as the SMWWC (NatureScot, 2017), the Codes of Conduct provided by the WiSe (Wildlife-Safe) Scheme (The WiSe Scheme, 2023) and Guide to Best Practice for Watching Marine Wildlife (SNH, 2017b), and the implementation of a EMP, any disturbance due to the physical presence and underwater noise from vessels are deemed to be short-term and temporary, with no potential for significant effect on animal vital rates. Therefore, the risk of disturbance from vessel activity for all marine mammals and basking sharks is assessed as being of low magnitude.

Evaluation of significance

Taking the low sensitivity of marine mammals and basking sharks, and the low magnitude of the impact, the overall effect of disturbance due to physical presence and underwater noise from vessels during operation and maintenance is considered to be negligible and not significant in EIA terms.

Receptor	Sensitivity	Magnitude of impact	Consequence
• Harbour porpoise; • White-beaked dolphin; • Common dolphin; • Risso's dolphin; • Minke whale; • White-sided dolphin; • Killer whale; • Humpback whale; • Harbour seal; • Grey seal; and • Basking shark.	Low	Low	Negligible

Impact significance – NOT SIGNIFICANT

12.6.2.3 Vessel collision

During the operation and maintenance stage, there will be a small increase in localised vessel activity. There may also be some localised vessel activity along the export cable (within the ECC) should any cable repairs or maintenance be required, but operation and maintenance vessels will predominantly be within the OAA and along existing routes to local ports. This may result in an increased likelihood of injury or mortality to marine mammals and basking sharks within these areas, through blunt trauma associated with collision with vessels. The severity of injuries associated with collision can range from minor, whereby the animal can recover, to mortality (Vanderlaan and Taggart, 2007; Schoeman *et al.*, 2020).

As described in section 12.6.1.2, the area surrounding the offshore Project already experiences high levels of vessel traffic (further detailed in chapter 15: Shipping and navigation). Therefore, the introduction of additional vessels during the operation and maintenance stage is not a novel impact for marine mammals and basking sharks which are present in the area.

Up to 12,695 transits are anticipated to be made by operation and maintenance vessels over the 30-year operational period (approximately 360 vessel transits per year- i.e. an average of approximately one transit per day; see Table 12-18). It is estimated that there will be a maximum of 19 vessels simultaneously on the site, although it is likely that a proportion of vessels would be stationary or slow moving for significant periods during the operation or maintenance activities and would therefore pose a low collision risk.

Given the lower number of vessels and vessel passes estimated during the operation and maintenance stage, the potential impact to marine mammals and basking sharks from vessel collision during operation and maintenance is predicted to be analogous with, or less than, that of the construction stage (including pre-construction). As outlined in section 12.6.1.2, the EMP as part of the Projects standard embedded mitigation (see section 12.5.4), includes adherence to wildlife best practice guidance and protocols such as the SMWWC (SNH, 2017a), the Codes of Conduct provided by the WiSe (Wildlife-Safe) Scheme (The WiSe Scheme, 2023) and Guide to Best Practice for Watching Marine Wildlife (SNH, 2017b). Therefore, the assessment of the sensitivity of each receptor, and the magnitude of the potential impacts due to collision risk during construction (including pre-construction) in section 12.6.1.3 also applies during the operation and maintenance stage and is not repeated here. Therefore, harbour porpoise, dolphin species and seal species are assessed to be of low sensitivity and minke whales, humpback whales and basking sharks are assessed to be of high sensitivity.

The magnitude of the impact during the operation and maintenance stage is not expected to differ from that during the construction stage (including pre-construction). Therefore, as described in section 12.6.2.3, considering that vessel collision is not a frequent cause of mortality in stranded animals and the EMP embedded mitigation which will reduce the likelihood and severity of vessel collisions, the impact for all receptors is defined as being of negligible magnitude.

Evaluation of significance

Taking the medium to high sensitivity of marine mammals and basking shark and the negligible magnitude of impact, the overall effect of vessel collision is considered to be negligible and not significant in EIA terms.

Receptor	Sensitivity	Magnitude of impact	Consequence
• Harbour porpoise; • White beaked dolphin; • Risso's dolphin; • Grey seal; • Harbour seal; • Common dolphin; • White-sided dolphin; and • Killer whale.	Low	Negligible	Negligible
• Minke whale; • Humpback whale; and • Basking shark.	High	Negligible	Negligible

Impact significance – NOT SIGNIFICANT

12.6.2.4 Displacement or barrier effects associated with physical presence of devices and infrastructure

There is potential for displacement or barrier effects to occur to marine mammals and basking sharks from the physical presence of the OAA infrastructure during the operation and maintenance stage, including from WTG and OSP foundations. The presence of these novel structures may impact the movement or behaviours of individuals or populations by restricting access to key habitats utilised by marine mammals and basking sharks, such as those important areas for foraging or reproduction.

Here, displacement refers to the spatial displacement of marine mammals and basking sharks and the loss of access to the area occupied by the offshore Project infrastructure during the Project's anticipated 30-year operational lifespan. Barrier effects occur where the presence of the offshore Project prevents access to other areas and is particularly applicable to migratory species which are reliant on key pathways or seasonal habitats and could be obstructed by the array infrastructure. This includes basking sharks, which travel long distances (390 to 460 km) to locate prey 'hotspots' at shelf-break fronts (Sims *et al*., 2003), such as off the Sea of Hebrides. Additionally, minke whales migrate between tropical breeding grounds in the winter and colder feeding regions in the summer (Risch *et al*., 2014; 2019), including waters around the UK, particularly Scotland.

Compared with monopile foundations, piled jacket and suction bucket foundation types which have a wider base may result in an increased risk of displacement to animals which spend more time at depth, such as Risso's dolphins (Arranz *et al*., 2018) and grey seals (Thompson *et al*., 1991).

The offshore export cable will either be buried or, where burial is not possible, will be run along the seabed with remedial cable protection. As there will be no obstruction of the water column, the export cable should not limit the movement of animals through the offshore ECC. Therefore, animals travelling between locations to the east and west of the site, will be able to traverse the offshore ECC or travel around the OAA to the north, with limited scope for barrier effects.

Potential displacement effects have been assessed at several currently operational windfarms. A monitoring programme at the Egmond aan Zee Offshore Wind Farm in The Netherlands reported a significant increase in harbour porpoise activity within the offshore windfarm compared to the reference area during the operational stage (Scheidat *et al*., 2011), indicating that the harbour porpoise presence was not adversely affected by the windfarm infrastructure. Long-term monitoring at the Horns Rev and Nysted offshore windfarms in Denmark frequently recorded harbour porpoises and harbour seals within the OAA of the operational windfarms, and within two years of operation the populations had recovered to levels that were comparable with the surrounding area (Diederichs *et al*., 2008). Studies at Dutch and Danish offshore windfarms (Lindeboom *et al*., 2011) also suggest that harbour porpoise may be attracted to increased foraging opportunities within operating offshore windfarms. Similarly, a tracking study undertaken by Russell *et al*. (2014) in Scotland and the Netherlands demonstrated that harbour and grey seals move between individual WTGs in a grid-like pattern, often repeatedly returning to the windfarm area, suggesting that they are utilising the area for foraging.

The size of the marine mammals and basking sharks in this assessment ranges from around 1.9 m for harbour porpoise to a maximum of 17 m for humpback whales (Clapham, 2000; Marine Scotland 2016). Considering the size of all species relative to the proportion of the available water column occupied by the infrastructure, and the minimum distance between foundations (944 m), individuals will be able to move readily between and around the WTG and OSP foundations at all depths. Therefore, habitat use by marine mammal and basking shark populations within the OAA is unlikely to be hindered by the physical presence of infrastructure during the operation of the offshore Project. There is also evidence that infrastructure can provide additional foraging opportunities for marine mammals which may negate the effects of displacement for some species (as detailed in section 12.6.2.5).

Marine mammals are likely to be able to pass through the OAA easily or move around the OAA including across the offshore ECC. The presence of marine mammals around offshore infrastructure at other offshore windfarms also suggests that some marine mammal species may have a high tolerance to changes in infrastructure in their environment and are able to adapt to its presence. Therefore, marine mammals and basking sharks are assessed to be of negligible sensitivity.

The spatial extent of any displacement is expected to be low, given the small proportion of the water column that will be occupied by infrastructure associated with the offshore Project compared with the size of the OAA and the large habitat ranges occupied by the assessed receptors. Whilst the behaviour of individual animals which pass close to or within the OAA may be affected on a local scale, positively or negatively, this is not likely to impact baseline conditions of the populations for any species or hinder movement between seasonal habitats. Therefore, the impacts for marine mammals and basking sharks are assessed to be of negligible magnitude.

Evaluation of significance

Taking the negligible sensitivity of marine mammals and basking sharks and the negligible magnitude of the impact, the overall effect of displacement or barrier effects associated with physical presence of devices and infrastructure during operation is considered to be negligible and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Negligible	Negligible	Negligible

Impact significance – NOT SIGNIFICANT

12.6.2.5 Indirect effects related to changes in availability or distribution of prey species

There is the potential for changes in the availability and/or distribution of marine mammal and basking shark prey during the operation and maintenance stage of the Project by removing or altering essential habitats, such as spawning, nursery and feeding areas, and by creation of new hard substrate (through the WTG's and OSPs themselves, and any cable protection required). This could subsequently affect the foraging ability and success of marine mammals and basking shark within the offshore Project and surrounding area.

As outlined in section 12.6.1.4, marine mammals and basking sharks prey on a range of species in UK and Scottish waters, including receptors which have been assessed in chapter 11: Fish and shellfish ecology. Effects to marine mammal and basking shark prey species, as assessed in chapter 11: Fish and shellfish ecology, are expected to occur through two main pathways from the windfarm operation: long-term habitat changes (including habitat loss and disturbance, potential fish or predator aggregation and barrier effects) and EMF emissions, in addition to impacts related to maintenance activities.

As stated in chapter 10: Benthic subtidal and intertidal ecology and chapter 11: Fish and shellfish ecology, there is also not considered to be any scope for effect on benthic and intertidal ecology resulting from 'Long-term loss or damage to benthic habitats and species', or on fish and shellfish resulting from 'Long-term habitat loss and disturbance' or

'Noise related impacts during operation'. Therefore, it is not anticipated for these impacts to cause any indirect effects to marine mammals and basking sharks.

The worst case permanent footprint of the offshore Project is 7.34 km^2, present for the duration of the operation and maintenance stage (30 years), as presented in chapter 11: Fish and shellfish ecology. In addition, the presence of up to 125 WTG and five OSP foundation structures, as well as scour and rock protection where required, may introduce new structures for habitat creation, with the potential for fish and predator aggregation.

12.6.2.5.1 Maintenance activities

Indirect effects relating to maintenance activities are expected to be analogous with, but most likely less than those during the construction stage (including pre-construction). Therefore, as per the assessment given in section 11.6.1.5, marine mammals and basking sharks are assessed to be of low sensitivity and the impact is defined as negligible magnitude.

Evaluation of significance

Taking the low sensitivity of marine mammals and basking sharks and the negligible magnitude of the impact, the overall effect of indirect effects related to changes in availability and distribution of prey species during maintenance is considered to be negligible and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Low	Negligible	Negligible

Impact significance – NOT SIGNIFICANT

12.6.2.5.2 Habitat change

Fixed-bottom infrastructure, including WTG foundations and scour protection, have been observed to function as fish aggregate devices (Reubens *et al.*, 2013a; 2013b). Increased productivity and prey species around fixed-bottom infrastructure has been attributed to factors such as provision of shelter, increased hard bottom substrate which supports biofouling organisms and reduced fishing pressure (Clausen *et al.*, 2021). The introduction of artificial substrate to the marine environment may alter benthic communities within the offshore Project, and potentially the surrounding area, which in turn, may affect which species are attracted to the area (Hemery, 2020). Consequently, marine predators such as marine mammals and basking sharks may target these areas for foraging and profit from the ecological changes that take place following installation of infrastructure (Degraer *et al*. 2020).

Grey and harbour seals have been observed to target marine infrastructure during foraging (Russell *et al.*, 2014). Increased foraging opportunities in addition to refugia from high vessel activity were also attributed to an increase in harbour porpoise activity around Egmond aan Zee Offshore Wind Farm (Lindeboom *et al.*, 2011; Scheidat *et al.*, 2011; Defingou *et al.*, 2019). Frequent marine mammal sightings and acoustic detections have also been recorded close to offshore O&G platforms (Todd *et al.*, 2009; Todd *et al.*, 2016; Delefosse *et al.*, 2018; Clausen *et al.*, 2021). Given the potential for increased productivity and subsequent increased foraging opportunities for marine mammal and basking shark prey around operational windfarms, adaptability is likely to be high. However, given the uncertainty of long-term impacts from offshore structures on marine food webs and predator-prey relationships (Xoubanova and Lawrence, 2022), all receptors have been precautionarily assessed to have low sensitivity.

The potential for impact on fish and shellfish, including prey species, from potential fish or predator aggregation has been assessed in chapter 11: Fish and shellfish ecology. Based on a review of the most recent available literature presented in the chapter, all fish and shellfish receptor groups were determined to be of low to high sensitivity and low magnitude of impact, resulting in a negligible to low overall effect, which is not significant in EIA terms. Therefore, impacts to the composition and distribution of fish species, including those which marine mammals and basking sharks prey upon, are not anticipated over the lifetime of the offshore Project.

There is also potential for other operational impacts from the offshore Project to affect fish and shellfish species, which have been assessed in chapter 11: Fish and shellfish ecology. This includes habitat loss and disturbance and from barrier effects to diadromous species, which may occur from permanent infrastructure and temporary habitat loss during maintenance activities. However, in the assessments of these impacts it was determined that the effect was considered to be low and not significant in EIA terms. Therefore, it is not anticipated for these impacts to cause any indirect effects to marine mammals and basking sharks.

Overall, there is not anticipated to be any indirect effects to marine mammals or basking sharks or their prey species from habitat change. Therefore, the impact is defined as being of negligible magnitude.

Evaluation of significance

Taking the low sensitivity of marine mammals and basking sharks and the negligible magnitude of the impact, the overall effect of indirect effects related to changes in availability and distribution of prey species from habitat change is considered to be negligible and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Low	Negligible	Negligible

Impact significance – NOT SIGNIFICANT

12.6.2.5.3 EMF effects

Whilst there is not considered to be any potential for significant direct impact from EMF effects on marine mammals and basking sharks (Table 12-14), there is potential for EMF to affect their prey. EMFs are generated by the electricity transfer from Alternating Current (AC) and Direct Current (DC) and are comprised of an electric field and magnetic field component. EMFs have the potential to alter the behaviour of marine organisms able to detect these fields. A detailed assessment of the effect from EMFs on fish and shellfish has been given in chapter 11: Fish and shellfish ecology, which was informed by a Project specific modelling study undertaken by a cable manufacturing contractor (currently confidential). The results of this impact assessment have been summarised here.

Up to 140, 145 kV inter-array High Voltage Alternating Current (HVAC) cables (500 km), six 420 kV interconnector HVAC cables (150 km) and five 420 kV offshore export cables (320 km) will be installed as part of the offshore Project. All offshore export cables will either be buried to a target depth of 1-3 m or covered by cable protection to a height of up to 3 m. Although the burial of cables and other protective measures such as cable protection are not considered to be effective ways to mitigate the full extent of magnetic fields in the marine environment, it does separate the most sensitive species from the source of the emissions, therefore reducing the maximum field strength likely to be encountered (e.g. at the seabed) (Copping *et al.*, 2021). In addition, design parameters and installation methods are expected to conform to industry standard specifications which includes shielding technology to reduce the direct emission of EMFs.

The results of the Project-specific EMF modelling by a cable manufacturing contractor (currently confidential). Showed that the magnetic fields rapidly dissipate when assuming 1 – 3 m burial or cable protection. Furthermore, magnetic fields at 1 m burial or protection depth resulted in magnetic fields of lower strength than the approximate natural geomagnetic field at the offshore Project.

As described in chapter 11: Fish and shellfish ecology, based on available literature, marine finfish are assessed as having a low sensitivity to EMF effects. Pelagic finfish (e.g. mackerel, herring and sprat) are not closely associated with the seabed and combined with their high mobility, are unlikely to be in the vicinity of any increased EMF associated with the offshore Project for any significant length of time. Demersal fish and eggs and larvae were assessed to have a medium sensitivity as they are more likely to overlap with the zone of increased EMF, and there are several demersal finfish species which have nursery grounds overlapping the fish and shellfish ecology offshore study area. Shellfish are considered to have low vulnerability to EMF effects, with no or minor effects from EMF encounters observed in previous studies (Albert *et al.*, 2020) and were assessed to have low sensitivity. Elasmobranchs possess specialist magnetic receptor cells, whilst diadromous fish have a magnetically sensitive skeletal structure and may use the Earth's EMFs during migration. Therefore, elasmobranchs and diadromous fish receptor groups were also assessed to have medium sensitivity. Considering that EMF emissions will be reduced through cable burial and/or cable protection measures, the impact is considered to occur over a local spatial extent, and overall, the impact on all fish and shellfish was defined to be of low magnitude.

As outlined in section 12.6.1.4, given the adaptability of marine mammal and basking sharks to find alternative prey species or locations, marine mammals and basking sharks are assessed to be of low sensitivity to changes in prey availability from the Project during construction (including pre-construction). This assessment is also applicable during the operation stage. As there was assessed to be no potential for significant effect on fish and shellfish species (as outlined in chapter 11), there is not expected to be an effect on marine mammal and basking shark species beyond a slight change from baseline conditions. Therefore, this impact is defined to be of negligible magnitude.

Evaluation of significance

Taking the high sensitivity of marine mammals and basking sharks and the negligible magnitude of the impact, the overall effect of indirect effects related to changes in availability and distribution of prey species from EMF effects on prey is considered to be negligible and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Low	Negligible	Negligible
Impact significance – NOT SIGNIFICANT		

12.6.3 Potential effects during decommissioning

In the absence of detailed information regarding decommissioning works, the impacts during the decommissioning of the offshore Project are considered analogous with, or likely less than, those of the construction stage (including pre-construction).

The worst case scenario for decommissioning of the WTGs and OSPs will be a clear seabed, where substructures and foundations that extend below the seabed will be cut approximately 1 m below the seabed to allow removal of the substructure. The same applies for the worst case scenario of the offshore export cables, inter-array cables and the interconnector cables, whereby all cables will be removed unless otherwise agreed.

A Decommissioning Programme will be developed [and approved] pre-construction to address the principal decommissioning measures for the offshore Project; this will be written in accordance with applicable guidance and will detail the management, environmental management and schedule for decommissioning. Prior to the commencement of any decommissioning works, the Decommissioning Programme will be reviewed and revised as required in accordance with the industry practice at that time. The decommissioning activities are expected to take a similar duration as the construction and pre-construction programme.

Given the nature of the decommissioning activities, which will largely be a reversal of the installation process, the impacts during decommissioning are expected to be similar to or less than those assessed for the construction stage. Therefore, the magnitude of impacts assigned to marine mammal and basking shark receptors during the construction stage (including pre-construction) is also applicable to the decommissioning stage. It is also assumed that the receptor sensitivities will not materially change over the lifetime of the offshore Project. Whilst significant declines in harbour seals within the North Coast and Orkney SMU have been observed since 2001 (Thompson *et al.*, 2019), and may continue throughout the lifecycle of the Project (see section 12.4.5), the project-alone impacts to harbour seals during construction were assessed to be of negligible significance for all impacts assessed and are expected to be similar to or less than this during the decommissioning stage. Whilst there is limited data available for other species, there is no evidence that local populations will change significantly throughout the lifetime of the Project (section 12.4.5). Therefore, for all species, the decommissioning effects are not expected to exceed those assessed for construction and pre-construction.

12.6.4 Summary of potential effects

A summary of the outcomes of the assessment of potential effects from the construction (including pre-construction), operation and maintenance and decommissioning of the Project is provided in Table 12-32.

No significant effects (in EIA terms) on marine mammals and basking shark receptors have been identified. Therefore, mitigation measures in addition to the embedded mitigation measures listed in section 12.5.4 are not considered necessary in terms of the EIA impact assessment.

However, it should be noted that whilst the impacts to marine mammals are not considered to be significant in EIA terms, all cetaceans are protected as EPS under the Habitats Regulations. A separate EPS Licence application and risk assessment will be undertaken, once all the appropriate information is collated to inform the PS. This information will also feed into the final MMMP.

Table 12-32 Summary of potential effects

POTENTIAL EFFECT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
Construction (including pre-construction) and decommissioning						
Injury to marine mammals from pre-construction geophysical surveys	All marine mammals	Low	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
Disturbance to marine mammals from pre-construction geophysical surveys	All marine mammals	Low	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
Injury to marine mammals from UXO clearance	Harbour porpoise, white-sided dolphin, common dolphin, Risso's dolphin, white-sided dolphin, killer whale, grey seal, harbour seal	Low	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Minke whale, humpback whale	Medium	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)

POTENTIAL EFFECT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
Disturbance to marine mammals from UXO clearance	All marine mammal receptors	Negligible	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
Injury to marine mammals from pile installation	Harbour porpoise	Low	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	White beaked dolphin, common dolphin, Risso's dolphin, white-sided dolphin, killer whale;	Medium	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Minke whale, humpback whale	Medium	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Harbour seal, grey seal	Low	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
Disturbance to marine mammals from pile installation	Harbour porpoise	Low	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)

POTENTIAL EFFECT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
	White-beaked dolphin	Low	Medium	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	Common dolphin, Risso's dolphin, minke whale, white-sided dolphin, killer whale, humpback whale	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Harbour seal	Medium	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Grey seal	Negligible	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
Injury to marine mammals from non-piling construction activities	Harbour porpoise, white-beaked dolphin, common dolphin, Risso's dolphin, white-sided dolphin, killer whale, harbour seal, grey seal	Low	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Minke whale, humpback whale	Medium	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)

POTENTIAL EFFECT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
Disturbance to marine mammals from all other non-piling construction activities	Harbour porpoise, white-beaked dolphin, common dolphin, Risso's dolphin, minke whale, white-sided dolphin, killer whale, humpback whale	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Harbour seal, grey seal	Negligible	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
Injury or disturbance to basking sharks from underwater noise generating activities	Basking shark	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
Disturbance due to physical presence and underwater noise from vessels	All marine mammal receptors and basking shark	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
Vessel collision	Harbour porpoise, white-beaked dolphin, common dolphin, Risso's dolphin, white-sided dolphin, killer whale, harbour seal, grey seal	Low	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)

POTENTIAL EFFECT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
	Minke whale, humpback whale, basking shark	High	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
Indirect effects related to changes in availability or distribution of prey species	All marine mammal receptors and basking shark	Low	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
Operation and maintenance						
Underwater noise from fixed WTGs	Minke whale, humpback whale	Low	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
Disturbance due to physical presence and underwater noise from vessels	All marine mammal receptors and basking shark	Low	Low	Negligible (not significant)	None required above embedded mitigation measures	Negligible (not significant)
Vessel collision	Harbour porpoise, white-beaked dolphin, common dolphin, Risso's dolphin, white-sided dolphin, killer whale, harbour seal, grey seal	Low	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)

POTENTIAL EFFECT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
	Minke whale, humpback whale, basking shark	High	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
Displacement or barrier effects associated with physical presence of devices and infrastructure	All marine mammal receptors and basking shark	Negligible	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
Maintenance activities	All marine mammal receptors and basking shark	Low	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
Habitat change*	All marine mammal receptors and basking shark	Low	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
EMF effects*	All marine mammal receptors and basking shark	Low	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)

*These impacts have been assessed as a component of the overarching impact 'Indirect effects related to changes in availability or distribution of prey species'.

12.7 Assessment of cumulative effects

12.7.1 Introduction

Potential impacts from the offshore Project have the potential to interact with those from other projects (developments), plans and activities, resulting in a cumulative effect on marine mammal and megafauna receptors. The general approach to the cumulative effects assessment is described in chapter 7: EIA methodology and further detail relevant to the assessment of marine mammals and basking sharks is provided below. A quantitative assessment of cumulative underwater noise impacts was undertaken in SS10: Marine mammal underwater noise impact assessment, which contains full detail of the assessments and has been summarised here.

The list of relevant developments for inclusion within the cumulative effects assessment is outlined in Table 12-33. This has been informed by a screening exercise, undertaken to identify relevant developments for consideration within the cumulative effects assessment for each EIA topic, based on defined Zones of Influence (ZoI).

The ZoIs were proposed for their respective offshore EIA topics based on their specialist understanding of each receptor. Based on the species likely to be present in the offshore Project area, the largest marine mammal MU, in this instance the CGNS MU, was used as the ZoI for marine mammals and basking sharks as the most conservative approach. Developments within this area which coincide spatially or with the offshore Project may act in combination and have a cumulative impact on marine mammals and basking sharks.

Table 12-33 List of developments considered for the marine mammals and megafauna cumulative impact assessment (CCS = Carbon Capture and Storage, O&G = Oil and Gas)

LOCATION	DEVELOPMENT TYPE	DEVELOPMENT NAME	DISTANCE TO OAA (km)	DISTANCE TO OFFSHORE ECC (km)	STATUS[7]	CONFIDENCE[8]
West of Orkney	Offshore Windfarm	West of Orkney Windfarm – transmission connection to the Flotta Hydrogen Hub	0	0	Pre-application	Low
Irish Sea	Offshore Windfarm	North Falls	847	814	Pre-application	Low

[7] *Status determined as of June 2023 as the cut-off for developments submitted for Scoping for qualitative assessment.*

[8] *Confidence ratings have been applied to each cumulative development where: 'Low' = pre-application or application, 'Medium' = consented and 'High' = under construction or operational.*

LOCATION	DEVELOPMENT TYPE	DEVELOPMENT NAME	DISTANCE TO OAA (km)	DISTANCE TO OFFSHORE ECC (km)	STATUS[7]	CONFIDENCE[8]
Irish Sea	Offshore Windfarm	Mona Offshore Wind Farm	539	518	Pre-application	Low
Irish Sea	Offshore Windfarm	Morgan Offshore Wind Farm	522	501	Pre-application	Low
North coast of Scotland (Caithness)	Offshore Windfarm	Pentland Floating Offshore Wind Farm (PFOWF)[9]	20	2	Consented	Medium
Irish Sea	Offshore Windfarm	Morecambe Offshore Windfarm	556	534	Pre-application	Low
Northeast Scotland (Outer Firth of Forth)	Offshore Windfarm	Berwick Bank Offshore Wind Farm	301	268	Application	Low
East coast of Scotland (Fife)	Offshore Windfarm	Levenmouth demonstration turbine	300	274	Operational	High
Northeast Scotland	Offshore Windfarm	Green Volt Floating Offshore Windfarm	216	190	Application	Low
East coast of England (adjacent to the UK Exclusive Economic Zone (EEZ) boundary)	Offshore Windfarm	Sofia	557	525	Consented	Medium
East coast of England	Offshore Windfarm	Hornsea Four	598	565	Consented	Medium

[9] *PFOWF will incorporate the currently consented Pentland Floating Offshore Wind Demonstrator turbine, and hence PFOWF only has been considered. The PFOWF Section 36 Consent and Marine Licence was granted for 10 years. However, the cumulative effects assessment has been based on the Project Design Envelope, as specified within the EIA, and therefore, an operational life of up to 30 years for the PFOWF has been considered. Since consent was granted in June 2023, PFOWF have submitted a Screening Report to MD-LOT with the intention to request a variation to the Section 36 Consent. This variation will incorporate refinements to the Project Design Envelope and to extend the operational life to 25 years.*

LOCATION	DEVELOPMENT TYPE	DEVELOPMENT NAME	DISTANCE TO OAA (km)	DISTANCE TO OFFSHORE ECC (km)	STATUS[7]	CONFIDENCE[8]
(Humber / the Wash)						
East coast of England	Offshore Windfarm	Dogger Bank South	560	527	Pre-application	Low
East coast of England (Norwich)	Offshore Windfarm	Norfolk Vanguard	765	732	Application	Low
East coast of England (Norwich)	Offshore Windfarm	East Anglia One North	817	784	Consented	Medium
East coast of England (Norwich)	Offshore Windfarm	East Anglia Two	823	790	Consented	Medium
East coast of England (Norwich)	Offshore Windfarm	East Anglia Three	800	766	Consented	Medium
East coast of England (Norwich)	Offshore Windfarm	Five Estuaries	855	822	Pre-application	Low
English Channel	Offshore Windfarm	Rampion 2	936	907	Pre-application	Low
East coast of England (Norwich)	Offshore Windfarm	Outer Dowsing	675	643	Pre-application	Low
Northeast Scotland (Caithness to Orkney)	Connector	Scottish Hydro Electric Transmission Limited (SHET-L) Caithness to Orkney HVAC Link	22	0	Consented	Medium
Celtic Sea	Offshore Windfarm	Valorous	834	818	Pre-application	Low

LOCATION	DEVELOPMENT TYPE	DEVELOPMENT NAME	DISTANCE TO OAA (km)	DISTANCE TO OFFSHORE ECC (km)	STATUS[7]	CONFIDENCE[8]
Celtic Sea	Offshore Windfarm	Erebus	814	799	Application	Low
North coast of Wales	Offshore Windfarm	Awel y Môr	590	568	Application	Low
Northeast Scotland (Moray Firth)	Offshore Windfarm	Caledonia Offshore Wind Farm	92	64	Pre-application	Low
Celtic Sea	Offshore Windfarm	White Cross Offshore Wind	857	841	Application	Low
East of England (Humber / the Wash)	Offshore Windfarm	Outer Dowsing	675	643	Pre-application	Low
East of Ireland (County Wicklow)	Offshore Windfarm	Codling Wind Park	641	628	Pre-application	Low
East coast of Ireland (County Dublin and Wicklow)	Offshore Windfarm	Dublin Array	622	610	Pre-application	Low
East coast of Ireland (County Dublin, Meath and Louth)	Offshore Windfarm	North Irish Sea Array Offshore Wind Farm	580	568	Pre-application	Low
Denmark	Offshore Windfarm	Thor	736	714	Pre-application	Low
Sweden	Offshore Windfarm	Galatea-Galene	951	934	Pre-application	Low
Sweden	Offshore Windfarm	Stora Middelgrund	978	961	Pre-application	Low

LOCATION	DEVELOPMENT TYPE	DEVELOPMENT NAME	DISTANCE TO OAA (km)	DISTANCE TO OFFSHORE ECC (km)	STATUS[7]	CONFIDENCE[8]
Ireland	Wave	Atlantic Marine Energy Test Site	614	627	Pre-application	Low
East Lothian (Scotland) to County Durham (Northeast England)	Connector	Scotland England Green Link 1	333	304	Pre-application	Low
Peterhead (Scotland) to North Yorkshire (Northeast England)	Connector	Scotland England Green Link 2	198	166	Pre-application	Low
Peterhead to Norway	Connector	NorthConnect	202	169	Consented (UK)	Medium
North France (La Matrye) to South of Ireland (Ballyadam)	Connector	Celtic Interconnector	790	784	Pre-application	Low
UK, Netherlands and Germany	Connector	NeuConnect	754	722	Pre-application	Low
East coast of England (Yorkshire)	CCS	Northern Endurance Partnership	500	470	Pre-application	Low
Northeast Scotland	CCS	Acorn	156	133	Pre-application	Low
East coast of England (Lincolnshire)	CCS	V-Net Zero (Viking)	623	593	Pre-application	Low
North coast of Wales (Liverpool Bay)	Pipeline	HyNet North West	602	578	Pre-application	Low

LOCATION	DEVELOPMENT TYPE	DEVELOPMENT NAME	DISTANCE TO OAA (km)	DISTANCE TO OFFSHORE ECC (km)	STATUS[7]	CONFIDENCE[8]
English Channel	Connector	French-Alberney-Britain (FAB) Link	910	887	Consented	Medium
Orkney (Faray)	Jetty	Faray slipway extension and landing jetty	68	72	Consented	Medium
East coast of Ireland (County Wicklow)	Offshore Windfarm	Arklow Bank Phase 2	672	660	Pre-application	Low
Northeast Scotland	Offshore Windfarm	Cenos Offshore Wind Farm	361	335	Pre-application	Low
West coast of Scotland (Islay)	Tidal	Sound of Islay Community Tidal turbine	343	340	Consented	Medium
East coast of England (Suffolk- Kent)	Cable	Sea Link	814	782	Pre-application	Low
North Scotland	O&G	Rosebank development	195	217	Application	Low
Northeast Scotland	O&G	Teal West Development	331	304	Application	Low
Northeast Scotland	O&G	Avalon Field Development	262	238	Application	Low
Various	O&G	Various oil and gas decommissioning	Various	Various	Planned	Low
Various	O&G	Seismic airgun surveys	Various	Various	Indicative	Low

Certain impacts assessed for the offshore Project alone are not considered in the cumulative assessment due to:

- The highly localised nature of the impacts;
- Management and mitigation measures in place for the offshore Project and on other developments will reduce the risk occurring; and/or
- Where the potential significance of the effect from the offshore Project alone has been assessed as negligible significance.

Therefore, impacts which have been excluded from the marine mammal and basking shark cumulative effects assessment are:

- Injury and disturbance from underwater noise-generating activities (pre-construction and construction stages) for basking sharks: basking sharks are not sensitive to underwater noise although they may be able to detect associated particle motion. The project-alone assessment concluded the consequence from this impact to be of negligible significance. Therefore, there is limited scope for underwater noise effects on basking sharks;
- Auditory injury (PTS) during pre-construction and construction: where PTS may result from activities such as pile driving and UXO clearance, as suitable mitigation will be put in place to reduce injury risk to marine mammals to negligible levels (as a requirement of EPS legislation);
- Disturbance due to physical presence and underwater noise from vessels (all Project stages) for all species: this impact is highly localised with negligible significance. In addition, it is likely that the majority of offshore developments will employ a EMP or follow best practice guidance (such as Marine Wildlife Watching Codes) to reduce the potential for impact to marine mammals, including vessel disturbance effects;
- Vessel collision (all Project stages): this impact is highly localised with negligible significance. In addition, it is likely that the majority of offshore developments will employ a EMP or follow best practice guidance (Marine Wildlife Watching Codes) to reduce the potential for impact to marine mammals, including collision effects;
- Displacement or barrier effects associated with physical presence of devices and infrastructure (operation stage only): marine mammals and basking sharks are highly mobile and would be able to pass through or around the WTGs and the project-alone assessment determined the consequence from this impact to be of negligible significance. Therefore, there is limited scope for there to be a cumulative displacement or barrier effect with other developments on marine mammal and basking shark receptors; and
- Indirect effects related to changes in availability or distribution of prey species (all Project stages): for all aspects of indirect effects which have been assessed, the consequence was determined to be of negligible significance in the Project-alone assessments, therefore there is considered to be limited scope for there to be a cumulative effect with other developments on marine mammal and basking shark receptors.

Whilst the effect of underwater noise during operation is anticipated to be highly localised and was determined to be of negligible significance in the Project-alone assessments, we note in the Scoping advice that MSS consider that cumulative impacts from operational noise warrant further assessment for LF group marine mammals. Therefore, underwater noise during operation has been scoped in for assessment in this cumulative effects assessment for minke whale and humpback whale.

Therefore, only the following impacts associated with the offshore Project taken forward in the cumulative assessment:

- The potential for disturbance from underwater noise to marine mammals (construction and pre-construction stage); and
- Underwater noise during operation for minke whale and humpback whale (operation stage).

12.7.2 Cumulative effects during construction and pre-construction

12.7.2.1 Disturbance from underwater noise generating activities

A quantitative cumulative assessment for underwater noise impact assessment for marine mammals has been undertaken in SS10: Marine mammal underwater noise impact assessment and has been summarised here. This assessment considers the potential for a cumulative from disturbance from underwater noise generating activities during the construction and pre-construction stages, including UXO clearance, piling, and seismic surveys. The offshore Project will be constructed between 2028 and 2031. The cumulative effects assessment includes all developments that are constructing or decommissioning (and thus creating underwater noise) at any period between 2027-2032 within each species-specific MU. It has been assumed that pre-construction UXO clearance occurs at the Project in 2027, followed by 3 years of piling activity 2028-2030 inclusive which allows the largest overlap between the construction period at the Project and other developments screened into the cumulative effects assessment.

12.7.2.1.1 Methods as described by SS10: Marine mammal underwater noise impact assessment

Offshore windfarms

Predicting the number of animals disturbed is not comparable between developments due to the use of different thresholds and methods. However, the number of animals impacted (from EIAs) have been presented for all Offshore Windfarm developments screened into the cumulative effects assessment and worst case disturbance ranges for impact piling were included in the assessment.

Where development data are unavailable the assessment followed JNCC (2020) advice, where unabated impact pile-driving clearance of a UXO is predicted to have an EDR of 26 km for harbour porpoise. In the absence of recommended EDRs, this has been applied to all marine mammal species as a proxy. A 15 km EDR has been used for EU developments where noise abatement methods are assumed and as a worst case scenario for floating offshore windfarm developments, where pin piles may be required. Estimates of absolute density were derived from SCANS-III data.

Seismic surveys

The number of seismic surveys that could occur over the cumulative effects assessment is not known. Therefore, one and two seismic surveys were assumed to occur at any one time for seals within in the North Coast and Orkney SMU, and cetaceans within the UK EEZ), respectively, given that the seal MU is significantly smaller than for cetaceans. JNCC (2020) advice has been followed, assuming a 12 km EDR for seismic surveys. This approach is also considered to be sufficiently precautionary to account for any behavioural disturbance resulting from high-resolution geophysical site surveys (HRGS), which are acknowledged to be of a lower magnitude than that of seismic surveys (JNCC *et al.*, 2020; Ruppel *et al.*, 2022).

As seismic airgun surveys are a moving source, data on shooting statistics between 2011 and 2020 were used to estimate an indicative distance which would be travelled whilst shooting (Sarah Canning JNCC *pers, comm* April 2023[10]). The average distance for 3D seismic surveys was 116 km, which was assumed to occur within a single 24 hr period, resulting in an estimated area of impact of 3,236 km^2 per day. The BEIS (2020) approach considers where the moving seismic sound source could impact an area of 5,228 km^2 within in a 24-hour period. However, this is likely to be "an unrealistic worst case scenario" and be highly precautionary BEIS (2020). In addition, a precautionary 5 km EDR has been used for High Resolution Geophysical Surveys (HRGS) as suggested by JNCC (2020).

Oil and gas decommissioning

Of the O&G developments screened into the cumulative effects assessment long list for marine mammals, only five provided quantitative assessment for underwater noise. However, most developments didn't provide estimates for impacted species, therefore, O&G decommissioning activities are not included in this assessment.

Other offshore developments

Any other offshore developments were assumed to have a maximum disturbance range of 5 km if no other quantitative assessment was provided.

12.7.2.1.2 Precaution in the assessment

There are seven main areas that result in the cumulative effects assessment having significant levels of precaution as detailed in SS10: Marine mammal underwater noise impact assessment:

- Summing across concurrent activities assuming there is no spatial overlap in impact footprints between individual activities;
- Inclusion of developments with high degree of uncertainty. In such instances, worst case scenarios are assumed in the absence of other information;
- The exact timing of pile driving for each development is unknown, therefore it has been assumed that these activities could occur at any point throughout the construction window. This has resulted in associated estimated disturbance levels far greater than would occur in reality. The timelines presented in the Preliminary Environmental Information Report (PEIR) and Offshore EIA Report chapters are worst case scenarios;
- As a worst case assumption monopiles have been assumed; however, a portion of these developments may instead use jacket foundations with pin-piles, which will have a much lower recommended effective deterrence range (15 km instead of 26 km, equating to a 66% smaller area) (JNCC, 2020) EDRs based on harbour porpoise and used in the absence of development specific assessments are considered precautionary for other marine mammals; and
- The assumption that the extent of the disturbance effects remains constant throughout the construction of each windfarm.

[10] *Data from: Stone, C.J. in prep. Compliance with JNCC guidelines during geophysical surveys in UK waters between 2011 and 2020 and long-term trends in compliance. JNCC Report.*

The following results showing potential disturbance to each species are highly precautionary, given all the levels of precaution inherent in this additive cumulative effects assessment approach.

In total, 53 offshore developments were screened into the cumulative assessment across the marine mammal species. However, only a number of these developments were included in the assessment for each species, as many did not include assessments for the specific species or expect them to be present at development sites according to SCANS-III data. Table 12-34 summarises the results of the quantitative underwater noise cumulative assessment (including developments without a quantitative impact assessment available) for each species from SS10: Marine mammal underwater noise impact assessment.

Table 12-34 Estimated number of animals impacted across the cumulative effects assessment. It is assumed UXO clearing will take place in 2027, followed by piling from 2028 to 2030 (SS10: Marine mammal underwater noise impact assessment)

SPECIES	NO. OFFSHORE DEVELOPMENTS INCLUDED IN ASSESSMENT	ESTIMATED NUMBER OF INDIVIDUALS DISTURBED				
		2026	2027	2028	2029	2030
Harbour porpoise	26 + 2 seismic surveys	36,788 (20.0% UK MU)	35,972 (19.6% UK MU)	33,472 (18.2% UK MU)	28,897 (15.7% UK MU)	28,276 (15.4% UK MU)
White-beaked dolphin	49 + 2 seismic surveys	1,802(5.3% UK MU)	2,046 (6.0% UK MU)	3,736 (11.0% UK MU)	3,122 (9.2% UK MU)	3,103 (9.1% UK MU)
Common dolphin	49 + 2 seismic surveys	3,607 (6.3% UK MU)	3,269 (5.7% UK MU)	3,624 (6.3% UK MU)	1,557 (2.7% UK MU)	850 (1.5% UK MU)
Risso's dolphin	49 + 2 seismic surveys	831 (9.6% % UK MU)	773 (8.9 % UK MU)	762 (8.8% UK MU)	696 (8.0% UK MU)	630 (7.3% UK MU)
Minke whale	49 + 2 seismic surveys	940 (9.1% UK MU)	1,224 (11.9% UK MU)	1,126 (10.9% UK MU)	885 (8.6% UK MU)	832 (8.1% UK MU)
Harbour seal	6 + 1 seismic surveys[2]	321 (16.5% SMU)	206 (10.6% SMU)	320 (16.4% SMU)	320 (16.4% SMU)	320 (16.4% SMU)
Grey seal	6 + 1 seismic surveys*	6,637 (19.4% SMU)	3,518 (10.3% SMU)	6,145 (18.0% SMU)	6,145 (18.0% SMU)	6,145 (18.0% SMU)

[*] The seal, North Coast and Orkney MU is significantly smaller than the cetacean MUs, therefore, it was concluded that there would not be more than one seismic survey occurring at any one time.

For harbour porpoise the Disturbance Effects on the Harbour Porpoise Population in the North Sea (DEPONS) model was used to help inform assessments. Even with the conservative distances used within model scenarios, population dynamics did alter from baseline conditions within the North Sea MU (SS10: Marine mammal underwater noise impact assessment). For each of the dolphin species the potential effect of piling is not fully understood and so assessment conclusions are conservative. Despite this, it is not expected that there will be any changes in the conservation status of harbour porpoise. Similarly, the assessment for minke whale is conservative as it is based on harbour porpoise response and also does not consider the fact that minke whales are generally only present in UK during summer (SS9: Marine mammal underwater noise assessment).

Harbour porpoise, minke whale and all the quantitatively assessed dolphin species (white-beaked dolphin, common dolphin and Risso's dolphin) have been assessed to have medium magnitude and low sensitivity, resulting in overall cumulative disturbance from underwater noise being minor, which is not significant in EIA terms.

The qualitatively assessed species (white-sided dolphin, killer whale and humpback whale) have been assessed using the quantitively assessed species as proxies as in section 12.6.1.2. Therefore, they have been assessed to have medium magnitude and low sensitivity, resulting in the overall cumulative disturbance from underwater noise being minor, which is not significant in EIA terms.

The impact of pile driving to harbour seals in the North Coast and Orkney MU is negligible, however with the addition of the possible seismic survey harbour seals have been precautionarily assessed to have low magnitude. Assessed to have a medium sensitivity the overall cumulative disturbance from underwater noise is minor which is not significant in EIA terms (SS10: Marine mammal underwater noise impact assessment).

Grey seals within the North Coast and Orkney MU are not expected to have any changes in conservation status (SS10: Marine mammal underwater noise impact assessment). Grey seals have been assessed to have negligible sensitivity to piling (section 12.6.1.1.4) which has also been assumed for seismic surveys. The disturbance expected to grey seals is concluded to be of medium magnitude and the overall cumulative disturbance from underwater noise is negligible which is not significant in EIA terms (SS10: Marine mammal underwater noise impact assessment).

12.7.3 Cumulative operation and maintenance effects

12.7.3.1 Operational noise

Continuous mechanical noise generated during windfarm operation may be detected by marine mammals and basking sharks, with the potential to mask communications and cause other behavioural or disturbance effects (Marmo *et al*., 2013; detailed in section 12.6.2.1). The LF noise is likely to be limited to the LF hearing group, therefore impacts to minke whales and humpback whales are considered as all other marine mammals and basking sharks have been scoped out (outlined in sections 12.6.1.1 and 12.6.2.1; Marmo *et al*., 2013; Southall *et al*., 2019).

As outlined in section 12.6.2.1, Marmo *et al*. (2013) predicted that harbour porpoise and minke whales may be able to detect sound from operational fixed-foundation WTGs up to 18 km away. However, other studies suggest that the operational noise is thought to be comparable to ambient noise after a few hundred meters and has negligible displacement effects with any impacts expected to be highly localised (Madsen *et al*., 2006; Teilmann *et al*., 2006a; Teilmann *et al*., 2006b; Nedwell *et al*., 2007; CEFAS 2010; Brasseur *et al*., 2012; Marmo *et al*., 2013).

Based on the potential for LF hearing group animals to detect operational WTG from up to 18 km away, there may be potential for an overlap in the underwater noise generated during operation between the offshore Project and PFOWF (located approximately 20 km to the south of the OAA). PFOWF is a floating-foundation development, which may also produce underwater noise from 'pinging' of the mooring lines. However, both developments concluded that any project-alone impacts will highly localised and of negligible significance. Whilst animals may be able to detect the noise further away, this is not expected to be significantly greater than background noise levels and there is not expected to be potential for a cumulative effect.

Minke whales and humpback whales are assessed to have as low sensitivity to operational noise and it is defined as being of negligible magnitude. Due to the localised effects of operational noise there is unlikely to be a cumulative impact and therefore the overall significance of effect remains negligible, which is not significant in EIA terms.

12.7.4 Cumulative decommissioning effects

There is limited information on the decommissioning of the offshore Project and that of other developments. However, the cumulative effects are expected to be less than or equal to the construction stage (including pre-construction).

A Decommissioning Programme will be developed pre-construction to address the principal decommissioning measures for the offshore Project and will be written in accordance with applicable guidance. The Decommissioning Programme will detail the environmental management, and schedule for decommissioning and will be reviewed and updated throughout the lifetime of the offshore Project to account for changing best practices.

12.7.5 Summary of cumulative effects

A summary of the outcomes of the assessment of cumulative effects for the construction (including pre-construction), operation and maintenance and decommissioning stages of the offshore Project is provided in Table 12-35.

Table 12-35 Summary of assessment of cumulative effects

POTENTIAL IMPACT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
Construction (including pre-construction) and decommissioning						
Disturbance from underwater noise generating activities	Grey seal	Negligible	Medium	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Harbour porpoise, white-beaked dolphin, common dolphin, Risso's dolphin, minke whale, white-sided dolphin, killer whale, humpback whale	Low	Medium	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	Harbour seal	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)

POTENTIAL IMPACT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
Operation and maintenance						
Operational noise	Minke whale, humpback whale	Low	Negligible	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)

12.8 Inter-related effects

Inter-related effects are the potential effects of multiple impacts affecting one receptor or a group of receptors. Inter-related effects include interactions between the impacts of the different stages of the offshore Project (i.e. interaction of impacts across construction (including pre-construction), operation and maintenance and decommissioning), as well as the interaction between impacts on a receptor within an offshore Project stage. The potential inter-related effects for marine mammals and megafauna receptors are described below.

12.8.1 Inter-related effects between offshore Project stages

All offshore Project stages have the potential to impact marine mammal and megafauna species. Impacts relating to displacement or barrier effects from the WTGs and indirect effects relating to prey species will only occur during the operation and maintenance stage. Therefore, there will be no combined effect with the construction (including pre-construction) or decommissioning stages.

The majority of underwater noise disturbance associated with the offshore Project will occur from impact piling activities and UXO clearance in the construction and pre-construction stages, respectively. Underwater noise from operational WTGs will be highly localised and was scoped out for all receptors with the exception of minke whales and humpback whales, where the assessment determined the effect would be a negligible and not significant in EIA terms. Underwater noise during construction (including pre-construction) and maintenance activities will be intermittent and temporary, and no displacement or barrier effect would be expected to persist in the long term as a result of these activities. Therefore, there is considered to be a limited potential for an interaction between the underwater noise during the construction (including pre-construction), operation and maintenance and decommissioning stages to result in a greater effect than when each stage is assessed in isolation.

There is potential for impacts to marine mammals and basking sharks from vessel disturbance at all Project stages; however, these are all assessed to be localised, temporary, and short-term effects and were not deemed to be significant as standalone impacts. Whilst there is potential for injury and mortality to marine mammals and basking sharks from vessel collision, taking into account embedded mitigation measures to reduce the likelihood and frequency of vessel collisions (see sections 12.5.4, 12.6.1.3 and 12.6.2.3), this was not assessed to be significant as a standalone impact in any development stage. Therefore, these impacts are not expected to cause any lasting effects which could span across development stages and significant inter-related effects are not predicted.

12.8.2 Inter-related effects within an offshore Project stage

There is potential for interaction between underwater noise impacts from pre-construction geophysical surveys and UXO clearance which may cause injury and disturbance to marine mammals, with potential for these activities to be conducted simultaneously. All marine mammals are assessed to have low sensitivity to injury and disturbance from geophysical surveys and UXO clearance, except minke whales and humpback whales which are assessed as having medium sensitivity to UXO clearance due to their sensitivity to LF underwater noise (Robinson *et al.*, 2022). However, the magnitude of impact from both impacts is deemed to be negligible meaning that any impacts will be negligible and not significant in EIA terms. Additionally, the impact from UXO is expected to be highly intermittent (maximum 22 days) over a 9-month period whilst underwater noise from geophysical surveys are anticipated to be temporary, short term and localised. Therefore, whilst there is potential for these activities to occur simultaneously, there is not expected to be potential for any significant adverse effect from these activities in combination.

During the construction (including pre-construction) and decommissioning stages, the greatest potential for interaction exists between underwater construction (including pre-construction) noise impacts from individual underwater noise generating activities, all of which were assigned a significance of negligible to minor. UXO clearance and pile driving will not be undertaken at the same time. Any disturbance or displacement resulting from underwater noise may reduce also the potential for vessel interactions or interaction with noise generated concurrently from other sources; thus reducing the likelihood of inter-related effects between noise sources or from vessel disturbance, vessel collision. It is therefore not anticipated that any inter-related effects between or with underwater noise will occur that are of greater significance than the individual assessments which have been presented.

During the operation and maintenance stage, the spatial extent associated with underwater noise, vessel disturbance, collision and displacement or barrier effects and indirect effects relating to prey species will be similar and receptors may be affected by these impacts simultaneously. However, considering the highly localised extent of these effects, the combined effect of these impacts during the operation and maintenance stage is not expected to result in a greater effect than the assessment of these impacts in isolation.

12.9 Whole Project assessment

The onshore Project is summarised in chapter 5: Project description and a summary of the effects of the onshore Project is provided in chapter 21: Onshore EIA summary. These onshore aspects of the Project have been considered in relation to the impacts assessed in section 12.6. The findings are presented below.

The onshore Project will undertake HDD operations above MHWS, with a HDD exit point offshore, during the cable installation. However, HDD rigs are installed onshore and the sound they produce that enters the water is often negligible (Hall and Francine 1991, Nguyen 1996, Willis *et al*. 2010). There are no designated sites with marine mammals and/or megafauna interests or known haul-out sites for seals in the vicinity of the cable landfall, so there will not be any significant impact to hauled-out seals. Therefore, there is not anticipated to be any impact on marine mammal and basking shark receptors.

It is not anticipated that there will be any other activities from the onshore Project that will have the potential to impact marine mammals and basking shark, as these activities are fully terrestrial and therefore there is no pathway for impact.

12.10 Ecosystem effects

Marine mammals and megafauna largely operate at the upper levels of the North Sea food web and are considered top predators along with seabirds and certain fish species (BEIS, 2022). A holistic approach has been undertaken in the identification of impacts to consider those that may occur at an ecosystem scale and particularly across trophic levels (e.g. impacts on prey species affecting their availability for predators). Changes in the abundance or distribution of marine mammals can have cascading effects on other species within the ecosystem. These can directly affect the prey species that they feed on (e.g. fish species), as the level of marine mammal foraging is affected. These effects can also affect other predators through any subsequent changes in prey availability. Ecosystem effects are also assessed within Chapter 10: Benthic subtidal and intertidal ecology, chapter 11: Fish and shellfish ecology and chapter 13: Offshore and intertidal ornithology.

Key prey species for many of the marine mammals considered in this assessment include clupeids (e.g. herring and sprat), gadoids (e.g. cod and whiting), sandeels and flatfish (e.g. plaice). Exceptions to this are humpback whales, which also consume small crustaceans such as calanoid copepods, Risso's dolphins which predominantly feed on cephalopods, grey seals which have also been observed to predate harbour porpoise, harbour seals and other grey seals, and killer whales which also hunt seals off Scotland. As filter feeders, basking sharks feed predominantly on zooplankton, and around Scottish waters, the species is generally observed feeding on calanoid copepods (Sims, 2008). Overall marine mammals are considered to be generalist feeders.

Impacts on prey species which could affect their abundance and distribution, and subsequently their availability to marine mammals which in turn may have consequences on their foraging success, were assessed in section 12.6.1.4 and 12.6.2.5, and concluded no significant effect. Marine mammals and megafauna, as largely generalist feeders, highly mobile and wide ranging were considered to be of low sensitivity to changes in prey availability. There is the potential that marine predators actually target areas where the introduction of infrastructure may attract prey species, leading to increased productivity and foraging opportunities (e.g. Russell *et al*. 2016), although this habitat change is not considered to result in a significant impact (see section 12.6.2.5.2).

The impact of any increase in predator aggregation at the offshore Project (including marine mammals and megafauna), once operational, was assessed as not significant in chapter 11: Fish and shellfish ecology. In addition, as no significant effects were identified for any impact on marine mammals and megafauna, there is not considered to be a significant long-term change in the presence, abundance or distribution of marine mammal predators as a result of the offshore Project which could cascade to result in an ecosystem-scale effect.

Consideration of ecosystem effects has been considered holistically throughout the ecological chapters of the Offshore EIA Report. No ecosystem effects are anticipated to occur in relation to marine mammals either as direct impacts to them as predators or through indirect effects to their prey species.

12.11 Transboundary effects

Transboundary effects arise when impacts from a development within one European Economic Area (EEA) state's territory affects the environment of another EEA state(s).

Impacts on marine mammals and basking sharks from all Project stages will be localised to the offshore Project and surrounding area and will be fully contained within UK EEZ waters. The closest international boundary[11] is the UK to Norway median line, located approximately 310 km west of the offshore study area. Therefore, there is no potential for the offshore Project to have an impact directly on animals outside the UK EEZ during the cumulative effects assessment.

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[11] *Whilst the Faroe UK median line represents the closest international boundary (approximately 144 km north of the offshore study area), the Faroe Islands are not part of the EEA and do not need to be considered under EIA Regulations.*

As marine mammals and megafauna are mobile species, animals which are within the marine mammal offshore study area may also range within international waters. For example, the MUs of harbour porpoise, common dolphin, white-beaked dolphin, white-sided dolphin, Risso's dolphin, and minke whale extend into Norwegian, Swedish, Danish, German, Dutch, Belgian and French international waters (IAMMWG, 2022). Humpback whales and basking sharks also range hundreds of kilometres across the western European shelf, (Sims *et al*., 2003; Southall *et al*., 2005; Rizzo *et al*., 2009; Witt *et al*., 2012). Therefore, there is potential for indirect transboundary impacts upon marine mammals and basking sharks from the offshore Project. However, the impacts from the offshore Project will be localised within UK waters. and are located a large distance from the nearest EEA waters. Additionally, the assessment of potential effects from the offshore Project alone and cumulatively (when mitigation measures are considered) determined that there will be no significant effect to marine mammal or basking shark populations from the offshore Project. Consequently, there is no potential for any significant transboundary effects upon marine mammal and megafauna receptors due to construction (including pre-construction), operation and maintenance and decommissioning of the offshore Project. The potential impacts are localised and are not expected to affect other EEA states (other than insignificantly).

There is also unlikely to be an adverse effect on marine mammals as a qualifying feature of any transboundary designated sites, with the closest designated site for marine mammals in European waters located approximately 551 km away from the offshore Project. Therefore, transboundary effects for marine mammals and megafauna do not need to be considered further.

12.12 Summary of mitigation and monitoring

This assessment has concluded that there will be no significant impacts under EIA Regulations for any of the marine mammal species and basking shark in relation to the predicted effects for the project alone, inter-related or cumulatively. Therefore, no further mitigation measures are proposed in addition to the embedded mitigation measures (Section 12.5.4).

A PS will be discussed and agreed (as a condition of Section 36 consent and/or Marine Licence) pre-construction. Once the PS is confirmed, the pre-piling mitigation methods to be employed will be detailed within the MMMP (see OP2: Outline Marine Mammal Mitigation Protocol). Additionally, the development of MMMP may be required for any UXO clearance activities, and pre-construction geophysical surveys. The development and agreement of these MMMPs will be a condition of Section 36 Consent and or Marine Licence (see OP2: Outline Marine Mammal Mitigation Protocol) and will be included in the EPS Licencing process.

It should be noted that whilst the impacts to marine mammals are not considered to be significant in EIA terms, all cetaceans are protected as EPS under the Habitats Regulations. A separate EPS Licence application and risk assessment will be undertaken, once all the appropriate information is collated to inform the PS. This information will also feed into the final Marine Mammal Mitigation Plan.

A monitoring programme, including the potential for monitoring of marine mammals and megafauna, will be developed in consultation with relevant stakeholders and be presented within the Project Environmental Monitoring Programme (PEMP) that will be subject to approval as part of the discharge of consent conditions.

12.13 References

6 Alpha Associates Limited, (2022b), Unexploded Ordnance Threat and Risk Assessment – ScotWind N1 Offshore Wind Farm.

6 Alpha Associates Ltd. (2022a). N1 ScotWind West of Orkney OWF - Underwater Noise Modelling Assessment Review: Considering UXO Disposal Best Practice.

Aarts, G., S. Brasseur, and R. Kirkwood. (2018). Behavioural response of grey seals to pile-driving. *Wageningen Marine Research Report* C006/18.

Albert, L., Deschamps, F., Jolivet, A., Olivier, F., Chauvaud, L., and Chauvaud, S. (2020). A current synthesis on the effects of electric and magnetic fields emitted by submarine power cables on invertebrates. *Marine Environmental Research*, 159, 104958. doi:10.1016/j.marenvres .2020.104958.

Albouy, C., Delattre, V., Donati, G., Frolicher, T. L., Albouy-Boyer, S., Rufino, M., Pellissier, L., Mouillot, D. and Leprieur, F. (2020). Global vulnerability of marine mammals to global warming. *Sci Rep* 10, 548.

Anderwald, P. and Evans, P.G.H. (2007). Minke whale populations in the North Atlantic: an overview with special reference to UK waters. Pp. 8-13. In: Robinson, K.P. Stevick P.T. and Macleod C.D. (eds). An integrated approach to non-lethal research on minke whales in European waters. Proceedings of the Workshop. *European Cetacean Society Special Publication Series* No. 47. 49pp.

Anderwald, P., A. Brandecker, M. Coleman, C. Collins, H. Denniston, M. D. Haberlin, M. O'Donovan, R. Pinfield, F. Visser, and L. Walshe. (2013). Displacement responses of a mysticete, an odontocete, and a phocid seal to construction-related vessel traffic. Endangered Species Research 21.

Anderwald, P., Evans, P., Dyer, R., Dale, A., Wright, P. and Hoelzel, A. (2012). Spatial scale and environmental determinants in minke whale habitat use and foraging. *Marine Ecology Progress Series*, 450, 259-274.

Arranz, P., Benoit-Bird, K.J., Southall, B.L., Calambokidis, J., Friedlaender, A.S., and Tyack, P.L. (2018). Risso's dolphins plan foraging dives. *Journal of Experimental Biology*, 221(4), jeb165209. Available online at: https://doi.org/10.1242/jeb.165209 [Accessed 10/04/2023].

Avila, I. C., Kaschner, K. and Dormann, C. F. (2018). Current global risks to marine mammals: Taking stock of the threats, *Biological Conservation* 221: 44-58.

Ayres, K.L., Booth R.K., Hempelmann, J.A., Koski, KL., Emmons CK., *et al*. (2012) Distinguishing the Impacts of Inadequate Prey and Vessel Traffic on an Endangered Killer Whale (*Orcinus orca*) Population. *PLoS ONE* 7(6): e36842. doi:10.1371/journal.pone.0036842

Bauer, G. B. 1986. The behaviour of humpback whales in Hawaii and modifications of behaviour induced by human interventions. Ph.D. dissertation, University of Hawaii, Honolulu, Hawaii. 314 pp.

Beck, C. A., W. D. Bowen, and S. J. Iverson. (2003). Sex differences in the seasonal patterns of energy storage and expenditure in a phocid seal. Journal of Animal Ecology 72:280-291.

Beck, S., Kuningas, S., Esteban, R., and Foote, A. D. (2012). The influence of ecology on sociality in the killer whale (Orcinus orca). *Behavioral Ecology*, 23(2), 246–253.

BEIS (2022). UK Offshore Energy Strategic Environmental Assessment 4 (OESEA 4). Appendix 1a.4 Fish and Shellfish. Available online at: https://www.gov.uk/government/consultations/uk-offshore-energy-strategic-environmental-assessment-4-oesea4 [Accessed 10/04/2023].

BEIS. (2020). Review of Consented Offshore Wind Farms in the Southern North Sea Harbour Porpoise SAC. The Department for Business Energy and Industrial Strategy.

Benhemma-Le Gall, A., I. M. Graham, N. D. Merchant, and P. M. Thompson. (2021). Broad-Scale responses of harbor porpoises to pile-driving and vessel activities during offshore windfarm construction. *Frontiers in Marine Science* 8:664724.

Benjamins, S., Harnois, V., Smith, H.C.M., Johanning, L., Greenhill, L., Carter, C. and Wilson, B. (2014). Understanding the potential for marine megafauna entanglement risk from renewable marine energy developments. Scottish Natural Heritage Commissioned Report No. 791.

Bishop, A., P. Pomeroy, and S. D. Twiss. (2015). Breeding male grey seals exhibit similar activity budgets across varying exposures to human activity. *Marine Ecology Progress Series* 527:247-259.

Blackwell, S. B., C. S. Nations, A. Thode, M. Kauffman, A. S. Conrad, R. G. Norman, and K. Kim. (2017). Effects of tones associated with drilling activities on bowhead whale calling rate. *PLoS ONE* 12(11).

Bloomfield, A. and Solandt, J.L. (2008). The Marine Conservation Society Basking Shark Watch 20-year report (1987-2006). Ross on Wye, UK: Marine Conservation Society.

Bolt, H., Harvey, P., Mandleberg, L., and Foote, A. (2009). Occurrence of killer whales in Scottish inshore waters: temporal and spatial patterns relative to the distribution of declining harbour seal populations. *Aquatic Conservation: Marine and Freshwater Ecosystems*. 19,636-656.

Booth, C. G., F. Heinis, and H. J. (2019). Updating the Interim PCoD Model: Workshop Report - New transfer functions for the effects of disturbance on vital rates in marine mammal species. Report Code SMRUC-BEI-2018-011, submitted to the Department for Business, Energy and Industrial Strategy (BEIS), February 2019 (unpublished).

Booth, C., and F. Heinis. (2018). Updating the Interim PCoD Model: Workshop Report - New transfer functions for the effects of permanent threshold shifts on vital rates in marine mammal species. Report Code SMRUC-UOA-2018-006, submitted to the University of Aberdeen and Department for Business, Energy and Industrial Strategy (BEIS), June 2018 (unpublished).

Botterell, Z. L. R., Penrose, R., Witt, M.J. and Godley, B.J. (2020). Long-term insights into marine turtle sightings, strandings and captures around the UK and Ireland (1910–2018). *Journal of the Marine Biological Association of the United Kingdom*, 100, 869-877.

Brandt, M. J., A. Diederichs, K. Betke, and G. Nehls. (2011). Responses of harbour porpoises to pile driving at the Horns Rev II offshore wind farm in the Danish North Sea. *Marine Ecology Progress Series* 421:205-216.

Brandt, M. J., A. Dragon, A. Diederichs, A. Schubert, V. Kosarev, G. Nehls, V. Wahl, A. Michalik, A. Braasch, C. Hinz, C. Katzer, D. Todeskino, M. Gauger, M. Laczny, and W. Piper. (2016). Effects of offshore pile driving on harbour porpoise abundance in the German Bight. Report prepared for Offshore Forum Windenergie.

Brandt, M. J., A.-C. Dragon, A. Diederichs, M. A. Bellmann, V. Wahl, W. Piper, J. Nabe-Nielsen, and G. Nehls. (2018). Disturbance of harbour porpoises during construction of the first seven offshore wind farms in Germany. *Marine Ecology Progress Series* 596:213-232.

Brasseur, S., Aarts, G., Meesters, E., T. van Polanen Petel., Dijkman, E., Cremer, J. and Reijnders, P. (2012). Habitat preference of harbour seals in the Dutch coastal area: analysis and estimate of effects of offshore wind farms. Report C043-10.

Brownlow, A., Onoufriou, J., Bishop, A., Davison, N. and Thompson, D. (2016). Corkscrew seals: grey (*Halichoerus grypus*) infanticide and cannibalism may indicate the cause of spiral lacerations in seals. *PLoS ONE*, 11(6): e0156464.

Canning, S. J., Santos, M. B., Reid, R. J., Evans, P. G. H., Sabin, R. C., Bailey, N. and Pierce, G. J. (2008). Seasonal distribution of white-beaked dolphins (*Lagenorhynchus albirostris*) in UK waters with new information on diet and habitat use. *Journal of the Marine Biological Association of the United Kingdom*. 88(6), 1159–1166.

Carter, M. I. D., Boehme, L., Duck, C. D., Grecian, J., Hastie, G. D., McConnell, B. J., Miller, D. L., Morris, C., Moss, S., Thompson, D., Thompson, P. and Russell, D. JF. (2020). Habitat-based predictions of at-sea distribution for grey and harbour seals in the British Isles: Report to BEIS, OESEA-16-76, OESEA-17-78. Sea Mammal Research Unit, University of St Andrews. 74.

Carter, M.I.D., Boehme, L., Cronin, M.A., Duck, C.D., Grecian, W.J., Hastie, G.D., Jessopp, M., Matthiopoulos, J., McConnell, B.J., Miller, D.L., Morris, C.D., Moss, S.E.W., Thompson, D., Thompson, P.M. and Russell, D.J.F. (2022). Sympatric Seals, Satellite Tracking and Protected Areas: Habitat-Based Distribution Estimates for Conservation and Management. Front. Mar. Sci. 9:875869.

Casper, B.M. and Mann, D.A. (2010). Field hearing measurements of the Atlantic sharpnose shark *Rhizoprionodon terraenovae*. *Journal of Fish Biology*, 75(10): 2768-2776.

Cates, K., DeMaster, D.P., Brownell Jr, R.L., Silber, G., Gende, S., Leaper, R., Ritter, F. and Panigada, S. (2017). Strategic plan to mitigate the impacts of ship strikes on cetacean populations: 2017-2020. IWC.

CEFAS (2010). Strategic review of offshore wind farm monitoring data associated with FEPA licence conditions – annex 4: underwater noise. Cefas report ME1117.

Christiansen, F., and D. Lusseau. (2015). Linking Behavior to Vital Rates to Measure the Effects of Non-Lethal Disturbance on Wildlife. *Conservation Letters* 8,424-431.

Christiansen, F., C. G. Bertulli, M. H. Rasmussen, and D. Lusseau. (2015). Estimating cumulative exposure of wildlife to non-lethal disturbance using spatially explicit capture–recapture models. *The Journal of Wildlife Management* 79,311-324.

Christiansen, F., M. Rasmussen, and D. Lusseau. (2013). Whale watching disrupts feeding activities of minke whales on a feeding ground. *Marine Ecology Progress Series* 478:239.

Chartered Institute of Ecology and Environmental Management (CIEEM). 2019. Guidelines for ecological impact assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine. September 2018 Version 1.1 - updated September 2019. Chartered Institute of Ecology and Environmental Management, Winchester.

Clapham, P.J., 2000. The humpback whale. Cetacean Societies, field studies of dolphins and whales. Chicago: *The University of Chicago*, pp.173-196.

Clausen, K.T., Teilmann, J., Wisniewska, D.M., Balle, J.D., Delefosse, M. and Beest, F.M. (2021). Echolocation activity of harbour porpoises, *Phocoena phocoena*, shows seasonal artificial reef attraction despite elevated noise levels close to oil and gas platforms. *Ecological Solutions and Evidence*. 2 (1),e12055.

Cockroft, V.G., Haschick, S.L., and Klages, N.T.W. (1993). The diet of Risso's dolphin, *Grampus griseus* (Cuvier, 1812), from the east coast of South Africa. Z. *Säugetierkd*, 58, 286–293.

Constantine, R., D. H. Brunton, and T. Dennis. (2004). Dolphin-watching tour boats change bottlenose dolphin (Tursiops truncatus) behaviour. *Biological Conservation* 117,299-307.

Copping, A.E., and Hemery, L.G. (2020). OES-Environmental 2020 State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World. Report for Ocean Energy Systems (OES). doi:10.2172/1632878.

Copping, A.E., Hemery, L.G., Viehman, H., Seitz, A.C., Staines, G.J. and Hasselman, D.J. (2021). Are fish in danger? A review of environmental effects of marine renewable energy on fishes. Biological Conservation, 262: 109297.

Corkeron, P. J. 1995. Humpback whales in Hervey Bay, Queensland: Behaviour and responses to whale-watching vessels. *Canadian Journal of Zoology* 73,1290– 1299.

Corwin J.T. (1981). Audition in Elasmobranchs. In: Tavolga W.N., Popper A.N., Fay R.R. (eds) Hearing and Sound Communication in Fishes. Proceedings in Life Sciences. Springer, New York, NY.

CSIP. 2017. Annual Report for the period 1st January – 31st December 2016 (Contract number MB0111). Compiled by R. Deaville (ZSL). Contributing authors: P.D. Jepson and M. Perkins (ZSL), A. Brownlow, N. Davison and M. ten Doeschate (SRUC), B. Smith, L. Allan and R.C. Sabin (NHM), R. Penrose (MEM), J.E.F. Barnett, N. Clear, A. Crosby and R. Williams (CWTMSN/UoE).

Culloch, R. M., P. Anderwald, A. Brandecker, D. Haberlin, B. McGovern, R. Pinfield, F. Visser, M. Jessopp, and M. Cronin. (2016). Effect of construction-related activities and vessel traffic on marine mammals. Marine Ecology Progress Series 549, 231-242.

DAERA. (2017). Skerries and Causeway SAC guidance and literature. Available online at: https://www.daera-ni.gov.uk/publications/skerries-and-causeway-sac. [Accessed 12/02/2023].

Dähne, M., A. Gilles, K. Lucke, V. Peschko, S. Adler, K. Krugel, J. Sundermeyer, and U. Siebert. (2013). Effects of pile-driving on harbour porpoises (*Phocoena phocoena*) at the first offshore wind farm in Germany. *Environmental Research Letters* 8:025002.

DECC. (2011). Review and Assessment of Underwater Sound Produced from Oil and Gas Sound Activities and Potential Reporting Requirements under the Marine Strategy Framework Directive. Genesis Oil and Gas Consultants report for the Department of Energy and Climate Change.

Defingou, M., Bils, F., Horchler, B., Liesenjohann, T., and Nehls, G. (2019). PHAROS4MPAs – A Review of Solutions to Avoid and Mitigate Environmental Impacts of Offshore Windfarms. *BioConsult SH on behalf of WWF France. pp. 264*.

DEFRA, Joint Nature Conservation Committee, Natural England, Marine Management Organisation, Department of Agriculture Environment and Rural Affairs (Northern Ireland), Department for Business Energy and Industrial Strategy, and Offshore Petroleum Regulator for Environment and Decommissioning. (2021). Policy paper overview: Marine environment: unexploded ordnance clearance joint interim position statement.

Degraer, S., Carey, D.A., Coolen, J.W., Hutchison, Z.L., Kerckhof, F., Rumes, B., and Vanaverbeke, J. (2020). Offshore wind farm artificial reefs affect ecosystem structure and functioning. *Oceanography*. 33(4), 48-57.

Delefosse, M., M. L. Rahbek, L. Roesen, and K. T. Clausen. (2018). Marine mammal sightings around oil and gas installations in the central North Sea. *Journal of the Marine Biological Association of the United Kingdom*. 98, 993-1001.

Diederichs, A., Hennig, V. and Niels, G. (2008). Investigation of the bird collision risk and the responses of harbour porpoises in the offshore wind farms Horns Rev, North Sea and Nysted, Baltic Sea, in Denmark Part II: Harbour porpoises. Universit¨at Hamburg and BioConsult SH, p 99.

Doherty, P.D., Baxter, J.M., Godley, B.J., Graham, R.T., Hall, G., Hall, J., Hawkes, L.A., Henderson, S.M., Johnson, L., Speedie, C. and Witt, M.J. (2017). Testing the boundaries: Seasonal residency and inter-annual site fidelity of basking sharks in a proposed Marine Protected Area. *Biological Conservation*. 209,68-75.

Donovan, C., J. Harwood, S. King, C. Booth, B. Caneco, and C. Walker. (2016). Expert elicitation methods in quantifying the consequences of acoustic disturbance from offshore renewable energy developments. Advances in Experimental Medicine and Biology.

Duarte, C.M., Pitt, K.A., Lucas, C.H., Purcell, J.E., Uye, S-I., Robinson, K., Brotz, L., Decker, M.B., Sutherland, K.R., Malej, A., *et al*. (2012). Is global ocean sprawl a cause of jellyfish blooms? *Front Ecol Environ*, 11, pp.91-97.

Dunlop, R. A., M. J. Noad, R. D. McCauley, L. Scott-Hayward, E. Kniest, R. Slade, D. Paton, and D. H. Cato. 2017. Determining the behavioural dose–response relationship of marine mammals to air gun noise and source proximity. *Journal of Experimental Biology* 220,2878-2886.

Dyndo, M., D. M. Wiśniewska, L. Rojano-Doñate, and P. T. Madsen. (2015). Harbour porpoises react to low levels of high frequency vessel noise. *Scientific Reports* 5,11083.

Edds-Walton, P. L. (2000). Vocalizations Of Minke Whales *Balaenoptera Acutorostrata* In The St. Lawrence Estuary. Bioacoustics 11 ,31-50.

Erbe, C., Marley, S.A., Schoeman, R.P., Smith, J.N., Trigg, L.E. and Embling, C.B., 2019. The effects of ship noise on marine mammals—a review. *Frontiers in Marine Science*, *6*, p.606. Available online at: https://www.frontiersin.org/articles/10.3389/fmars.2019.00606 [Accessed 08/09/2023].

Evans, P. G. H. (1990). Marine Mammals in the English Channel in relation to proposed dredging scheme. Sea Watch Foundation, Oxford.

Evans, P., and K. Hintner. (2013). Review of the direct and indirect impacts of fishing activities on Marine Mammals in Welsh Waters.

Evans, P.G.H and Waggitt, J.J. (2020). Impacts of climate change on marine mammals, relevant to the coastal and marine environment around the UK. MCCIP Science Review 2020, 421–455.

Evans, P.G.H. (2008). An analysis of sightings of Cetacea in British waters. *Mammal Review*, 6, 5 - 14.

Evans, P.G.H., Baines, M.E. and Coppock, J. (2011). Abundance and behaviour of cetaceans and basking sharks in the Pentland Firth and Orkney Waters. Scottish Natural Heritage Commissioned Report No.419.

European Commission. (2021) Guidance document on wind energy developments and EU nature legislation. Directorate-General for Environment, Publications Office of the European Union. Available online at: https://data.europa.eu/doi/10.2779/095188 [Accessed 08/09/2023].

Fernandez-Betelu, O., I. M. Graham, K. L. Brookes, B. J. Cheney, T. R. Barton, and P. M. Thompson. (2021). Far-Field Effects of Impulsive Noise on Coastal Bottlenose Dolphins. Frontiers in Marine Science 8.

Finneran, J. J. (2015). Noise-induced hearing loss in marine mammals: A review of temporary threshold shift studies from 1996 to 2015. *The Journal of the Acoustical Society of America* 138,1702-1726.

Gavrilchuck, K., Lesage, V., Ramp, C., Sears, R., Bérubé, M., Bearhop, S. and Beauplet, G. (2014). Trophic niche partitioning among sympatric baleen whale species following the collapse of groundfish stocks in the Northwest Atlantic. *Marine Ecology Progress Series*, 497, pp.285-301.

Gedamke, J., D.P.Costa, and A. Dunstan (2001) Localization and visual verification of a complex minke whale vocalization. *The Journal of the Acoustical Society of America* 109,3038-3047.

Genesis. (2011). Review and Assessment of Underwater Sound Produced from Oil and Gas Sound Activities and Potential Reporting Requirements under the Marine Strategy Framework Directive. Report for the Department of Energy and Climate Change.

GoBe. (2018). Hornsea Project Three Offshore Wind Farm Environmental Statement: Volume 2, Chapter 4 – Marine Mammals. PINS Document Reference: A6.2.4 APFP Regulation 5(2)(a).

Goold, J. C. (1996). Acoustic assessment of populations of common dolphin *Delphinus delphis* in conjunction with seismic surveying. *Journal-Marine Biological Association of The United Kingdom* 76:811-820.

Graham, I. M., A. Farcas, N. D. Merchant, and P. Thompson. (2017a). Beatrice Offshore Wind Farm: An interim estimate of the probability of porpoise displacement at different unweighted single-pulse sound exposure levels. Prepared by the University of Aberdeen for Beatrice Offshore Windfarm Ltd.

Graham, I. M., E. Pirotta, N. D. Merchant, A. Farcas, T. R. Barton, B. Cheney, G. D. Hastie, and P. M. Thompson. (2017b). Responses of bottlenose dolphins and harbor porpoises to impact and vibration piling noise during harbor construction. Ecosphere 8.

Graham, I. M., N. D. Merchant, A. Farcas, T. R. C. Barton, B. Cheney, S. Bono, and P. M. Thompson. (2019). Harbour porpoise responses to pile-driving diminish over time. *Royal Society Open Science* 6:190335.

Hague, E. L., Sinclair, R. R. and Sparling, C. E. (2020). Regional baselines for marine mammal knowledge across the North Sea and Atlantic areas of Scottish waters. Available online: https://data.marine.gov.scot/sites/default/files/Scottish%20Marine%20and%20Freshwater%20Science%20%28SMFS%29%20Vol%2011%20No%2012%20Regional%20baselines%20for%20marine%20mammal%20knowledge%20across%20the%20North%20Sea%20and%20Atlantic%20areas%20of%20Scottish%20waters.pdf# [Accessed 10/11/2023].

Greene Jr, C. R. (1986). Acoustic studies of underwater noise and localization of whale calls. Sect. 2 In: Responses of bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea.

Hall, J.D. and J. Francine. (1991). Measurements of underwater sounds from a concrete island drilling structure located in the Alaskan sector of the Beaufort Sea. *Journal of the Acoustical Society of America.* 90(3),1665- 1667.

Hammond, P.S., Berggren, P., Benke, H., Borchers, D.L., Collet, A., Heide-Jørgensen, M.P., Heimlich, S., Hiby, A.R., Leopold, M.F. and Øien, N. (2002). Abundance of harbour porpoise and other cetaceans in the North Sea and adjacent waters. *Journal of Applied Ecology*, 39(2), 361-376.

Hammond, P.S., Lacey, C., Gilles, A., Viquerat, S., Börjesson, P., Herr, H., Macleod, K., Ridoux, V., Santos, M.B., Scheidat, M., Teilmann, J., Vingada, J. and Øien, N. (2021). Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys. SCANS-III Report, 42.

Hammond, P.S., Macleod, K., Berggren, P., Borchers, D.L., Burt, L., Cañadas, A., Desportes, G., Donovan, G.P., Gilles, A., Gillespie, D. and Gordon, J. (2013). Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management. *Biological Conservation*, 164, 107-122.

Harwood, J., S. King, R. Schick, C. Donovan, and C. Booth. (2014a). A protocol for Implementing the Interim Population Consequences of Disturbance (PCoD) approach: Quantifying and assessing the effects of UK offshore renewable energy developments on marine mammal populations. Report Number SMRUL-TCE-2013-014. Scottish Marine And Freshwater Science, 5(2).

Harwood, J., S. L. King, R. S. Schick, C. Donovan, and C. G. Booth. (2014b). A protocol for implementing the interim population consequences of disturbance (PCoD) approach: Quantifying and assessing the effects of UK offshore renewable energy developments on marine mammal populations. Page 33 Scottish Marine and Freshwater Science

Hartman, K.L., Visser, F. and Hendriks, A.J.E. (2008). Scoial structure of Risso's Dolphin (*Grampus griseus*) at the Azores: a stratified community based on highly associated units. *Canadian Journal of Zoology*. https://doi.org/10.1139/Z07-138

Hastie, G. D., P. Lepper, J. C. McKnight, R. Milne, D. J. F. Russell, and D. Thompson. (2021). Acoustic risk balancing by marine mammals: anthropogenic noise can influence the foraging decisions by seals. *Journal of Applied Ecology*.

Heinänen, S., and H. Skov. (2015). The identification of discrete and persistent areas of relatively high harbour porpoise density in the wider UK marine area. JNCC Report No. 544., JNCC, Peterborough.

Hemery, L.G. (2020). Changes in Benthic and Pelagic Habitats Caused by Marine Renewable Energy Devices. In A.E. Copping and L.G. Hemery (Eds.), OES-Environmental 2020 State of the Science Report: Pentland Floating Offshore Wind Farm EIA – PFOWF Offshore EIAR Document Number: GBPNTD-ENV-XOD-RP-00006 144 Environmental Effects of Marine Renewable Energy Development Around the World. Report for Ocean Energy Systems (OES),105-125.

Hughes, S.L. *et al*., 2018. Scottish Ocean Climate Status Report 2016, Marine Scotland Science. Available at: https://data.marine.gov.scot/dataset/scottish-ocean-climate-status-report-2016 [Accessed 08/09/2023].

IAMMWG. (2022). Updated abundance estimates for cetacean Management Units in UK waters (Revised 2022). JNCC Report No. 680, JNCC Peterborough, ISSN 0963-8091.

IAMMWG. (2021). Updated abundance estimates for cetacean Management Units in UK waters. JNCC Report No. 680, JNCC Peterborough, ISSN 0963-8091.Inter-Agency Marine Mammal Working Group (IAMMWG). (2021). Updated abundance estimates for cetacean Management Units in UK waters. JNCC Peterborough.

IUCN (2010). Loggerhead turtle (*Caretta caretta*) – North West Atlantic subpopulation. Available online at: https://www.iucnredlist.org/species/pdf/119339029/attachment [Accessed 07/09/2023].

Jansen, O. E., Leopold, M. F., Meesters, E. H. W. G., and Smeenk, C. (2010). Are white-beaked dolphins Lagenorhynchus albirostris food specialists? Their diet in the southern North Sea. *Journal of the Marine Biological Association of the United Kingdom*. 90(8), 1501–1508.

Janßen, H., Augustin, C.B., Hinrichsen, H.H. and Kube, S. (2013). Impact of secondary hard substrate on the distribution and abundance of *Aurelia aurita* in the western Baltic Sea. *Marine Pollution Bulletin*, 75, pp.224-234.

Jefferson, T.A., Weir, C.R., Anderson, R.C., Ballance, L.T., Kenney, R.D., and Kiszka, J.J. (2013). Global distribution of Risso's dolphin, Grampus griseus: a review and critical evaluation. *Mammal Review*, 44(1), 5668.

JNCC, NE, and CCW. (2010). The protection of marine European Protected Species from injury and disturbance. Guidance for the marine area in England and Wales and the UK offshore marine area.

JNCC. (2010a). Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise. Available online: https://data.jncc.gov.uk/data/31662b6a-19ed-4918-9fab-8fbcff752046/JNCC-CNCB-Piling-protocol-August2010-Web.pdf [Accessed 10/10/2022].

JNCC. (2010b). JNCC guidelines for minimising the risk of injury to marine mammals from using explosives. Available online: https://data.jncc.gov.uk/data/24cc180d-4030-49dd-8977-a04ebe0d7aca/JNCC-Guidelines-Explosives-Guidelines-201008-Web.pdf [Accessed 10/10/2022].

JNCC. (2017). JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys. August 2017.

JNCC. (2019). Joint Cetacean Data Programme. Available online at: https://jncc.gov.uk/our-work/jointcetacean-data-programme/ [Accessed 19/01/2023].

JNCC. (2020). Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs (England, Wales & Northern Ireland). Report No. 654, JNCC, Peterborough.

JNCC. (2021). Southern North Sea SAC. Available online at: https://jncc.gov.uk/our-work/southern-north-sea-mpa/ [Accessed on 18/02/2023].

Jones, E. L., McConnell, B. J., Sparling, C. and Matthiopoulos, J. (2013). Grey and harbour seal usage maps. Report to Scottish Government MR5. Sea Mammal Research Unit, University of St Andrews. pp 35.

Jones, E., G. Hastie, S. Smout, J. Onoufriou, N. D. Merchant, K. Brookes, and D. Thompson. (2017). Seals and shipping: quantifying population risk and individual exposure to vessel noise. *Journal of Applied Ecology* 54,1930-1940.

Karpovich, S. A., J. P. Skinner, J. E. Mondragon, and G. M. Blundell. (2015). Combined physiological and behavioral observations to assess the influence of vessel encounters on harbor seals in glacial fjords of southeast Alaska. *Journal of Experimental Marine Biology and Ecology* 473,110-120.

Kastelein, R. A., L. Helder-Hoek, S. Van de Voorde, A. M. von Benda-Beckmann, F.-P. A. Lam, E. Jansen, C. A. de Jong, and M. A. Ainslie. (2017). Temporary hearing threshold shift in a harbor porpoise (*Phocoena phocoena*) after exposure to multiple airgun sounds. *The Journal of the Acoustical Society of America* 142,2430-2442.

Kastelein, R. A., R. Gransier, and L. Hoek. (2013). Comparative temporary threshold shifts in a harbor porpoise and harbor seal, and severe shift in a seal (L). *Journal of the Acoustical Society of America.* 134,13-16.

Kastelein, R., N. Jennings, W. Verboom, D. De Haan, and N. Schooneman. (2006). Differences in the response of a striped dolphin (*Stenella coeruleoalba*) and a harbour porpoise (Phocoena phocoena) to an acoustic alarm. *Marine Environmental Research* 61:363-378.

Kavanagh, A. S., M. Nykänen, W. Hunt, N. Richardson, and M. J. Jessopp. (2019). Seismic surveys reduce cetacean sightings across a large marine ecosystem. *Scientific Reports* 9:19164.

Kempster, R. M. and Collin, S. P. (2011). Electrosensory pore distribution and feeding in the basking shark *Cetorhinus maximus* (Lamniformes: Cetorhinidae). *Aquatic Biology*. 12, 33-36.

King, S. L., R. S. Schick, C. Donovan, C. G. Booth, M. Burgman, L. Thomas, and J. Harwood. (2015). An interim framework for assessing the population consequences of disturbance. Pages 1150-1158 *Methods in Ecology and Evolution*.

La Manna, G., M. Manghi, G. Pavan, F. Lo Mascolo, and G. Sara. (2013). Behavioural strategy of common bottlenose dolphins (Tursiops truncatus) in response to different kinds of boats in the waters of Lampedusa Island (Italy). *Aquatic Conservation-Marine and Freshwater Ecosystems* 23,745-757.

Lacey, C., Gilles, A., Börjesson, P., Herr, H., Macleod, K., Ridoux, V., Santos, M.B. et al. (2022). Modelled density surfaces of cetaceans in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys. SCANS-III Project Report 2, 31pp and Appendices.

Leopold, M.F. 2015. Eat and be eaten, Porpoise diet studies. *PhD thesis*, Wageningen University, The Netherlands.

Leopold, M. F., Begeman, L., van Bleijswijk, J. D. L., IJsseldijk, L. L., Witte, H. J., and Gröne, A. (2015). Exposing the grey seal as a major predator of harbour porpoises. *Proceedings of the Royal Society B: Biological Sciences*. 282(1798), p.20142429.

Leopold, M.F., Rotshuizen, E. and Evans, P.G.H. (2018). From nought to 100 in no time: how humpback whales (*Megaptera novaeangliae*) came into the southern North Sea. *Lutra*, 61(1), pp.165-188.

LGL, R., and Greeneridge. (1986). Responses of bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea.

Lindeboom, H.J., Kouwenhoven, H.J., Bergman, M.J.N., Bouma, S., Brasseur, S.M.J.M., Daan, R., Fijn, R.C., De Haan, D., Dirksen, S., Van Hal, R. and Lambers, R.H.R. (2011). Short-term ecological effects of an offshore wind farm in the Dutch coastal zone; a compilation. *Environmental Research Letters*, *6*(3), 035101.

Lusseau, D. (2003). Male and female bottlenose dolphins *Tursiops* spp. have different strategies to avoid interactions with tour boats in Doubtful Sound, New Zealand. *Marine Ecology Progress Series.* 257, 267-274.

Madsen, P. T., Wahlberg, M., Tougaard, J., Lucke, K. and Tyack, P. (2006). Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs. *Marine Ecology Progress Series.* 309, 279-295.

Malme, C., P. Miles, C. Clark, P. Tyack, and J. Bird. (1984). Investigations of the Potential Effects of Underwater Noise from Petroleum Industry Activities on Migrating Gray Whale Behavior—Phase II. U-S. Department of the Interior Minerals Management Service.

Marine Conservation Society (n.d.). Basking Shark Code of Conduct: Boat-users, Kayakers, Swimmers, Divers and Surfers | CMS. Available online at: https://www.cms.int/en/publication/basking-shark-code-conduct-boatusers-kayakers-swimmers-divers-and-surfers [Accessed 10/11/2022].

Marine Management Organisation (2014). Review of environmental data associated with post-consent monitoring of licence conditions of offshore wind farms. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/317787/1031.pdf [Accessed 07/09/2023].

Marine Scotland (2015). Scotland's National Marine Plan. Available online at: https://www.gov.scot/publications/scotlands-national-marine-plan/ [Accessed 06/10/2022].

Marine Scotland. (2014). *Guidance on the Offence of Harassment at Seal Haul-out Sites*. Marine Scotland Commissioned Report. 10.

Marine Scotland. (2016). Habitats and species surveys in the Pentland Firth and Orkney waters. Topic Sheet Number 34. Available online at: https://www.gov.scot/binaries/content/documents/govscot/publications/factsheet/2019/11/marine-scotlandtopic-sheets-renewables/documents/habitats-and-species-surveys-in-the-pentland-firth-and-orkney-watersupdated-october-2016/habitats-and-species-surveys-in-the-pentland-firth-and-orkney-waters-updatedoctober 2016/govscot%3Adocument/habitats%2Bspecies%2Bpentland%2Bfirth.pdf [Accessed 08/09/2023].

Pentland Floating Offshore Wind Farm EIA – PFOWF Offshore EIAR Document Number: GBPNTD-ENV-XOD-RP-00006 146.

Marine Scotland. (2020).The protection of Marine European Protected Species from injury and disturbance, Guidance for Scottish Inshore Waters. July 2020. Available online at: https://www.gov.scot/binaries/content/documents/govscot/publications/advice-and-guidance/2020/07/marineeuropean-protected-species-protection-from-injury-and-disturbance/documents/marine-european-protectedspecies-guidance-july-2020/marine-european-protected-species-guidance-july2020/govscot%3Adocument/EPS%2Bguidance%2BJuly%2B2020.pdf [Accessed 12/03/23].

Marley, S., C. Salgado-Kent, C. Erbe, and I. M. Parnum. (2017). Effects of vessel traffic and underwater noise on the movement, behaviour and vocalisations of bottlenose dolphins in an urbanised estuary. *Nature*.

Marmo, B., Roberts, I., Buckingham, M.P., King, S. and Booth, C. (2013). Modelling of noise effects of operational offshore wind turbines including noise transmission through various foundation types. *Scottish Marine and Freshwater Science Vol 4 No 5. Marine Scotland Science*.

McGarry, T., O. Boisseau, S. Stephenson, and R. Compton. (2017). Understanding the Effectiveness of Acoustic Deterrent Devices (ADDs) on Minke Whale *(Balaenoptera acutorostrata*), a Low Frequency Cetacean. Report for the Offshore Renewables Joint Industry Programme (ORJIP) Project 4, Phase 2. Prepared on behalf of the Carbon Trust.

Meissner, A. M., F. Christiansen, E. Martinez, M. D. Pawley, M. B. Orams, and K. A. Stockin. (2015). Behavioural effects of tourism on oceanic common dolphins, *Delphinus* sp., in New Zealand: the effects of Markov analysis variations and current tour operator compliance with regulations. *PLoS ONE* 10:e0116962.

Mellinger, D. K., C. D. Carson, and C. W. Clark. (2000). Characteristics of minke whale (Balaenoptera acutorostrata) pulse trains recorded near Puerto Rico. *Marine Mammal Science* 16,739-756.

Middlemas, S.J., Armstrong, J.D. and Thompson, P.M. (2003). The significance of marine mammal predation on salmon and sea trout. Salmon at the Edge, Chapter 5, 43-60.

Middlemas, S.J., Barton, T.R., Armstrong, J.D. and Thompson, P.M. (2005). Functional and aggregative responses of harbour seals to changes in salmonid abundance. *Proceedings of the Royal Society*. 273, 193-198.

Mitchell, I., Aonghais Cook, A., Douse, A., Foster, S., Kershaw, M., Neil McCulloch, N., Murphy, M. and Hawkridge, J. (2018). Marine Bird Breeding Success/failure. UK Marine Online Assessment Tool. Available online at: https://moat.cefas.co.uk/biodiversity-food-webs-and-marine-protected-areas/birds/abundance/ [Accessed 20/01/2023]

Morris, C.D., Duck, C.D.,and Thompson, D. (2021). Aerial surveys of seals in Scotland during the harbour seal moult, 2016-2019. NatureScot Research Report 1256.

MS-LOT (2022a). Habitat Regulations Appraisal Screening response under the Conservation (Natural Habitats, &c.) Regulations 1994), The Conservation of Offshore Marine Habitats and Species Regulations 2017 and The Conservation of Habitats and Species Regulations 2017.

Murphy, C.T., Reichmuth, C., and Mann, D. (2015). Vibrissal sensitivity in a harbor seal (*Phoca vitulina*). *Journal of Experimental Biology*. 218(15), 2463–2471.

Murphy, S., Pinn, E.H. and Jepson, P.D. (2013). The short-beaked common dolphin (*Delphinus delphis*) in the North-eastern Atlantic: Distribution, ecology, management and conservation status. *Oceanography and Marine Biology: An Annual Review*, 51, 193-280.

NatureScot. (2020). Priority Marine Features in Scotland's seas. Available online at: https://www.nature.scot/professional-advice/protected-areas-and-species/priority-marine-features-scotlands-seas [Accessed 02/01/2023].

NatureScot. (2020a). Conservation and Management Advice: Inner Hebrides and the Minches SAC. July 2020. [Accessed 02/01/2023].

NatureScot (2020b) Conservation and Management Advice for North-east Lewis NCMPA. https://sitelink.nature.scot/site/10476 [Accessed 08/09/2023].

NatureScot (2020c) Conservation and Management Advice for Southern Trench NCMPA. https://sitelink.nature.scot/site/10477 [Accessed 02/01/2023].

NatureScot (2020d) Conservation and Management Advice for Sea of Hebrides NCMPA. https://sitelink.nature.scot/site/10474 [Accessed 02/01/2023].

Nedwell, J R., Langworthy, J., and Howell, D. (2003). Assessment of subsea noise and vibration from offshore wind turbines and its impact on marine wildlife. Initial measurements of underwater noise during construction of offshore wind farms, and comparisons with background noise. Subacoustech Report No. 544R0423, published by COWRIE, May 2003.

Nedwell, J. R., Parvin, S. J., Edwards, B., Workman, R., Brooker, A. G. and Kynoch, J. E. (2007) Measurement and Interpretation of Underwater Noise During Construction and Operation of Wind farms in UK waters, Subacoustech Report No. 544R0738 to COWRIE Ltd. ISBN: 978-0-9554279-5-4.

Nedwell, J., and D. Howell. (2004). A review of offshore windfarm related underwater noise sources. Cowrie Rep 544:1-57.Neumann, D. R., and M. B. Orams. (2003). Feeding behaviours of short-beaked common dolphins, *Delphinus delphis*, in New Zealand. *Aquatic Mammals* 29,137-149.

Neumann, D. R., and M. B. Orams. (2003). Feeding behaviours of short-beaked common dolphins, *Delphinus delphis*, in New Zealand. *Aquatic Mammals* 29:137-149.

New, L. F., J. Harwood, L. Thomas, C. Donovan, J. S. Clark, G. Hastie, P. M. Thompson, B. Cheney, L. Scott-Hayward, and D. Lusseau. (2013). Modelling the biological significance of behavioural change in coastal bottlenose dolphins in response to disturbance. Functional Ecology 27:314-322.

Nguyen, J.-P. (1996). Drilling: Oil and gas field development techniques. Balvet, B.B. (trans.). Editions TECHNIP. Institut Français du Pétrole, Paris. P.384.

National Marine Fisheries Service (NMFS). (2018). Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing. Available online at: https://www.fisheries.noaa.gov/resource/document/technical-guidance-assessing-effects-anthropogenic-sound-marine-mammal-hearing

Normandeau, Exponent, T. Tricas, and A. Gill (2011). Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Pacific OCS Region, Camarillo, CA. *OCS Study BOEMRE* 2011-09.

Northridge S., Tasker M., Webb A., Camphuysen K. and Leopold M. (1997). White-beaked *Lagenorhynchus albirostris* and Atlantic whitesided dolphin *L. acutus* in Northwest European and US North Atlantic waters. Report of the International Whaling Commision 47, 797–805.

Nowacek, S. M., R. S. Wells, and A. R. Solow. (2001). Short-term effects of boat traffic on bottlenose dolphins, Tursiops truncatus, in Sarasota Bay, Florida. *Marine Mammal Science*. 17, 673-688.

Oakley, J. A., A. T. Williams, and T. Thomas. (2017). Reactions of harbour porpoise (*Phocoena phocoena*) to vessel traffic in the coastal waters of South West Wales, UK. *Ocean and Coastal Management* 138:158-169.

Onoufriou, J., Jones, E., Hastie, G., and Thompson, D. (2016). Investigations into the interactions between harbour seals (*Phoca vitulina*) and vessels in the inner Moray Firth. Marine Scotland Science.

Orkney Islands Council (2022). Orkney Islands Regional Marine Plan: Consultation Draft.

OSPAR. (2009). Overview of the impacts of anthropogenic underwater sound in the marine environment. Report 441:2009.

OWPL (2022). West of Orkney Windfarm Offshore HRA Screening Report. Offshore Wind Power Limited. Document number: L100632-S09-A-REPT-001.

Palka, D.L. and Hammond, P.S. (2001). Accounting for responsive movement in line transect estimates of abundance. Canadian Journal of Fisheries and Aquatic Scientists 58 (4), pp.777-87.

Paxton, C.G.M., Scott-Hayward, L., Mackenzie, M., Rexstad, E. and Thomas, L. (2016) *Revised Phase III Data Analysis of Joint Cetacean Protocol Data Resource*. JNCC, Peterborough.

Paxton, C.G.M., Scott-Hayward, L.A.S. and Rexstad, E. (2014). Statistical approaches to aid the identification of Marine Protected Areas for minke whale, Risso's dolphin, white-beaked dolphin and basking shark. Scottish Natural Heritage Commissioned Report No. 594. Available online at: https://www.nature.scot/doc/naturescot-commissioned-report-594-statistical-approaches-aid-identification-marine-protected-areas [Accessed 08/09/2023].

Peltier, H., Beaufils, A., Cesarini, C., Dabin W., Dars, C., Demaret, F., Dhermain, F., Doremus, G., Labach H., Van Canneyt, O. and Spitz, J. (2019). Monitoring of Marine Mammal Strandings Along French Coasts Reveals the Importance of Ship Strikes on Large Cetaceans: A Challenge for the European Marine Strategy Framework Directive. *Frontiers in Marine Science*, 6, pp. 486.

Pierce, G. J., Santos, M. B., Reid, R. J., Patterson, I. a. P., and Ross, H. M. (2004). Diet of minke whales *Balaenoptera acutorostrata* in Scottish (UK) waters with notes on strandings of this species in Scotland 1992–2002. *Journal of the Marine Biological Association of the United Kingdom*. 84(6), 1241–1244.

Pirotta, E., B. E. Laesser, A. Hardaker, N. Riddoch, M. Marcoux, and D. Lusseau. (2013) Dredging displaces bottlenose dolphins from an urbanised foraging patch. *Marine Pollution Bulletin* 74, 396-402.

Pirotta, E., N. D. Merchant, P. M. Thompson, T. R. Barton, and D. Lusseau. (2015). Quantifying the effect of boat disturbance on bottlenose dolphin foraging activity. *Biological Conservation* 181, 82-89.

Pirotta, E., N.D Merchant, P.M. Thompson, T.R. Barton and D. Lusseau (2014) Quantifying the effect of boat disturbance on bottlenose dolphin foraging activity. *Biological Conservation* 181, 82-89.

Piwetz, S. (2019). Common bottlenose dolphin (*Tursiops truncatus*) behavior in an active narrow seaport. *PLoS ONE*. https://doi.org/10.1371/journal.pone.0211971

Popper A N, Hawkins A D, Fay R R, Mann D A, Bartol S, Carlson T J, Coombs S, Ellison W T, Gentry R L, Halvorsen M B, Løkkeborg S, Rogers P H, Southall B L, Zeddies D G, Tavolga W N (2014). Sound exposure guidelines for Fishes and Sea Turtles. Springer Briefs in Oceanography.

Purcell, J.E. (2012). Jellyfish and ctenophore blooms coincide with human proliferations and environmental perturbations. Annu. Rev. Mar. Sci., 4, 209-235.

Ransijn, J. (2022). Marine mammal predator-prey interactions in the North Sea. PhD Thesis, University of St Andrews.

Reeves, R.R., Smeenk, C., Kinze, C.C., Brownell, R.L. and Lien, J. (1999). White-beaked dolphin Lagenorhynchus *albirostris* Gray, 1846. *Handbook of Marine Mammals*, 6, 1- 30pp. Academic Press, London.

Reid, J.B., Evans, P.G.H. and Northridge, S.P. (2003). *Atlas of Cetacean distribution in north-west European waters*. JNCC, Peterborough.

Reubens, J.T., Braeckman, U., Vanaverbeke, J., Van Colen, C., Degraer, S. and Vincx, M., 2013a. Aggregation at windmill artificial reefs: Catch Per Unit Effort of Atlantic cod (*Gadus morhua*) and pouting (*Trisopterus luscus*) at different habitats in the Belgian part of the North Sea. Fisheries Research, 139, 28-34.

Reubens, J.T., Pasotti, F., Degraer, S. and Vincx, M., 2013b. Residency, site fidelity and habitat use of Atlantic cod (*Gadus morhua*) at an offshore wind farm using acoustic telemetry. Marine Environmental Research, 90, 128-135.

Richardson, J., and B. Wursig. (1990). Reactions of Bowhead Whales, *Balaena mysticetu*, to Drilling and Dredging Noise in the Canadian Beaufort Sea. Marine Environmental Research 29,26.

Rigby, C.L., Barreto, R., Carlson, J., Fernando, D., Fordham, S., Francis, M.P., Herman, K., Jabado, R.W., Liu, K.M., Marshall, A., Romanov, E. and Kyne, P.M. (2021). *Cetorhinus maximus* (amended version of 2019 assessment). The IUCN Red List of Threatened Species 2021: e.T4292A194720078. Available online at: https://dx.doi.org/10.2305/IUCN.UK.2021-1.RLTS.T4292A194720078.en [Accessed 22/02/2023]

Risch, D., C. W. Clark, P. J. Dugan, M. Popescu, U. Siebert, and S. M. Van Parijs. (2013). Minke whale acoustic behavior and multi-year seasonal and diel vocalization patterns in Massachusetts Bay, USA. Marine Ecology Progress Series 489,279-295.

Risch, D., Castellote, M., Clark, C.W., Davis, G.E., Dugan, P.J., Hodge, L.E., Kumar, A., Lucke, K., Mellinger, D.K., Nieukirk, S.L. and Popescu, C.M., 2014. Seasonal migrations of North Atlantic minke whales: novel insights from large-scale passive acoustic monitoring networks. *Movement Ecology*, 2(1), 1-17.

Risch, D., Wilson, S.C., Hoogerwerf, M., Van Geel, N.C., Edwards, E.W. and Brookes, K.L., 2019. Seasonal and diel acoustic presence of North Atlantic minke whales in the North Sea. *Scientific Reports*, 9(1), 1-11.

Rizzo, L.Y. and Schulte, D., 2009. A review of humpback whales' migration patterns worldwide and their consequences to gene flow. *Journal of the Marine Biological Association of the United Kingdom*, 89(5), pp.995-1002.

Robinson, K.P., Eisfeld, S.M., Costa, M. and Simmonds, M.P. (2010). Short-beaked common dolphin (*Delphinus delphis*) occurrence in the Moray Firth, north-east Scotland. *Marine Biodiversity Records*, 3: e55doi: 10.1017/S1755267210000448.

Robinson, K.P., Tetley, M.J. and Mitchelson-Jacob, E.G. (2009). The distribution and habitat preference of coastally occurring minke whales (*Balaenoptera acutorostrata*) in the outer southern Moray Firth, northeast Scotland. *Journal of Coastal Conservation*. 13(1), 39-48.

Robinson, S. P., L. Wang, S.-H. Cheong, P. A. Lepper, J. P. Hartley, P. M. Thompson, E. Edwards, and M. Bellmann. (2022). Acoustic characterisation of unexploded ordnance disposal in the North Sea using high order detonations. Marine Pollution Bulletin 184,114178.

Ruppel, C. D., T. C. Weber, E. R. Staaterman, S. J. Labak, and P. E. Hart. (2022). Categorizing Active Marine Acoustic Sources Based on Their Potential to Affect Marine Animals. *Journal of Marine Science and Engineering* 10:1278.

Russell, D. J. F., G. D. Hastie, D. Thompson, V. M. Janik, P. S. Hammond, L. A. S. Scott-Hayward, J. Matthiopoulos, E. L. Jones, and B. J. McConnell. (2016b). Avoidance of wind farms by harbour seals is limited to pile driving activities. Pages 1642-1652 *Journal of Applied Ecology*.

Russell, D. J., G. D. Hastie, D. Thompson, V. M. Janik, P. S. Hammond, L. A. Scott-Hayward, J. Matthiopoulos, E. L. Jones, and B. J. McConnell. (2016a). Avoidance of wind farms by harbour seals is limited to pile driving activities. *Journal of Applied Ecology* 53:1642-1652.

Russell, D.G.F., Jones, E.L. and Morris, C.D. (2017). Updated Seal Usage Maps: The estimated at-sea Distribution of Grey and Harbour Seals. *Scottish Marine and Freshwater Science* Vol 8 No 25. Marine Scotland Science.

Russell, D.J., Brasseur, S.M., Thompson, D., Hastie, G.D., Janik, V.M., Aarts, G., McClintock, B.T., Matthiopoulos, J., Moss, S.E., and McConnell, B. (2014). Marine mammals trace anthropogenic structures at sea. *Current Biology*, 24, R638-R639.

Russell, D. J. F., B. McConnell, D. Thompson, C. Duck, C. Morris, J. Harwood, and J. Matthiopoulos. (2013). Uncovering the links between foraging and breeding regions in a highly mobile mammal. *Journal of Applied Ecology* 50:499-509.

Russell, D., and G. Hastie. (2017). Associating predictions of change in distribution with predicted received levels during piling. *Report produced for SMRU Consulting*.

Rutenko, A. N., and V. G. Ushchipovskii. (2015). Estimates of acoustic noise generated by supply vessels working with oil-drilling platforms. *Acoustical Physics* 61:556-563.

Salomons, E. M., B. Binnerts, K. Betke, and A. M. v. Benda-Beckmann. (2021). Noise of underwater explosions in the North Sea. A comparison of experimental data and model predictions. *The Journal of the Acoustical Society of America*, 149,1878-1888.

Santos, M.B., Pierce, G.J., Reid, R.J., Patterson, I.A.P., Ross, H.M. and Mente, E. (2001). Stomach contents of bottlenose dolphins (*Tursiops truncates*) in Scottish waters. J. Mar. Biol. Ass. U.K., 81, 873-878.

Scheidat, M., Tougaard,J., Brasseur, S., Carstensen, J., L Van Polanen-Petel, T., Teilmann, J. and Reijnders, P. (2011). Harbour porpoises (*Phocoena phocoena*) and wind farms: a case study in the Dutch North Sea. *Environmental Research Letters*, 6(2), 025102.

Schoeman, R.P., Patterson-Abrolat, C. and Plön, S. (2020). A Global Review of Vessel Collisions With Marine Animals. *Frontiers in Marine Science*, *7*, 292.

SCOS (2021). Scientific Advice on matters Related to the Management of Seal Populations: 2021. NERC Special Committee on Seals. Available at: http://www.smru.st-andrews.ac.uk/files/2022/08/SCOS-2021.pdf.

Scottish Government (2019). The National Island's Plan. Available online at: https://www.gov.scot/publications/national-plan-scotlands-islands/documents/ [Accessed 08/08/2023].

Scottish Government (2020). Sectoral Marine Plan: Regional Local Guidance. Available online at: https://www.gov.scot/publications/sectoral-marine-plan-regional-locational-guidance/documents [Accessed 18/01/2023].

Scottish Government (2022a). Scottish Biodiversity Strategy to 2045. Available online at: https://www.gov.scot/publications/scottish-biodiversity-strategy-2045-tackling-nature-emergency-scotland/ [Accessed 02/02/2023].

Scottish Government (2022b). A Blue Economy Vision for Scotland. Available online at: https://www.gov.scot/publications/blue-economy-vision-scotland/pages/6/ [Accessed 01/06/2023].

Scottish Government (2023). Marine Mammals ScotMER Receptor Group: Marine mammals evidence map: January 2023. Available online at: https://www.gov.scot/publications/marine-mammals-specialist-receptor-group/ [Accessed 01/06/2023].

Sims, D.W., 2008. Sieving a living: a review of the biology, ecology and conservation status of the plankton-feeding basking shark *Cetorhinus maximus*. *Advances in marine biology*, 54, pp.171-220.

Sims, D.W., Southall, E.J., Richardson, A.J., Reid, P.C. and Metcalfe, J.D., 2003. Seasonal movements and behaviour of basking sharks from archival tagging: no evidence of winter hibernation. *Marine Ecology Progress Series*, 248, pp.187-196.

Sinclair, R., S. Kazer, M. Ryder, P. New, and U. Verfuss. (2021). Review and recommendations on assessment of noise disturbance for marine mammals. NRW Evidence Report No. 529.

Sivle, L. D., P. H. Kvadsheim, C. Curé, S. Isojunno, P. J. Wensveen, F.-P. A. Lam, F. Visser, L. Kleivane, P. L. Tyack, and C. M. Harris. (2015). Severity of expert-identified behavioural responses of humpback whale, minke whale, and northern bottlenose whale to naval sonar. *Aquatic Mammals* 41:469.

Smith, J., Sinclair, R. and Brown, A. (2022). Pentland Floating Offshore Wind Farm Offshore EIAR (Volume 2): Main Report Chapter 11: Marine Mammals and Other Megafauna.

SNH. (2017a). Scottish Marine Wildlife Watching Code. Available online at: https://www.nature.scot/sites/default/files/2017-06/Publication%202017%20-%20The%20Scottish%20Marine%20Wildlife%20Watching%20Code%20SMWWC%20-%20Part%201%20-%20April%202017%20%28A2263518%29.pdf [Accessed 16/04/2022].

SNH (2017b). A Guide to Best Practice for Watching Marine Wildlife. Available online at: https://www.nature.scot/doc/guide-best-practice-watching-marine-wildlife-smwwc [Accessed 07/09/2023].

Southall, B. L., Finneran, J. J., Reichmuth, C., Nachtigall, P. E., Ketten, D. R., Bowles, A. E., Ellison, W.T., Nowacek, D.P and Tyack, P. L. (2019). Marine mammal noise exposure criteria: updated scientific recommendations for residual hearing effects. *Aquatic Mammals*. *45(2)*, 1258-232.

Southall, E.J., Sims, D.W., Metcalfe, J.D., Doyle, J.I., Fanshawe, S., Lacey, C., Shrimpton, J., Solandt, J.-L. and Speedie, C.D. (2005). Spatial distribution patterns of basking sharks on the European shelf: preliminary comparison of satellite tag geolocation, survey and public sightings data. *Journal of the Marine Biological Association of the UK*, 85, 1083–1088.

Sparling, C. E., J. R. Speakman, and M. A. Fedak. (2006). Seasonal variation in the metabolic rate and body composition of female grey seals: fat conservation prior to high-cost reproduction in a capital breeder? *Journal of Comparative Physiology* B 176:505-512.

Speedie, C.D., Johnson, L.A. and Witt, M.J. (2009). Basking Shark Hotspots on the West Coast of Scotland: Key sites, threats and implications for conservation of the species. Scottish Natural Heritage, Inverness, Scotland, Commissioned Report No.339., pp. 59.

Stamation, K.A., Croft, D.B., Shaughnessy, P.D., Waples, K.A. and Briggs, S.V. (2010). Behavioral responses of humpback whales (*Megaptera novaeangliae*) to whale-watching vessels on the southeastern coast of Australia. *Marine Mammal Science*. 26(1), 98-122.

Stöber U, Thomsen F (2021). How could operational underwater sound from future offshore wind turbines impact marine life. *The Journal of the Acoustical Society of America*. 149, 1791-1795.

Stone, C. J., K. Hall, S. Mendes, and M. L. Tasker. (2017). The effects of seismic operations in UK waters: analysis of Marine Mammal Observer data. *Journal of Cetacean Research and Management* 16,71-85.

Stringell, T., Hill, D., Rees, D., Rees, F., Rees, P., Morgan G., Morgan, L. and Morris, C. (2015) Predation of Harbour Porpoises (*Phocoena phocoena*) by Grey Seals (*Halichoerus grypus*) in Wales. *Aquatic Mammals* 2015, 41(2), 188-191

Stringell, T., Hill, D., Rees, D., Rees, F., Rees, P., and Morgan, G. (2015). Short Note: Predation of Harbour Porpoises (*Phocoena phocoena*) by Grey Seals (*Halichoerus grypus*) in Wales. *Aquatic Mammals*. 41(2), 188–191.

Taormina, B., Bald, J., Want, A., Thouzeau, G., Lejart, M., Desroy, N. and Carlier, A., 2018. A review of potential impacts of submarine power cables on the marine environment: Knowledge gaps, recommendations and future directions. *Renewable and Sustainable Energy Reviews*, *96*, 380-391.

Teilmann, J., Christiansen, C.T., Kjellerup, S., Dietz, R. and Nachmann, G. (2013). Geographic, seasonal, and diurnal surface behavior of harbor porpoises. *Marine Mammal Science*, 29, 60-76.

Teilmann, J., Tougaard, J. and Carstensen, J. (2006a). Summary on harbour porpoise monitoring 1999-2006 around Nysted and Horns Rev Offshore Wind Farms.

Teilmann, J., Tougaard, J., Cartensen, J., Dietz, R. and Tougaard, S. (2006b). Summary on seal monitoring 1999- 2005 around Nysted and Horns Rev Offshore Wind Farms. Report by ENERGI E, 2 2006.

Tetley, M. J., Mitchelson-Jacob, E. G. and Robinson, K. P. (2008). The summer distribution of coastal minke whales (Balaenoptera acutorostrata) in the southern outer Moray Firth, NE Scotland, in relation to co-occurring mesoscale oceanographic features. *Remote Sensing of Environment*. *112*(8), 3449–3454.

The WiSe Scheme (2023). WiSe Codes of Conduct. Available online at: https://www.wisescheme.org/ [Accessed 02/06/2023].

Thompson P M, Hastie G D, Nedwell J, Barham R, Brookes K L, Cordes L S, Bailey H, McLean N (2013). Framework for assessing impacts of pile-driving noise from offshore wind farm construction on a harbour seal population. Environmental Impact Assessment Review 43 (2013), 73-85.

Thompson, D., Duck, C.D., Morris, C.D. and Russell, D.J. (2019). The status of harbour seals (*Phoca vitulina*) in the UK. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *29*, pp.40-60.

Thompson, D., Hammond, P.S., Nicholas, K.S., and Fedak, M.A. (1991). Movements, diving and foraging behaviour of grey seals (*Halichoerus grypus*). Journal of the Zoological Society of London, 244, 223-232.

Thompson, D.J., Onoufriou, J., Brownlow, A. and Morris, C. (2015). Data based estimates of collision risk: an example based on harbour seal tracking data around a proposed tidal turbine array in the Pentland Firth. *Scottish Natural Heritage*.

Thompson, F., S. R. McCully, D. Wood, F. Pace, and P. White. (2009). A generic investigation into noise profiles of marine dredging in relation to the acoustic sensitivity of the marine fauna in UK waters with particular emphasis on aggregate dredging: PHASE 1 Scoping and review of key issues., MALSF.

Tinker, J.P. and Howes, E.L., 2020. The impacts of climate change on temperature (air and sea), relevant to the coastal and marine environment around the UK. *MCCIP Science Review* 2020, pp.1–30. Available at: http://www.mccip.org.uk/media/2003/01_temperature_2020.pdf.

Todd, N. R. E., M. Cronin, C. Luck, A. Bennison, M. Jessopp, and A. S. Kavanagh. (2020). Using passive acoustic monitoring to investigate the occurrence of cetaceans in a protected marine area in northwest Ireland. *Estuarine, Coastal and Shelf Science* 232,106509.

Todd, V. L., I. B. Todd, J. C. Gardiner, E. C. Morrin, N. A. MacPherson, N. A. DiMarzio, and F. Thomsen. (2015). A review of impacts of marine dredging activities on marine mammals. *ICES Journal of Marine Science: Journal du Conseil* 72,328-340.

Todd, V. L., W. D. Pearse, N. C. Tregenza, P. A. Lepper, and I. B. Todd. (2009). Diel echolocation activity of harbour porpoises (*Phocoena phocoena*) around North Sea offshore gas installations. *ICES Journal of Marine Science*, 66(4), 734 – 745.

Todd, V.L., Warley, J.C., and Todd, I.B. (2016). Meals on Wheels? A Decade of Megafaunal Visual and Acoustic Observations from Offshore Oil and Gas Rigs and Platforms in the North and Irish Seas. *PLoS ONE*, 11 (4), e0153320.

Todd, V.L.G., Todd, I.B., Gardiner, J.C., Morrin, E.C.N., MacPherson, N.A., DiMarzio, N.A. and Thomsen, F. (2014). A review of impacts of marine dredging activities on marine mammals. *ICES Journal of Marine Science*, 72(2), 328-340. https://academic.oup.com/icesjms/article/72/2/328/676320.

Tougaard J, Hermannsen L, Madsen P T (2020). How loud is the underwater noise from operating offshore wind turbines? *The Journal of the Acoustical Society of America*, 148(5), .2885 – 2893.

Tubelli, A. A., A. Zosuls, D. R. Ketten, M. Yamato, and D. C. Mountain. (2012). A prediction of the minke whale (*Balaenoptera acutorostrata*) middle-ear transfer function. *Journal of the Acoustical Society of America* .132,3263-3272.

Tubelli, A. A., Zosuls, A., Ketten, D. R., and Mountain, D. C. (2018). A model and experimental approach to the middle ear transfer function related to hearing in the humpback whale (*Megaptera novaeangliae*). *The Journal of the Acoustical Society of America*. 144(2), 525–535.

Tyack, P., and L. Thomas. (2019). Using dose–response functions to improve calculations of the impact of anthropogenic noise. *Aquatic Conservation Marine and Freshwater Ecosystems*. 29(S1),242-253.

Tyler-Walters, H., James, B., Carruthers, M. (eds.), Wilding, C., Durkin, O., Lacey, C., Philpott, E., Adams, L., Chaniotis, P.D., Wilkes, P.T.V., Seeley, R., Neilly, M., Dargie, J. and Crawford-Avis, O.T. (2016). Descriptions of Scottish Priority Marine Features (PMFs). Scottish Natural Heritage Commissioned Report No. 40.

Van Neer, A., Gross, S., Kesselring, T., Wohlsein, P., Leitzen, E., and Siebert, U. (2016). Behavioural and pathological insights into a case of active cannibalism by a grey seal (*Halichoerus grypus*) on Helgoland, Germany. *Journal of Sea Research*, 148-149: 12-16

Van Walraven, L., Driessen, F., van Bleijswijk, J., Bol, A., Luttikhuizen, P.C., Coolen, J.W.P., Bos, O.G., Gittenberger, A., Dchrieken, N., Langenberg and van der Veer, H.W. (2016). Where are the polyps? Molecular identification, distribution and population differentiation of *Aurelia Aurita* jellyfish polyps in the southern North Sea area. *Marine Biology*, 163, 172.

Vanderlaan, A.S. and Taggart, C.T. (2007). Vessel collisions with whales: the probability of lethal injury based on vessel speed. *Marine mammal science*, *23*(1), 144-156.

Verboom, W. (2014). Preliminary information on dredging and harbour porpoises. JunoBioacoustics.

Verfuss, U.K., Sinclair, R.R., and Sparling, C.E. (2019). A review of noise abatement systems for offshore wind farm construction noise, and the potential for their application in Scottish waters. Scottish Natural Heritage Research Report No. 1070.

Vodopivec, M., Peliz, A.J. and Malej, A. (2017). Offshore marine constructions as propagators of moon jellyfish dispersal. Environ. Res. Lett., 12, 084003.

Von Benda-Beckmann, A. M., G. Aarts, H. Ö. Sertlek, K. Lucke, W. C. Verboom, R. A. Kastelein, D. R. Ketten, R. van Bemmelen, F.-P. A. Lam, and R. J. Kirkwood. (2015). Assessing the impact of underwater clearance of unexploded ordnance on harbour porpoises (*Phocoena phocoena*) in the southern North Sea. *Aquatic Mammals* 41, 503.

Webb, A., Irwin, C. and Humphries, G. (2018). Distribution and abundance of basking sharks (*Cetorhinus maximus*) and minke whales (*Balaenoptera acutorostrata*) within the Sea of the Hebrides MPA proposal – a pilot digital aerial survey. Scottish Natural Heritage Research Report No. 974

Weir, C., Hodgins, N., Dolman, S. and Walters, A. (2019). Risso's dolphins (*Grampus griseus*) in a proposed Marine Protected Area off east Lewis (Scotland, UK), 2010– 2017. *Journal of the Marine Biological Association of the United Kingdom*.(3), 703 – 714.

Whyte, K. F., D. J. F. Russell, C. E. Sparling, B. Binnerts, and G. D. Hastie. (2020). Estimating the effects of pile driving sounds on seals: Pitfalls and possibilities. J Acoust Soc Am 147, 3948.

Willis, M.R., Broudic, M., Bhurosah, M. and Masters, I. (2010). Noise Associated with Small Scale Drilling Operations. *3rd International Conference on Ocean Energy.6 Oct 2021 Bilbao*, *Spain*, 1-5.

Wisniewska, D. M., M. Johnson, J. Teilmann, U. Siebert, A. Galatius, R. Dietz, and P. T. Madsen. (2018). High rates of vessel noise disrupt foraging in wild harbour porpoises (*Phocoena phocoena*). *Proceedings of the Royal Society B: Biological Sciences* 285:20172314.

Wisniewska, D. M., M. Johnson, J. Teilmann, U. Siebert, A. Galatius, R. Dietz, and P. T. Madsen. (2018). High rates of vessel noise disrupt foraging in wild harbour porpoises (*Phocoena phocoena*). *Proceedings of the Royal Society B: Biological Sciences* 285,20172314.

Witt, M.J., T. Hardy, L. Johnson, C. M. McClellan, S.K. Pikesley, S. Ranger, P.B. Richardson, J-L, Solandt, C. Speedie, R. Williams and B.J. Godley. (2012) Basking sharks in the northeast Atlantic: spatio-temporal trends from sightings in UK waters. *Marine Ecology Progress Series. 459, 121-134.*

Xoubanova, S. and Lawrence, Z. (2022). Review of fish and fisheries research to inform ScotMER evidence gaps and future strategic research in the UK. Scottish Government.

Waggitt, J.J., Evans, P.G. H., Andrade, J., Banks, A.N., Boisseau, O., Bolton, M., Bradbury, G., *et al*. (2019). Distribution maps of cetacean and seabird populations in the North-East Atlantic. *Journal of Applied Ecology*, 57, 253– 269.

12.14 Abbreviations

ABBREVIATIONS	DEFINITION
AC	Alternating Current
ADD	Acoustic Deterrent Device
ASCOBANS	Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas
BEIS	Department for Business, Energy and Industrial Strategy
CaP	Cable Plan
CBRA	Cable Burial Risk Assessment
CCS	Carbon Capture and Storage
CES	Crown Estate Scotland
CGNS	Celtic and Greater North Seas
CI	Confidence Interval
CIEEM	Chartered Institute of Ecology and Environmental Management
CSIP	Cetacean Strandings Investigation Programme
DAS	Digital Aerial Survey
DC	Direct Current
DDV	Drop Down Video
DEFRA	Department for Environment, Food and Rural Affairs
DEPONS	Disturbance Effects on the Harbour Porpoise Population in the North Sea

ABBREVIATIONS	DEFINITION
DPO	Draft Plan Option
ECC	Export Cable Corridor
EDR	Effective Deterrent Range
EEA	European Economic Area
EEC	European Economic Community
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EMF	Electromagnetic Field
EMP	Environmental Management Plan
EPS	European Protected Species
EU	European Union
FAB	French-Alberney-Britain
FID	Financial Investment Decision
FTRAG	Forth and Tay Regional Advisory Group
GEN	General Policy
HDD	Horizontal Directional Drilling
HF	High Frequency
HIE	Highlands and Islands Enterprise

ABBREVIATIONS	DEFINITION
HRA	Habitats Regulations Appraisal
HRGS	High Resolution Geophysical Surveys
HVAC	High Voltage Alternating Current
IAMMWG	Inter-Agency Marine Mammal Working Group
ICES	International Council for the Exploration of the Sea
INLA	Integrated Nested Laplace Approximation
INNS	Invasive Non-Native Species
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
km	kilometre
km^2	square kilometre
LF	Low Frequency
LSE	Likely Significant Effects
m	metre
m^2	square metre
nm	nautical mile
MARPOL	The International Convention for the Prevention of Pollution from Ships
MBES	Multibeam echosounder
MD-LOT	Marine Directorate - Licensing and Operations Team

ABBREVIATIONS	DEFINITION
MFRAG	Moray Firth Regional Advisory Group
MHWS	Mean High-Water Springs
MLWS	Mean Low-Water Springs
mm	Millimetre
MMO	Marine Mammal Observers
MMMP	Marine Mammal Mitigation Protocol
MPA	Marine Protected Area
MPCP	Marine Pollution Contingency Plan
MS-LOT	Marine Scotland - Licensing and Operations Team
MSFD	Marine Strategy Framework Directive
MSS	Marine Scotland Science
MU	Management Unit
MW	Megawatt
NCMPA	Nature Conservation Marine Protected Area
NMFS	National Marine Fisheries Service
O&G	Oil and Gas
OAA	Option Agreement Area
OIC	Orkney Islands Council
OMMRI	Orkney Marine Mammal Research Initiative

ABBREVIATIONS	DEFINITION
OSP	Offshore Substation Platform
OWPL	Offshore Wind Power Limited
PAM	Passive Acoustic Monitoring
PCW	Phocid Carnivores in Water
PDE	Project Design Envelope
PEIR	Preliminary Environmental Information Report
PEMP	Project Environmental Monitoring Programme
PMF	Priority Marine Feature
PS	Piling Strategy
PTS	Permanent Threshold Shift
RIAA	Report to Inform Appropriate Assessment
RMS	Root Mean Square
RMU	Regional Management Unit
SAC	Special Area of Conservation
SCANS	Small Cetaceans in the European Atlantic and North Sea
ScotMER	Scottish Marine Energy Research
SCOS	Special Committee on Seals
SEL	Sound Exposure Level
SEL_{CUM}	Cumulative Sound Exposure Level

ABBREVIATIONS	DEFINITION
SHET-L	Scottish Hydro Electric Transmission Limited
SL	Source Level
SMA	Seal Management Area
SMRU C	Sea Mammal Research Unit Consulting
SMU	Seal Management Unit
SMWWC	Scottish Marine Wildlife Watching Code
SNCB	Statutory Nature Conservation Body
SOPEP	Shipboard Oil Pollution Emergency Plan
SPL	Sound Pressure Level
SSC	Suspended Sediment Content
SSS	Side Scan Sonar
SSSI	Site of Special Scientific Interest
THC	The Highland Council
TTS	Temporary Threshold Shift
UK	United Kingdom
UK BAP	United Kingdom Biodiversity Action Plan
UKCS	United Kingdom Continental Shelf
USB	Universal Serial Bus
USBL	Ultra-short baseline

ABBREVIATIONS	DEFINITION
UXO	Unexploded Ordnance
VHF	Very High Frequency
VMP	Vessel Management Plan
WTG	Wind Turbine Generator
ZoI	Zone of Influence

12.15 Glossary

TERM	DEFINITION
95% confidence interval (CI)	A measure of uncertainty in the mean value. If the analysis was repeated, 95% of the time the mean population estimate would fall within this range. The smaller the CI range the more confident we can be that the mean estimate is an accurate reflection of the true population size.
Absolute abundance	The most accurate estimate of population size. In the case of diving mammals, this includes an estimate for the number that are believed to be submerged at the time of survey.
Barrier effect	Barrier effects occur where the presence of the offshore Project prevents access to other areas.
Cephalopod	An animal of the class Cephalopoda, which includes squid, octopus, cuttlefish and nautilus.
Cetacean	An animal from the order Cetacea which includes the aquatic mammals whales, dolphins and porpoises.
Clupeid	Fish of the Clupeidae family (e.g. herring and sprat).
Crustacean	Large, mainly aquatic arthropods (e.g. crabs and lobster).
CV	The *coefficient of variation* is a standard measure that describes the dispersion of data points around the mean. The lower the CV the more precise the estimate. It is calculated as the SD / mean.
Decibel (*dB*)	A unit of measurement used to describe the intensity or loudness of sound. A difference of 10 dB corresponds to a factor of 10 in sound power.
Demersal finfish	Fish that live on or near the seabed.
Density estimate (*animals/km*^{2})	The average number of animals per square km surveyed over the whole area.
Displacement	The loss of access to, or use of, an area.
eDNA	DNA that accumulates in the environment (e.g. through excretions or secretions), rather than through direct sampling of an organism.
Foundation	The foundation on which the WTGs or OSPs are installed.

TERM	DEFINITION
Gadoid	Fish from the Gadiformes order (e.g. cod, haddock and whiting).
Landfall	The location where the export cables will be brought ashore. The interface between the offshore and onshore environment.
Offshore Export Cable Corridor (ECC)	The area within which the offshore export cables will be installed.
Offshore export cables	A high voltage alternating current (HVAC) subsea power cable system, consisting of a three-core armoured submarine power cable with one (or more) fibre optic units embedded in the interstice, running from the OSPs to the transition joint bay (up to the point of MHWS). The offshore export cables transmit the electricity generated from the Offshore Windfarm to the onshore export cables for transmission onwards to the onshore substation.
Offshore Project	The entire offshore Project, which defines the Red Line Boundary for the Section 36 consent and the Marine Licence applications, including all offshore components seaward of mean high-water springs (MHWS) (Wind Turbine Generators (WTGs), cables, foundations, offshore substation platforms (OSPs) and all other associated infrastructure), and all Project stages from pre-construction to decommissioning, including temporary works. The offshore Project is the focus of this Offshore EIA Report.
Offshore substation platform (OSP)	Offshore platforms consisting of HVAC substations.
Offshore Wind Power Limited (OWPL)	The developer of the Project and the Applicant for the associated consents and licences.
Onshore Project	The entire onshore Project, which defines the Red Line Boundary for the planning application, including all onshore components landward of mean low water springs (MLWS) (underground cables, substation, access, and all other associated infrastructure) and all Project stages from pre-construction to decommissioning.
Option agreement area (OAA)	The OAA covers the array area in which the generation infrastructure including WTGs, OSPs and interconnector cables will be located. The OAA is the area of seabed that OWPL have been awarded through the ScotWind leasing process, over which CES will grant a lease in the event that the developer succeeds in obtaining all the necessary consents and the Project achieves Final Investment Decision (FID).
Pelagic finfish	Fish that live in the water column.
Permanent Threshold Shift (PTS)	The threshold above which a permanent shift in hearing sensitivty occurs caused by acoustic trauma, which is assumed to be irreversible.

TERM	DEFINITION
Piling Strategy	An embedded mitigation measure that will outline the strategy and guidelines for the installation of piles during the construction stage, including outlining any noise mitigation measures which will be implemented during piling activities (e.g. soft-start and ramp-up procedures and other measures under JNCC (2010a)) to reduce potential underwater noise effects during construction and pre-construction.
Pinniped	An animal from the clade Pinnipedia, which includes seals, sea lions and walrus.
Population estimate (*number*)	The mean number of animals estimated within the survey area.
Project Design Envelope	Project Parameters that are assessed as part of the EIA for a Project.
Relative abundance	In the case of diving mammals, this is the estimated population size based on animals recorded on or above the sea surface and does not account for any that may be diving and thus submerged at the time of survey.
Sound Exposure Level (*SEL*)	A measure of sound which takes into account the received level of sound and the duration of exposure.
Sound Exposure Level, cumulative (SEL_{cum})	A metric for the cumulative sound energy an animal is exposed to over a standard time period or multiple instances of a noise source.
Sound Exposure Level, single strike (SEL_{ss})	Calculation of the sound exposure level representative of a single noise impulse, typically a pile strike.
Sound Pressure Level (*SPL*)	The sound pressure level is an expression of sound pressure using the decibel (dB) scale; the standard frequency pressures of which are 1 µPa for water and 20 µPa for air.
Sound Pressure Level Peak (SPL_{peak})	The highest (zero-peak) positive or negative sound pressure, in decibels.
Standard deviation (SD) of population estimate	The amount of variation or dispersion of a set of values. A low SD indicates that the bootstrap values tend to be close to the mean of the set.
Swim bladder	Gas filled sac present in teleost fish.
Temporary Threshold Shift (TTS)	A temporary change in hearing sensitivity which is assumed to be reversible. Exposure to high levels of sound over relatively short time periods could cause the same level of TTS as exposure to lower levels of sound over longer time periods.
Unweighted sound level	Sound levels which have not been adjusted, for example to account for the hearing ability of a species.

TERM	DEFINITION
Weighted sound level	A sound level which has been adjusted to account for the hearing ability of a particular species, such as filters used by Southall *et al.* (2019) for marine mammals.
West of Orkney Windfarm / 'the Project'	The entire offshore and onshore Projects, including all offshore components and onshore components and all Project stages from pre-construction to decommissioning. For the avoidance of doubt this does not include the offshore or onshore infrastructure associated with the connection to the Flotta Hydrogen Hub.
Wind turbine generator (WTG)	The wind turbines that generate electricity consisting of tubular towers and blades attached to a nacelle housing mechanical and electrical generating equipment.
Zooplankton	The animal component of the planktonic community Plankton.