Pentland floating offshore wind farm

Volume 2: Offshore EIAR

Chapter 11: Marine Mammals and Other Megafauna

PENTLAND FLOATING OFFSHORE WIND FARM

OFFSHORE EIAR (VOLUME 2): MAIN REPORT

CHAPTER 11: MARINE MAMMALS AND OTHER MEGAFAUNA

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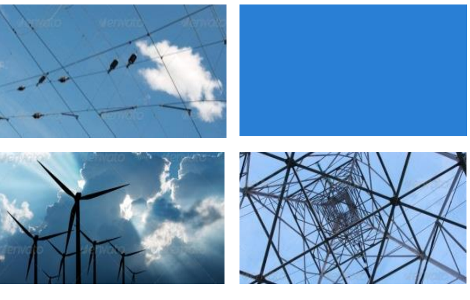

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GLOSSARY OF PROJECT TERMS

Key Terms	Definition
Dounreay Trì Floating Wind Demonstration Project (the 'Dounreay Trì Project')	The 2017 consented project that was previously owned by Dounreay Trì Limited (in administration) and acquired by Highland Wind Limited (HWL) in 2020. The Dounreay Trì Project consent was for two demonstrator floating Wind Turbine Generators (WTGs) with a marine licence that overlaps with the Offshore Development, as defined. The offshore components of the Dounreay Trì Project consent are no longer being implemented.
Highland Wind Limited	The Developer of the Project (defined below) and the Applicant for the associated consents and licences.
Landfall	The point where the Offshore Export Cable(s) from the PFOWF Array Area, as defined, will be brought ashore.
Offshore Export Cable(s)	The cable(s) that transmits electricity produced by the WTGs to landfall.
Offshore Export Cable Corridor (OECC)	The area within which the Offshore Export Cable(s) will be located.
Offshore Site	The area encompassing the PFOWF Array Area and OECC, as defined.
Onshore Site	The area encompassing the PFOWF Onshore Transmission Infrastructure, as defined.
Pentland Floating Offshore Wind Farm (PFOWF) Array and Offshore Export Cable(s) (the 'Offshore Development')	All offshore components of the Project (WTGs, inter-array and Offshore Export Cable(s), floating substructures, and all other associated offshore infrastructure) required during operation of the Project, for which HWL are seeking consent. The Offshore Development is the focus of this Environmental Impact Assessment Report.
PFOWF Array	All WTGs, inter-array cables, mooring lines, floating sub-structures and supporting subsea infrastructure within the PFOWF Array Area, as defined, excluding the Offshore Export Cable(s).
PFOWF Array Area	The area where the WTGs will be located within the Offshore Site, as defined.
PFOWF Onshore Transmission Infrastructure (the 'Onshore Development')	All onshore components of the Project, including horizontal directional drilling, onshore cables (i.e. those above mean low water springs), transition joint bay, cable joint bays, substation, construction compound, and access (and all other associated infrastructure) across all project phases from development to decommissioning, for which HWL are seeking consent from The Highland Council.
PFOWF Project (the 'Project')	The combined Offshore Development and Onshore Development, as defined.

ACRONYMS AND ABBREVIATIONS

BND	Bottlenose dolphin
CaP	Cable Plan
CBRA	Cable Burial Risk Assessment
CCS	Carbon Capture and Storage
CEMP	Construction Environmental Management Plan
CES MU	Coastal East Scotland Management Unit
CGNS MU	Celtic and Greater North Sea Management Unit
CI	Confidence Interval
CWSH MU	Coastal West Scotland and the Hebrides Management Unit
EDR	Effective Deterrent Range
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EMEC	European Marine Energy Centre
EMF	Electromagnetic Fields
EPS	European Protected Species
EU	European Union
GNS MU	Greater North Sea Management Unit
HDD	Horizontal Directional Drilling
HIE	Highlands and Islands Enterprise
HVAC	High Voltage Alternating Current
IAMMWG	Inter-Agency Marine Mammal Working Group
INNS	Invasive Non-native Species
iPCoD	Interim Population Consequences of Disturbance
IUCN	International Union for Conservation of Nature
JCP	Joint Cetacean Protocol
JNCC	Joint Nature Conservation Committee
kg	kilogram
km	kilometre
km^2	square kilometre
m	metre
m^2	square metres
MBES	Multibeam Echo Sounder
MHWS	Mean High Water Springs
mm	millimetre
MMMP	Marine Mammal Management Plan
MPA	Marine Protected Area

MRE	Marine Renewable Energy
MS-LOT	Marine Scotland Licensing and Operations Team
MSS	Marine Scotland Science
MU	Management Unit
MW	Megawatts
NCO	North Coast and Orkney
NCMPA	Nature Conservation Marine Protected Area
NM	Nautical Miles
NS MU	North Sea Management Unit
Offshore EIAR	Offshore Environmental Impact Assessment Report
OW	Oceanic Waters
PDE	Project Design Envelope
PEIR	Preliminary Environmental Information Report
PEMP	Project Environmental Monitoring Plan
PFOWF	Pentland Floating Offshore Wind Farm
PMF	Priority Marine Features
PO	Plan Option
PTS	Permanent Threshold Shift
SCANS	Small Cetacean Abundance in the North Sea
SCOS	Special Committee on Seals
SEL	Sound Exposure Level
SMA	Seal Management Areas
SMU	Seal Management Units
SMWWC	Scottish Marine Wildlife Watching Code
SPL	Sound Pressure Level
SSS	Side Scan Sonar
SSSI	Sites of Special Scientific Interest
THC	The Highland Council
TTS	Temporary Threshold Shift
UK	United Kingdom
UKCS	United Kingdom Continental Shelf
USBL	Ultra-short Baseline
UXO	Unexploded Ordnance
VMP	Vessel Management Plan
WTG	Wind Turbine Generator

11 MARINE MAMMALS AND OTHER MEGAFAUNA

11.1 Introduction

The potential effects of the Pentland Firth Offshore Wind Farm (PFOWF) Array and Offshore Export Cable(s), hereafter referred to as the 'Offshore Development', during construction, operation and maintenance, and decommissioning are assessed in this chapter on two types of marine megafauna which are regularly encountered off the North Coast of Scotland: marine mammals and basking sharks (*Cetorhinus maximus)*.

Sea turtles are another taxon of marine megafauna which may be encountered off the coast of Scotland; however, they are considered very rare visitors to the Pentland Firth, based on confirmed and unconfirmed sightings records and accounts (www.NBNAtlas.org). Of the five species of sea turtle which have been recorded in the United Kingdom (UK), the leatherback turtle (*Dermochelys coriacea*) is the only species considered a regular constituent of the UK marine fauna. Records of this species are concentrated in the south and west coasts of England, Ireland and Wales, with limited sightings in Scotland along the west coast and in the Northern Isles (BEIS, 2022). As their occurrence is very rare within the Offshore Site, sea turtles have not been considered further within this assessment of impacts upon marine megafauna.

This chapter also includes an assessment of the potential cumulative impacts with other relevant projects.

The following specialists have contributed to this assessment:

- Subacoustech Environmental Ltd (Subacoustech): Underwater noise propagation modelling;
- SMRU Consulting Ltd (SMRU Consulting): Underwater noise impact assessment; and
- Xodus Group Ltd: Drafting this Environmental Impact Assessment Report (EIAR) chapter.

Further details of the Project Team's competency, including lead authors for each chapter, are provided in Volume 3: Appendix 1.1: Details of the Project Team of this Offshore Environmental Impact Assessment Report (Offshore EIAR).

Table 11.1 below provides a list of all the supporting studies which relate to the Marine Mammal and Other Megafauna impact assessment. All supporting studies are appended to this Offshore EIAR.

Table 11.1 Supporting Studies

Details of study	Location of Supporting Studies
Pentland Floating Offshore Wind Farm (PFOWF): Underwater noise modelling – Subacoustech Environmental Report No. P296R0108	Offshore EIAR (Volume 3): Technical Appendix 10.1
Pentland Floating Offshore Wind Farm (PFOWF): Underwater Noise Impact Assessment - SMRU Consulting Report No. SMRUC-XOD-2022-002	Offshore EIAR (Volume 3): Technical Appendix 11.1
Environmental Baseline Report – MMT Pentland Floating Offshore Wind Farm, Geophysical & Environmental Survey 2021- 103760-HWL-MMT-SUR-REP-ENVEBSRE.	Offshore EIAR (Volume 3): Technical Appendix 9.1

Effects on marine mammal and basking shark receptors are further assessed where identified as a qualifying interest of Special Areas of Conservation (SACs), screened into the Report to Inform the Appropriate Assessment (RIAA). The RIAA is submitted alongside this EIAR as part of the overall application.

11.2 Legislation, Policy, and Guidance

In addition to those described in Chapter 3: Policy and Legislative Context of this EIAR, the following relevant legislation and guidance relating to marine mammals and basking sharks has been considered in the preparation of this Chapter.

11.2.1 Legislation

Marine mammals are afforded varying levels of protection under international and national legislation. Within UK waters, cetaceans (whales, dolphins, and porpoises) are protected through the following:

- European Protected Species (EPS) listing under Annex IV of the European Union (EU) Habitats Directive;
- Schedule 5 of the Wildlife and Countryside Act 1981;
- Marine Strategy Framework Directive (MSFD) Descriptor 11: Energy including Underwater Noise;
- Marine (Scotland) Act 2010;
- Convention on the Conservation of Migratory Species of Wild Animals;
- OSPAR Commission;
- The Conservation (Natural Habitats, &C.) Regulations 1994 (as amended) for Scottish territorial waters; and
- The Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended) in UK Offshore Waters.

Bottlenose dolphin (*Tursiops truncatus*) and harbour porpoise (*Phocoena phocoena*), gain additional protections through Annex II of the Habitats Directive, which includes provisions for their consideration in designating SACs.

These pieces of legislation make it an offence to deliberately or recklessly injure or disturb these species within Scottish inshore and offshore waters; however, the definition of disturbance legally varies between these two jurisdictions. Table 11.2 provides the definitions of disturbance for both inshore and offshore waters relevant to the Offshore Development.

Table 11.2 Definitions of disturbance offences against EPS in Scottish Territorial Waters and Scottish Offshore Waters

Definition	Area of Consideration	
	Scottish Territorial Waters	**Scottish Offshore Waters**
Legal Jurisdiction	Up to and inclusive of 22 kilometres (km) (12 nautical miles [NM])	Beyond 22.2 km (12 NM)
Relevant Legislation	The Conservation (Natural Habitats, &c.) Regulations 1994 (as amended)	Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended)
Definition of Relevant Offences	Regulation 39: *(1) It is an offence–* *(a) deliberately or recklessly to capture, injure or kill a wild animal of a European protected species;* *(b) deliberately or recklessly–* *(i) to harass a wild animal or group of wild animals of a European protected species;* *(ii) to disturb such an animal while it is occupying a structure or place*	Regulation 45: *(1) Subject to regulations 46 and 55, a person who—* *(a) deliberately captures, injures, or kills any wild animal of a European protected species,* *(b) deliberately disturbs wild animals of any such species,* *(c) deliberately takes or destroys the eggs of such an animal, or* *(d) damages or destroys, or does anything to cause the deterioration of, a breeding site or resting place of such an animal,* *is guilty of an offence.*

Definition	Area of Consideration	
	Scottish Territorial Waters	Scottish Offshore Waters
	which it uses for shelter or protection; *(iii) to disturb such an animal while it is rearing or otherwise caring for its young;*	
	(iv) to obstruct access to a breeding site or resting place of such an animal, or otherwise to deny the animal use of the breeding site or resting place; *(v) to disturb such an animal in a manner that is, or in circumstances which are, likely to significantly affect the local distribution or abundance of the species to which it belongs; or* *(vi) to disturb such an animal in a manner that is, or in circumstances which are, likely to impair its ability to survive, breed or reproduce, or rear or otherwise care for its young;* *(c) deliberately or recklessly to take or destroy the eggs of such an animal; or* *(d) to damage or destroy a breeding site or resting place of such an animal.* *(2) Subject to the provisions of this Part, it is an offence to deliberately or recklessly disturb any dolphin, porpoise or whale (cetacean).*	*(2) For the purposes of paragraph (1)(b), disturbance of animals includes in particular any disturbance which is likely—* *(a) to impair their ability—* *(i) to survive, to breed or reproduce, or to rear or nurture their young; or* *(ii) in the case of animals of a hibernating or migratory species, to hibernate or migrate; or* *(b) to affect significantly the local distribution or abundance of the species to which they belong.*

Whilst pinnipeds are not EPS, grey seal (*Halichoerus grypus*) and harbour seal (*Phoca vitulina*) are protected through the following legislation:

- Annex V of the Habitats Directive, which defines them as species of community interest, meaning that any taking of these species in the wild is subject to management measures;
- Annex II of the Habitats Directive, which includes provisions for their consideration in designating SACs; and
- Through the designation of seal haul-outs, which are coastal locations that seals use to breed, pup, moult and rest which are designated under the *Protection of Seals (Designation of Haul-Out Sites) (Scotland) Order 2014 (as amended)*. All haul-outs in Scotland are protected from adverse anthropogenic impacts under *Section 117 of the Marine (Scotland) Act 2010*.

Additionally, all marine mammal species (both pinnipeds and cetaceans) which regularly occur within Scottish waters are designated as Priority Marine Features (PMFs) (Tyler-Walters *et al.,* 2016). PMFs are habitats and species that are considered to be marine nature conservation priorities in Scottish waters (NatureScot, 2020a).

Basking sharks are similarly protected by legislation which makes it illegal to intentionally kill, injure, or harass any individuals of this species:

- Schedule 5 of the Wildlife and Countryside Act (1981); and
- The Nature Conservation (Scotland) Act 2004.

Additionally, listing as a UK Biodiversity Action Plan (UK BAP) species has highlighted to regulators the urgent need for management intervention for basking sharks in UK waters.

11.2.2 Policy and Guidance

To support the legal protections for marine mammals and basking sharks, the UK and Scottish Governments, their Statutory Nature Conservation Bodies (SNCBs), and relevant conservation charities have published a suite of policy and guidance for marine users; they include:

- The UK Post-2010 Biodiversity Framework and the Scottish Biodiversity Strategy, including the 2020 Challenge for Scotland's Biodiversity;
- The European Commission's Guidance document on wind energy developments and EU nature legislation (European Commission, 2021);
- Scotland's National Marine Plan: A Single Framework for Managing our Seas, including the following Policies which are relevant to marine mammal and basking shark receptors:
  - 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 Priority Marine Features;
    - (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;
  - GEN 21 Cumulative impacts: Cumulative impacts affecting the ecosystem of the marine plan area should be addressed in decision making and plan implementation;
- 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.).

The above list has been taken into account within the assessment of environmental impacts provided below and in the development of effective mitigation and management measures for the proposed activities.

Additionally, this impact assessment has been guided by the assessment methodology provided in the *Guidelines for ecological impact assessment in the UK and Ireland: terrestrial, freshwater and coastal* (CIEEM, 2016). These methods have been adapted for the assessment of impacts against marine mammal and basking shark receptors and are detailed in Section 11.5.3.

11.3 Scoping and Consultation

Scoping and consultation have been ongoing throughout the Environmental Impact Assessment (EIA) process and have played an important part in ensuring the scope of the baseline characterisation and impact assessment are appropriate with respect to the Offshore Development given the requirements of the regulators and their advisors.

Relevant comments from the EIA Scoping Opinion, the Scoping Opinion Addendum, and other consultation specific to marine mammals and basking sharks, provided by Marine Scotland Licensing Operations Team (MS-LOT), Marine Scotland Science (MSS), NatureScot, and The Highland Council (THC), are summarised in Table 11.3, which provides a high-level response on how these comments have been addressed within this Offshore EIAR.

Table 11.3 Summary of consultation responses specific to marine mammals

Consultee	Comment / Issue Raised	Offshore Development Approach and Section ID
Scoping Opinion		
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. potential UXO clearance and some geophysical surveys.* *Impacts will require consideration under EPS licensing and potentially in combination with other noisy activities depending on the noise outputs, timings and duration. These should be considered in the EIAR rather than solely post-consent.*	All relevant activities will undergo the relevant consideration under EPS and EIA Guidance and Regulations. Based on an initial desk-based UXO assessment (Ordtek, 2021), it is assumed that it will be possible to avoid any UXO identified during the survey and should further mitigation be required, such as clearance or detonation, this would be subject to separate assessment and applications. However, to provide a comprehensive assessment of potential worst case impacts associated with Offshore Development activities, an initial assessment of noise-related impacts from UXO clearance and survey work has been undertaken in the construction phase impact assessment (see Section 11.6.1).
NatureScot	***Disturbance due to physical presence of vessels*** *It is very difficult to separate disturbance caused by vessel presence from vessel noise. We know that vessel construction activity can show considerable disturbance to harbour porpoise (e.g. during offshore wind farm construction it has been shown to cause disturbance prior to ADDs being used). We are content that 'physical presence' is scoped out providing disturbance from vessel activity is fully considered within the underwater noise assessment.*	Disturbance from vessel noise has been assessed in lieu of impacts associated with vessel presence, which have been scoped out from assessment. The outcomes of the assessment of vessel-related noise impacts to marine mammals are presented within the underwater noise impact assessment provided in Section 11.6.1.1.
NatureScot	***Approach to underwater noise modelling*** *The methodology and metrics for underwater noise modelling and assessment of cumulative effects should be discussed and agreed with Marine Scotland and NatureScot. To assist this process we provide initial advice as outlined below.*	The advice provided has been incorporated into the noise modelling methods utilised by Subacoustech Environmental Ltd. in Offshore EIAR (Volume 3): Technical Appendix 10.1 Underwater Noise Modelling Report in support of this impact assessment. The Underwater Noise Impact Assessment Report provided in Offshore EIAR (Volume 3): Technical Appendix 11.1 details the methodologies employed. The initial advice on marine mammal densities, population consequences and cumulative impacts, and mitigation and monitoring, along with responses to this advice, are covered in the rows below.

Consultee	Comment / Issue Raised	Offshore Development Approach and Section ID
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 (Russell et al., 2017)*	Marine mammal densities have been considered in the baseline using the Carter *et al.* (2020) seal density data and updated Small Cetacean Abundance in the North Sea (SCANS)-III survey data (Hammond *et al.,* 2021). Where absolute density data were unavailable, relative density has been taken from Waggitt *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)*	The application of the Interim Population Consequences of Disturbance (iPCoD) approach to the assessment of underwater noise impacts from Offshore Development activities and cumulatively with other projects has been undertaken by SMRU Consulting in support of this impact assessment. Details on the population consequences modelling are provided in Offshore EIAR (Volume 3): Technical Appendix 11.1 and summarised in Sections 11.6.1.1 and 11.6.2.1.
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.*	The Scoping Report Addendum included details on proposed population modelling for the impact assessment of underwater noise, including the use of iPCoD modelling. This report has been reviewed by NatureScot, with no specific comments provided on the proposed methodologies.
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 EIAR.*	The proposed embedded mitigation methods cover all published guidance relevant to minimising the risk of injury to marine mammals and minimising disturbance to marine megafauna. The applied guidance is listed in Section 11.2 and details of its application to the Offshore Development's activities are provided in Sections 11.5.5 and 11.10.
NatureScot	***Key Species*** *Key species to be addressed for this proposal are harbour porpoise, bottlenose dolphin, white beaked dolphin, minke whale, Risso's dolphin, harbour seal and grey seal. Advice is provided in Appendix B on the expected assessment methods required for HRA, EIA and European Protected Species (EPS) licensing.*	Noted. These species have been identified within the baseline and have been considered within the assessment as, presented in Section 11.4.4. Advice in Appendix B has been considered throughout this assessment.

Consultee	Comment / Issue Raised	Offshore Development Approach and Section ID
NatureScot	***Baseline / Key species*** *We are aware that the IAMMWG (2015) MU abundance estimates are currently being updated by JNCC. However, please note the MU boundaries are not currently being revised. Abundance estimates have been updated recently for some cetacean MUs in Scottish waters, a summary can be found in Table 3 of the recently published Regional Baselines Report. For baseline surveys w advise further discussion is required regarding correction factors for availability bias and data analysis.*	Noted. Section 11.4.2 identifies all the key data sources used within this assessment including the 'Updated abundance estimates for cetacean MUs in UK waters. JNCC Report No. 680, JNCC Peterborough, ISSN 0963-8091 (IAMMWG, 2021)'. HiDef, who undertook the site-specific digital aerial surveys, has used availability correction factors which reflect the best currently available. Correction factors are detailed within the baseline sections and have been determined using published data on population parameters.
MS-LOT on behalf of Scottish Ministers	***Definition of Project Area*** *With regards to the proposed study area, the Scottish Ministers assume that the Developer intended to refer to the study area as the Offshore Study Area rather than "the Marine Licence area…" and that this was done in error.*	Noted, this was in error. The Offshore Study Area is defined in detail in Section 11.4.1.
MS-LOT on behalf of Scottish Ministers	***Marine mammal baseline data*** *With regards to the baseline information, the Scottish Ministers are broadly content with the key resources identified however, highlight the additional reports and updated references recommended by NatureScot and MSS. These reports must be included in the review of the baseline data and fully considered in the EIA Report. The Scottish Ministers recommend further discussion with NatureScot and MSS regarding correction factors for availability bias and data analysis for baseline studies.*	HiDef, who undertook the site-specific digital aerial surveys, has used availability correction factors which reflect the best currently available. Correction factors are detailed within the baseline sections and have been determined using published data on population parameters.
MS-LOT on behalf of Scottish Ministers	***Long-term habitat change*** *Within Table 8-7, the Developer summarises the potential impacts on marine mammals and basking sharks during the different phases of the Offshore Proposed Development. The Scottish Ministers broadly agree with the impacts to be scoped in to the EIA Report however, advise the additional impacts*	This advice has been incorporated into the impact assessment for marine mammal and basking shark receptors through the inclusion of the identified impact pathways within the named relevant Offshore Development phases.

Consultee	Comment / Issue Raised	Offshore Development Approach and Section ID
	identified in the MSS and NatureScot advice regarding pre-construction noise impacts, entanglement risk, long-term habitat change, alternative methods for installing the anchors and disturbance from vessel activity must be fully considered and assessed in the EIA Report. In addition, cumulative impacts from construction and decommissioning noise must also be scoped in to the EIA Report.	
MS-LOT on behalf of Scottish Ministers	***Long-term habitat change and survey data*** *Within Table 8-8, the Developer summarises the principle methods of assessment to be employed within the EIA Report. MSS in its advice highlight that it is unclear how the initial twelve months of aerial surveys will address the potential for long-term changes to habitat. The Scottish Ministers highlight MSS's recommendation that the Developer refers to the surveys mentioned in the benthic, fish and shellfish and commercial fisheries sections which constitute a more appropriate methodology to evidence this impact pathway. For the avoidance of doubt, long-term habitat change should be scoped in for the operation phase and decommissioning phase, as supported by the MSS representation.*	Long term habitat change has been assessed for both the operational and decommissioning phases (Sections 11.6.2.5 and 11.6.3.1). Baselines and assessments within the benthic and fish ecology chapters (Chapters 9 and 10, respectfully) has been used to inform the assessment of impacts on marine mammals from long term habitat change.
MS-LOT on behalf of Scottish Ministers	***Pre-construction noise impacts*** *The Scottish Ministers advise that the EIA Report must assess all phases of the Offshore Proposed Development from pre-construction to decommissioning, to allow assessment of the Offshore Proposed Development as a whole. Pre-construction activities which can emit significant underwater noise, such as potential unexploded ordnance clearance and geophysical surveys must be considered and assessed in the EIA Report. As highlighted by both MSS and NatureScot these impacts will also require to be considered under European Protected Species licensing and potentially in combination with other noisy activities.*	A pre-construction UXO survey using a magnetometer is planned for Summer 2022 or 2023 to identify any UXOs that may need to be avoided by minor re-routeing of the cables or minor modifications of the anchor positions. Other acoustic survey methods may also be required (i.e., multibeam echo sounder and side scan sonar). Based on an initial desk-based UXO assessment (Ordtek, 2021), it is assumed that during construction it will be possible to avoid any UXO identified during the survey and should further mitigation be required, such as clearance or detonation, this would be subject to separate assessment and applications. However, for purposes of providing a comprehensive assessment of potential worst case impacts associated with Offshore Development activities, an initial assessment of noise-related impacts from UXO clearance and survey work has been undertaken in the construction phase impact assessment (see Section 11.6.1).

Consultee	Comment / Issue Raised	Offshore Development Approach and Section ID
MS-LOT on behalf of Scottish Ministers	***Approach to underwater noise modelling*** *With regards to the methodology and approach to underwater noise modelling, population consequences and assessment of cumulative effects the Scottish Ministers advise that these must be discussed and agreed with MSS and NatureScot. The Scottish Ministers direct the Developer to NatureScot's representation in which initial advice has been provided on marine mammal densities and population modelling and highlight the reports, data sources and models referenced.*	The advice from NatureScot regarding relevant marine mammal population parameters and data sources for population models has been taken on board for the population modelling undertaken by SMRU Consulting. The iPCoD model used to estimate the levels of effects from noise-generating activities on a population scale has been consulted on with MSS and NatureScot and is the preferred method for estimating population-level impacts to marine mammals.
MS-LOT on behalf of Scottish Ministers	***Risk of Entanglement*** *The Scottish Ministers highlight MSS advice that taut lines would represent a lower risk of entanglement. The Scottish Ministers agree with MSS that the potential for entanglement in debris caught up on the mooring lines must be included in the EIA Report and that strategies to minimise or remove such debris must also be considered.*	The risk of injury from entanglement has been assessed in Section 11.6.2.2, and mitigation considered to reduce this risk is detailed in Section 11.5.5.
MS-LOT on behalf of Scottish Ministers	***Mitigation and monitoring*** *In relation to mitigation and monitoring, the Scottish Ministers advise that where impact pathways have been identified, the full range of mitigation techniques and published guidance is considered fully and discussed in the EIA Report. NatureScot supports this recommendation.*	The embedded mitigations cover all published guidance relevant to minimising the risk of injury to marine mammals and minimising disturbance to marine megafauna. The applied guidance has been listed in Section 11.2 and details of their application to the proposed Offshore Development activities are provided in Sections 11.5.5 and 11.10.
MSS	***Marine mammal baseline data*** *MSS have reviewed the scoping report in relation to marine mammals. We note the intention to include white-beaked dolphin, harbour porpoise, bottlenose dolphin, minke whale, harbour seals and grey seals in the EIAR, and the intention to include other species, but would appreciate further information on what those species are and how the species to be included will be identified. We recommend that both Paxton et al. (2016),*	In addition to the species listed, Risso's dolphin and common dolphin have been included in the impact assessment due to evidence of their presence from dedicated aerial surveys (HiDef, 2015; 2021). Given that the objective of the Paxton *et al.* (2016) study was to provide modelled relative density estimates of harbour porpoise habitat use across the United Kingdom Continental Shelf, the JNCC recommends that absolute density estimates, such as those provided in the SCANS and adjacent waters survey reports, be preferentially used. This advice has been taken on board for the impact assessments. For cetacean species which do not have absolute density estimates for SCANS-III survey of

Consultee	Comment / Issue Raised	Offshore Development Approach and Section ID
	Waggitt et al. (2020) and Hague et al. (2020) are considered in the review of baseline information.	Block S (i.e., Risso's dolphin and common dolphin) or do not have density estimates representative of certain populations of interest (i.e., coastal bottlenose dolphins), the Paxton *et al.* (2016) data was not utilised, as it predicted a 0 density estimate across the Offshore Site. Rather, alternative methods were used to characterise the occurrence of those species. Relative density data from Waggitt *et al.* (2020) has been used to characterise the expected distribution of common dolphin across the Offshore Site and in surrounding waters, whilst absolute density data from the SCANS-III surveys from the adjacent survey block (Block K) has been used to characterise the distribution of Risso's dolphin.
MSS	***Construction noise impacts*** *We note and welcome the statement in section 5.2.4 that hammer piling will not be used to install the moorings. This will reduce the potential impacts from underwater noise to marine mammals. Some of the suggested alternative methods for installing the moorings (e.g. drilling) in Table 5-4 may also produce relatively high levels of underwater noise, and we would expect to see an assessment of the impact of this in the EIAR.*	As per the Scoping Report Addendum, impact piling is being considered for the Offshore Development, and a detailed assessment of potential impacts from this activity is provided within this impact assessment, as it now forms the realistic worst case scenario activity for underwater noise. Subsequent responses to this change, as received from the Scoping Report Addendum, are provided below within this table.
MSS	***Construction noise impacts*** *In Table 13-1, we consider that cumulative impacts from construction and decommissioning noise should be scoped in. It is unclear why there is a separate row for "construction noise".*	Underwater noise generation from anchor installation, via driven (impact) and drilled piles, has been assessed in detail through underwater noise propagation modelling (see Offshore EIAR [Volume 3]: Technical Appendix 10.1) and quantitative impact assessment (see Offshore EIAR [Volume 3]: Technical Appendix 11.1). The results are summarised within the impact assessment of effects to marine mammals generated by activities associated with the construction phase, as well as cumulatively with other projects' construction activities (see Sections 11.6.1.1 and 11.7.2). In the absence of detailed information regarding decommissioning works, the implications for marine mammals and basking sharks are considered analogous with or likely less than those of the construction phase. Therefore, the worst case parameters defined for the construction phase also apply to decommissioning. A Decommissioning Programme will be developed pre-construction to address the principal decommissioning measures for the Offshore Development, this will be written in accordance with applicable guidance and detail the management,

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		environmental management and schedule for decommissioning. The Decommissioning Programme will be reviewed and updated throughout the lifetime of the Offshore Development to account for changing best practice.
MSS	***Pre-construction noise impacts*** *We also note that the area is considered to be a low risk for presence of unexploded ordnance (UXO). Should it be the case that UXOs are found on the site, a full assessment of the noise likely to be produced in clearing the ordnance will be required, as well as an assessment of the impacts to marine mammals. It would be preferable to include this in the ES, if possible, to allow assessment of the Offshore Development as a whole. A suitable mitigation strategy will be required.*	UXO clearance has been assessed as a potential impact pathway within the noise impact assessment. However, it is noted that, at this time, UXO clearance is not anticipated to be required and further detailed assessment will be undertaken to support a Marine License application if any such activity is deemed necessary in the future; relevant mitigations against this activity will be developed at the time of application, if UXO clearance is needed.
MSS	*We advise that it would be useful if any further geophysical surveys that may be required are included in the EIAR where possible. This is to allow assessment of the Offshore Development as a whole. It is likely that any such activity will need to be considered through the EPS licensing process too (see updated guidance on EPS EPS+guidance+July+2020.pdf (www.gov.scot).*	Geophysical surveys are included as a potential impact pathway for underwater noise disturbance to marine mammals within the underwater noise impact assessment for the construction phase (see Section 11.6.1.1).
MSS	***Operational impacts*** *We recommend that entanglement risk is included as a potential impact to marine mammals in the EIAR, particularly as a decision has not been made on the type of mooring lines to be used. Taut lines would represent a lower risk of entanglement. We also consider that the potential for entanglement in debris caught on the mooring lines should be included in the EIAR. We would recommend that strategies to minimise or remove such debris are considered.*	An assessment of entanglement risk has been included within the impact assessment in Section 11.6.2.2. This includes both direct entanglement (i.e., with mooring lines and inter-array cables) as well as indirect entanglement with derelict fishing lines and gears which have become attached to the Offshore Development infrastructure.
MSS	***Decommissioning impacts*** *The impacts for the Decommissioning phase to be scoped in / out mirrors those identified for the Construction phase.*	It is noted that long-term habitat change remains poorly characterised for offshore renewable energy industries, and particularly for the burgeoning industry of floating offshore wind. However, this does not undermine the importance of this issue to marine habitats and fauna. In lieu of these uncertainties, the site-specific

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	However, without a decommissioning methodology it is difficult to determine whether the impacts will be the same as those during construction. For example, it is possible that methods used to remove the turbines and anchors may produce underwater noise that would require assessment. MSS also recommends that long-term habitat change, which is scoped in for the Operation phase but not considered for the Construction phase, should also be scoped in for the Decommissioning phase due to the inherent uncertainty regarding end-of-life decisions for the Offshore Development (e.g. the removal of foundations).	geophysical and benthic surveys which have been undertaken to characterise the marine environment of the Offshore Site prior to development will be used to define the baseline habitat against which long-term habitat change can be measured. Desk-based studies, including EcoPATH modelling, have been used to characterise the relationships between habitat change and changes in the distribution of marine megafauna for marine renewable energy projects. These have also been used as a proxy in the qualitative assessment provided below. Groundtruthing the anticipated effects of long-term habitat change from offshore wind farms on marine megafauna is the aim of the PrePARED Project (Predators and Prey Around Renewable Energy Developments), which is being funded by the Crown Estate Scotland (CES) and the Offshore Wind Evidence & Change programme. The outcomes of this research will inform future decisions about Offshore Development activities over the operational lifetime of the Offshore Development, as well as end-of-life activities (e.g., the preparation of a Decommissioning Plan and the identification of appropriate mitigations therein). This impact pathway has, therefore, additionally been considered within the Decommissioning phase of the Offshore Development in Section 11.6.3.
MSS	***Long-term habitat change*** *It is unclear how the initial 12 months of aerial surveys will address the potential for long-term changes to habitat. These aerial surveys will characterise the occurrence of marine mammals and basking sharks in the development area, but will not capture any behavioural data (i.e. foraging patterns) nor will they describe the current condition / status of the habitat itself. We recommend referring to the surveys mentioned in the Benthic, Fish and Shellfish and Commercial Fisheries sections (i.e. benthic and geophysical surveys undertaken in 2021) here instead, as a more appropriate methodology to evidence this impact pathway.*	The 2021 MMT benthic surveys have now been referenced to provide a more robust baseline characterisation of the marine environment within the Offshore Study Area. This is provided in Section 11.4.3.1 and referenced in the relevant impact assessment sections covering long-term habitat change in Sections 11.6.2 and 11.6.3. The dedicated aerial surveys undertaken by HiDef, described in Section 11.4.3.2, have been used within the baseline to confirm the presence of particular species, thereby aiding in the identification of receptor species requiring assessment against the activities proposed for the Offshore Development. In agreement with the consultation, these surveys do not provide evidence of long-term changes to the marine environment or habitats which support marine mammals and basking sharks.
MSS	***Review and refinement of species*** *Following MS-LOT's request for clarification dated 16th September MSS acknowledge that there is no mechanism for MS-LOT to request the applicant amend the Scoping Report. Consequently, MSS recommend that MS-LOT make clear in the*	The dedicated aerial surveys undertaken by HiDef, described in 11.4.3.2, have been used within the baseline to confirm the presence of particular species, thereby aiding in the identification of receptor species requiring assessment against the activities proposed for the Offshore Development.

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	Scoping Opinion that: Following the completion of the bird and marine mammal surveys in 2021, the species of cetacean included in the EIA should be reviewed and refined, if necessary. The wording in the Scoping Report, although similar, does not make an explicit comitiment to refine the species included in the EIA as a result of the bird and marine mammal surveys. MSS note this is a region where there are relatively few baseline data on marine mammals, therefore the marine mammal surveys will be important for informing which, if any, additional cetacean species beyond those identified in the Scoping Report are included in the EIA.	
Scoping Opinion Addendum		
NatureScot	***Marine mammal baseline data*** *Section 5.1 outlines the updated [Inter-Agency Marine Mammal Working Group] IAMMWG management units that they plan to use for estimating density baselines. However, the figure (189) given for the East Scotland [bottlenose dolphin] BND management unit is not correct. NatureScot recommends the use of 224 for the total bottlenose dolphin population in the East Scotland management unit (Hammond et al, 2021).*	This revised estimate has been amended within the environmental baseline section in relation to bottlenose dolphin (see Section 11.4.4.1.2), per the findings of Arso-Civil *et al.* (2021).
NatureScot	***Disturbance due to physical presence of vessels*** *As stated in our scoping response, for disturbance due to physical presence of vessels we are content that 'physical presence' is scoped out providing disturbance from vessel activity is fully considered within the underwater noise assessment.*	Underwater noise associated with vessel activity has been assessed in full, with the construction phase being identified as the period when the largest vessels and most numerous fleet is likely to be present at the Offshore Site. The Offshore EIAR (Volume 3): Technical Appendix 11.1 includes the assessment of vessel-related noise and Section 11.6.1.1.4 summarises the outcomes of this assessment.
NatureScot	***Approach to underwater noise modelling*** *We are content with the proposed underwater noise modelling methods.*	Noted with thanks.

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NatureScot	***Marine mammal densities*** *For the disturbance assessment 5.3.3, other sources of density information (or proxies for density) should be considered. SCANs surveys are a snapshot from 1 day in July/August and are not sufficient to reflect what animals are using the coastal strip or for any seasonal differences. Obviously they will have their own survey data to refer to, and we also suggest they also look at the regional baselines (see Hague et al 2020 and Carter et al 2020) if not already covered in the scoping opinion.*	The baseline information used to inform the density data used in the underwater noise impact assessment and throughout the EIA are detailed in Section 11.4. This includes data from: the dedicated monthly aerial surveys; Hague *et al.* (2020); Carter *et al.* (2020); Waggitt *et al.* (2020); Paxton *et al.* (2016); and Evans *et al.* (2011); in addition to the revised SCANS-III density estimates provided by Hammond *et al.* (2021). These data offer greater insight into the seasonal habitat use of key species across the Offshore Site and the surrounding waters of the Pentland Firth. Justifications have been provided for which density estimates were carried forward into the quantitative assessment of impacts for each species.
MSS	***Relevant design envelope parameters*** *MSS consider the following changes to the Offshore Development parameters (worst case scenario; as identified in Table 2) to be relevant to impacts on marine mammals:* > An increase in the number of moorings and anchors per wind turbine, from 3-6 to a potential maximum of 12 > An increase in the anchor spread radius from 600 m to 1,250 m. > The addition of 3-8 (potentially 12) driven piles (8 m diameter) per WTG, rather than the sole option of drilled piles as per original scoping. > Potential reduction in number of turbines, dependent on choice of turbine height (potential from 10 WTGs down to 5)	The Design Envelope has been refined further since the submission of the Scoping Report Addendum. The refined maximum parameters, as relevant to marine mammals and basking shark, are detailed in Table 11.25.
MSS	*We consider that with the inclusion of driven piles to the Project Design Envelope (PDE), the primary impact pathway of concern for marine mammals from this Offshore Development is now underwater noise during the construction phase.*	The impact pathway of underwater noise generation from mooring installation, via driven (impact) and drilled piles, has been assessed in detail through underwater noise propagation modelling (see Offshore EIAR [Volume 3]: Technical Appendix 10.1) and quantitative impact assessment (see Offshore EIAR [Volume 3]: Technical Appendix 11.1). The results are summarised within

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		the impact assessment of effects to marine mammals generated by activities associated with the construction phase (see Section 11.6.1.1).
MSS	***Updated baseline*** *MSS note that IAMMWG (2021) has been used for abundance estimates. MSS are currently awaiting the full methodology from this report to be presented. However, the values presented in IAMMWG (2021) include those from an earlier version of the SCANS-III analysis, and have subsequently been updated. We therefore recommend that the abundance estimates provided in the updated Hammond et al. (2021) report are used. We are content with the shape and areas of the management units provided in IAMMWG (2021).*	This has been noted, and the recommended data have been incorporated into the species accounts provided in the baseline characterisation of cetaceans in Section 11.4.4.1.
MSS	*MSS note that the bottlenose dolphin Coastal East Scotland MU abundance published in IAMMWG (2021) is incorrect and is currently being updated. We recommend the use of the weighted mean population size of 224 (95% CI = 214 – 234), using data from 2015-2019 based on the population estimates presented in Arso Civil et al. (2021). This approach incorporates the variability in population estimates over this timeframe and has been discussed and agreed with University of Aberdeen and University of St Andrews, the two institutions involved in monitoring the population, and NatureScot. The workings for this calculation can be found on the NatureScot website.*	The recommended revised estimate for the Coastal East Scotland Management Unit (CES MU) has been amended within the environmental baseline section on bottlenose dolphins (Section 11.4.4.1.2), per the findings of Arso-Civil *et al.* (2021).
MSS	***Additional impacts*** *MSS acknowledge that there are no past consultee comments relating to the number of mooring lines, number of anchors and mooring spread and we agree that the impacts from these altered parameters are not new, nor will they change the assessment methodology. However, we consider that the proposed increase in the number and spread of mooring lines will increase the amount of mooring line in the water column, thereby potentially increasing the risk of entanglement to marine mammals. We note that the exact design and material*	The Design Envelope has been refined further since the submission of the Scoping Report Addendum. The refined maximum parameters, as relevant to marine mammals and basking sharks, are detailed in Table 11.25. The impact assessment covers entanglement risk on a qualitative basis, based on available knowledge. Whilst it is agreed that the addition of mooring lines into the marine environment may increase the risk of entanglement to marine mammals and basking shark, the dimensions of the mooring lines (i.e., at widths ≥ 150 millimetres [mm]) have not changed, nor have the design elements of the mooring lines in terms of tension on the lines. The impact assessment covers both direct and indirect entanglement against the revised parameters, as well as

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	of the mooring lines, which will determine the likelihood of entanglement, has not yet been confirmed and MSS would welcome further information on the technologies to be used, once available. Also of concern is the risk of secondary entrapment in derelict fishing gear and other marine debris that become caught in the mooring lines themselves. As per our previous scoping advice, we would recommend that strategies to minimise or remove such debris are considered. MSS note that our original scoping advice recommended that underwater noise from possible UXO clearance and any further geophysical surveys should be included the EIAR if possible, to allow assessment of the Offshore Development as a whole. We cannot see reference to either of these impact pathways in Table 5.2.	those which remain unchanged. Mitigations to limit the accumulation of debris on the lines have been developed and are described in Section 11.5.5. Additionally, possible UXO clearance and the planned geophysical survey activities have been incorporated into the assessment of underwater noise impacts. Noise propagation modelling undertaken by Subacoustech Environmental Ltd. in (see Offshore EIAR [Volume 3]: Technical Appendix 10.1) and a desk-based study lead by SMRU Consulting (see Offshore EIAR [Volume 3]: Technical Appendix 11.1) provide detailed analyses of these two impact pathways. Section 11.6.1.1 summarises the outcomes of these assessments.
MSS	***Changes to method of assessment*** *Given the expected increases in underwater noise emissions from the new Project Design Envelope as a result of the potential use of driven piles, MSS agree that it will be necessary to undertake appropriate underwater noise modelling techniques at this stage and welcome the additional detail provided in the Scoping Addendum Report. MSS advise that for the assessment of underwater noise impacts, a suitable site specific, range dependent, underwater noise propagation model should be used. MSS would expect a detailed methodology and the assumptions used in the underwater noise modelling should be provided for transparency, to determine that the method used is appropriate to assess potential impacts. We recommend the use of dual criteria for Permanent Threshold Shift (PTS) onset (cumulative sound exposure level (SEL) and instantaneous peak sound pressure level (SPL)) and the use of a dose-response relationship to predict disturbance. We agree with the use of harbour porpoise dose-response curve for other cetacean species and the use of the harbour seal dose-response curve for grey seals, given a lack of other suitable data. We note that although there are*	These changes to the assessment of underwater noise have been noted and incorporated into the EIA. A detailed characterisation of the noise propagation modelling and its assumptions is provided in the modelling report by Subacoustech Environmental Ltd. in Pentland (see Offshore EIAR [Volume 3]: Technical Appendix 10.1). Furthermore, information on the selection and implementation of criteria for determining noise-related impacts to marine mammals, in terms of injury and disturbance, and details on the population consequences modelling are provided in Offshore EIAR (Volume 3): Technical Appendix 11.1.

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	caveats to this method, it is likely a precautionary approach due to the hearing sensitivity of these species. MSS are content to provide further advice on suitable underwater noise propagation modelling.	
MSS	***Population consequences and cumulative impacts*** *MSS agree that the use of iPCoD for quantifying the population-level consequences of disturbance and PTS for harbour porpoise, bottlenose dolphin, minke whale and both grey and harbour seals, is appropriate. The most up-to-date demographic parameters to use for these species within iPCoD are available in Sinclair et al. (2020). However, we note that the iPCoD approach cannot be used for both Risso's dolphin and white-beaked dolphin; species that are to be included in the assessment. MSS recommends that a quantitative assessment that predicts the numbers of individuals expected to be impacted is still carried out for these species, with the applicant presenting these numbers in the wider context of the population size and conservation status.*	iPCoD modelling undertaken for the Offshore Development (see Offshore EIAR [Volume 3]: Technical Appendix 11.1) informed by the demographic parameters in Sinclair *et al.* (2020) has been used where appropriate to characterise the disturbance and injury-related impacts to harbour porpoise, bottlenose dolphins, minke whales and grey and harbour seals (Southall *et al*, 2019). For the remaining key species, which includes Risso's dolphin, white-beaked dolphin, and common dolphin, a quantitative assessment of the number of animals impacted (injury and disturbance) has been provided, based on predicted impact ranges and available density estimates, with these numbers placed in the wider context of population size as percentages of the relevant Management Units (MUs). The outcomes of this quantitative assessment, in terms of the number of animals impacted and the resulting percentage of each MU impacted, are provided in Section 11.6.1.1. It is noted that for Risso's dolphin, white-beaked dolphin, and common dolphin, predicted disturbance impacts from pile driving (which results in the greatest predicted extent of disturbance) correspond to ≤0.77% of the relevant MU; therefore, it would not have been considered necessary to undertake iPCoD modelling were it available for those species.
MS-LOT	***Marine mammal baseline data*** *With regards to the updated baseline detailed in section 5.1 of the Scoping Report, the Scottish Ministers highlight the additional reports and updated references recommended by NatureScot and MSS. These reports and references must be included in the review of the baseline data and fully considered in the EIA Report.*	These data sources have been incorporated into the marine mammal baseline species accounts and are considered within the impact assessment in Section 11.6.
MS-LOT	***Underwater noise impacts*** *Within table 5.2 of the Scoping Report the Developer summarises the potential impacts to marine mammals and other megafauna associated with the change in parameters. With the inclusion of driven piles, the primary impact pathway*	The Design Envelope has been refined further since the submission of the Scoping Report Addendum. The refined maximum parameters, as relevant to marine mammals and basking shark, are detailed in Table 11.25. The impact pathway of underwater noise generation from mooring installation, via driven and drilled piles, has been assessed in detail through underwater noise

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	of concern for marine mammals from this Offshore Development is now underwater noise during the construction phase. As regards the number of mooring lines, number of anchors and mooring spread, while Scottish Ministers agree that the impacts from these altered parameters are not new, nor will they change the assessment methodology, the risk of entanglement may increase. This view is supported by the MSS advice and the Scottish Ministers advise that MSS' recommendations on additional impacts must be fully implemented in the EIA Report.	propagation modelling (see Offshore EIAR [Volume 3]: Technical Appendix 10.1) and quantitative impact assessment (see Offshore EIAR [Volume 3]: Technical Appendix 11.1). The results are summarised within the impact assessment of effects to marine mammals generated by activities associated with the construction phase (see Section 11.6.1.1). The impact assessment covers entanglement risk on a qualitative basis, based on available knowledge. While it is agreed that the addition of mooring lines into the marine environment may increase the risk of entanglement to marine mammals and basking sharks, the dimensions of the mooring lines (i.e., at widths ≥ 150 mm) haven't changed, nor the design elements of the mooring lines in terms of tension on the lines. The impact assessment below covers both direct and indirect entanglement against the revised and unchanged parameters. Mitigations to limit the accumulation of debris on the lines have been developed. They are described in Section 11.5.5.
MS-LOT	*Given the expected increases in underwater noise emissions as a result of the inclusion of driven piles, the Scottish Ministers agree that it will be necessary to update the methods of assessment to include appropriate underwater noise modelling techniques and advise that a suitable site specific, range dependent, underwater noise propagation model should be used. A detailed methodology and the assumptions used in the underwater noise modelling should be provided in the EIA Report and the Scottish Ministers direct the Developer to the additional advice provided by MSS as regards the prediction of permanent threshold shift ("PTS") onset and disturbance and recommend this is followed. The Scottish Ministers agree with the use of the harbour porpoise dose-response curve for other cetacean species and the use of the harbour seal dose-response curve for grey seals, as supported by MSS advice.*	These agreed changes to the assessment of underwater noise have been noted and incorporated into the EIA. A detailed characterisation of the noise propagation modelling and its assumptions is provided in the modelling report by Subacoustech in Offshore EIAR (Volume 3): Technical Appendix 10.1. Furthermore, information on the selection and implementation of criteria for determining noise-related impacts to marine mammals, in terms of injury and disturbance, are provided in the Offshore EIAR (Volume 3): Technical Appendix 11.1.
MS-LOT	***Marine mammal densities*** *As regards the assessment of disturbance from piling, the Scottish Ministers direct the Developer to the NatureScot representation in respect of other sources of density information and advise that these are fully considered in the EIA Report to*	The baseline information used to inform the density data used in the underwater noise impact assessment and throughout the EIA are detailed in Section 11.4. This includes data from: the dedicated aerial surveys; Hague *et al.* (2020); Carter *et al.* (2020); Waggitt *et al.* (2020); Paxton *et al.* (2016); and Evans *et al.* (2011); in addition to the revised SCANS-III density estimates provided by Hammond *et*

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	more accurately reflect the species using the marine area around the Proposed Development, taking into account any seasonal differences in their population densities.	*al.* (2021). These data offer greater insight into the seasonal habitat use of key species to the Offshore Site within the Offshore Study Area and across the Pentland Firth. Justifications have been provided for which density estimates were subsequently carried forward into the quantitative assessment of impacts for each species.
MS-LOT	***Population consequences and cumulative impacts*** *The Scottish Ministers agree with the Developer regarding the use of Interim Population Consequences of Disturbance ("iPCoD") for quantifying the population-level consequences of disturbance and PTS for harbour porpoise, bottlenose dolphin, minke whale, grey seals and harbour seals. However, as this approach is not possible for Risso's dolphin and white-beaked dolphin, the Scottish Ministers advise that an alternative quantitative approach that predicts the numbers of individuals expected to be impacted should be carried out for these species. The Developer must present this data within the context of population size and conservation status within the EIA Report. This view is supported by the MSS advice.*	iPCoD modelling undertaken for the Offshore Development (see Offshore EIAR [Volume 3]: Technical Appendix 11.1) informed by the demographic parameters in Sinclair *et al.* (2020) has been used where appropriate to characterise the disturbance and injury-related impacts to harbour porpoise, bottlenose dolphin, minke whale, grey seals, and harbour seals (Southall *et al.*, 2019). For the remaining key species, which includes Risso's dolphin, white-beaked dolphin, and common dolphin, a quantitative assessment of the number of animals impacted (injury and disturbance) has been provided, based on predicted impact ranges and available density estimates, with these numbers placed in the wider context of population size as percentages of the relevant MUs. The outcomes of this quantitative assessment, in terms of the number of animals impacted and the resulting percentage of each MU impacted, are provided in Section 11.6.1.1. It is noted that for Risso's dolphin, white-beaked dolphin, and common dolphin, predicted disturbance impacts from pile driving (which results in the greatest predicted extent of disturbance) correspond to ≤0.77% of the relevant MU; therefore, it would not have been considered necessary to undertake iPCoD modelling, were it available for those species.
Cumulative Project List		
THC	*Having reviewed the submitted document, I would suggest the following projects are also included in the cumulative assessment:* *- Space Hub Sutherland (in all chapters of the EIAR not just the SLVIA section)*	The Space Hub Sutherland project is approximately 38 km south-west of the Offshore Site. Considering the intervening distance between the Offshore Site and the Space Hub Sutherland project, as well as the very short duration of the launch exclusion zones and that the EIA for the project noted no significant effects on aquatic ecology during operations, there is no potential for a cumulative impact with the Offshore Development with respect to Marine Mammal and Other Megafauna receptors. The Space Hub Sutherland Project is considered in Chapter 18: Other Users of the Marine Environment.

11.4 Baseline Characterisation

This section assesses the marine mammal and basking shark receptors that may be present within the Offshore Site (Figure 11.1). To understand habitat use by marine mammals and basking sharks within the Offshore Site and its surrounds, a desk-based review of available data which covers the Offshore Study Area and the surrounding region has been undertaken. These data are supplemented by site-specific aerial surveys which included marine mammal observations. The output of this review is presented in the sections below.

11.4.1 Study Area

The Offshore Study Area comprises the original Marine Licence area (affiliated with the Dounreay Trì Project) plus a 4-kilometre (km) buffer in all directions to encompass the survey area captured by the most recent dedicated aerial surveys, which are the most conservative (see Figure 11.2) (HiDef, 2021). It should be noted that the original Marine Licence area has been refined and reduced in size for the Offshore Development, as set out in Chapter 3:Site Selection and Alternatives. Therefore, particular attention has been given to this revised region when characterising baseline data (see Figure 11.2).

The Offshore Study Area sits within the Pentland Firth and Orkney Waters marine region (Evans *et al.,* 2011) which has been the focal biogeographic region used to spatially define habitat use by marine megafauna. However, for particularly wide-ranging species, such as minke whales, basking sharks and some dolphin species, habitat use has been characterised on a broader regional scale (e.g., coastal or oceanic; west or east Scotland; or by the relevant body of water) to understand the relative importance of this focal region.

In terms of available data on cetacean habitat use, the Offshore Study Area falls within Block S of the Small Cetacean Abundance in the North Sea (SCANS)-III survey used to define density and abundance of cetaceans in UK and Northern European waters (Hammond *et al.,* 2021). In those instances where species-specific data was unavailable for key receptors in Block S, data from an adjacent SCANS-III survey block, site-specific surveys, or from modelled predicted density estimates (Waggit *et al.*, 2021) has been utilised. It should be acknowledged that the adjacent SCANS-III survey blocks consider regions beyond the Pentland Firth and Orkney. Furthermore, population data used to define the species Management Units (MUs) for cetacean populations utilising the Offshore Study Area are on a much broader, regional-seas scale.

The Offshore Study Area also overlaps the North Coast and Orkney (NCO) harbour and grey seal Seal Management Areas (SMAs), which have been defined based on the most recent annual population productivity reports for these species (SCOS, 2021). These SMAs define the geographic extent of the Seal Management Units (SMUs), which are distinct populations of breeding seals.

MUs are currently undefined for basking sharks in the UK and genetic research has shown very little differentiation, indicating the presence of a single global population (Rigby *et al.,* 2021). It has therefore been assumed that the biogeographic extent of basking sharks is circumglobal within polar to tropical seas.

The following areas are referred to in this impact assessment:

- Offshore Site: The area encompassing the PFOWF Array and Offshore Export Cable Corridor (OECC), within which the applications are being sought (see Figure 11.1);
- PFOWF Array Area: The area where the Wind Turbine Generators (WTGs) will be located within the Offshore Site;
- Offshore Export Cable Corridor: The area within which the Offshore Export Cable(s) will be located; and
- Offshore Study Area: Marine mammal species have different key habitats and ranges. Broadly speaking, however, the 'Offshore Study Area' refers to the local population to which the species found in the Offshore Site belongs (this is also known as the relevant MU or SMU and is described further in Section 11.4). Basking sharks belong to a global population and as such, the Offshore Study Area has been limited to the distribution of this species across the United Kingdom Continental Shelf (UKCS).

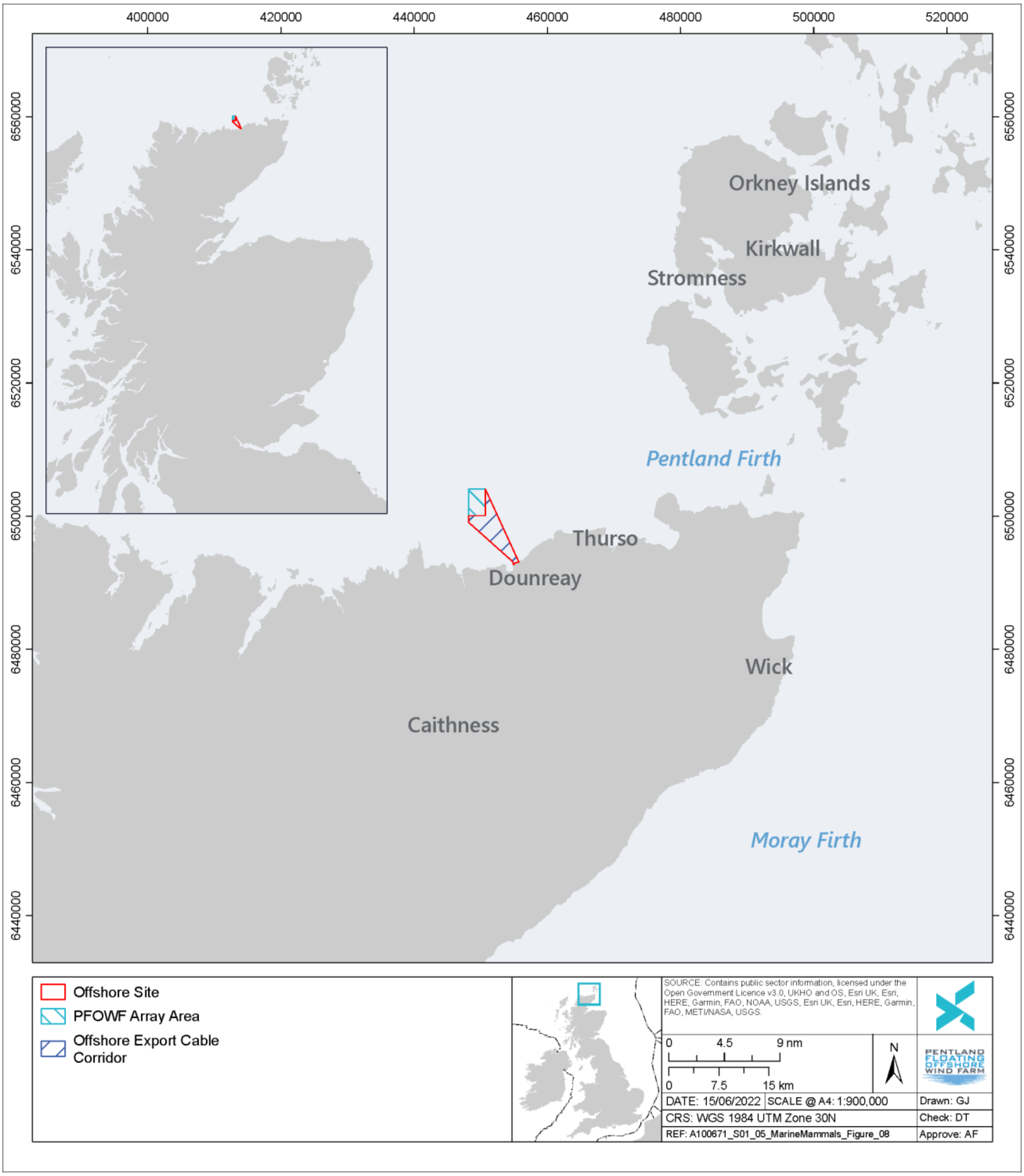

Figure 11.1 Location of the Offshore Site against the focal region of the Pentland Firth and Orkney

11.4.2 Sources of Information

A review was undertaken of the literature and data relevant to marine mammals and basking sharks and was used to provide an overview of the existing environment within the Offshore Study Area and surrounding waters. The primary data sources used in the preparation of this chapter are listed below in Table 11.4.

Table 11.4 Summary of key sources of information pertaining to marine mammals and basking sharks

Title	Source	Year	Author
Predicted habitat use of grey and harbour seals	Carter, M. I. D. *et al.* (2020) Habitat-based predictions of at-sea distribution for grey and harbour seals in the British Isles. Sea Mammal Research Unit, University of St Andrews, Report to BEIS, OESEA-16-76/OESEA-17-78.	2020	Carter *et al.*
Improving understanding of bottlenose dolphin movements along the east coast of Scotland. Final report, provided to European Offshore Wind Deployment Centre (EOWDC)	Arso Civil, M., *et al.* (2021). Improving understanding of bottlenose dolphin movements along the east coast of Scotland. Final report, provided to EOWDC.	2021	Arso Civil *et al.*
Abundance and behaviour of cetaceans and basking sharks in the Pentland Firth and Orkney Waters	Evans P., Baines M. and Coppock J. (2011) Abundance and behaviour of cetaceans and basking sharks in the Pentland Firth and Orkney Waters. Report by Hebog Environmental Ltd & Sea Watch Foundation. Scottish Natural Heritage Commissioned Report No.419.	2011	Evans *et al.*
Regional baselines for marine mammal knowledge across the North Sea and Atlantic areas of Scottish waters	Hague E., Sinclair R. and Sparling C. (2020) Regional baselines for marine mammal knowledge across the North Sea and Atlantic areas of Scottish waters, *Scottish Marine and Freshwater Series*, **11**(12).	2020	Hague *et al.*
SCANS I, II, and III Survey Reports, with a focus on the data presented in the most recent survey report (as updated in 2021)	Hammond P., Lacey C., Gilles A., Viquerat S., Borjesson P., Herr H., Macleod K., Ridoux V., Santos M., Scheidat M., Teiman J., Vingada J., Oien N. (2017) Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys.	2021	Hammond *et al.*
Aerial surveys of the Offshore Study Area between September 2020 and August 2021	HiDef (2021). Digital video aerial surveys of seabirds and marine mammals at Highland Wind Limited Pentland Floating Offshore Wind Farm Project: Annual Report September 2020 to August 2021.	2021	HiDef
Aerial surveys of the Dounreay Demonstration Centre Project (0.5 km west of the Offshore Site) between May 2015 and April 2016	HiDef (2016). Digital video aerial surveys of seabirds and marine mammals at the Highlands and Islands Dounreay Demonstration Centre project: final report.	2016	HiDef
Aerial surveys of the Original Development Area between January and December 2015	HiDef (2015). Digital video aerial surveys of seabirds and marine mammals at the Dounreay Trì Project: final report.	2015	HiDef

Title	Source	Year	Author
Abundance estimates of cetaceans within UK MUs	Inter-Agency Marine Mammal Working Group (IAMMWG). 2021. Updated abundance estimates for cetacean MUs in UK waters. JNCC Report No. 680, JNCC Peterborough, ISSN 0963-8091.	2021	IAMMWG
A Framework for Studying the Effects of Offshore Wind Development on Marine Mammals and Turtles	Kraus, S.D., R.D. Kenney, and L. Thomas. (2019). A Framework for Studying the Effects of Offshore Wind Development on Marine Mammals and Turtles. Report prepared for the Massachusetts Clean Energy Center, Boston, MA 02110, and the Bureau of Ocean Energy Management.	2019	Kraus *et al.*
Revised Phase III Data Analysis of Joint Cetacean Protocol (JCP) Data Resources	Paxton, C., L. Scott-Hayward, M. Mackenzie, E. Rexstad, and L. Thomas. 2016. Revised Phase III Data Analysis of JCP Data Resources. JNCC Report No.517.	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	Paxton, C., L. Scott-Hayward, and E. Rexstad. 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.	2014	Paxton *et al.*
Atlas of Cetacean distribution in north-west European waters	Reid, J. B., Evans, P. G., & Northridge, S. P. (2003). Atlas of cetacean distribution in north-west European waters. Joint Nature Conservation Committee.	2003	Reid *et al.*
Estimated at-sea Distribution of Grey and Harbour Seals	Russell D., Jones E. and Morris C., (2017) Estimated at-sea Distribution of Grey and Harbour Seals, *Scottish Marine and Freshwater Science*, **8**(25).	2017	Russell *et al.*
Scientific Advice on Matters Related to the Management of Seal Populations.	Special Committee on Seals (SCOS) (2021), Scientific Advice on Matters Related to the Management of Seal Populations: 2020	2021	SCOS
Distribution maps of cetacean and seabird populations in the North-East Atlantic	Waggitt, J.J., Evans, P.G., Andrade, J., Banks, A.N., Boisseau, O., Bolton, M., Bradbury, G., Brereton, T., Camphuysen, C.J., Durinck, J. and Felce, T. (2020). Distribution maps of cetacean and seabird populations in the North-East Atlantic. *Journal of Applied Ecology*, **57**(2): 253-269.	2020	Waggitt *et al.*
Basking sharks in the northeast Atlantic: spatio-temporal trends from sightings in UK waters	Witt, M.J., Hardy, T., Johnson, L., McClellan C.M., Pikesley, S.K., Ranger, S., Richardson, P.B., Solandt, J-L., Speedie, C., Williams, R333., and Godley, B.J. 2012. Basking sharks in the northeast Atlantic: spatio-temporal trends from sightings in UK waters. *Marine Ecology Progress Series*, **459**:121-134	2012	Witt *et al*.

11.4.3 Site-specific Surveys

11.4.3.1 MTT 2021 benthic surveys

In 2021, dedicated geophysical and environmental surveys were undertaken by MMT, on behalf of Highland Wind Limited (HWL), to characterise the environmental conditions at the Offshore Site. The outcomes of these surveys are provided in Chapter 9: Benthic Ecology and additional details on the findings of the surveys are provided in Offshore EIAR (Volume 3): Appendix 9.1: Environmental Baseline Report.

In summary, the MMT surveys characterised the habitat of the PFOWF Array Area as being comprised of deep circalittoral mixed and coarse sediments (i.e., subtidal sands and gravels), which are the most common subtidal habitat type along the UK coastline. Within the Offshore Site, these sediments support some kelp beds and Annex I stony and bedrock reefs. The kelp beds are located in the nearshore region in the landfall approaches of the OECC, whilst the reef features are found closer to the PFOWF Array Area within the OECC. The reefs support epifaunally-dominant 'mixed faunal turf communities' and the polychaete worm, '*Pomatoceros triqueter*, with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles'.

The MMT surveys also identified several epibenthic fish species through video transects and grab sampling, including sandeel (likely lesser sandeel [*Ammodytes tobianus*]), ling (*Molva molva*), skate (likely common skate [*Dipturus batis*]), and European plaice (*Pleuronectes platessa*). Some of these species, such as European plaice and sandeel, are recognised as important prey for marine mammals. However, each of these species were only recorded in a single grab sample (in the case of the sandeels and skate) or a single video transect (for the juvenile ling and European plaice), meaning the Offshore Site is unlikely to support high densities of these species.

11.4.3.2 Dedicated aerial surveys

Aerial surveys of the PFOWF Array Area were undertaken within the Offshore Study Area between September 2020 and August 2021 to collect data on marine mammals and seabirds. For this survey, a series of eight and 10 strip transects were flown monthly, perpendicular to the coastline. HiDef designed a survey that placed 1 km spaced transects within the original Offshore Development Area, which overlaps the PFOWF Array Area, and 2-km spaced transects across the surrounding buffer. The total area of survey coverage was 80 square kilometres (km^2), but increased to 150 km^2 from April 2021 onwards, following an increase in the buffer width surrounding the PFOWF Array Area from 2 km to 4 km, as requested by NatureScot and confirmed by Marine Scotland.

Additionally, aerial surveys covering the PFOWF Array Area and a portion of the OECC were undertaken in 2015 for the Dounreay Trì Project (HiDef, 2015) and in 2016 for the Highlands and Islands Enterprise (HIE) Dounreay Demonstration Centre project (HiDef, 2016). Between January and December 2015, HiDef was commissioned to undertake monthly aerial seabird and marine megafauna surveys for the Dounreay Trì Project. Thirteen aerial surveys were conducted within this period, with two surveys occurring in the month of June (HiDef, 2015). Twelve surveys were also conducted between May 2015 to April 2016 on behalf of the HIE Dounreay Demonstration Centre project (HiDef, 2016).

Similar to the methods utilised in the September 2020 to March 2021 HiDef (2021) surveys, the 2015 line transects for the Dounreay Trì Project were flown at 1-km spaced transects across the original Offshore Development Area, increasing to 2 km within the 2-km buffer zone surrounding the site. This generated a survey coverage area of 80 km^2 (HiDef, 2015). The HIE aerial transects differed in that they covered a much greater total survey area to encompass a larger proposed development site. However, survey coverage of the Offshore Site is reduced for these surveys as they were centred on the Dounreay Demonstration Centre project to the west of the original Development Area. Moreover, line transect spacing for these surveys was greater than for the 2015 or 2021 HiDef surveys (1.7 km spacing, with 3.5 km spacing in the 3-km buffer which overlaps the Offshore Site; HiDef, 2016).

Figure 11.2 illustrates the aerial survey transect coverage of the 2015 and 2021 HiDef surveys of the Original Development Area for the Dounreay Trì Project and the 2015-2016 HiDef surveys of the HIE Dounreay Demonstration Centre project in relation to the Offshore Site.

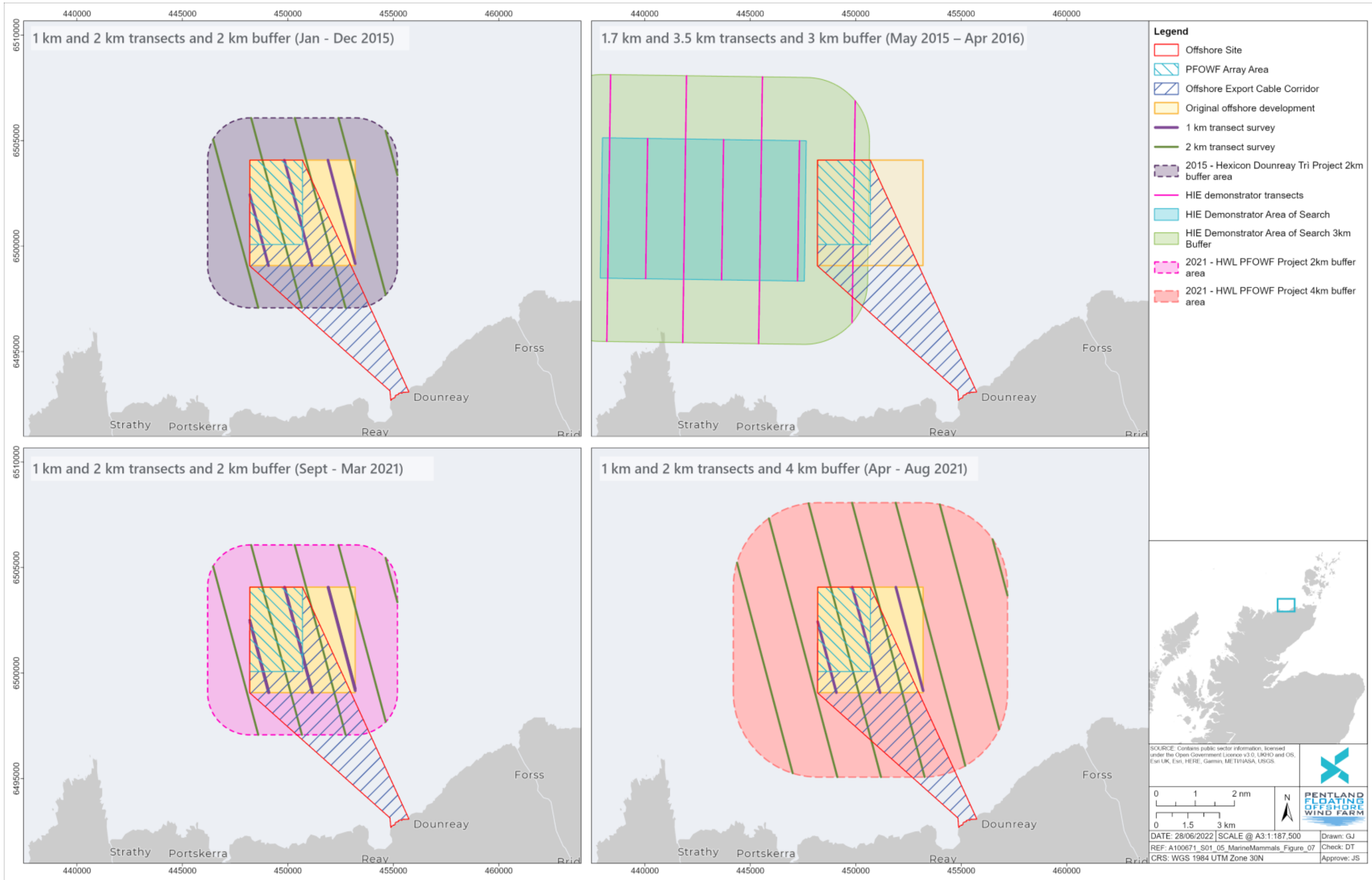

Figure 11.2 Dedicated aerial survey coverage across the PFOWF Array Area (HiDef, 2015, 2016 and 2021)

11.4.4 Baseline Description

This section describes the existing environment in relation to marine mammals, which include several species of cetacean (i.e., whales, dolphins and porpoises) and two species of pinniped (i.e., seals), as well as basking sharks, regularly found within the Offshore Site.

11.4.4.1 Cetaceans

The Pentland Firth supports five species of cetaceans as frequent or seasonal occupants: harbour porpoise; bottlenose dolphin; white-beaked dolphin (*Lagenorhynchus albirostris*); minke whale (*Balaenoptera acutorostrata*); and Risso's dolphin (*Grampus griseus*). Of these, harbour porpoise and white-beaked dolphin are the most widespread and frequently encountered species, occurring regularly in this region throughout the year (Evans *et al.,* 2011; Hague *et al.,* 2020). Minke whales are also recorded as annual seasonal visitors, though their distribution increases dramatically within the Moray Firth (Evans *et al.,* 2011; Hague *et al.,* 2020). The coastal waters of the Moray Firth and east Scotland also support a population of coastal bottlenose dolphins (IAMMWG, 2021), whilst the deeper offshore waters are inhabited by a separate offshore ecotype of this species (Louis *et al.,* 2014).

Common dolphins (*Delphinus delphis*) are most abundant along the west coast of Scotland and in open ocean waters (Hague *et al.,* 2020). However, this species has been recorded within the Pentland Firth as a 'casual visitor' (Evans *et al.,* 2011), including during the most recent site-specific aerial survey of the Offshore Site (HiDef, 2021).

Killer whales (*Orcinus orca*) are sighted on occasion in the Pentland Firth, with increasing frequency to the north of the Offshore Site in the Orkney Isles (Evans *et al.,* 2011). However, very low population numbers, coupled with unpredictable, wide-ranging movements, have precluded meaningful density estimates or predictions of habitat use for this species.

In addition to common dolphins and killer whales, several other cetacean species have been recorded within the Offshore Site and surrounding waters on an irregular basis. These include: Atlantic white-sided dolphin (*Lagenorhynchus obliquidens*), fin whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaeangliae*), and long-finned pilot whale (*Globicephala melas*) (Reid *et al.,* 2003; Evans *et al.,* 2011). As the occurrence of these species is considered both rare and unpredictable within the Offshore Site (Reid *et al.,* 2003; Evans *et al.,* 2011; Hammond et al., 2021), they have not been considered further in this impact assessment.

Several key data sources have been used to detail the habitat use of the cetacean species considered important within the Offshore Site. They include the most recent report by the Inter-Agency Marine Mammal Working Group (IAMMWG) (2021) on the UK's cetacean MUs; predictive habitat modelling undertaken by Waggitt *et al.* (2020); published survey data from Hammond *et al.* (2021); and aerial surveys of the Offshore Site undertaken by HiDef (2021) and commissioned for the Dounreay Trì Project (HiDef, 2015) and HIE Dounreay Demonstration Centre project (HiDef, 2016). From these data sources, abundance and density estimates for relevant populations have been defined; these are provided within the species accounts below.

Table 11.5 outlines the specific cetacean population MUs and their biogeographic distributions, which are considered in this impact assessment. Further details on how these MUs were selected are provided in the species accounts below.

Table 11.5 MUs of cetacean populations identified as important to the Offshore Site (IAMMWG, 2021)

Species	MU	MU Abundance[1]
Harbour porpoise	North Sea (NS) and West Scotland (WS)	NS: 346,601 WS: 28,936
Bottlenose dolphin	Coastal Ecotype: Coastal East Scotland (CES) and Coastal West Scotland and the Hebrides (CWSH)	CES: 224[2] CWSH: 45

Species	MU	MU Abundance[1]
	Offshore Ecotype: Oceanic Waters (OW) and Greater North Sea (GNS)	OW: 70,249 GNS: 2,022
White-beaked dolphin	Celtic and Greater North Seas (CGNS)	43,951
Risso's dolphin	CGNS	12,262
Common dolphin	CGNS	102,656
Minke whale	CGNS	20,118

[1] Five-year weighted mean of annual estimates.

[2] As the abundance estimate provided within IAMMWG (2021) for the CES MU was based on an older version of the SCANS-III survey report (Hammond *et al.*, 2017), these data have been taken from the photo-ID work and modelling presented in Arso-Civil *et al.* (2021), per the recommendation of consultees (see Table 11.3).

Figure 11.3 gives spatial context to the cetacean MUs taken forward for consideration within the impact assessment due to their proximity to the Offshore Site. The location of the Offshore Site falls within 6.2 km of the boundary line for the western Scottish bottlenose dolphin and harbour porpoise MUs. For precautionary purposes, these MUs have been considered in the impact assessment.

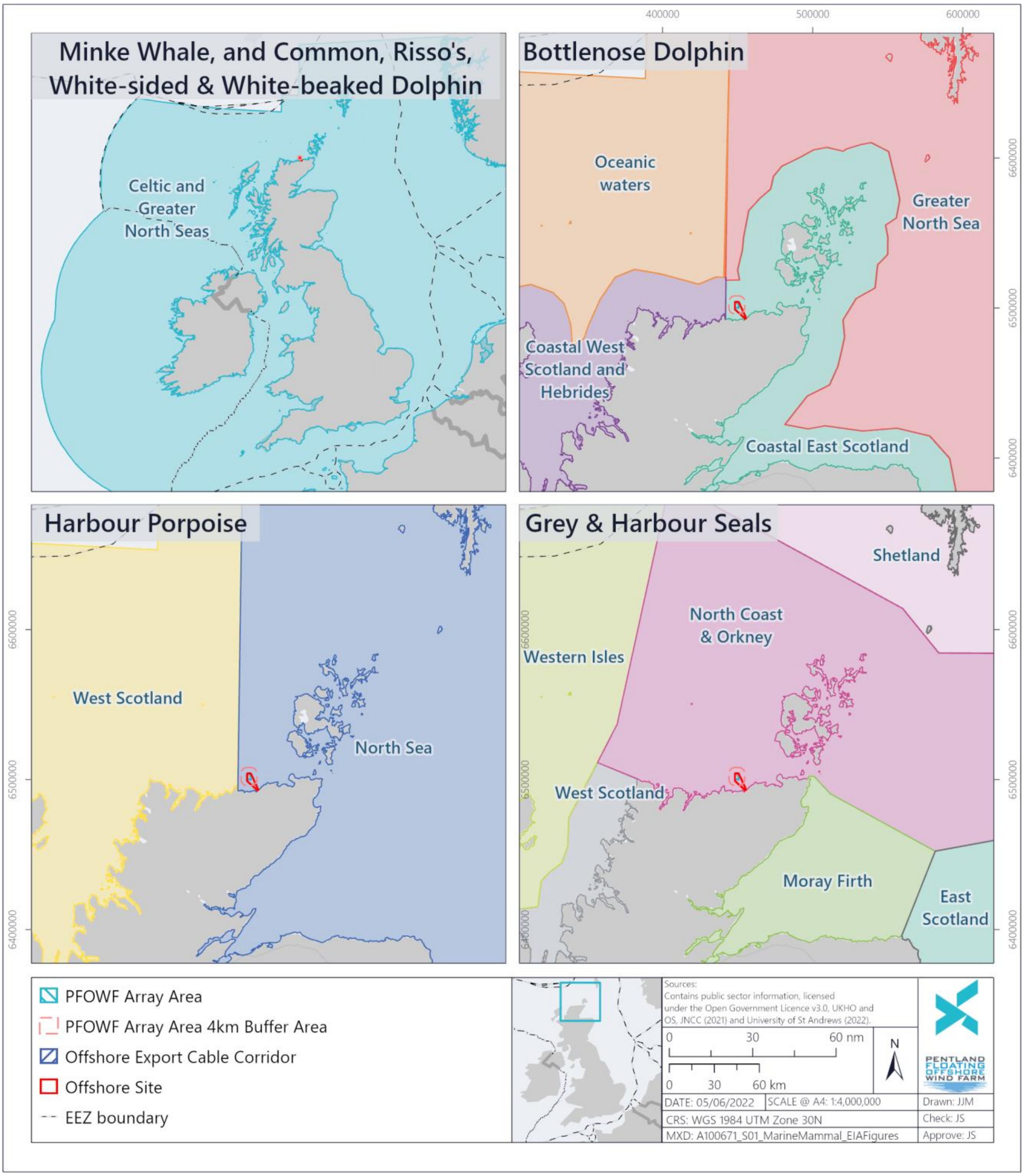

Figure 11.3 Biogeographic extent of cetacean MUs and SMAs in relation to the Offshore Site (IAMMWG, 2021; SCOS, 2020)

Of the key cetacean species identified in Table 11.5, three were recorded during the site-specific aerial surveys; they include: harbour porpoise, white-beaked dolphin and Risso's dolphin (HiDef 2015; 2016; 2021). Additionally, three common dolphins were sighted during the September 2021 monthly survey (HiDef, 2021). A summary of the survey data is presented in Table 11.6.

Table 11.6 Cetacean sightings recorded during aerial surveys of the Offshore Site

Aerial Survey Data Source	Species Names[1]	Number of Animals Sighted[2]	Month(s) of Sighting(s)
HiDef (2021)	Harbour porpoise	24	January, March, April, June, July, August
	Common dolphin	3	September
	Unidentified cetacean species	1	September
HiDef (2016)	Harbour porpoise	12	May, July, September, January, March
	White-beaked dolphins	14	May, July, December
HiDef (2015)	Harbour porpoise	3	May, June, November
	White-beaked dolphins	15	January, February, March, December
	Risso's dolphin	3	March

[1] In some cases, specific species were unable to be determined and therefore remain unidentified within the table.

[2] There are several sightings recorded as potentially being seals or small cetaceans (e,g., harbour porpoise) which surveyors were unable to differentiate at the taxa level. These have been provided in Table 11.16 with the pinniped sightings.

All species of cetacean are deemed Scottish PMFs and are thus considered to be marine nature conservation priorities in Scottish waters. This listing, coupled with the protections afforded in UK and EU legislation, has enabled the designation of various protected areas for the conservation and management of cetaceans. The conservation objectives and status of relevant protected sites are detailed in Section 11.4.4.4.

For the majority of cetacean species, the most recent assessment of conservation status (JNCC, 2019) concluded that the overall conservation status of most species (including harbour porpoise, bottlenose dolphins, white-beaked dolphins, Risso's dolphin, common dolphins and minke whales) remained 'unknown' due to a lack of data to inform an assessment of population trends and availability of suitable habitat. Table 11.7 highlights key information on the conservation status of key cetacean species, in terms of their current and future prospective ecological condition, based on the outcomes of JNCC (2019).

Table 11.7 Conservation status of key cetacean species (JNCC, 2019)

Species	Range	Population	Habitat	Future Prospects	Conservation Status	Overall Trend
Harbour porpoise	FV	XX	XX	FV	XX	XX
Bottlenose dolphin	FV	XX	XX	XX	XX	XX
White-beaked dolphin	FV	XX	XX	XX	XX	XX
Risso's dolphin	FV	XX	XX	XX	XX	XX
Common dolphin	FV	XX	XX	XX	XX	XX
Minke whale	FV	XX	XX	XX	XX	XX
Key: FV = Favourable, + = Improving U1 = Unfavourable to Inadequate, XX = Unknown						

The following sections provide further detail on the biology, habitat use, and distributions of the cetacean species which require further consideration in the assessment of potential impacts from the proposed activities within the Offshore Study Area.

11.4.4.1.1 Harbour porpoise

Ecology

Harbour porpoises are present in UK waters year-round with sightings records peaking during the summer months (Evans, 2011). These small cetaceans favour shallow continental shelf waters of approximately 150 metres (m) or less and areas with highly sloped topographic features, where prey species, such as whiting (*Merlangius merlangus*), may be concentrated by hydrographic and ecological processes (Santos and Pierce, 2003; Booth *et al.,* 2013). In the Southern North Sea, harbour porpoise have been shown to make seasonal movements inshore towards the coast during the winter months (JNCC and Natural England, 2019), possibly to capitalise on shallow benthic prey, such as sandeels (Santos and Pierce, 2003).

Calving is estimated to take place in Scottish waters sometime between April and June, with a subsequent weaning period of up to 12 months, during which sensitivity to disturbance is expected to be elevated for mothers and calves (Evans, 2011).

Harbour porpoise are the most abundant cetacean to occur in the North Sea, with individuals concentrated in the Southern North Sea in UK waters, from the coastline skirting Northumberland down to Norfolk (Hammond *et al.,* 2021). Abundance estimates for this species decrease further north in the North Sea, with low to very low densities estimated for the north and north-east coasts of Scotland (Hammond *et al.,* 2021).

Management unit

Two MUs have been identified for this species which overlap the Offshore Study Area: the North Sea MU and West Scotland MU (see Table 11.5) (IAMMWG, 2021). The North Sea MU was estimated to contain 346,601 individuals in 2016 (95% confidence interval [CI]: 289,498 to 419,967), which is similar to the estimate derived from SCANS-II in 2005 of 369,560 (241,338 to 565,906). The West Scotland MU was estimated to contain 28,936 individuals in 2016 (95% CI: 21,140 to 39,608), which is similar to the estimate derived from SCANS-II in 2005 of 24,435 (95% CI: 9,681 to 161,675). Therefore, both MUs are considered stable.

Density data

Table 11.8 outlines the density estimates for harbour porpoise populations across the Offshore Study Area and the surrounding waters.

Table 11.8 Available density estimates for harbour porpoise within the Offshore Study Area

Data Source	Area	Temporal Scale	Density (No. indivs/km^2)
SCANS-III	Survey Block S	Summer 2016	0.152
Site-specific surveys, HiDef (2021)[1]	Original Development Area + 2 / 4-km buffer	Monthly, September 2020 to August 2021	Min. = 0.000 (adjusted) Max = 0.740 (adjusted) Average = 0.153 (adjusted)
Site-specific surveys, HiDef (2016)	Original Development Area + 3-km buffer	Monthly, May 2015 to April 2016	Min. = 0.000 Max = 0.280 Average = 0.063
Site-specific surveys, HiDef (2015)	Original Development Area + 2 km buffer	Monthly, January 2015 to December 2015	Min. = 0.000 Max = 0.040 Average = 0.009
JCP Phase III (Paxton *et al.*, 2016)	North Commercial Area (a region immediately north of	Data collected between 1994 and 2010 but	Winter: 0.810

Data Source	Area	Temporal Scale	Density (No. indivs/km^2)
	Sutherland and Caithness, including the west Orkneys)	abundance estimate provided for 2010 only	Spring: 0.529 Summer: 0.579 Autumn: 0.347 Average: 0.566
Waggitt *et al.* (2020)	Offshore Study Area	Data collected between 1980 and 2018	Jan: 0.210 (mean) Jul: 0.379 (mean)

[1] Harbour porpoise density estimates presented for the 2020 to 2021 site-specific surveys have been adjusted to account for the estimated proportion of animals which were fully submerged and unavailable for detection (i.e. not visible) during the aerial survey (HiDef, 2021). This was done by correcting relative density estimates (derived from surfacing and partially submerged animals) to account for the proportion of animals breaking the surface at the instant the aircraft passed (12.5% of animals), then scaling to the proportion of time-tagged animals were recorded breaking the surface within the relevant month (see Teilmann *et al.*, 2013) to the specific survey. This approach avoids making any assumption about the depth to which harbour porpoise are visible from an aerial survey.

Harbour porpoise constituted the most frequently sighted species across the Offshore Study Area and year-round. Density estimates from the HiDef (2015; 2016; 2021) surveys showed harbour porpoise occurring in relatively low densities across the survey areas throughout all survey years, with estimated adjusted densities in 2020 to 2021 ranging between 0.000 to 0.740 individuals per square kilometre (individuals/km^2; average 0.153 individuals/km^2). HiDef (2021) describes harbour porpoise distribution as widespread across the survey area, with a higher density area to the east of the survey area buffer.

The SCANS-III survey of Block S consisted of a total of 1,370.9 km of effort. The main species sighted was harbour porpoise with an estimated abundance of 6,147 individuals (95% CI: 3,401 to 10,065) and an estimated density of 0.152 individuals/km^2 (Hammond *et al.*, 2021). The estimated density surface for harbour porpoise, modelled using the SCANS-III data, shows considerably lower densities expected off the north coast of Scotland, compared to more southern parts of the North Sea (Lacey & Hammond, 2020 – Appendix 3 within Hague *et al.*, 2020).

Paxton *et al.* (2016) provided density estimates for harbour porpoise for the North Commercial Area (a region immediately north of Sutherland and Caithness, including the west Orkneys). Paxton *et al.* (2016) estimated the 2010 porpoise density to vary seasonally between 0.347 and 0.810 individuals/km^2, with an average of 0.566 individuals/km^2 across the year. It is important to stress that Paxton *et al.* (2016) state that the results of the Joint Cetacean Protocol (JCP) analysis should be considered indicative rather than an accurate representation of species distribution, and that due to the patchy distribution of data, the estimates are less reliable than those obtained from the SCANS surveys. Consequently, the JCP density estimates have not been taken forward for the quantitative impact assessment.

The density estimates provided in Waggitt *et al.* (2020) show an increased harbour porpoise presence in the northern North Sea in the summer, with density estimates of 0.379 individuals/km^2 within the PFOWF Array Area in July. Whilst the Waggitt *et al.* (2020) density maps may be representative of the relative density of larger areas compared to others, there is no indication of whether the more recent sightings data are weighted more heavily than older data, which limits the interpretation of how predictive the maps are to current distribution patterns. Therefore, they are not considered to be suitable density estimates for use in quantitative impact assessment.

The SCANS-III density estimates are expected to be most representative of the baseline occurrence of harbour porpoise within the Offshore Site and have, therefore, been taken forward for the quantitative impact assessment.

Summary

Harbour porpoises are expected to be present throughout the Offshore Study Area year-round, though in low densities. Density estimates for harbour porpoise in this area vary greatly between 0.00 to 0.81 individuals/km^2 (see Table 11.8). The average adjusted density estimate for harbour porpoise from the HiDef (2021) site-specific surveys (0.153 individuals/km^2) was almost the same as that derived from the SCANS-III survey (0.152 individuals/km^2). Therefore, the SCANS-III density estimate was selected as the most appropriate to take forward to the quantitative impact assessment.

11.4.4.1.2 Bottlenose dolphin

Ecology

Bottlenose dolphins are one of the most cosmopolitan delphinid species in the world, occupying inshore and offshore waters across a large range of temperate and tropical latitudes. Two ecotypes characterise global bottlenose dolphin populations: (1) a larger, more gregarious offshore ecotype which is wide-ranging and occurs in both open-ocean waters and along continental shelf edges; and (2) a coastal ecotype which predominantly forms small groups as subsets of a larger, residential population occupying bays, inlets, and estuaries (Louis *et al.*, 2014).

Bottlenose dolphins breed throughout the year in UK waters (Anderwald *et al.*, 2010), and appear to be generalist predators. Historical data suggests a peak in summer occupancy within the shallow inner Moray Firth by resident individuals of the Coastal East Scotland Management Unit (CES MU) (Wilson *et al.*, 1997). This is likely a reflection of seasonal changes in prey availability and not due to reproductive behaviour (Wilson *et al.*, 1997; Thompson *et al.*, 2011).

In Scotland, coastal bottlenose dolphins appear to have a wide but patchy distribution, with three distinct populations separated across the east and west coasts (Cheney *et al.*, 2013). There is one resident population of coastal bottlenose dolphins on the east coast of Scotland emanating from the Moray Firth southward towards North Berwick, though they occasionally utilise the waters of the Pentland Firth and Northern Isles (IAMMWG, 2021).

Management unit

Four species MUs have been identified for this species which overlap with the Offshore Site and its potential impact ranges (see Table 11.5) (IAMMWG, 2021).

- CES MU: 224 bottlenose dolphins[i];
- Coastal West Scotland and the Hebrides (CWSH) MU: 45 bottlenose dolphins (95% CI: 33 to 66);
- Oceanic Waters MU: 70,249 bottlenose dolphins (95% CI: 49,720 to 99,255); and
- Greater North Sea (GNS) MU: 2,022 bottlenose dolphins (95% CI: 548 to 7,458).

The CES MU and CWSH MU comprise coastal ecotype bottlenose dolphins, with the CWSH MU believed to form the easternmost extent of their biogeographic distribution. The Oceanic Waters MU and GNS MU comprise offshore ecotype bottlenose dolphins.

Density data

Table 11.9 outlines the density estimates for bottlenose dolphin populations across the Offshore Study Area and the surrounding waters.

[i] Five-year weighted mean of annual estimate taken from Arso Civil *et al.* (2021).

Table 11.9 Available density estimates for bottlenose dolphins within the Offshore Study Area

Data Source	Area	Temporal Scale	Density (No. indivs/km^2)
SCANS-III	Survey Block S	Summer 2016	0.0037
Site-specific surveys, HiDef (2021)	Original Development Area + 2 / 4-km buffer	September 2020 to August 2021	n/a
Site-specific surveys, HiDef (2016)	Original Development Area + 3-km buffer	May 2015 to April 2016	n/a
Site-specific surveys, HiDef (2015)	Original Development Area + 2 km buffer	January 2015 to December 2015	n/a
JCP Phase III (Paxton *et al.,* 2016)	North Commercial Area (a region immediately north of Sutherland and Caithness, including the west Orkneys)	Data collected between 1994 and 2010 but the abundance estimate is provided for 2010 only	Winter: 0.002 Spring: 0.003 Summer: 0.003 Autumn: 0.002 Average: 0.002
Waggit *et al.* (2020)	Offshore Study Area	Data collected between 1980 and 2018	n/a– *only offshore ecotype considered in report*

No bottlenose dolphins were identified in the Offshore Study Area during the site-specific HiDef surveys. There were, however, several unidentified dolphin sightings which occurred across all years of study (HiDef, 2015; 2016; 2021), so it is possible that bottlenose dolphins may have been present but were unable to be identified at the species level.

The SCANS-III survey of Block S comprised a total of 1,370.9 km of survey effort. Bottlenose dolphin abundance was estimated as 151 individuals (95% CI: 0 to 527) with an estimated density of 0.0037 individuals/km^2 (Hammond *et al.*, 2021).

Paxton *et al.* (2016) provided density estimates for bottlenose dolphin for the North Commercial Area (a region immediately north of Sutherland and Caithness, including the west Orkneys). Paxton *et al.* (2016) estimated the 2010 bottlenose dolphin density to be between 0.002 to 0.003 individuals/km^2, with an average of 0.002 individuals/km^2 across the year (see Table 11.9). It is important to stress that Paxton *et al.* (2016) state that the results of the JCP analysis should be considered indicative rather than an accurate representation of species distribution, and that due to the patchy distribution of data, the estimates are less reliable than those obtained from the SCANS surveys. Consequently, the JCP density estimates have not been taken forward for the quantitative impact assessment.

The density estimates provided in Waggitt *et al.* (2020) are strictly for the offshore ecotype of bottlenose dolphins. This ecotype is much less likely to be occupying the Offshore Study Area than the coastal ecotype, and these data are therefore not considered suitable density estimates to use for assessing impacts within this area.

The SCANS-III density estimates are expected to be most representative of the baseline occurrence of bottlenose dolphins within the Offshore Site and have, therefore, been taken forward for the quantitative impact assessment.

Summary

Sightings of bottlenose dolphins in the CWSH MU are primarily located in and around the Sound of Barra and throughout the Inner Hebrides, with most sightings around Mull, the Small Isles, and Skye (Hebridean Whale and Dolphin Trust, 2018). Whilst there have been sightings of bottlenose dolphins along the north coast of mainland Scotland, Orkney, and the Shetlands, the number of animals using the north coast appears to be low (Cheney *et al.*, 2013), and much of these rely on publicly reported sightings where species identification may be unreliable given the known presence of other dolphin species in the area (Risso's dolphin and white-beaked dolphin) (Reid *et al.*, 2003). In addition, no individuals have been recorded during any of the dedicated aerial surveys of the Offshore Study Area or its immediate surroundings (HiDef, 2015; 2016; 2021). Other survey data indicate that, if present, bottlenose dolphins will occur in low densities, with estimates varying from 0.002 to 0.0037 individuals/km^2 (see Table 11.9). Density estimates from both SCANS-III (Hammond *et al*., 2021) and Paxton *et al.* (2014) are similar (0.0037), but as the SCANS-III estimate is more recent, this was selected as the most appropriate for the quantitative impact assessment.

11.4.4.1.3 White-beaked dolphin

Ecology

White-beaked dolphins are widespread across the northern European continental shelf and are considered to be the second most abundant cetacean in the North Sea after harbour porpoise (Banhuera-Hinestroza *et al.,* 2009; Hammond *et al.,* 2021). Similar to harbour porpoise, white-beaked dolphins predominantly utilise shallow shelf waters of approximately 50 m to 100 m in depth (Reid *et al.*, 2003), although this species may be spotted hundreds of kilometres offshore, particularly in north-west Scotland and the Shetland Channel (Hammond *et al.,* 2021). They appear to feed on a variety of demersal and pelagic fishes, as well as squids and crustaceans (Kiszka and Braulik, 2018).

The mating season for white-beaked dolphins is thought to occur between July and August, with a subsequent gestation period lasting approximately 11 months (Culik, 2010). As such, females and their calves may be present at any time of year throughout their range. Groups generally comprise less than 10 individuals; however, larger aggregations of up to 50 individuals formed from several subgroups are not uncommon, and temporary aggregations formed by several hundred animals have been recorded in the North Sea (Reid *et al.,* 2003). Generally, such large aggregations are more commonly seen further offshore.

Management unit

The UK population of white-beaked dolphin spans both the Celtic Sea and North Sea, without any prominent biogeographic distinction in distribution between marine jurisdictions. As such, a single Celtic and Greater North Sea Management Unit (CGNS MU) has been named for the species. It comprises an estimated 43,951 individuals (95% CI: 28,439 to 67,924) spread patchily across the northern extent of the contiguous continental shelf of northern Europe (see Table 11.5) (IAMMWG, 2021).

Density data

Table 11.10 outlines the density estimates for white-beaked dolphin populations across the Offshore Study Area and the surrounding waters.

Table 11.10 Available density estimates for white-beaked dolphins within the Offshore Study Area

Data Source	Area	Temporal Scale	Density (No. indivs/km^2)
SCANS-III	Survey Block S	Summer 2016	0.021
Site-specific surveys, HiDef (2021)	Original Development Area + 2 / 4-km buffer	September 2020 to August 2021	n/a
Site-specific surveys, HiDef (2016)	Original Development Area + 3-km buffer	May 2015 to April 2016	Min: 0.00 Max: 0.48 Average: 0.08
Site-specific surveys, HiDef (2015)	Original Development Area + 2 km buffer	January 2015 to December 2015	Min: 0.00 Max: 0.31 Average: 0.052
JCP Phase III (Paxton *et al.,* 2016)	North Commercial Area (a region immediately north of Sutherland and Caithness,	Data collected between 1994 and 2010 but the	Winter: 0.002 Spring: 0.008

Data Source	Area	Temporal Scale	Density (No. indivs/km^2)
	including the west Orkneys)	abundance estimate provided for 2010 only	Summer: 0.003 Autumn: 0.003 Average: 0.004
JCP (Paxton *et al.,* 2014)	North coast of Scotland	Data collected between 1994 and 2012	Winter: 0 to 0.1 Spring: 0 to 0.5 Summer: 0 to 1 Autumn: 0 to 0.1
Waggitt *et al.* (2020)	Offshore Study Area	Data collected between 1980 and 2018	Jan: 0.083 (mean) Jul: 0.146 (mean)

White-beaked dolphins were the second most frequently sighted species during the dedicated aerial surveys (Table 11.6). Data from the HiDef (2015; 2016; 2021) surveys showed white-beaked dolphins were sighted in the greatest numbers, but less frequently throughout the year than harbour porpoise, and the species was completely absent from the most recent survey (HiDef, 2021). The density estimates within the Offshore Study Area for this species were variable over the months during 2015 and 2016, ranging from 0.000 to 0.480 individuals/km^2, with the average ranging from 0.052 individuals/km^2 (HiDef 2015) to 0.080 individuals/km^2 over the two survey periods (see Table 11.10) (HiDef, 2016). The densities are slightly higher than for harbour porpoise, due to the larger group sizes attributed to white-beaked dolphin sightings (HiDef, 2015; 2016). No white-beaked dolphins were sighted in the 2020 to 2021 surveys (HiDef, 2021).

The SCANS-III survey of Block S consisted of a total of 1,370.9 km of effort. White-beaked dolphins had an estimated block-wide abundance of 868 individuals (95% CI: 0 to 2,258) and an estimated density of 0.021 individuals/km^2 (Hammond *et al.*, 2021).

Paxton *et al.* (2016) provided density estimates for white-beaked dolphins for the North Commercial Area (a region immediately north of Sutherland and Caithness, including the west Orkneys). This study estimated the 2010 white-beaked dolphin density to range from 0.002 to 0.008 individuals/km^2 (average density of 0.004 individuals/km^2), with the highest densities in the spring. Additionally, Paxton *et al.* (2014) predicted white-beaked dolphin densities across coastal waters in Scotland and estimated that density along the north coast varies between 0.00 to 1.00 individuals/km^2, with the highest density of one being calculated from Summer 1994 data. It is important to stress that Paxton *et al.* (2016) state that the results of the JCP analysis should be considered indicative rather than an accurate representation of species distribution, and that due to the patchy distribution of data, the estimates are less reliable than those obtained from the SCANS surveys. Consequently, the JCP density estimates have not been taken forward for the quantitative impact assessment.

The density estimates from Waggitt *et al.* (2020) indicate an increased presence of white-beaked dolphin in the northern North Sea in the summer months, with density estimates within the PFOWF Array Area of 0.146 individuals/km^2 in July, compared with 0.083 individuals/km^2 in January (see Table 11.10). Whilst the Waggitt *et al.* (2020) density maps may be representative of the relative density of larger areas compared to others, there is no indication of whether the more recent sightings data are weighted more heavily than older data, which limits the interpretation of how predictive the maps are to current distribution patterns. Therefore, they are not considered to be suitable density estimates for use in quantitative impact assessment.

It is noted that the SCANS-III density estimate of 0.02 individuals/km^2 for white-beaked dolphins within Block S is considerably lower than annual averages from the site-specific surveys of the Original Development Area from 2015 (0.052 individuals/km^2) and across the HIE Dounreay Demonstration Centre project between May 2015 to April 2016 (0.08 individuals/km^2). They are also lower than the estimate of 0.217 individuals/km^2 associated with the neighbouring SCANS-III block, Block K (west of the Offshore Development), into which noise disturbance impact ranges are likely to extend. Therefore, as a precautionary approach, the highest average density from site-specific surveys of 0.08 individuals/km^2 has been taken forward for quantitative impact assessment.

Summary

White-beaked dolphins are expected to be present throughout the Offshore Study Area year-round, although greater numbers of animals may be observed in the summer months (Paton *et al.,* 2014; Waggitt *et al.,* 2020). Density estimates for white-beaked dolphin were variable, ranging from 0.00 to 1.00 individuals/km². However, the highest density came from Paxton *et al.* (2014) where the estimates are less reliable than those obtained from the SCANS surveys due to the patchiness in the data distribution. Therefore, despite being a smaller density estimate, the SCANS-III estimate of 0.021 individuals/km² was considered the most appropriate value for quantitative assessment of impacts to this species occurring within and around the Offshore Site.

11.4.4.1.4 Risso's dolphin

Ecology

Risso's dolphins occur in varying densities along the western extent of the UKCS and along the edge of the continental slope where they target pelagic prey (NaureScot, 2014; Hague *et al.,* 2020; Hammond *et al.,* 2021). In the UK, small resident populations have emerged which mainly occupy depths of up to 100 m, though they may forage in deeper waters opportunistically (NatureScot, 2014). Around north-east Lewis, one such population appears to be resident to the shallow waters of a sandeel (*Ammodytidae spp.*) spawning ground, potentially capitalising on other species which target these minute benthic fish (NatureScot, 2020b), as well as squid and cuttlefish. Within Scotland, Risso's dolphins are most readily observed within the Hebridean Sea, where the density and abundance of this species appear to be greatest (Hammond *et al.*, 2021). There is limited knowledge of Risso's dolphin breeding and calving behaviours. They are thought to breed year-round; however, there is some evidence of a summer peak in calving in the North Atlantic (Evans, 2008).

Management unit

Within the UK marine environment, Risso's dolphins are managed as a single MU: the CGNS MU. The estimated abundance of Risso's dolphins within the MU is 12,262 individuals (95% CI: 5,227 to 28,764) (IAMMWG, 2021). This is the first estimate of MU abundance for Risso's dolphins so there is no information on the stability of the MU.

Density data

Table 11.11 outlines the density estimates for Risso's dolphin populations across the Offshore Study Area and the surrounding waters.

Table 11.11 Available density estimates for Risso's dolphins within the Offshore Study Area

Data Source	Area	Temporal Scale	Density (No. indivs/km²)
SCANS-III	Survey Block K[1]	Summer 2016	0.0135
Site-specific surveys, HiDef (2021)	Original Development Area + 2 / 4-km buffer	September 2020 to August 2021	0
Site-specific surveys, HiDef (2016)	Original Development Area + 3-km buffer	May 2015 to April 2016	0
Site-specific surveys, HiDef (2015)	Original Development Area + 2 km buffer	January 2015 to December 2015	Min: 0.00 Max: 0.14 Average: 0.011
JCP Phase III (Paxton *et al.,* 2016)	North Commercial Area (a region immediately north of Sutherland and Caithness, including the west Orkneys)	Data collected between 1994 and 2010 but the abundance estimate provided for 2010 only	Winter: 0.000 Spring: 0.005 Summer: 0.002 Autumn: 0.000 Average: 0.002

Data Source	Area	Temporal Scale	Density (No. indivs/km^2)
JCP (Paxton *et al.,* 2014)	North coast of Scotland	Data collected between 1994 and 2012	Winter: 0 to 0.05 Spring: 0 to 0.05 Summer: 0 to 0.05 Autumn: 0 to 0.05
Waggitt *et al.* (2020)	Offshore Study Area	Data collected between 1980 and 2018	Jan: 0.00 (mean) Jul: 0.003 (mean)

[1] Risso's dolphin density estimates are unavailable for Block S, so the value has been taken from adjacent Block K.

Three Risso's dolphins were observed during one site-specific survey in March 2015, resulting in a density estimate of 0.14 individuals/km^2 (HiDef, 2015). No further Risso's dolphin observations were made in subsequent surveys.

Data from the SCANS-III surveys suggest that the number of Risso's dolphins within the survey region encompassing the Offshore Site (Block S) was too low to produce meaningful density estimates for the species (Hammond *et al.,* 2021). As such, the adjacent SCANS-III survey area, Block K, was used to provide density data for the assessment. Risso's dolphin had an estimated block-wide abundance of 440 individuals (95% CI: 0 to 1,222) and an estimated density of 0.0135 individuals/km^2 (Hammond *et al.,* 2021). However, it should be noted that this is considered an overestimation of the density likely to be encountered within the Offshore Site as Risso's dolphins were not sighted in Block S, suggesting that the region does not support large numbers of this species.

Paxton *et al.* (2016) provided density estimates for bottlenose dolphin for the North Commercial Area (a region immediately north of Sutherland and Caithness, including the west Orkneys). Paxton *et al.* (2016) estimated the 2010 Risso's dolphin density to be between zero and 0.005 individuals/km^2. Additionally, Paxton *et al.* (2014) predicted Risso's dolphin densities across coastal waters in Scotland and estimated that density along the north coast varies between zero and 0.05 individuals/km^2, with density ranges being the same throughout the year. The density estimates for the Offshore Study Area are considerably lower than that predicted for North Lewis. It is important to stress that Paxton *et al.* (2016) state that the results of the JCP analysis should be considered indicative rather than an accurate representation of species distribution, and that due to the patchy distribution of data, the estimates are less reliable than those obtained from the SCANS surveys. Consequently, the JCP density estimates were not taken forward for the quantitative impact assessment.

The density estimates from Waggitt *et al.* (2020) within the PFOWF Array Area indicated no presence of Risso's dolphins in the northern North Sea in January and a very low presence of 0.003 individuals/km^2 in July (see Table 11.11). The density estimates expected in the vicinity of the Offshore Site are considerably lower than those predicted for the deeper waters along the UKCS. Whilst the Waggitt *et al.* (2020) density maps may be representative of the relative density of larger areas compared to others, there is no indication of whether the more recent sightings data are weighted more heavily than older data, which limits the interpretation of how predictive the maps are to current distribution patterns. Therefore, they are not considered to be suitable density estimates for use in quantitative impact assessment.

The SCANS-III density estimates are expected to be most representative of the baseline occurrence of Risso's dolphins within the Offshore Development area, as only one sighting of this species was recorded during the site-specific aerial surveys compared to several across the larger SCANS-III survey of Block S. As such, these data are considered more reliable and have, therefore, been taken forward for the quantitative impact assessment.

Summary

Although Risso's dolphins have been recorded on occasion within the Pentland Firth (Evans *et al.,* 2011; HiDef, 2015; Hammond *et al.,* 2021), the large majority of individuals are anticipated to be concentrated in the Hebrides and Western Isles of Scotland and further offshore (Evans *et al.,* 2011; Hammond *et al.,* 2021). Risso's dolphins are considered rare within the North Sea, making the location of the Offshore Study Area likely one of limited importance to this species (Evans *et al.,* 2011). Density estimates were low, ranging from 0.00 to 0.14 individuals/km^2 (maximum from site-specific surveys; see Table 11.11). The average adjusted density estimate for Risso's dolphin from the HiDef (2015) site-specific surveys of 0.011 individuals/km^2 was very close to that derived from the SCANS-III survey of 0.0135 individuals/km^2 (Hammond *et al.,* 2021). Therefore, the SCANS-III density estimate was selected as the most appropriate for the quantitative impact assessment.

11.4.4.1.5 Common dolphin

Ecology

Common dolphins are one of the most abundant cetacean species in the deep offshore and shelf waters of the North-East Atlantic Ocean (Murphy *et al.,* 2021). This gregarious species can be found coastally and pelagically targeting high metabolic value prey, such as cod (*Gadidae*), herring (*Clupea harengus*), mackerel (*Scombridae*), and squids (Braulik *et al.,* 2021). The UK common dolphin population is concentrated in the south-west, and individuals are most frequently sighted in the Hebridean Sea, Celtic Sea, and Irish Sea. In Scotland, common dolphins are most often seen along the west coast and in the Inner and Outer Hebrides (Evans *et al.,* 2011; Hammond *et al.,* 2021). However, records of common dolphin sightings in the north and east of Scotland appear to be increasing in recent decades, with sightings becoming more frequent in the Northern Isles (Evans *et al.,* 2011) and the Moray Firth (Robinson *et al.*, 2010). Mating and calving take place in summer (i.e., between May and September), which coincides with the movement of individuals from offshore populations closer to shore (Robinson *et al.*, 2010; Evans *et al.*, 2011).

Management unit

Like white-beaked dolphins and Risso's dolphins, common dolphins are managed under the singular CGNS MU. The population managed under this MU is estimated to contain 102,656 individuals (95% CI: 58,932 to 178,822) spread across the temperate European North-East Atlantic Ocean (IAMMWG, 2021). Re-modelling of the SCANS-II data showed that the previous abundance estimate was 181,880 individuals, though with very large confidence intervals around this estimate (95% CI: 88,447 to 374,015) (IAMMWG, 2021).

Density data

Table 11.12 outlines the density estimates for common dolphin populations across the Offshore Study Area and the surrounding waters.

Table 11.12 Available density estimates for common dolphins within the Offshore Study Area

Data Source	Area	Temporal Scale	Density (No. indivs/km^2)
SCANS-III	Survey Block S, K, or T	Summer 2016	n/a (and none sighted in adjacent blocks)
Site-specific surveys, HiDef (2021)	Original Development Area + 2 / 4-km buffer	September 2020 to August 2021	Min: 0.00 Max: 0.14 Average: 0.012
Site-specific surveys, HiDef (2016)	Original Development Area + 3-km buffer	May 2015 to April 2016	n/a
Site-specific surveys, HiDef (2015)	Original Development Area + 2 km buffer	January 2015 to December 2015	n/a
JCP Phase III (Paxton *et al.,* 2016)	North Commercial Area (a region immediately north of Sutherland and Caithness, including the west Orkneys)	Data collected between 1994 and 2010 but the abundance estimate provided for 2010 only	Winter: 0.013 Spring: 0.023 Summer: 0.066 Autumn: 0.167 Average: 0.067

Data Source	Area	Temporal Scale	Density (No. indivs/km²)
Waggit *et al.* (2020)	Offshore Study Area	Data collected between 1980 and 2018	April (mean): 0.0128 (0.0097 to 0.0164) May (mean): 0.0193 (0.0146 to 0.0247) June (mean): 0.0356 (0.0273 to 0.0452) July (mean): 0.0640 (0.0495 to 0.0807) August (mean): 0.0932 (0.0725 to 0.1168)

The most recent aerial survey of the PFOWF Array Area included a single sighting of three animals during the September 2020 survey, resulting in a density estimate of 0.14 individuals/km^2 (see Table 11.12; HiDef, 2021). No sightings occurred during the 2015 and 2016 surveys and no common dolphins were observed in the SCANS-III survey of Block S (or in adjacent Blocks K or T).

Paxton *et al.* (2016) provided density estimates for common dolphins for the North Commercial Area (a region immediately north of Sutherland and Caithness, including the west Orkneys). Paxton *et al.* (2016) estimated the 2010 common dolphin density ranged from 0.013 to 0.167 individuals/km^2 (average of 0.067 individuals/km^2), with the greatest density observed during autumn (see Table 11.12). It is important to stress that Paxton *et al.* (2016) state that the results of the JCP analysis should be considered indicative rather than an accurate representation of species distribution, and that due to the patchy distribution of data, the estimates are less reliable than those obtained from SCANS surveys. Consequently, the JCP density estimates were not taken forward for the quantitative impact assessment.

As absolute density estimates for common dolphins occurring within the Pentland Firth are unavailable from published survey data (Hammond *et al.,* 2021), species distribution modelling was used to provide an estimate of the possible number of individuals that may be encountered across the Offshore Study Area. Modelling undertaken by Waggitt *et al.* (2020) utilised various environmental parameters to predict and map the expected distribution of this species from collated sightings records across various surveys. Whilst the resulting map has not been verified across its entire extent, it still provides useful monthly density estimates which can help better characterise potential patterns in spatio-temporal habitat use by common dolphins within the Offshore Site.

The density estimates provided in Waggitt *et al.* (2020) show a low density of common dolphin in the northern region of the North Sea in both summer and winter. In the absence of SCANS-III densities for Block S, or adjacent Blocks K and T, more extensive monthly density parameters were extracted for common dolphin than for other cetacean species to ensure a suitable density estimate covering the Offshore Site was available for the impact assessment. Density estimate confidence intervals ranged from 0.0097 to 0.1168 individuals/km^2 (see Table 11.12).

The maximum overall density from the monthly density estimates from Waggitt *et al.* (2020) was taken forward for consideration within the quantitative impact assessment. It is acknowledged that reservations have been made about how accurately the outputs of Waggitt *et al.* (2020) reflect current distribution patterns. Whilst it is noted above that they are not considered to be suitable density estimates for use in quantitative impact assessment, in the absence of reliable density estimates for common dolphins from other sources, these have been selected. This decision was based on the precautionary approach and will provide the most conservative estimate of the number of individuals which could potentially be impacted across the Offshore Study Area.

No sightings of common dolphins were confirmed during the 2015 and 2016 dedicated aerial surveys and no common dolphins were observed in the SCANS-III survey of Block S, or adjacent Block K or T, nor in waters north of Scotland in the SCANS-II survey conducted in 2005. Overall, there are very low sightings rates across the Offshore Site from both historical and contemporary data, as well as low predicted densities from analyses across multiple datasets, with caveats raised regarding their application to quantitative assessment. Therefore, the average density value of 0.012 individuals/km^2 from the most recent dedicated aerial surveys (HiDef, 2021) is considered the most representative of the Offshore Site and was taken forward for the quantitative impact assessment.

Summary

Data indicate that common dolphin may be present in the vicinity of Offshore Development, although habitat use in the Pentland Firth and North Coast of Scotland remains relatively low and common dolphins are considered 'rare' within this region (Hague *et al.,* 2020). In the absence of a density estimate from the SCANS-III survey due to no observation within Block S (or adjacent blocks), the maximum mean density estimate from the monthly densities from Waggitt *et al.* (2020), 0.0932 individuals/km^2, was taken forward for consideration within the quantitative impact assessment as a precautionary approach to estimating the number of individuals which could potentially be impacted across the Offshore Study Area.

11.4.4.1.6 Minke whale

Ecology

Minke whales are the most abundant species of whale recorded within the UKCS, where it occurs as a seasonal summer visitor (Evans, 2011; Hague *et al.,* 2020). The smallest of the baleen whale species, minke whales feed on herring and other seasonal prey aggregations formed by Scotland's unique marine topography along the southern Moray coast and within the Hebridean Sea (Hauge *et al.,* 1995; NatureScot, 2020c; Hammond *et al.,* 2021). Minke whales are usually sighted alone or in pairs; however, this species may form larger aggregations of 10 to 15 individuals or may occur individually at elevated densities during feeding events (Reid *et al.,* 2003). These larger aggregations have been recorded within the Southern Trench of the outer Moray Firth, a known summer feeding hotspot for both adults and juveniles of this species (NatureScot, 2020d) and the area has been designated as a Marine Protected Area (MPA) for minke whales. Relative density estimates of minke whales within this area are high but taper off quickly in surrounding waters further north along the east coast of Scotland (NatureScot, 2020d). In the UK, minke whales feed primarily on herring, haddock (*Melanogrammus aeglefinus*), mackerel (*Scomber scombrus*), and sandeel (Cooke, 2018). Outwith the summer foraging season, minke whale breeds and calves in the winter months (Risch *et al.*, 2014), sometime between October and March, with a peak in calving in February (Kavanagh *et al.*, 2018).

Management unit

Similar to white-beaked dolphins, Risso's dolphins, and common dolphins, minke whales are managed as a single population across the CGNS MU. The abundance estimate for minke whales in this MU is 20,118 individuals in 2016 (95% CI: 14,061to 28,786) (IAMMWG, 2021). This is almost the same as the abundance estimate derived from the SCANS-II data (20,136) in 2005, which suggests that the MU population is stable.

Density data

Table 11.13 outlines the density estimates for minke whale populations across the Offshore Study Area and the surrounding waters.

Table 11.13 Available density estimates for minke whales within the Offshore Study Area

Data Source	Area	Temporal Scale	Density (No. indivs/km^2)
SCANS-III	Survey Block S	Summer 2016	0.0095
Site-specific surveys, HiDef (2021)	Original Development Area + 2 / 4-km buffer	September 2020 to August 2021	n/a

Data Source	Area	Temporal Scale	Density (No. indivs/km²)
Site-specific surveys, HiDef (2016)	Original Development Area + 3-km buffer	May 2015 to April 2016	n/a
Site-specific surveys, HiDef (2015)	Original Development Area + 2 km buffer	January 2015 to December 2015	n/a
JCP Phase III (Paxton *et al.,* 2016)	North Area of commercial interest	Data collected between 1994 and 2010 but abundance estimate provided for 2010 only	Winter: 0.005 Spring: 0.005 Summer: 0.028 Autumn: 0.002 Average: 0.010
JCP (Paxton *et al.,* 2014)	North coast of Scotland	Data collected between 1994 and 2012	0.0 to 0.5
Waggitt *et al.* (2020)	PFOWF Array Area	Data collected 2018	Jan (mean): 0.009 Jul (mean): 0.024

No minke whales were sighted during any of the site-specific surveys (HiDef 2015; 2016; 2021); however, they were recorded during the SCANS surveys. The SCANS-III survey of Block S consisted of a total of 1,370.9 km of effort. Minke whales were sighted in this survey block though in low numbers, resulting in an abundance estimate of 383 minke whales across Block S (95% CI: 0 to 1,364) and an estimated density of 0.0095 individuals/km^2 (Hammond *et al.,* 2021). The estimated density surface for minke whales, modelled using the SCANS-III data, shows considerably lower densities expected off the north coast of Scotland compared to the Moray Firth and areas off the east coast of Scotland (Lacey & Hammond, 2020 – Appendix 3 within Hague *et al.,* 2020).

Paxton *et al.* (2016) provided density estimates for minke whale for the North Commercial Area (a region immediately north of Sutherland and Caithness, including the west Orkneys). Paxton *et al.* (2016) estimated the 2010 minke whale density to vary seasonally between 0.002 individuals/km^2 in the autumn to 0.028 individuals/km^2 in the summer (average of 0.010 individuals/km^2). Additionally, Paxton *et al.* (2014) predicted minke whale density estimates across coastal waters in Scotland and estimated that minke whale density along the north coast varies between 0.0 to 0.1 individuals/km^2 and 0.2 to 0.5 individuals/km^2, with higher densities being estimated for the summer months. Density estimates for the north coast of Scotland were predicted to be considerably lower than those predicted for the Moray Firth and the Sea of the Hebrides. It is important to stress that Paxton *et al.* (2016) state that the results of the JCP analysis should be considered indicative rather than an accurate representation of species distribution, and that due to the patchy distribution of data, the estimates are less reliable than those obtained from the SCANS surveys. Consequently, the JCP density estimates were not taken forward for the quantitative impact assessment.

The density estimates provided in Waggitt *et al.* (2020) show an increased minke whale presence in the northern North Sea summer months, with density estimates within the PFOWF Array Area of 0.024 individuals/km^2 in July. Whilst the Waggitt *et al.* (2020) density maps may be representative of the relative density of larger areas compared to others, there is no indication of whether the more recent sightings data are weighted more heavily than older data, which limits the interpretation of how predictive the maps are to current distribution patterns. Therefore, they are not considered to be suitable density estimates for use in quantitative impact assessment.

The SCANS-III density estimates are expected to be most representative of the baseline occurrence of minke whale within the Offshore Development area and have, thus, been taken forward for the quantitative impact assessment.

Summary

Minke whales are seasonal visitors to the area and are only expected to be present in the summer months at very low densities. Density estimates for minke whales in this area vary greatly between 0.00 to 0.5 individuals/km^2, depending on the time of year. No minke whales were sighted during any of the site-specific surveys (HiDef 2015; 2016; 2021) and neither the JCP nor the Waggitt *et al.* (2020) data are considered to be suitable density estimates for a quantitative impact assessment. Therefore, the SCANS-III density estimate of 0.0095 individuals/km^2 was considered the most appropriate for the quantitative impact assessment.

11.4.4.2 Pinnipeds

Pinniped diversity within the UK is limited to two species which regularly utilise both the terrestrial and marine habitats for survival and reproduction: the harbour seal and grey seal (Jones *et al.,* 2015; Hague *et al.,* 2016). Both of these species are phocids, or true seals, whose distributions vary seasonally between terrestrial / nearshore occupancy and offshore foraging periods. Seasonal patterns in distribution are governed by reproductive and life-history stages. Both species tend to concentrate close to shore, particularly during their respective pupping and moulting seasons, and then spread out during their at-sea period.

Seal tagging data have indicated that the foraging movements of harbour seals are generally restricted to within a 40 km to 50 km range of their haul-out sites, whilst grey seal movements mainly involve foraging within 100 km of a haul-out site, though they've been sighted foraging several hundred kilometres offshore (Carter *et al.,* 2020; SCOS, 2021). Grey seals are generalist predators which typically capitalise on benthic and demersal prey species in water depths of up to 100 m, though they are capable of deeper foraging dives (Bowen, 2016; SCOS, 2021). Conversely, harbour seals forage in shallower waters at depths of up to 50 m (Tollitt *et al.,* 1998), and females continue to undertake foraging trips whilst weaning their young (Lowry, 2016).

The nearshore environment along the west coast of Scotland and in the Northern Isles makes for particularly good terrestrial habitat for breeding, pupping, and moulting, whilst the surrounding waters are comparatively abundant with prey. Scotland supports the greatest number of seals within the UK, providing habitat to approximately 77.3% of the grey seal and 84.5% of the harbour seal populations therein (based on 95% CI estimates of abundance) (SCOS, 2021). The Offshore Site sits within the NCO SMU, which is the biogeographic region relevant to both species (see Figure 11.3) (SCOS, 2021).

Harbour seals and grey seals are listed as *Least Concern* on the International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species (Bowen, 2016; Lowry, 2016). However, they are listed as PMFs in Scotland, making them species of conservation importance in Scottish waters (NatureScot, 2020a). Through protections afforded under the EU Habitats Directive, as transposed into UK legislation, and the Marine (Scotland) Act 2010, protected sites have been designated to reduce disturbance impacts to seals in key terrestrial habitats, including haul-outs. Further detail on these sites is provided in Section 11.4.4.4.2 below.

The most recent assessment of conservation status (JNCC, 2019) concluded that, for grey seals in the UK, the species has a 'favourable' conservation status. However, the assessment concluded an 'unfavourable to inadequate' conservation status for harbour seals,due to the declining population trends around the UK. Table 11.14 highlights key information on the conservation status of both seal species, in terms of their current and future prospective ecological condition, based on the outcomes of JNCC (2019).

Table 11.14 Conservation status of key pinniped species (JNCC, 2019)

Species	Range	Population	Habitat	Future prospects	Conservation Status	Overall Trend
Harbour seal	FV	U1	XX	U1	U1	XX
Grey seal	FV	FV	FV	FV	FV	+
Key: FV = Favourable, + = Improving U1 = Unfavourable to inadequate, XX = Unknown						

Three key data sources were used to identify and detail the environmental baseline of harbour seals and grey seals: annual population parameter reports from the Special Committee on Seals (SCOS) (2021); at-sea distribution maps from Russell *et al.* (2017); and predicted habitat usage maps from Carter *et al.* (2020) (see Table 11.4). From these data sources, abundance and density estimates for seals within the Offshore Study Area have been defined for the respective SMUs defined by the SCOS (2021). These data are provided in Table 11.15 below, and Figure 11.3 gives spatial context to the SMUs.

Table 11.15 Density and abundance estimates for pinniped species within the SMU relevant to the Offshore Study Area

Species	SMU	SMU Abundance	Density (No. individuals/km^2)[3]
Reference	**SCOS (2021)**		**Carter *et al.* (2020)**
Harbour seal	NCO	Count: 1,405 Scaled[1]: 1,951	Grid cell-specific predicted relative density over the impact area (see Figure 11.5), corrected to reflect absolute density.[3]
Grey seal	NCO	Count: 8,599 Scaled[2]: 35,979	Grid cell-specific predicted relative density over the impact area (see Figure 11.5), corrected to reflect absolute density.[3]

[1] Assumes that 72% of the total harbour seal population is hauled-out during the August surveys (Lonergan *et al.,* 2013). To account for the portion of the population at sea, the data are thus scaled as: 1,405 / 72*100 = 1,951.

[2] Assumes that 23.9% of the total grey seal population is hauled-out during the August surveys (Russell *et al.,* 2016). To account for the portion of the population at sea, the data are thus scaled as: 8,599 / 23.9*100 = 35,979.

[3] The grid cell-specific seal predicted relative densities from Carter *et al.* (2020) were combined with estimates of the total at-sea population size in 2018 as provided in Carter *et al.* (2020) (grey seal = 150,700; harbour seal = 42,800) to provide predictions of absolute density of seals in each grid cell (5km x 5 km) and converted to seals/km^2.

Only grey seals were recorded to the species level within the Offshore Study Area during the HiDef (2015; 2016; 2021) dedicated aerial surveys. Several unidentified seals, which may have included harbour seals, as well as seals or small cetaceans which could not be differentiated at the taxa level, were recorded during each of the survey years. A summary of the dedicated survey data is presented in Table 11.16 below.

Table 11.16 Pinniped sightings recorded during aerial surveys of the Offshore Study Area

Aerial Survey Data Source	Species Names[1]	No. Individuals Sighted	Month(s) Sighted
HiDef (2021)	Unidentified seal species	1	June
	Unidentified seal/small cetacean species	2	January, July
HiDef (2016)	Grey Seal	1	May
	Unidentified seal species	1	February
	Unidentified seal/small cetacean species	2	July, January
HiDef (2015)	Grey Seal	3	March, June, July
	Unidentified seal species	2	March
	Unidentified seal/small cetacean species	4	January, May, November

[1] In some cases, specific species or marine mammal taxa (i.e. whether pinniped or cetacean) were unable to be determined and therefore remain unidentified within the table.

The following sections provide further detail on the distributions of harbour and grey seals in reference to the Offshore Site.

11.4.4.2.1 Harbour seal

Ecology

Harbour seals have a near-circumpolar distribution, with at least four subspecies recognised, each from the eastern and western Pacific Ocean and eastern and western Atlantic Ocean. Individuals occupying UK waters represent roughly 5% of the global population of harbour seal and approximately 50% of the individuals occurring in European waters (Lowry, 2016).

Harbour seals remain at sea for the majority of the year, with a short terrestrial period for breeding, weaning, and moulting. Pupping occurs in the summer months of June and July, with a subsequent catastrophic moult taking place in August for UK harbour seals (SCOS, 2021). Individuals are considered particularly vulnerable to terrestrial disturbance during these periods (Marine Scotland, 2014).

South-East England remains a longstanding key habitat for the species, with population estimates generally showing an upward trend interannually (SCOS, 2021). Two historic declines in harbour seal abundance (in 1988 and 2002) have been attributed to epizootic events caused by Phocine Distemper Virus. Whilst the population in the south-east of England has since recovered from these events, elsewhere along the east and north coasts of Scotland and the Northern Isles, populations have continued to decline (SCOS, 2021). Recently published (2019) survey data have illustrated the possible onset of a population decline within the southeast England region as well, which would make western Scotland the only remaining region with populations that have either stabilised or are increasing (SCOS, 2021).

Harbour seals are exceptionally abundant along the west coast of Scotland, throughout the Sea of the Hebrides and in the Northern Isles (SCOS, 2021). On the east coast of Scotland, harbour seal density estimates are much lower, with relatively few individuals concentrated in the inner bays of the major estuaries and very few animals counted along the peninsular coastlines of Caithness, Moray, Angus, and Fife (SCOS, 2021). This observation carries over to the exposed north coast of Scotland, in which seal count data suggest a relatively small number of individuals occupy the coastline at low densities on the eastern and western extents (SCOS, 2021).

In 2011, the Scottish Government extended existing protections to harbour seals through the designation of 'Seal Conservation Areas' in those regions with elevated abundance or which contain protected sites for the species. Consequently, four Seal Conservation Areas have been established in Orkney and Shetland, the Western Isles, the Moray Firth, and the central east coast of Scotland (including the Firth of Tay and Firth of Forth), all of which lie outside of the Offshore Site.

Seal Management Unit

The Offshore Site falls within the biogeographic range of the NCO SMU, which is estimated to contain nearly two thousand individuals when scaled using sightings availability estimates (see Table 11.15) (SCOS, 2021). This SMU, whose population is concentrated in Orkney, comprises approximately 5.2% of the harbour seal population in Scotland and 4.4% of the total UK population (SCOS, 2021).

The NCO SMU has been in substantial decline for many years. The haul-out count for the SMU in 1996 to1997 was 8,787 harbour seals, which dropped to 1,405 harbour seals in the latest count period between 2016 and 2019 (SCOS, 2021). The latest counts are approximately 85% lower than the 1997 count; and from 2006 onwards, the population has declined by an estimated 10.4% per year (Thompson *et al.*, 2019; SCOS, 2021). The counts for the Sanday SAC (within the NCO SMU) show a similar trend, with a continued decline of 17.8% per year since 2006 (Thompson *et al.*, 2019).

Haul-out counts

Harbour seal haul-out sites along the north coast of Scotland are concentrated to the east of the Offshore Site at Gills Bay / John O'Groats and to the west of the Offshore Site at Tongue. There are very few harbour seal haul-out sites near the Offshore Site (see Figure 11.4). The nearest haul-out sites counted during the SMRU Consulting August seal haul-out surveys are Crosskirk, Port of Brims, and Armadale, though only one harbour seal was counted at each of these sites in 1997 and 2013. There are beaches near the proposed OECC which seals have been noted to utilise, including south of the test site at Warebeth Beach.

At-sea density

No harbour seals were sighted in any of the dedicated aerial surveys (see Table 11.16) (HiDef 2015; 2016; 2021).

Estimates of at-sea density of harbour seal within the PFOWF Array Area are considerably lower than those predicted for the coastal waters around the Orkney Islands (see Figure 11.5) (Carter *et al.*, 2020). The estimated density for harbour seals within the grid cells with a more than 50% overlap with the PFOWF Array Area plus 4-km buffer (six grid cells totalling 150 km^2) is very low, ranging between 0.0048 to 0.0163 individuals/km^2, with a mean value of 0.009 individuals/km^2. The sum of predicted seals for these six grid cells is 1.4 harbour seals.

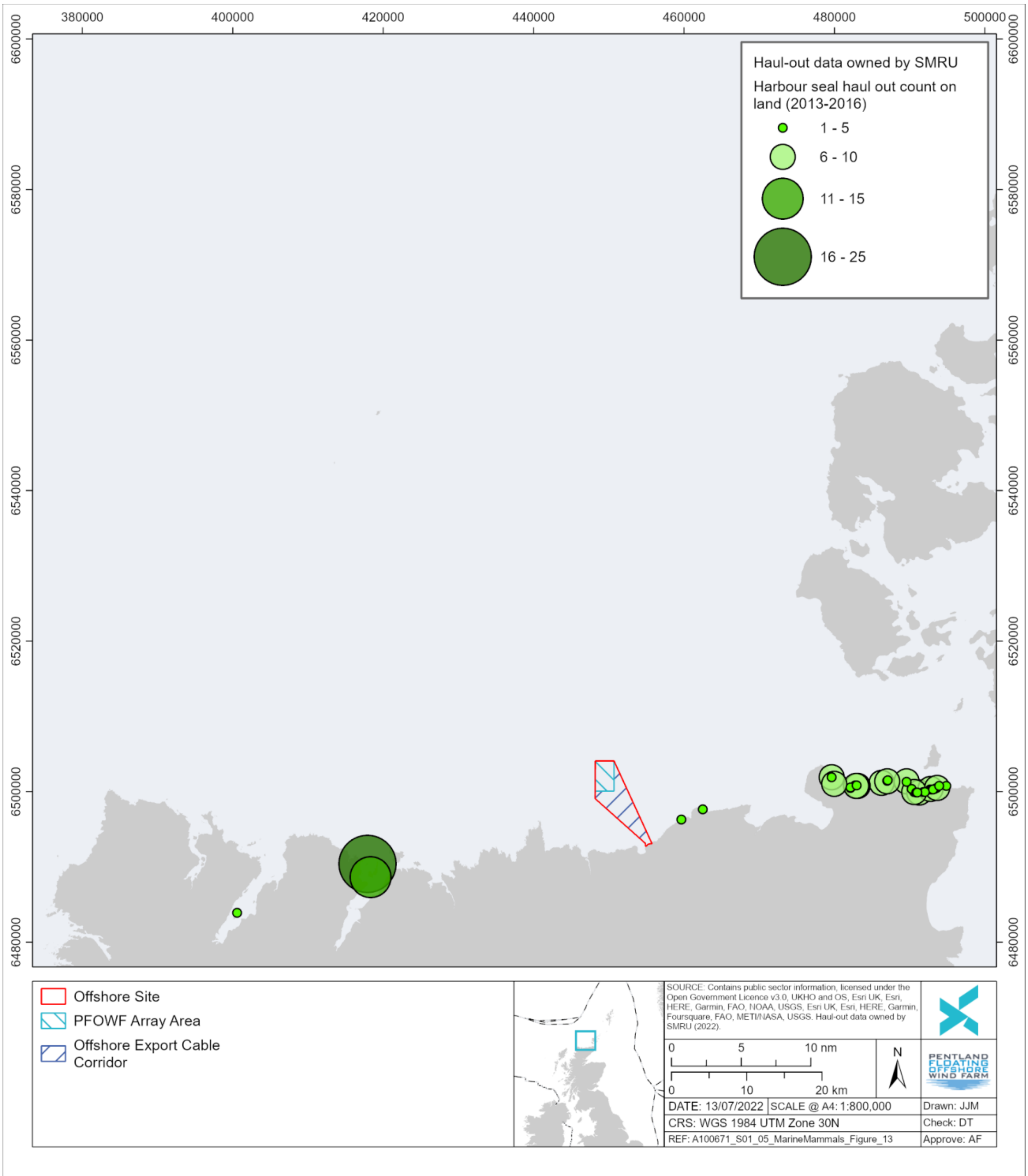

Figure 11.4 Harbour seal haul-out counts across the western north coast of Scotland (data provided by SMRU Consulting)

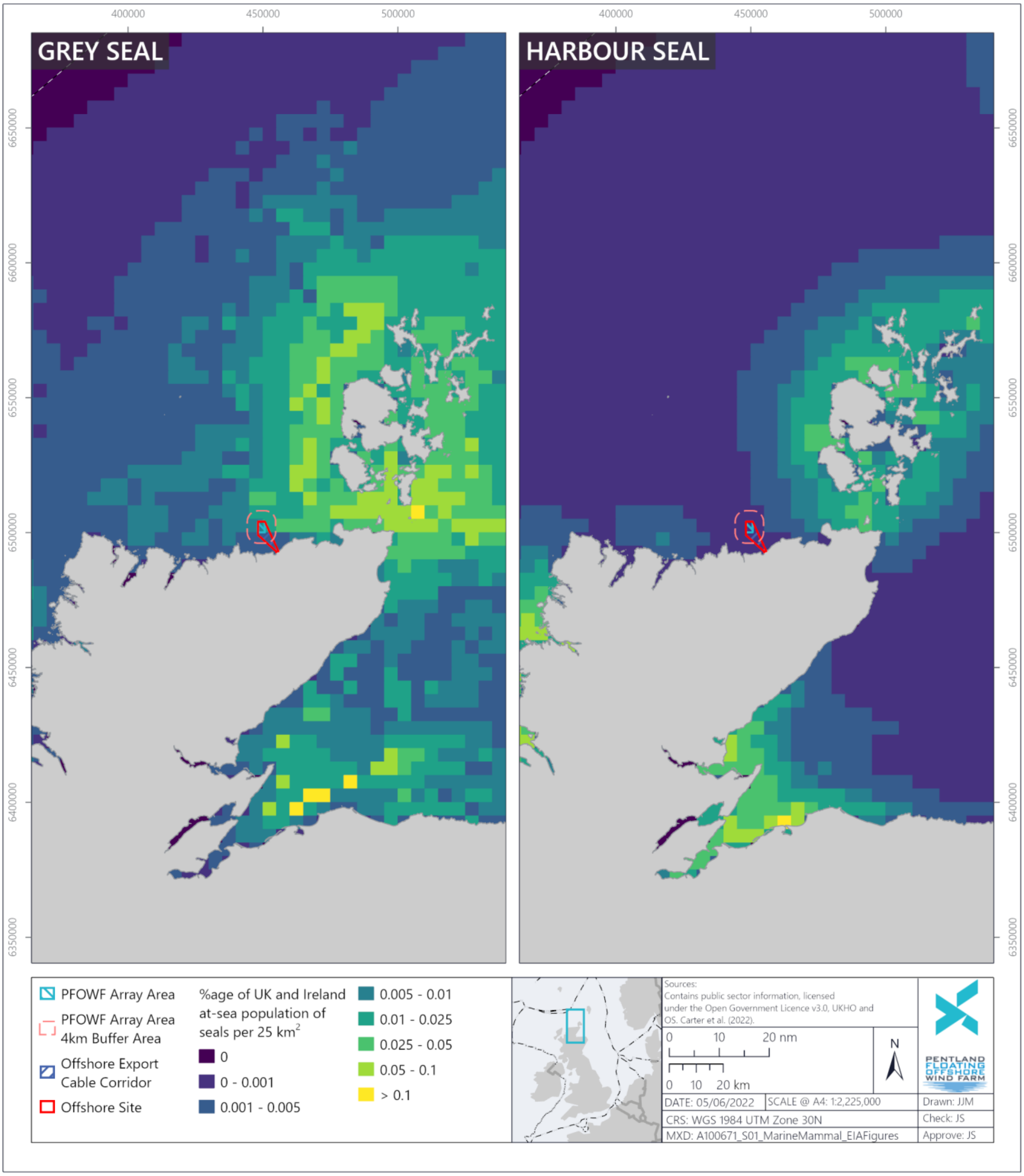

Figure 11.5 At-sea distribution of grey seal and harbour seal derived from seal telemetry data (Carter *et al.*, 2020)

Telemetry data

The telemetry tracks from harbour seals tagged in the NCO SMU (data owned by the Sea Mammal Research Unit) show that they primarily remain within the NCO SMU, with only limited movement into the Shetland MU. There is evidence in the telemetry data of very limited connectivity between the Offshore Site and the Yell Sound Coast SAC on Shetland, and no evidence of connectivity with the Sanday SAC in Orkney.

Summary

As evidenced by available seal count data (SCOS, 2021) and the lack of harbour seal sightings during the dedicated aerial surveys (HiDef 2015; 2016; 2021), the Offshore Site does not appear to form a particularly important habitat to this species in Scotland. Whilst some individuals may be encountered across the Offshore Study Area, such encounters are likely to involve very small numbers of animals and occur on an irregular basis. The Carter *et al.*(2020) habitat-based predicted distribution map provides the most appropriate density surface and was carried forward into the quantitative impact assessment.

11.4.4.2.2 Grey seal

Ecology

Grey seals are much less cosmopolitan species than harbour seals and are only found within the North Atlantic Ocean, with a single subspecies identified in the Baltic Sea (Bowen, 2016). Approximately 36% of the world's grey seals breed in the UK, and 81% of the UK's population of grey seals breed at colonies in Scotland (SCOS, 2021). The largest breeding colonies in Scotland are on the Orkney and Monach Islands (SCOS, 2021). Grey seals breed in the autumn, although pupping varies by location, occurring predominantly between September and late November in north and west Scotland (SCOS, 2021).

Seal Management Unit

The Offshore Site is encapsulated by the grey seal NCO SMU, which supports approximately 36,000 individuals when scaled against availability estimates (see Table 11.15) (SCOS, 2021). The Orkney colony central to this SMU supports approximately 43% of the pup production in Scotland and there is likely to be movement of individuals between this island colony and the mainland, based on available tagging data (see Figure 11.5) (Carter *et al*., 2020).

Haul-out counts

Grey seal haul-out sites along the north coast of Scotland are concentrated to the east of the Offshore Site at Gills Bay / John O'Groats, and to the west of the Offshore Site at Tongue / Whiten Head / Eilean Hoan. Very few grey seal haul-out sites are located near the Offshore Site (Figure 11.6). The nearest haul-out site, counted during the SMRU Consulting August seal haul-out surveys, is Ness of Litter where only one grey seal was counted in 2008. In addition to this, there are beaches near the proposed OECC which seals have been noted to utilise, including south of Warebeth Beach.

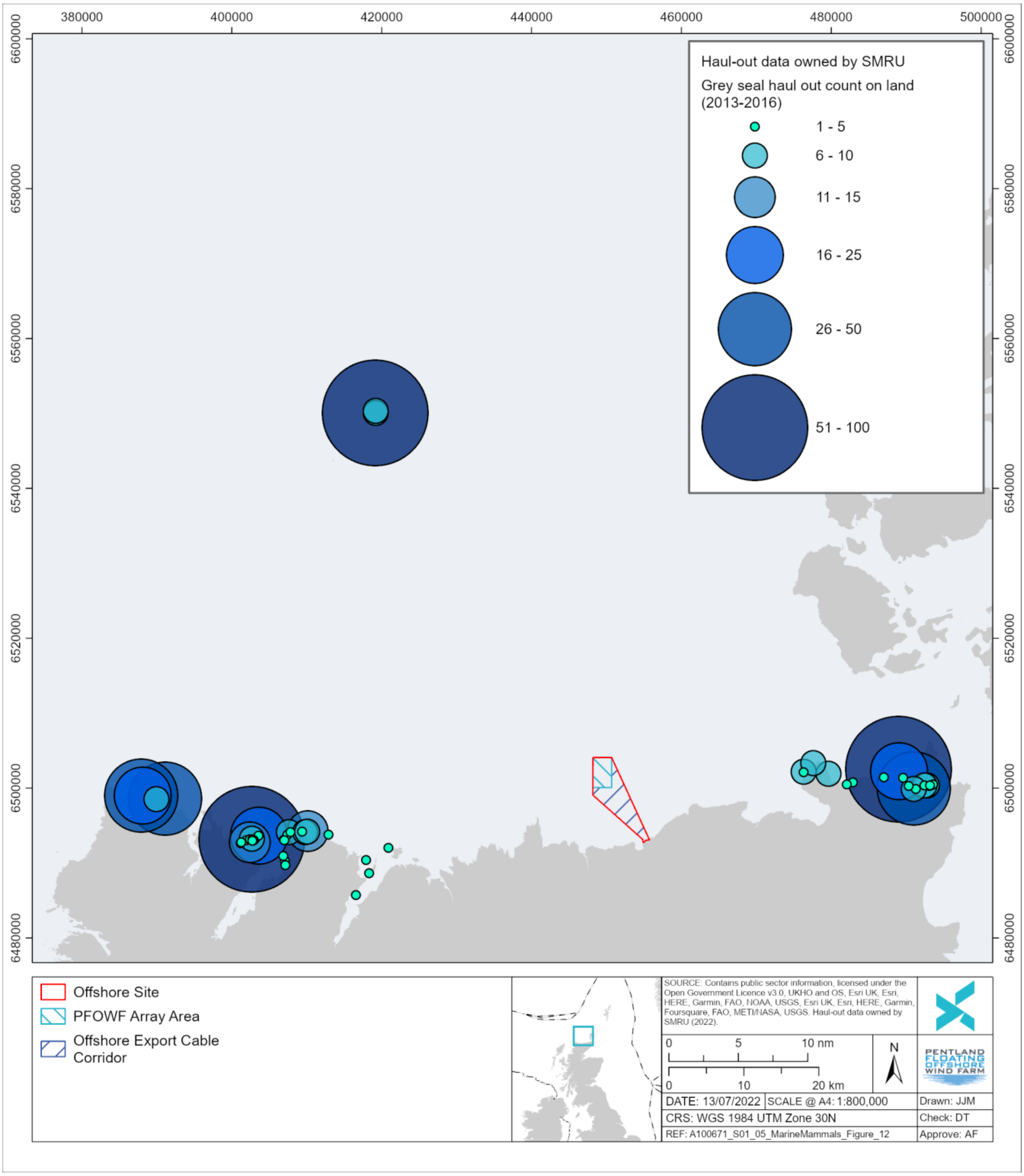

Figure 11.6 Grey seal haul-out counts across the western north coast of Scotland (data provided by SMRU Consulting)

At-sea density

Only a small number of individual grey seals were sighted in the Offshore Study Area during the 2015 and 2016 dedicated aerial surveys undertaken by HiDef. These sightings were limited to four individuals recorded during the spring and summer months (see Table 11.16), during the at-sea period for this species. Table 11.17 summarises the monthly density estimates for grey seal populations identified during the dedicated aerial surveys between May 2015 and April 2016 and January to December 2015 (HiDef 2015; 2016).

Table 11.17 Monthly density estimates for grey seals from the dedicated aerial surveys (HiDef 2015; 2016)

Survey Period	Density (No. indivs/ km^2)	Population estimate	Lower 95% confidence limit of population	Upper 95% confidence limit of population
May 2015 to April 2016	0.01	1	0	2
January to December 2015	0.01	1	0	2

The estimated at-sea density of grey seals within the PFOWF Array Area is considerably lower than that predicted for the coastal waters around the Orkney Islands (see Figure 11.5) (Carter *et al.,* 2020). The estimated density for grey seals within grid cells with a more than 50% overlap with the PFOWF Array Area plus 4-km buffer (six grid cells totalling 150 km^2) is relatively low, ranging between 0.277 to 1.045 individuals/km^2, with a mean value of 0.601 individuals/km^2. The sum of the predicted number of seals for these six grid cells is 90 grey seals.

Telemetry data

Telemetry track data (data owned by the Sea Mammal Research Unit) from grey seals tagged in the NCO SMU show this species ranges much further than harbour seals, with grey seal tracks from animals tagged in the NCO SMU being recorded in the Shetland, Moray Firth, East Scotland, North-East England, West of Scotland, and Western Isles SMUs.

Summary

As evidenced by available seal count data (SCOS, 2021) and the low number of sightings during the dedicated aerial surveys (HiDef 205; 2016; 2021), the Offshore Study Area does not appear to form particularly important habitat to this species in Scotland. Whilst some individuals may be encountered across the Offshore Study Area, such encounters are likely to involve very small numbers of animals and occur on an irregular basis. The Carter *et al.* (2020) habitat-based predicted distribution map provides the most appropriate density surface and was carried forward into the quantitative impact assessment.

11.4.4.3 Basking sharks

Ecology

The basking shark is the largest fish species to occur in UK waters; individuals can reach up to 12 m in length. Having been hunted until the mid-1990s, this species is listed as *Endangered* by the IUCN Red List of Threatened Species (Rigby *et al.,* 2021) and is now protected by a suite of national and international legislation. Basking sharks are included in several key international conventions, including: Appendix II of the Berne Convention, Appendix I/II of the Convention on Migratory Species (Bonn Convention), and Annex V of the Convention for the Protection of the Marine Environment of the North East Atlantic (i.e., the 'OSPAR Convention'). Basking sharks are protected in the UK through the definition of 'offences' by the Wildlife and Countryside Act 1981 (as amended) and in the Nature Conservation (Scotland) Act 2004, whilst the Wildlife and Natural Environment (Scotland) Act 2011 provides a mechanism for licensing potential offences (e.g., disturbance) within Scottish waters. Basking sharks are also listed in several conservation policy documents for their importance as a UK species, including their designation as a Scottish PMF (Tyler-Walters *et al.,* 2016) and their inclusion in the Scottish Biodiversity List.

As cosmopolitan filter-feeders with a circumglobal distribution (Doherty *et al.,* 2017), basking sharks solitarily traverse the open ocean opportunistically foraging for planktonic prey (Bloomfield & Solandt, 2008; Gore *et al.,* 2008). When not occupying deep-ocean waters, basking sharks appear to target oceanic and tidal fronts, such as those seen in the English Channel and along the west coast of Scotland, as they provide more stable foraging opportunities for planktavores (Sims *et al.,* 2000; Priede and Miller, 2008). Foraging activity appears to increase in the summer months in response to increases in zooplankton abundance (Sims *et al.,* 2005). Elevated seasonal densities of basking shark along these foraging hotspots promote an increase in social activity during the summer season and groups of basking sharks can be seen engaging in courtship behaviours along the thermal fronts (Sims *et al.,* 2000).

There is some evidence of seasonal migrations by this species, which appears to occur on both trans-Atlantic and trans-equatorial bearings (Gore *et al.,* 2008; Skomal *et al.,* 2009). Tagging data on individuals in the North-East Atlantic Ocean have shown a seasonal trans-Atlantic migration (Gore *et al.,* 2008), with the Irish Sea and Firth of Clyde serving as key migratory pathways (Sims *et al.,* 2005). Whilst several movement pathways have been identified in the North-East Atlantic Ocean, tagging data indicate that there is much plasticity in individual movement strategies and the use of specific migration routes by entire populations is unlikely (Doherty *et al.,* 2017).

In the UK, basking sharks may be seen throughout the North and North-East Atlantic Ocean, Irish Sea, and Hebridean Sea (Southall *et al.,* 2005; Witt *et al.,* 2012). They visit Scottish coastlines seasonally, arriving in the spring and departing in the autumn. In the summer, individuals spend the majority of their time near the surface, where they appear to be 'basking' whilst feeding on plankton. Summer also functions as a potential breeding season for the species in Scotland, with aggregations of individuals peaking in July and August, including in the Pentland Firth (Evans *et al.,* 2011). Although mainly found around the Western Isles, basking sharks can be seen in the Northern Isles and along the north and east coasts of Scotland as an occasional visitor (Evans *et al.,* 2011).

Density and abundance

Basking sharks were not recorded during any of the dedicated aerial surveys (HiDef, 2015; 2016; 2021), and historical sightings within the Pentland Firth are fairly irregular, without conclusive trends in abundance or distribution (Evans *et al.,* 2011). Sightings have been recorded throughout the year on an *ad hoc* basis, but appear to peak in the summer months (Evans *et al.,* 2011). However, dedicated basking shark surveys are extremely limited in the UK and estimations of absolute density are not available for this species outwith identified hotspots, such as the Sea of the Hebrides and South-West England (Webb *et al.*, 2018; Austin *et al.*, 2019). Consequently, whilst individuals may occupy the Offshore Study Area sporadically, the area does not appear to constitute vital habitat for this species.

Summary

In the absence of density or abundance data for this species, a qualitative impact assessment has been undertaken under the precautionary assumption that individuals may be encountered within the Offshore Site during the life-cycle of the Offshore Development. Based on the above information on patterns of distribution, interactions between the Offshore Development and visiting basking sharks are most likely to occur during the summer foraging season. As the annual foraging season may also function as a breeding season, the summer months are likely to be a particularly sensitive period for this species and this has been considered in the qualitative assessment below.

11.4.4.4 Protected sites

Protected sites considered relevant to the assessment of impacts from the proposed Offshore Development activities have been identified for cetaceans, seals, and basking sharks. The estimated distances to these sites reflect the fact that connectivity with sites protecting marine megafauna will be strictly via travel by sea, as none of these species are considered to regularly travel any meaningful distances over land. As such, least-path distances have been calculated which discount movement over land or waters which fall below the mean high water springs (MHWS) limit. In this way, the distances will be greater than that which would be estimated using straight-line measurements; however, they are more biologically meaningful for the purposes of this impact assessment.

11.4.4.4.1 Protected sites with cetacean features

There are several protected sites designated for the conservation of cetacean features within Scotland which are considered relevant to the Offshore Site, gives its location and that of the cetacean MUs which overlap it. These sites include two SACs (see Figure 11.7) and three Nature Conservation Marine Protected Areas (NCMPAs) (see Figure 11.8). None of these sites directly overlap the Offshore Site.

The UK National Site Network site nearest to the Offshore Site is the Inner Hebrides and the Minches SAC, which is located 112 km to the south-west. This site, which covers the Hebridean Sea from The Minch down to the Sound of Jura, has been designated for the protection of harbour porpoise which occurs in very high densities in the summer months within its boundaries (NatureScot, 2020e). The harbour porpoises which occupy this site are affiliated with the West Scotland MU, which has over 28,000 individuals (IAMMWG, 2021). The Inner Hebrides and the Minches SAC is believed to support one-third of the harbour porpoise population in Scotland during the summer months (NatureScot, 2020e).

The Moray Firth SAC is the second closest UK National Site Network site to the Offshore Site by sea and is located approximately 125 km south-east. It is designated for supporting the only known resident population of bottlenose dolphins in the North Sea (NatureScot, 2021), which are affiliated with the CES MU (IAMMWG, 2021). It is recognised that small sub-groups of bottlenose dolphins from the Moray Firth SAC may transit along the coastline to the Firth of Forth, though they predominantly utilise the more accessible sheltered waters of the Firth of Tay and Eden Estuary. The area comprising the Offshore Site constitutes the northernmost extent of this MU's range, and given their affiliation with very shallow waters, is not considered to form important habitat for this species.

There are three NCMPAs designated for the conservation of cetaceans within Scottish waters which are of relevance to the Offshore Site: the North-East Lewis NCMPA (121.1 km to the south-west), designated for the protection of Risso's dolphins (NatureScot, 2020b); and the Southern Trench NCMPA (133.6 km to the south-east), and the Sea of the Hebrides NCMPA (225.3 km to the south-west), both of which have been designated for the protection of minke whales, which occur in very high densities during the summer months (NatureScot, 2020c; 2020d). The Southern Trench NCMPA and the Sea of the Hebrides NCMPA both contain oceanic fronts formed by unique geomorphologies which provide seasonal foraging habitat to minke whales (NatureScot, 2020c; 2020d). The Sea of the Hebrides NCMPA also appears to form key habitat which is utilised as a migratory pathway by this species (Macleod, *et al.,* 2004; NatureScot, 2020d). Around the North-East Lewis NCMPA, Risso's dolphins of all age classes, including juveniles, occur in increased abundance around the headlands and peninsulas of the north-east corner of the island, making it a unique location for marine mammal conservation within the UK (NatureScot, 2020b).

All other UK National Site Network sites with cetacean features are located more than 500 km from the Offshore Site, with the Southern North Sea SAC being the closest (JNCC, 2021a). Whilst this site does support harbour porpoise from the North Sea Management Unit (NS MU), its distance from the Offshore Site reduces the potential for negative effects to the conservation objectives of this site, as is the case for all of the European sites with harbour porpoise qualifying features which overlap the NS MU. A detailed assessment of potential impacts to cetacean SACs, including identification of those sites which are deemed relevant for Habitats Regulation Appraisal, has been carried out within the RIAA (HWL, 2022).

Figure 11.7 depicts UK National Site Network and European sites with cetaceans as a qualifying feature, illustrating their spatial relationship with the Offshore Site. Distances to the nearest sites for each of the Annex II cetacean species (harbour porpoise and bottlenose dolphin) have been provided.

Figure 11.8 illustrates Scottish NCMPAs with cetaceans as a primary feature and their spatial relationship with the Offshore Site. The distance to the nearest site has been provided.

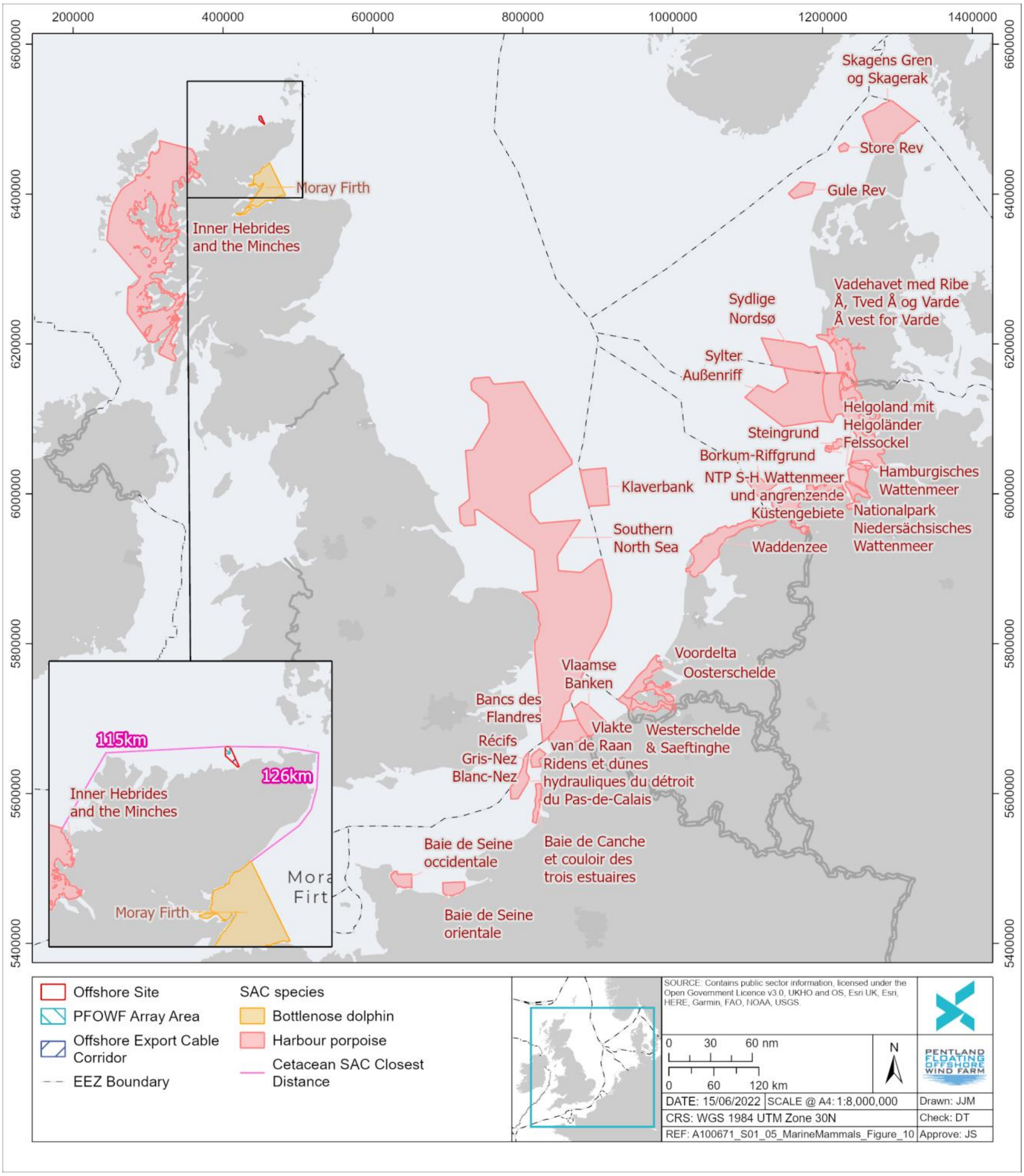

Figure 11.7 SACs with cetaceans as qualifying features which overlap the Offshore Study Area

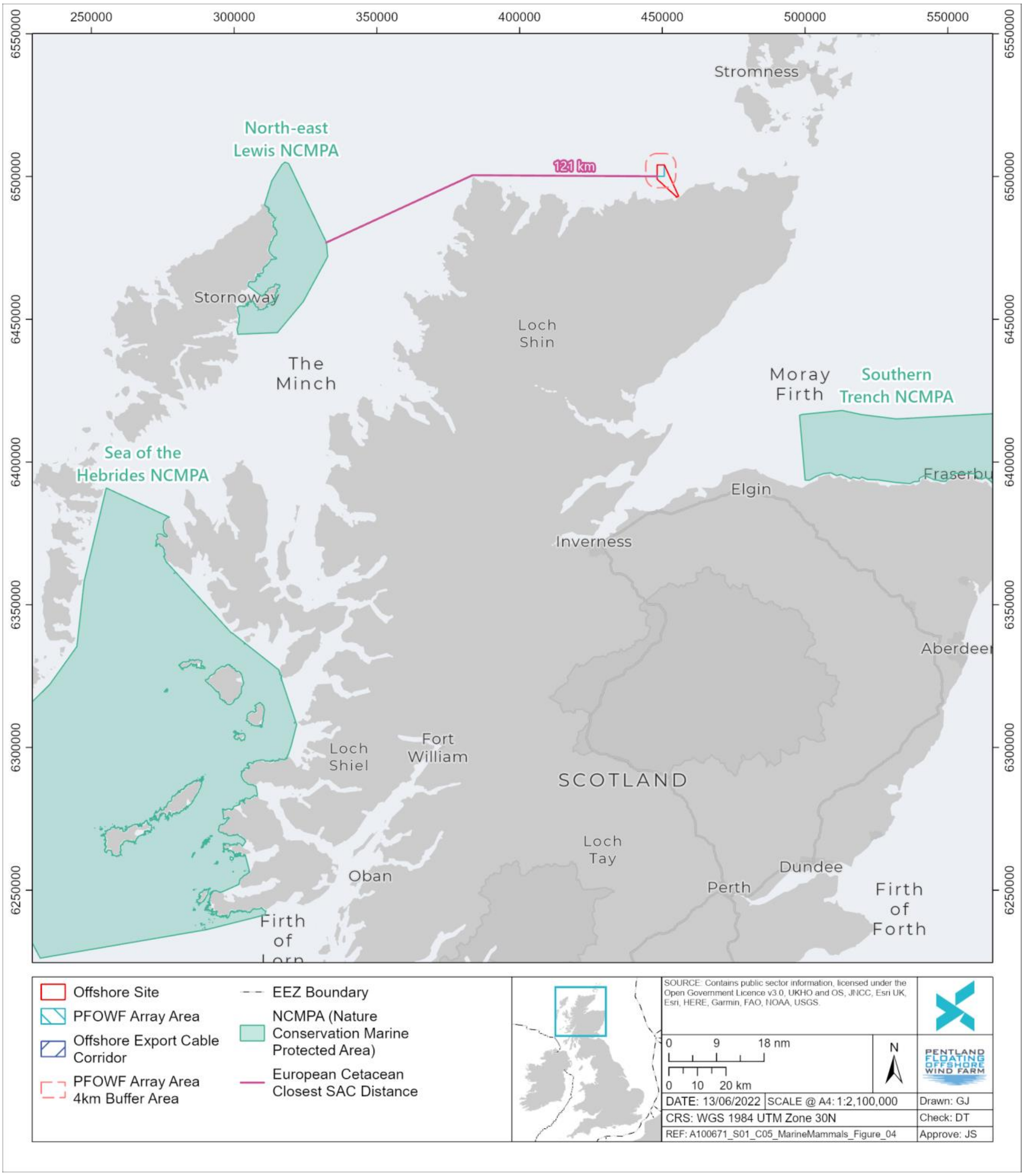

Figure 11.8 NCMPAs designated to protect cetaceans in Scottish waters in relation to the Offshore Site

Table 11.18 provides information on the UK National Site Network and Nature Conservation protected sites with cetacean qualifying features which are relevant to the Offshore Study Area, based on their overlap with the key cetacean MUs (see Table 11.5). A detailed assessment of impacts to UK National Site Network sites has been provided in the RIAA (HWL, 2022) which accompanies this Offshore EIAR. Consultation received on the Nature Conservation Appraisal (NCA) Screening Report (HWL, 2022) advises that only those activities which affect features within the boundary of an NCMPA need to be considered for assessment (see Section 4 of the RIAA [HWL, 2022]).

Table 11.18 Protected sites with cetacean features relevant to the Offshore Study Area (up to 500 km distance)

Site	Designation	Qualifying Species of Interest	Distance to Site (km) [1]	Affiliated MU	Site detail
Inner Hebrides and the Minches	SAC	Harbour porpoise	112.0	WS	> Second largest MPA in Europe and only harbour porpoise MPA in Scotland; > Supports approximately 32% of the Scottish west coast harbour porpoise population; and > The highest density of harbour porpoise in Scotland.
North-East Lewis	NCMPA	Risso's dolphin	121.1	CGNS	> One of two locations in the UK where Risso's dolphin occurs in high densities.
Moray Firth	SAC	Bottlenose dolphin	125.0	CES	> Only North Sea resident population and northern-most population globally; and > The site supports 224 individuals; a proportion of this population present year-round.
Southern Trench	NCMPA	Minke whale	133.6	CGNS	> Area of high seasonal density for juvenile and adult minke whales; and > Summer feeding hotspot.
Sea of the Hebrides	NCMPA	Basking shark and minke whale	225.3	CGNS	> Very high densities of basking shark and minke whale; and > Summer feeding hotspot.
Skerries and Causeway	SAC	Harbour porpoise	401	WS	> Supports a local population of harbour porpoise year-round.
Southern North Sea	SAC	Harbour porpoise	439	NS	> Supports approximately 17.5% of the UK harbour porpoise population (JNCC, 2021a).

[1] Distance has been taken as the 'least cost path' of travel by sea for cetaceans (and basking sharks), which does not consider the straight-line distance to each site or the minimum distance an individual would travel between the Offshore Site and the protected site.

11.4.4.4.2 Protected sites with pinniped features

A variety of protected sites are designated to protect seals in Scottish and UK waters; these include designated seal haul-outs, Sites of Special Scientific Interest (SSSIs), and SACs. There are two SACs designated for the protection of seals within the Pentland Firth and Orkney waters (see Table 11.19 and Figure 11.7 and Figure 11.8).

All UK National Site Network sites designated for the protection of seals as a primary feature are over 90 km from the Offshore Site by sea. The nearest is the Faray and Holm of Faray SAC / SSSI (92.7 km north of the Offshore Site by sea), which has been designated for the protection of grey seals. Annual pup production data estimates that this site supports roughly 9% of the UK pup production for this species (JNCC, 2021b). There is evidence in the telemetry data of very limited connectivity between the Offshore Site and the Faray and Holm of Faray SAC. Additionally, the Sanday SAC / SSSI is located a further 24 km north in Orkney (116.9 km north of the Offshore Site) and has been designated for the protection of harbour seals. This site supports approximately 4% of the UK harbour seal population (JNCC, 2021c) and constitutes the largest aggregation of harbour seals in Scotland.

Individuals at these two UK National Site Network sites are affiliated with the North Coast and Orkney grey seal and harbour seal SMUs; therefore, project-related impacts to those populations have the potential to impact the integrity or conservation objectives of those sites. A detailed assessment of potential impacts to pinniped SACs, including identification of those sites which are deemed relevant for Habitats Regulation Appraisal, has been carried out within the RIAA (HWL, 2022).

Under Section 117 of the Marine (Scotland) Act 2010, the Scottish Government identified and designated haul-out sites for harbour seals and grey seals, where seals come ashore to rest, moult, or breed. The designated haul-out sites were chosen with a focus on implementing legislation to protect seals from harassment at those sites, rather than direct use for marine spatial planning. It is an offence to intentionally or recklessly harass a seal at a haul-out site. There are 194 designated seal haul-outs and 45 breeding colonies located in Scottish waters, the majority of which occur in the Northern Isles and Outer Hebrides (NMPi, 2022).

There are several designated seal haul-out sites within 40 km of the Offshore Site: Eilean nan Ron (Tongue) (26.9 km), Kyle of Tongue Sandbanks (33.5 km), and Loch Eriboll & Whiten Head (35.1 km) to the west, and Gills Bay to the east (38.3 km) (see Table 11.19). Some of the larger designated haul-outs are also considered SSSIs, including the following protected sites in Orkney: Selwick, Eynhallow, Switha, Muckle Green Holm, and Little Green Holm. However, all of these protected sites are located more than 40 km from the Offshore Site, limiting potential interactions with seals associated with these haul-outs, as the at-sea density of seals declines with increasing distance from their haul-out.

Figure 11.9 depicts the Scottish UK National Site Network sites with seals as a qualifying feature, whilst Figure 11.10 shows the designated seal haul-outs and breeding colonies of relevance to the North Coast and Orkney SMUs which encompass the Offshore Site. Distances to the nearest sites for each of the Annex II seal species have been provided.

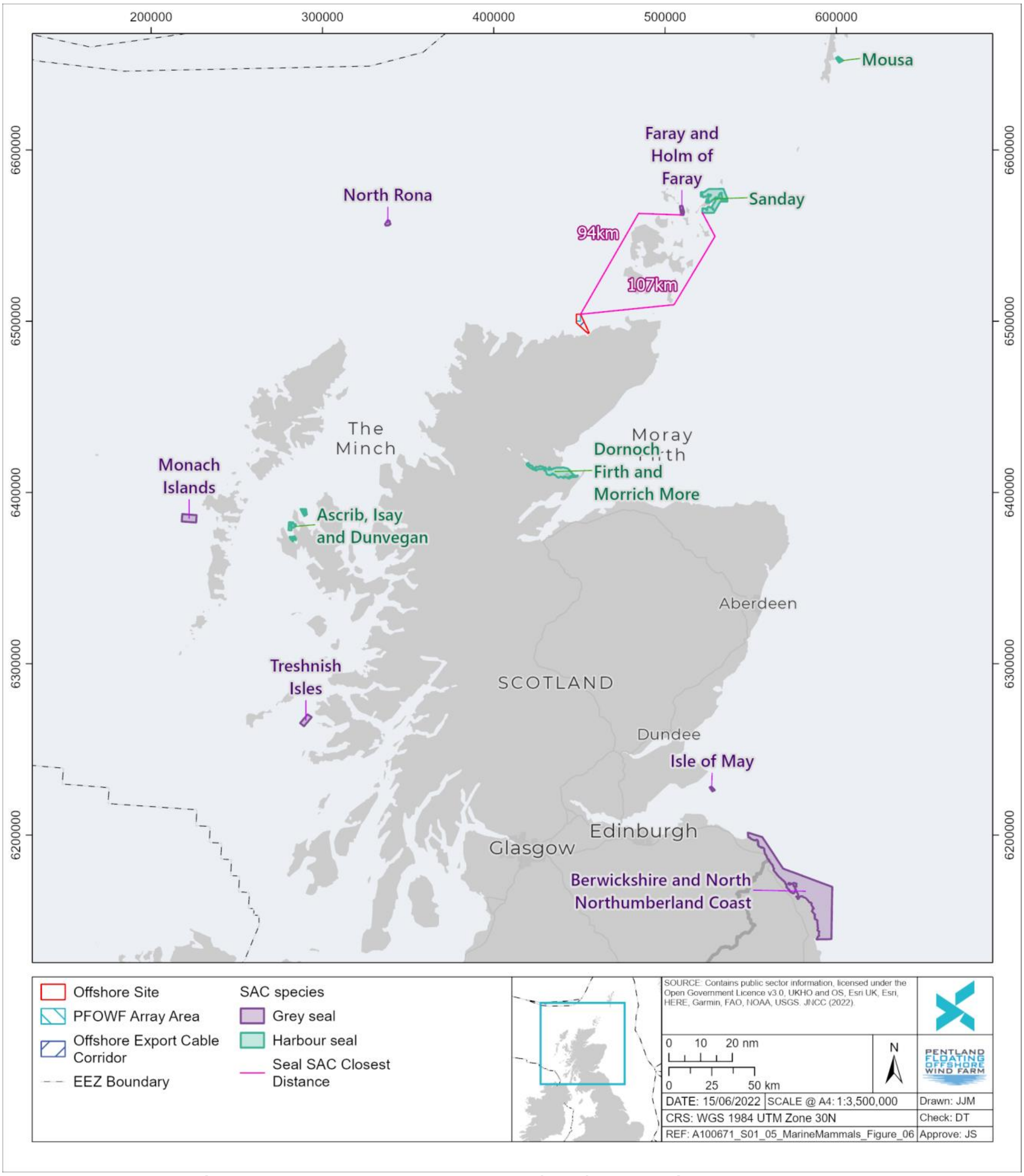

Figure 11.9 UK National Site Network sites with pinnipeds as qualifying features in Scotland. Distances have been highlighted for those sites which are relevant to the Offshore Development based on their overlap with the NCO SMU.

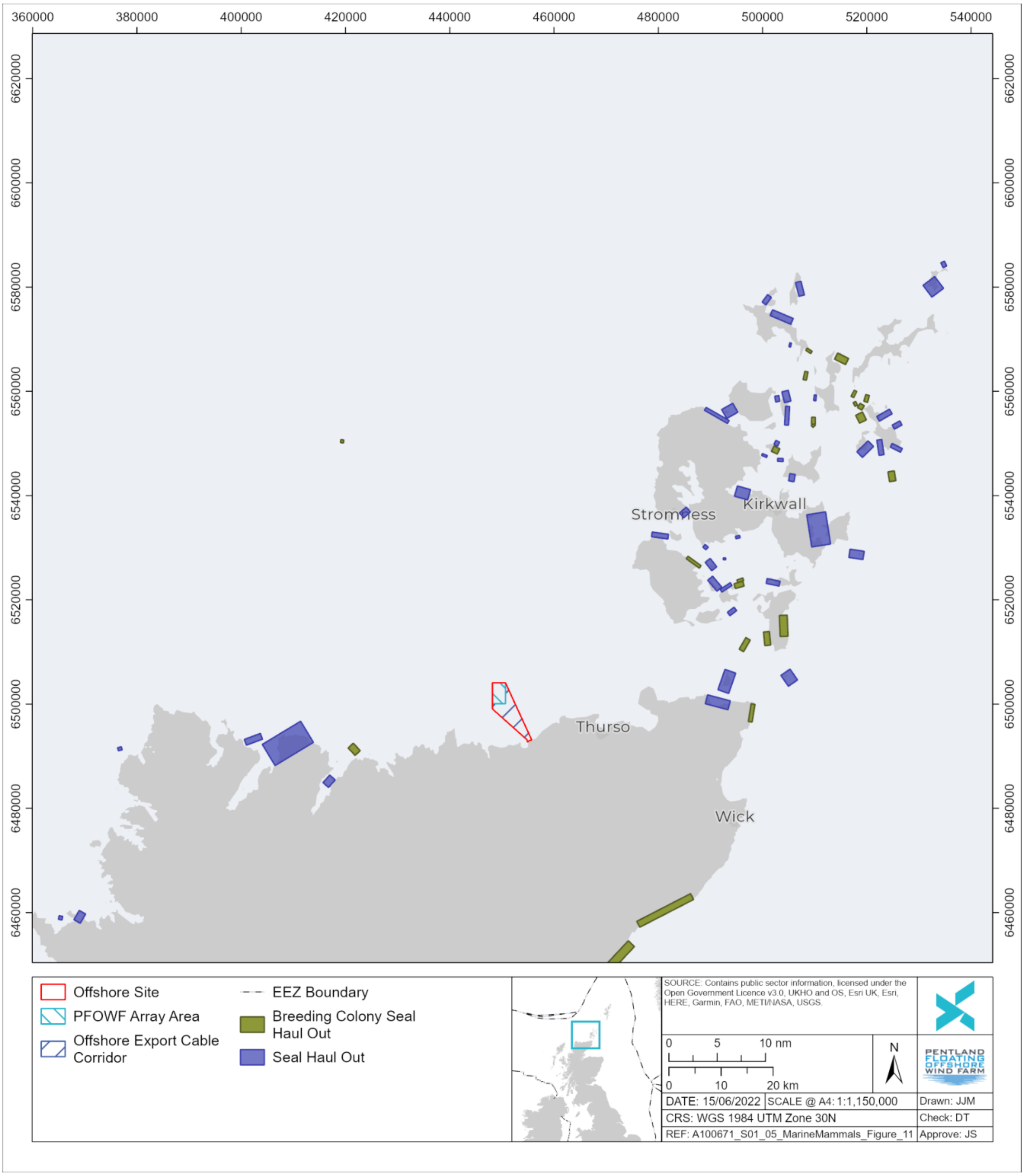

Figure 11.10 Designated seal haul-outs relevant to the Offshore Study Area

Table 11.19 provides information on the UK National Site Network sites with pinniped qualifying features and seal haul-outs which are relevant to the Offshore Study Area, based on their overlap with the NCO SMU. Only those seal haul-outs within 50 km of the Offshore Site have been provided, as this is the range at which harbour seals regularly forage during the breeding season when they occupy their haul-outs. Whilst this distance is less for grey seal, the same 50-km figure was used as a metric as a precaution. A detailed assessment of impacts to UK National Site Network sites has been provided in the RIAA (HWL, 2022) which accompanies this Offshore EIAR.

Table 11.19 Protected sites with pinniped features relevant to the Offshore Study Area

Site	Designation	Qualifying Species of interest	Distance to Site (km)[1]	Site Detail
Faray and Holm of Faray	SAC / SSSI	Grey seal	93	Breeding and moulting site which supports 9% of annual UK grey seal pup production (JNCC, 2021b).
Sanday	SAC / SSSI	Harbour seal	117	Largest aggregation of harbour seals in Scotland which supports 4% of UK harbour seal population (JNCC, 2021c).
Eilean nan Ron (Tongue)	Designated seal haul-out	Grey seal	27	Grey seal breeding colony haul-out.
Kyle of Tongue Sandbanks	Designated seal haul-out	Harbour seal	34	Harbour seal haul-out.
Loch Eriboll and Whiten Head	Designated seal haul-out	Harbour seal	35	Harbour seal haul-out.
Gills Bay	Designated seal haul-out	Harbour seal	38	Harbour seal haul-out.
Selwick	Designated seal haul-out	Harbour seal	39	Harbour seal haul-out.
Stroma	Designated seal haul-out	Harbour seal	41	Harbour seal haul-out.
North East Hoy	Designated seal haul-out	Grey seal	42	Grey seal breeding colony haul-out.
North and East Fara	Designated seal haul-out	Harbour seal	43	Harbour seal haul-out.
Eilean Hoan	Designated seal haul-out	Harbour seal	45	Harbour seal haul-out.
Switha	Designated seal haul-out	Harbour seal	45	Harbour seal haul-out.
Cava	Designated seal haul-out	Harbour seal	45	Harbour seal haul-out.
Flotta Oil Terminal	Designated seal haul-out	Harbour seal	45	Harbour seal haul-out.
Swona	Designated seal haul-out	Grey seal	45	Grey seal breeding colony haul-out.
Holm of Houton	Designated seal haul-out	Harbour seal	46	Harbour seal haul-out.
Bay of Ireland	Designated seal haul-out	Harbour seal	47	Harbour seal haul-out.

Site	Designation	Qualifying Species of interest	Distance to Site (km)[1]	Site Detail
Duncansby Head	Designated seal haul-out	Grey seal	47	Grey seal breeding colony haul-out.
North Flotta	Designated seal haul-out	Grey seal	48	Grey seal breeding colony haul-out.
Barrel of Butter	Designated seal haul-out	Harbour seal	48	Harbour seal haul-out.
Calf of Flotta	Designated seal haul-out	Grey seal	49	Grey seal breeding colony haul-out.
Dunbeath-Wick	Designated seal haul-out	Grey seal	49	Grey seal breeding colony haul-out.

[1] Distance has been taken as the 'least cost path' of travel by sea for pinnipeds, which does not consider the straight-line distance to each site or the minimum distance an individual would travel between the Offshore Site and the protected site.

11.4.4.4.3 Protected sites with basking shark features

The only site in Scotland designated for the protection of basking sharks is the Sea of the Hebrides NCMPA (see Table 11.18) located 225.3 km south-west of the Offshore Site by sea (see Figure 11.8) (NatureScot, 2020c). This site covers the seas between the eastern coastline of the Outer Hebrides and the west coast of the Inner Hebrides, including Skye, Mull, and the Ardnamurchan Peninsula. This region forms a key habitat for basking shark in the UK, particularly between April and October, when regional abundance is highest. This species occurs in very high densities within the Sea of the Hebrides because, similar to minke whales, basking sharks target its front features for prey. Basking sharks also utilise the site to engage in social and courtship behaviours (NatureScot, 2020c), making this region very important for the conservation of this elusive oceanic species.

The consultation received on the NCA Screening Report (HWL, 2022) advises that only those activities which affect features within the boundary of an NCMPA need to be considered for assessment (see Section 4 of the RIAA [HWL, 2022]). Therefore, impacts to protected sites with basking shark features are not considered further within this impact assessment.

11.4.5 Future Baseline

The baseline description for marine mammals and basking sharks within the Offshore Study Area has been detailed in Section 11.4.4. The abundance and distribution of marine megafauna species, including marine mammals and basking sharks, continue to change in response to environmental and anthropogenic pressures, including resource competition (either with other marine species or commercial fisheries), broad-scale habitat change, coastal development, and climate change. These pressures may alter future marine mammal and basking shark distributions across the Offshore Study Area.

Resource competition has mediated habitat use and distribution in the UK's harbour and grey seal populations, and current trends are likely to continue for the immediate future. Annual count data indicate that harbour seal populations have declined along the east coast of Scotland and in Orkney, but have nearly doubled in West Scotland (SCOS, 2020). Areas experiencing declines of this species are also seeing increasing numbers of grey seals, which have moved northward into Scotland to replace harbour seals along the eastern coastline (SCOS, 2020). Continued competition with humans for resources, such as commercially fished prey species or access to coastal habitats which may be marginalised through coastal development, is also likely to continue to shape harbour porpoise, dolphin, and seal distributions around the UK. The future baseline for commercial fishing activity is described in Chapter 13: Commercial Fisheries whilst the future baseline for coastal habitats is described in Chapter 7: Marine Physical Processes.

Similarly, changes in prey species distributions may mediate changes to marine mammal and basking shark distributions over the Offshore Development's life-cycle. Increases in warmer-water fish species have been documented within the Pentland Firth and Orkney region, as well as shifts in the timing of fish spawning, and this may have important implications for the timing and occurrence of marine predators within the Offshore Study Area (Mitchell *et al.*, 2020). Additionally, climate-mediated changes to marine mammal distributions have been observed in recent decades with northward shifts of warmer-water species, such as short-beaked common dolphins, becoming more commonplace (Evans *et al.*, 2020). The influence of climate change on marine predator and prey species is described in Chapter 20: Climate Change and Carbon.

Due to the complex and often compounding nature of environmentally- and anthropogenically-mediated pressures on marine mammal and basking shark habitat use, it is not possible to make accurate predictions on changes to the current baseline description over the Offshore Development's life-cycle.

11.4.6 Summary of Baseline Environment

In summary, multiple marine megafauna receptors have potential sensitivities to the Offshore Development which have been identified as requiring further consideration within this impact assessment. These include several marine mammal species and basking sharks. The key marine mammal receptor species which have been taken forward for assessment include:

> Harbour porpoise;
> Bottlenose dolphin;
> White-beaked dolphin;
> Risso's dolphin;
> Common dolphin;
> Minke whale;
> Harbour seal; and
> Grey seals

Receptors and potential impacts scoped into the assessment, as well as impacts scoped out for further assessment, are provided in Section 11.5 with justifications.

11.4.7 Data Gaps and Uncertainties

As part of the development of the survey methodology, an extensive literature review was undertaken to define marine mammal and basking shark presence within the Offshore Site and its surrounding marine environment. Combined with the data collected during the site-specific aerial surveys, a robust baseline is available for the assessment of impacts to key Marine Mammal and Other Megafauna receptors from activities associated with the Offshore Development.

It should be noted, however, that neither contemporary nor historical sightings records indicate the Pentland Firth to be primary habitat for common dolphins, which are typically found to the west of this region in deeper waters. However, this species was sighted across the PFOWF Array Area during the HiDef (2021) aerial surveys and has therefore been taken forward for further consideration on the basis of precaution. There are as yet no absolute density estimates for common dolphins within the Offshore Study Area or its surrounding waters, only estimates of relative density predicted for this region using established environmental conditions (Waggitt *et al.,* 2020). This gap in data availability is a reflection of this species' occurrence being sporadic within the Pentland Firth (Evans *et al.,* 2011), which complicates the collection of sufficient and complete sightings data for the purposes of density estimation.

Waggitt *et al.* (2020) collated a wide array of survey data on varying temporal and spatial scales for twelve cetacean species and then used species distribution models to standardise the data such that monthly distribution maps could be generated. The outputs of this modelling were monthly predicted density surfaces at a 10 km resolution. Within the study, however, the standardisation of cetacean aerial survey data was limited by the correction of data against 'availability bias' (i.e., how detectable animals were during survey), which can vary with observer technique, and aircraft speed and height, as well as 'perception bias' (i.e., visible cues by animals which are missed by observers) (Waggitt *et al.,* 2020; Pike *et al.,* 2011). In the absence of consistent characterisations of survey methods which influence these biases across these datasets, the correction factor utilised was distilled down to the proportion of time each species spends at the sea surface and was based on previously published data. The authors note that this is a simplistic approach to aerial survey data correction, and it introduces the need for a balanced interpretation of the resulting modelled distributions. Therefore, whilst the density estimates obtained from these maps are representative of relative density across the UKCS, they should not be interpreted as absolute density estimates for use in strictly quantitative assessments of habitat use. They are therefore provided in the above baseline characterisation of common dolphins for illustrative purposes and are used to discuss impacts to this receptor species through a qualitative lens.

11.5 Impact Assessment Methodology

11.5.1 Impacts Requiring Assessment

This assessment covers all impacts identified during the scoping process, as well as any further potential impacts that have been highlighted as the EIA has progressed. It should be noted that impacts are not necessarily relevant to all stages of the Offshore Development.

Table 11.20 below indicates all of the direct and indirect impacts assessed with regard to marine mammals and basking sharks and indicates the Offshore Development phases to which they relate. Cumulative impacts are discussed in Section 11.7.

Table 11.20 Potential impacts requiring further assessment

Potential Impact	Description
Construction	
Noise-related impacts to marine mammals from construction activities	During the construction phase, there is potential for underwater noise emissions to generate physiological impacts, barrier effects and displacement to marine mammal receptors. The activities which have been identified as being possible sources of disturbance and/or injury include anchor pile installation; geophysical and UXO survey activities (including pre- and post-installation surveys); and additional construction activities (i.e., vessel noise from installation works, cable laying, trenching, and rock placement, etc.).
Noise-related impacts to basking sharks from low-frequency construction noise	Low-frequency sound associated with the possible drilling-based installation of the anchor piles has the potential to introduce important levels of sound for any basking sharks occupying the Offshore Study Area at the time of construction.
Operation and Maintenance	
Noise-related impacts to marine mammals during operation and maintenance	During the operation and maintenance phase, underwater noise emissions associated with mooring line 'pinging' (sudden re-tensioning of mooring lines which makes a snap or ping sound), maintenance and monitoring surveys and vessel noise have the potential to generate physiological impacts, barrier effects, and/or displacement to marine mammal receptors.
Entanglement risk to marine mammals and basking sharks	The introduction of mooring lines and cables into the marine environment may generate a risk of injury to marine mammals or basking sharks resulting from direct entanglement with these lines, or indirect entanglement with debris, such as derelict fishing gears, which themselves become entangled in the mooring and cable infrastructure. The potential for ghost fishing gear entanglement with the offshore infrastructure is characterised within Chapter 13: Commercial Fisheries.
Collision risk to marine mammals and basking sharks	The floating substructures may have the potential to introduce collision risk to marine mammals or basking sharks entering the PFOWF Array Area.
Displacement or barrier effects	The physical presence of the array infrastructure, including substructures, mooring lines and cables, may impact marine mammals and basking sharks through changes in habitat use

Potential Impact	Description
	which could result in displacement from the Offshore Site or barrier effects which limit access to key habitats surrounding the Offshore Study Area.
Long-term habitat change	Over the lifetime of the Offshore Development, there is potential that long-term habitat change can result from the existence of the Offshore Development within the Pentland Firth. Long-term habitat change may include changes to habitat quality (e.g., depleted prey resources or foraging opportunities, or conversely, the concentration of prey resources) resulting from the introduction of infrastructure (including hard substrate) into the marine environment.
Decommissioning	
Long-term habitat change	Long-term habitat change, including the potential for changes to habitat quality (e.g., depleted resources or foraging opportunities) is considered on a worst-case basis, in the absence of a full decommissioning programme.

The assessment of noise-related impacts on marine mammals was a desk-based exercise making use of project-specific modelling. The impact assessment was undertaken by SMRU Consulting and supported by Subacoustech, who undertook the underwater noise propagation modelling.

It should be noted that an unexploded ordnance (UXO) survey using a magnetometer will be undertaken in Summer 2022 or 2023 to identify any UXO that may need to be avoided by minor re-routeing of the cables, or minor modifications of the anchor positions. Multibeam echo sounder (MBES) and side scan sonar (SSS) will also be required during this survey.

An initial desk-based UXO assessment undertaken by Ordtek (2021) has indicated that there is a low likelihood of encountering UXO during the planned activities, and it should be possible to avoid any UXO which may be encountered. Should UXO be identified during any phase of the project, consultation with key stakeholders would be undertaken to inform the decision to detonate, clear or avoid and what mitigation may be required. Any plans to detonate or clear a UXO would be subject to separate assessment and licence applications which would be informed by the outcomes of the UXO survey campaign.

To provide a comprehensive assessment of the realistic worst case impacts associated with Offshore Development activities, an initial indicative assessment of noise-related impacts from UXO clearance has been undertaken for the construction phase of the Offshore Development in Section 11.6.1.1 below.

All other impacts assessed in this chapter have been informed by the available data and through consultation with relevant stakeholders. Although some of the identified impact pathways do not possess real-world examples illustrating their potential to impact marine mammal or basking shark populations (e.g., entanglement in floating mooring lines and cables associated with offshore wind and marine renewable energy [MRE] infrastructure), these activities have been considered using the Precautionary Principle.

11.5.2 Impacts Scoped Out of the Assessment

The following impacts were scoped out of the assessment during EIA scoping:

> Corkscrew injury to seals from vessel activities:

  Research by Brownlow *et al.* (2016) has shown irrefutable evidence that 'corkscrew' injuries can be caused by grey seal predation on weaned grey seal pups (reported from the Isle of May). Furthermore, there have been observations of an adult male grey seal killing and eating young harbour seals in Germany (van Neer *et al.,* 2016). Based on these recent findings, the Regulators and Statutory Nature Conservation Bodies (SNCBs) now consider that the use of vessels with ducted propellers, which were initially thought to be responsible for the spiral lacerations seen on seals in recent years, may not pose any increased risk of injury to seals over and above normal shipping activities. Moreover, it is expected that many of the vessels which will be employed during the proposed activities will have normal (non-ducted) propellers. Shipping activities will be managed through Vessel Management Plans (VMPs), as detailed in Section 11.5.5 below. Consequently, the risk of corkscrew injury to seals is not anticipated to result from any of the proposed activities associated with the Offshore Development;

> Disturbance from electromagnetic field (EMF) emissions:

  Although there is limited research into the effects of EMFs on marine mammals and basking sharks, there is also very little indication that the emission of EMFs generates acute or severe adverse effects on those taxa. Marine mammals are considered less sensitive to EMFs than elasmobranchs, which utilise EMFs to aid in migration, orientation and hunting (Copping *et al.,* 2020). However, there are no data on basking shark perception of EMFs, only the assumption that they possess the ability to detect them (Kempster and Collin, 2011). Based on evidence from the EMF study undertaken for the Offshore Development (Prysmian, 2022), EMF emissions from the Offshore Export Cable(s) will be well below those from the Earth's magnetic field and are anticipated to be indetectable within a few tens of metres of the cables (Drewery, 2011). It is therefore highly unlikely that the Offshore Development has the potential to bring about perceptible physiological or behavioural changes to widely distributed and free-ranging marine megafauna receptors;

> Disturbance or displacement from temporary increases in suspended sediments:

  All marine megafauna found in UK waters have some level of adaptation to deal with short-term reductions in visibility, such as those experienced when foraging at depth or outwith daylight hours. Habitat use by cetaceans and basking sharks predominantly takes place within the water column, so these animals are less likely to interact with temporary increases in turbidity occurring near the seabed. Seals, which are more likely to forage at depth and on the sea floor, regularly experience elevated levels of localised sediment suspension (e.g., due to a reduction in water column volume or as a result of their foraging techniques). As such, this taxa has adapted to utilise their vibrissae (whiskers) and other tactile information as the primary sense during times of reduced visibility (Murphy *et al.,* 2015). For these reasons, no significant disturbance or displacement impacts to any marine megafauna are anticipated from the proposed Offshore Development activities;

> Disturbance in the very nearshore environment due to underwater noise generated by horizontal directional drilling (HDD):

  HDD is planned for landfall (the first 400 m to 700 m from Mean High Water Springs) of the Offshore Export Cable(s) as it leaves the Onshore Site and enters the marine environment. However, as the noise source itself comes from machinery on land and underground and the noise source will be radiated into the seabed within the highly energetic coastal environment. A study by Nedwell *et al.* (2012) indicates that the noise which will be generated by the HDD activities is anticipated to be <130 dB re. 1µPa at the seabed, will not exceed the ambient noise of the nearshore environment. Therefore, there is no potential for adverse effects on marine mammals, and this impact has not been considered further within this assessment;

> Disturbance due to the physical presence of vessels:

  As agreed in consultation with NatureScot (see Table 11.3), it is difficult to separate disturbance caused by vessel presence from that generated by vessel noise. The consultees have agreed that they are content that disturbance due to the physical presence of vessels is scoped out, providing that disturbance-related impacts to marine mammals are fully considered in an underwater noise assessment. Section 11.6.1.1.4 includes a full assessment of vessel noise and any potential disturbance impacts it may have on marine mammal receptors. In line with the advice received, disturbance from the physical presence of vessels has not been considered further in the impact assessment below; and

> Collision risk with vessels:

  Vessel movements will be managed under a Vessel Management Plan (VMP), which has been outlined in Section 11.5.5. The VMP includes safety measures to protect and reduce the risk of direct interactions with marine wildlife using protocols supplied in the Scottish Marine Wildlife Watching Code (NatureScot, 2017). This type of mitigation is considered to be standard and thus inherently part of the Offshore Development Design. As such, the risk of injury resulting from the collision of marine mammals and basking sharks with vessels has not been considered further.

11.5.3 Assessment Methodology

The EIA process and methodology are described in detail in Chapter 6: EIA Methodology. Offshore Development specific criteria have been developed for the sensitivity the receptor, and the likelihood and magnitude of impact as detailed below.

The assessment methodology provided for Marine Mammal and Other Megafauna receptors has been developed to reflect the sensitivities and conservation needs of highly mobile species. Definitions of impact magnitude and significance have been adapted from the *Guidelines for ecological impact assessment in the UK and Ireland: terrestrial, freshwater and coastal* (CIEEM, 2016) with those receptors in mind.

11.5.3.1 Receptor sensitivity

The sensitivity of a species receptor can be viewed as the ability of that species to tolerate change. The sensitivities of the marine mammal and megafauna species under consideration have been delineated using available data and are described in detail in Section 11.4.

The approach taken in this assessment is that a marine mammal or basking shark population that is of high sensitivity is considered to be a receptor with no ability to adapt to, tolerate, or recover from potential changes resulting from Offshore Development-specific impacts. Accordingly, if a species population is considered to be of low sensitivity, the Offshore Development is not anticipated to have the potential to generate any important effects on the population over its biogeographic extent.

The benchmark conservation status considered within the assessment of marine mammal sensitivity is 'Favourable Conservation Status', as defined within the *Favourable Conservation Status: UK Statutory Nature Conservation Bodies Common Statement* (JNCC, 2018). The approach of this assessment is to determine the value of the Offshore Site to each species, by considering the likely number of individuals within the Offshore Site and the nature of their habitat use, rather than aiming to define the overall conservation value of each species. However, the biodiversity conservation importance of each species remains an important factor in the evaluation process of impact significance, which is defined in Section 11.5.3.4.

Table 11.21 summarises the criteria used to define receptor sensitivity throughout this assessment.

Table 11.21 Receptor sensitivity assessment criteria

Sensitivity	Criteria
Very High	No ability to adapt behaviour so that individual vital rates (survival and reproduction) are highly likely to be significantly affected. No tolerance: The effect will cause a significant change in individual vital rates (survival and reproduction). No ability for the animal to recover from any impact on vital rates (survival and reproduction).
High	Very limited ability to adapt behaviour so that individual vital rates (survival and reproduction) are likely to be significantly affected. Very limited tolerance: The effect is likely to cause a significant change in individual vital rates (survival and reproduction). Very limited ability for the animal to recover from any impact on vital rates (survival and reproduction).
Moderate	Limited ability to adapt behaviour so that individual vital rates (survival and reproduction) may be significantly affected. Limited tolerance: The effect may cause a significant change in individual vital rates (survival and reproduction). Limited ability for the animal to recover from any impact on vital rates (survival and reproduction).

Sensitivity	Criteria
Low	Ability to adapt behaviour so that individual vital rates (survival and reproduction) may be affected, but not at a significant level. Some tolerance: No significant change in individual vital rates (survival and reproduction). Ability for the animal to recover from any impact on vital rates (survival and reproduction).
Negligible	Receptor is able to adapt behaviour so that individual vital rates (survival and reproduction) are not affected. Receptor is able to tolerate the 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.

11.5.3.2 Receptor value

The value or importance of a receptor is based on a pre-defined judgement based on legislative requirements, guidance, or policy, which are shaped by the views of key stakeholders, experts, and specialists.

All Marine Mammal receptors are of intrinsically 'high' conservation value due to their inclusion in Annex IV of the EU Habitats Directive as an EPS and/or as qualifying interests of UK and European protected sites (i.e., SACs). Similarly, basking sharks are listed as '*Vulnerable'* on the IUCN Red List of Threatened Species, which also equates to a receptor value designation of 'high'. For these reasons, receptor value has not been used to differentiate impact outcomes to the species populations under consideration. Rather, the assessment has focused on the individual species' sensitivities to the impact pathways being assessed.

11.5.3.3 Defining impact magnitude

Defining impact magnitude requires consideration of how the following factors will impact on the baseline conditions:

- Spatial Extent: The area over which the impact will occur;
- Duration: The period of time over which the impact will occur;
- Frequency: The number of times the impact will occur over the Offshore Development's life-cycle;
- Intensity: The severity of the impact;
- Likelihood: The probability that the impact will occur and the probability that the receptor will be present; and
- Reversibility: The ability for the receiving environment / exposed receptor to return to baseline conditions.

Based on these parameters, and expert judgement, a summarised description on the assignment of magnitude criteria is provided in Table 11.22.

The impact magnitude is defined by the extent of the impact outcomes and their durations. A high impact magnitude relates to irreversible changes to a species population or its habitat area, whilst a low impact magnitude is associated with a minor shift from the baseline conditions for a species receptor, including short-term changes, which will not affect the overall character or conservation status of that receptor.

Table 11.22 Magnitude of impact criteria

Magnitude	Criteria
High	Total loss of, or major alteration to conservation status or integrity of a receptor with the situation likely to be irreversible, even in the long-term. Fundamental alteration to the character and composition of any proposed or designated protected sites.
Moderate	Clear effect on the conservation status or integrity of the receptor in the short to medium term (i.e., 6 to 15 years), although this is likely to be reversible in the long-term (i.e. 15 years or more) through replacement.
Low	A minor shift away from baseline conditions. Effects will be detectable but unlikely to be of a scale or duration to have a significant effect on the conservation status or integrity of the receptor in the short term (i.e. 1 to 5 years). Overall baseline character of the site will not be substantially altered.
Negligible	A very slight change from the baseline conditions. Changes are barely detectable, approximating to the 'no change' situation. Any effects are likely to be reversible within 12 months and not affect the conservation status or integrity of the receptor.
No Change	The 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.

11.5.3.4 Evaluation to determine significance of effect

Significance of an effect is determined by correlating the magnitude of the impact and the sensitivity of receptor in conjunction with professional judgement, using industry best practice guidance, science and accepted approaches.

To ensure a transparent and consistent approach throughout the Offshore EIAR, a matrix approach has been adopted to guide the assessment of significance of effects in Table 11.23. There is however latitude for professional assessment where deemed appropriate in the application of this matrix.

Table 11.23 Significance of effects matrix

Significance of Effects Matrix					
Sensitivity of Receptor	Magnitude of Impact				
	No Change	Negligible	Low	Moderate	High
Negligible	Negligible	Negligible	Negligible	Negligible	Minor
Low	Negligible	Negligible	Minor	Minor	Moderate
Moderate	Negligible	Minor	Minor	Moderate	Major
High	Negligible	Minor	Moderate	Major	Major
Very High	Negligible	Minor	Major	Major	Major

Definitions of significance of effect are described in Table 11.24. For the purposes of the Offshore EIAR, any effect with a significance of moderate or greater is generally considered 'significant' in EIA terms and additional mitigations may be required. While effects identified as minor or negligible are generally considered to be 'not significant' in EIA terms.

Table 11.24 Assessment of consequence

Assessment Consequence	Description (consideration of receptor sensitivity and value and impact magnitude)	Significance of Effect
Major Effects	Effects (beneficial or adverse) are likely to be highly noticeable and long-term, or permanently alter the character of the baseline and are likely to disrupt the function and/or status / value of the receptor. They may have broader systemic consequences. These effects are a priority for mitigation in order to avoid or reduce the anticipated significance of the effect.	Significant
Moderate Effects	Effects (beneficial or adverse) are likely to be noticeable and result in lasting changes to the character of the baseline and may cause hardship to, or degradation of, the receptor, although the overall function and value of the baseline / receptor is not disrupted. Such effects are a priority for mitigation in order to avoid or reduce the anticipated significance of the effects.	Significant
Minor Effects	Effects (beneficial or adverse) are expected to comprise noticeable changes to baseline conditions, beyond natural variation, but are not expected to cause long-term degradation, hardship, or impair the function and value of the receptor. Such effects are not typically contentious and will not generally require additional mitigation but may be of interest to stakeholders.	Not Significant
Negligible	Effects are expected to be either indistinguishable from the baseline or within the natural level of variation. These effects do not require mitigation and are not anticipated to be a stakeholder concern and/or a potentially contentious issue in the decision-making process.	Not Significant

11.5.4 Design Envelope Parameters

As detailed in Chapter 5: Project Description, this assessment considers the Offshore Development parameters which are predicted to result in the greatest environmental impact, the ‘realistic worst case scenario’. The realistic worst case scenario represents, for any given receptor and potential impact on the receptor, various options in the Design Envelope that would result in the greatest potential for change to receptor in question. In this way, use of the ‘realistic worst case scenario’ provides for a cautious assessment of the potential impacts of the Offshore Development on the environment, in alignment with the *Good Practice Guidance for Applications under Section 36 and 37 of the Electricity Act 1989* (Scottish Government, 2022a).

Given that the realistic worst case scenario is based on the design option (or combination of options) that represents the greatest potential for change, confidence can be held that the development of any alternative options within the design parameters will give rise to no effects greater or worse than those assessed in this impact assessment. Table 11.25 presents the realistic worst case scenario for potential impacts on marine mammals and basking sharks during the construction, operation and maintenance, and decommissioning phases of the Offshore Development.

For marine mammals and basking sharks, the realistic worst case scenario has been derived by applying the contemporary understanding of the key species’ sensitivities to the proposed activities and identifying which aspects of the Design Envelope would be most likely to result in the largest impact magnitude for each. This includes a consideration of the maximum parameters of components for the Offshore Development with the potential to interact with those receptors considered.

Where there are a number of options for the various Offshore Development components, the option which has the largest potential impact on each of the species receptors has been assessed at the maximum parameters identified. In the case of piling, for example, the impact pilling parameters have been assessed for noise-related impacts as they have the greatest potential underwater noise impact magnitude, based on the noise propagation modelling undertaken by Subacoustech (2022) in Offshore EIAR (Volume 3): Technical Appendix 10.1: Underwater Noise Modelling Report. Soft start procedures have been assumed during the modelling and have been included as an embedded mitigation.

Similarly, for entanglement impacts from lines and cables within the water column, catenary mooring configurations have been identified as the worst case scenario, both in terms of their marine footprint and their physical character (i.e., their slackness forms a significant indicator of entanglement risk).

Table 11.25 details the Design Envelope scenarios which are considered to be the 'realistic worst case' and have, therefore, been carried forward to provide a cautious assessment of impacts to marine mammal and basking shark receptors. Source level values for the noise-related impacts were taken from Subacoustech (2022) in Offshore EIAR (Volume 3): Technical Appendix 10.1 and references are provided therein.

Table 11.25 Design parameters specific to the assessment of impacts to marine megafauna receptors

Potential Impact	Design Envelope Scenario Assessed
Construction Phase	
Noise-related impacts to marine mammals associated with construction noise, including the risk of physiological impacts, barrier effects, and displacement	**Anchors: Impact piles** > Up to nine impact piles per WTG (63 piles total), each pile being up to a maximum of 5 m in diameter. The following scenario is considered as the worst case for the impact assessment: o 5-m diameter tubular pile, 20 m length. Installed using a hammer with maximum blow energy of 2500 kJ over a total period of eight hours per pile. A maximum of three piles installed in 24 hours; o A minimum of one pile installed in 24 hours; o A maximum of 63 days of piling; and > Soft-start procedures assume 5% of maximum hammer energy for the first five minutes, doubling every five minutes for up to 20 minutes before full hammer energy is employed. > Note that drilled piles remain an option that will be considered within the EIA. However, drilling operations do not represent the worst case in terms of noise propagation for marine mammals as found in the Offshore EIAR (Volume 3): Technical Appendix 11.1. **Geophysical surveys** (includes pre- and post-installation surveys and surveys to confirm the presence of any UXOs) > MBES: o Frequency: 200 kHz to 400 kHz; and o SPL: 218 (peak), 213 (rms) $dB_{re\ 1\ \mu Pa\ @\ 1m}$; > SSS: o Frequency: 300 kHz and 900 kHz; o SPL: 210 (peak), 242 (rms) $dB_{re\ 1\ \mu Pa\ @\ 1m}$; > Ultra-short Baseline: o Frequency: 20 kHz to 35 kHz; and o SPL: 194 (peak), 188 (rms) $dB_{re\ 1\ \mu Pa\ @\ 1m}$. **UXO Clearance** In response to consultation received during the Scoping phase, UXO has been included for consideration within this Offshore EIAR. UXO clearance is not planned nor anticipated to be required for the Offshore Development, based on the risk assessment carried out by Ordtek (2021). Any UXO clearance activities which are identified as being required during the UXO and geophysical survey campaign will be considered in consultation with the relevant stakeholders and will be covered under a separate licence. Should clearance be

Potential Impact	Design Envelope Scenario Assessed
	required during the pre-construction phase, it would generate temporary underwater noise emissions with the potential to injure or disturb marine megafauna. > High-order detonation charge size: 525 kilograms (plus donor charge). **Other construction activities** > Suction dredging forms the worst case intermittent, non-impulsive noise source during construction: o SPL: 186 (rms) $dB_{re\ 1\ \mu Pa\ @\ 1m}$; > Vessel noise from various survey vessels, cable installation, crew transfer, and support vessels: o A maximum of 10 vessels will be in the Offshore Site simultaneously; o Large vessels (>100 m) produce the loudest continuous noise source; o SPL: 168 (rms) $dB_{re\ 1\ \mu Pa\ @\ 1m}$.; and o 1,630 concurrent vessel days from 10 different vessels.
Noise-related impacts to basking sharks from low frequency construction noise	**Anchors: Drilled piles** > Maximum number of piles: 63 (nine per WTG); > Drilling forms the worst case scenario for underwater noise for basking sharks: o Pile diameter: 3 m; o Burial depth: 49.5 m; o Average duration drilling for one WTG location: seven days; and o Total days of drilling: 49 days (seven days per WTG).
Operation and Maintenance Phase	
Noise-related impacts to marine mammals associated with operational noise, including the risk of physiological impacts, barrier effects, and displacement as a result of operational monitoring surveys and vessel activities	**Mooring lines** (Specifically mooring line pinging: The sudden re-tension in a mooring line following a period of slackness, resulting in a ‘pinging’ or ‘snapping’ noise.) Scenario based on modelling of noise data analysed at the Hywind Project (the only project to date where this phenomenon has been reported) (see Offshore EIAR [Volume 3]: Technical Appendix 10.1): > Up to 23 pings per day (average rate of less than once per hour); > 10 WTGs = predicted potential SEL_{cum} (unweighted) of 160 dB re 1 $\mu Pa^2 s$; and > Therefore, seven WTGs (as proposed for the Offshore Development) = <SEL_{cum} (unweighted) of 160 dB re 1 $\mu Pa^2 s$. Operational noise impacts on marine mammals is expanded upon in Offshore EIAR (Volume 3): Technical Appendix 10.1. **Vessel Noise** (from crew transfer and support vessels) > Large vessels (>100 m) produce the loudest continuous noise source; and > SPL: 168 (rms) $dB_{re\ 1\ \mu Pa\ @\ 1m}$.

<table>
<tr><th>Potential Impact</th><th>Design Envelope Scenario Assessed</th></tr>
<tr><td>Risk of injury resulting from entanglement of marine mammals or basking sharks with mooring lines or cables, including secondary interactions with derelict fishing gears</td><td rowspan="3">WTGs
WTGs have the potential to influence prey and subsequent predator distributions (e.g., by acting as fish aggregates) through the introduction of novel structures in the marine environment;
A total of seven WTGs;
Minimum WTG spacing: 800 m; and
Total array area: 10 km^2.
Substructures
The semi-submersible substructure option will have the greatest surface area and potential for movement within the water column, based on design:
Maximum footprint: 15,625 square metres (m^2);
Maximum length and breadth of 125 m x 125 m, height 50 m (30 m in air, 20 m below sea); and
Below-sea surface area: 25,625 m^2 per WTG.
Cables
Buoyancy modules attached to the inter-array and offshore export cables may introduce barriers to movement within the water column and/or displacement from the Offshore Study Area, as well as increase entanglement risk;
Between 150 mm and 300 mm diameter; and
Maximum of 5 km of dynamic inter-array cabling and 500 m of dynamic offshore export cabling in water column.
Moorings
Total moorings: 63 (nine per WTG);
Changes in water quality which may affect prey distributions may result from the movement of mooring lines and chains along the seabed;
Moorings may also introduce lines in the water column which can entangle other floating manmade objects (e.g. derelict fishing lines and gears);
Catenary mooring systems:
Expected to have the largest benthic footprint (based on a 1,650 m mooring line length): up to 1,485 m per line on the seabed;
The largest spread radius: 1,500 m per line;
Semi-taut mooring systems:
Expected to have the largest pelagic footprint (based on a 1,050 m mooring line length): Up to 525 m per line within the water column;
Mooring systems may use single or combined materials, including synthetic ropes, steel wire ropes and cables, and steel chains:
Chains / cables will be 175 mm thick; and
Synthetic ropes will be 350 mm thick.</td></tr>
<tr><td>Collision risk to marine mammals and basking sharks due to floating infrastructure</td></tr>
<tr><td>Displacement or barrier effects resulting from the physical presence of devices and infrastructure, including substructures, mooring lines and cables</td></tr>
</table>

Potential Impact	Design Envelope Scenario Assessed
Long-term habitat change, including the potential for changes to habitat quality (e.g., depleted resources or foraging opportunities)	**Anchors** > Anchors will introduce hard substrate into the marine environment, thereby changing the baseline habitat; and > Gravity anchors are anticipated to have the largest benthic footprint: o The maximum number of anchors per WTG: 9 (63 in total); o A maximum seabed footprint of 625 m^2 per anchor; o A maximum seabed footprint of scour protection per anchor of 260 m^2; o A maximum area of seabed preparation (levelling) of 900 m^2 per anchor; o A maximum temporary total anchor footprint of 56,700 m^2; and o A maximum permanent total anchor and scour protection footprint of 55,755 m^2. **Cables** > Remedial cable protection along the export and inter-array cables will introduce hard substrate into the marine environment, thereby changing the baseline habitat; > Additionally, surface-laid cables have the potential to introduce EMFs to the marine environment which may impact habitat use by prey species of marine mammals and basking shark: o Voltage: up to 110 kV; however, the worst case voltage for EMFs is 66 kV; > Inter-array cables are expected to be dynamic, with some sections in water and other sections laid on the seabed between WTGs: o The maximum length of cable on the seabed is 20 km (all cables combined); o The temporary zone of influence during the installation of the inter-array cables assumes 100% of the cable route will require seabed preparation, with realistic worst case scenario covering 200,000 m^2; o Fifty percent remedial cable protection for inter-array cables on seabed so 10,000 m in total. Maximum cable protection height and width of 1 m and 7 m, respectively. A total area of 70,000 m^2; o A maximum of 14 gravity anchors (two per dynamic cable section). The footprint of each anchor will be 20 m2 = 280 m2 total; o The total non-temporary footprint of inter-array cables: 70,280 m^2; o The offshore export cable(s) will be buried to a minimum target depth of 0.6 m, remedial protection will be used where not possible: o The maximum total combined length of cable is approximately 25 km; o The temporary zone of influence during the installation of the offshore export cable(s) assumes 100% of the cable route will require seabed preparation, at worst case scenario covering 375,000 m^2; o Fifty percent remedial cable protection for offshore export cable(s) on the seabed so 12,500 m in total. Maximum cable protection height and width of 1 m and 7 m respectively. Total area of 87,500 m^2; and o The total non-temporary footprint of inter-array cables: 87,500 m^2.

Potential Impact	Design Envelope Scenario Assessed
	HDD protection methods > Two successful drilled holes (this may require up to five bore attempts); > The HDD exit point(s) is expected to be approximately 600 m offshore. The water depth range in this region is between 15 m to 40 m; > The maximum offshore HDD length is 700 m; and > The hole bore diameter is 750 mm.
Decommissioning Phase	
Potential noise disturbance impacts arising during the decommissioning phase are expected to be similar to, but not exceeding, those arising during the construction phase.	In the absence of detailed information regarding decommissioning works, the implications for marine mammals and basking sharks are considered analogous with or likely less than those of the construction phase. Therefore, the worst case parameters defined for the construction phase also apply to decommissioning. The decommissioning approach is set out in Chapter 5: Project Description. It is expected that all offshore components will be completely removed to shore for re-use, recycling and disposal during decommissioning, unless there is compelling evidence to leave certain components (e.g., the buried sections) *in situ*. The only exceptions to this may be scour protection, which may not be practical or desirable to recover and piles may be cut off 1 m below the seabed. It may be preferable to leave the scour protection *in situ* to preserve the marine habitat that may have developed over the life of the Offshore Development; this is particularly the case for remedial protection placement / boulders as these are generally quite small in grade size and thousands in quantity so not practical to recover. A Decommissioning Programme will be developed pre-construction to address the principal decommissioning measures for the Offshore Development, this will be written in accordance with applicable guidance and detail the management, environmental management and schedule for decommissioning. The Decommissioning Programme will be reviewed and updated throughout the lifetime of the Offshore Development to account for changing best practice. Relevant stakeholders and regulators will be consulted to establish the approach. The seabed will be restored, as far as reasonably practicable, to the condition it was prior to the construction of the Offshore Development.
Long-term habitat change, including the potential for changes to habitat quality (e.g., depleted resources or foraging opportunities)	In the absence of a full decommissioning plan at this early stage of the Offshore Development, it has been assumed that all infrastructure at the surface, within the water column and on the seabed will be fully removed, with only the scour protection and piles (which may be cut off 1 m below the seabed) under consideration for a possible leave *in situ* decommissioning option.

11.5.5 Embedded Mitigation and Management Plans

As part of the Offshore Development design process, a number of designed-in measures and management plans have been proposed to reduce the potential for impacts on marine mammal and basking shark receptors; these are provided in Table 11.26. As there is a commitment to implement these measures, which will likely be secured through Section 36 Consent and Marine Licence conditions, they are considered inherently part of the design of the Offshore Development and have therefore been considered in the assessment presented below (i.e., the determination of magnitude of impact and therefore significance of effects assumes implementation of these measures). These measures are considered standard industry practice for this type of development.

Activities involving clearance or detonation of UXO are not planned for the Offshore Development; therefore, mitigation protocols have not been developed at this stage. If, following the UXO surveys, it is determined that UXO clearance is needed, activities which relate to UXO clearance or detonation will be carried out under a separate Marine Licence application which would include mitigation protocols which will align with the relevant guidance at that time (e.g., *JNCC guidelines for minimising the risk of injury to marine mammals from using explosives* [JNCC, 2010a]).

Table 11.26 Embedded mitigation measures and management plans specific to marine mammals and basking shark for the Offshore Development

Embedded Mitigation Measure and Management Plans	Justification
Management Plans	
Project Environmental Monitoring Programme	Through the EIA process, conclusions on the potential environmental impact of the Offshore Development have been made. Where required, a monitoring programme will be put in place to provide further evidence to support these conclusions and provide information for future offshore wind farm developments.
Construction Method Statement (CMS)	A CMS will be developed in accordance with the Construction Environmental Management Plan (CEMP) detailing how the Offshore Development activities and plans identified within the CEMP will be carried out, and highlighting any possible dangers / risks associated with particular project activities.
Construction Environmental Management Plan	The CEMP will set out procedures to ensure all activities with the potential to affect the environment are appropriately managed and will include: a description of works and construction processes, roles and responsibilities, description of vessel routes and safety procedures, pollution control and spillage response plans, incident reporting, chemical usage requirements, waste management plans, plant service procedures, communication and reporting structures and timeline of work. It will detail the final design selected and take into account Marine Licence Conditions and commitments.
Operational Environmental Management Plan (OEMP)	An OEMP will guide ongoing activities during the operations and maintenance phase. The OEMP will also set out the procedures for managing and delivering the specific environmental commitments, including a Marine Pollution Contingency Plan and INNS [invasive non-native species] Management Plan. Adopting these protocols will reduce risk in relation to the spread of INNS across all phases of the Offshore Development
Cable Plan	The Cable Plan (CaP) will be provided post-consent and detail the location/ route and cable laying techniques of the inter-array and Offshore Export Cable(s) and detail the methods for cable surveys during the operational life of the cables. This will be supported by survey results from the geotechnical, geophysical, and benthic surveys. The Cable Plan will also detail the EMFs of the cables deployed. A Cable Burial Risk Assessment (CBRA) will also be undertaken and included within the Cable Plan, which will detail cable specifications, cable installation, cable protection, target burial depths / depth of lowering, and any hazards the cables will present during their lifespan.
Piling Strategy	A Piling Strategy will be drafted if impact piling is selected as the optimal installation mechanism for the WTG foundations. The strategy will provide full details of the piling activities and parameters, including expected noise levels, duration of activities, and any required mitigations for this installation technique.

Embedded Mitigation Measure and Management Plans	Justification
Marine Mammal Mitigation Plan (MMMP)	An MMMP will be developed and implemented throughout all phases of the Offshore Development to ensure the risk of injury to marine mammals is negligible and all possible disturbance effects are reduced. Best Available Technology will be employed along with due consideration of the local environment (e.g. protected sites or other important habitats) in line with the JNCC (2010) guidance: "The protection of marine European Protected Species from injury and disturbance' and the Marine Scotland (2020) guidance: *The protection of Marine European Protected Species from injury and disturbance, Guidance for Scottish Inshore Waters*. The MMMP will: > Follow the guidance from *Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise* (JNCC, 2010b), in relation to pilling activities; and > Consider the guidance from 'JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys' (JNCC, 2017) in relation to geophysical surveys where appropriate, based on the risk of injury associated with the equipment being employed.
Vessel Management Plan	A VMP will be developed and implemented throughout all Offshore Development phases. The VMP will follow the guidance from the Scottish Marine Wildlife Watching Code (SMWWC) (NatureScot, 2017) in relation to protecting marine wildlife from encounters: > Relevant vessel crew will be trained in the SMWWC to ensure the risk of injury to marine wildlife is negligible and all possible disturbance effects are reduced; and > A traffic management scheme will be included to reduce vessel overlaps reducing further disturbances to marine mammals.
Embedded Mitigation	
Removal of marine growth	The substructures will be designed to accommodate marine growth; however, to manage weight / drag-induced fatigue, growth levels will be inspected regularly, and subsequent removal of this growth will be undertaken, using water jetting tools, as required.
Removal of debris from floating lines and cables	The accumulation of marine debris on floating lines and cables has the potential to generate adverse interactions between mobile marine species and project infrastructure. Derelict fishing gears are of particular concern due to the entanglement risk they introduce to marine megafauna, including marine mammals and basking sharks. Mooring lines and floating inter-array cables will be inspected during the operation and maintenance phase using a risk-based adaptive management approach. Mooring line and cable inspections are expected to occur at a higher frequency initially and then reduce in frequency over a number of years, with changes to inspection periods based on evidence of risk garnered from the inspections. Additionally, a small number of floating substructures will likely be equipped with sensors monitoring tension and inclination on mooring lines. This will detect any larger debris and anomalies. Any inspected or detected debris on the floating lines and cables will be recovered, based on a risk assessment which considers the impact on the environment, risk to asset integrity, and cost of intervention.

Embedded Mitigation Measure and Management Plans	Justification
Minimum Spacing between WTGs	The minimum spacing between each WTG (from the centre of each WTG structure) will be 800 m. This will reduce the likelihood of collision and entanglement to marine mammals.
Target depth of lowering	Static cables will be trenched and buried to a target depth of 0.6 m. Where this cannot be achieved, remedial cable protection will be applied. This will provide some separation between the cables and basking sharks, therefore reducing the effect of EMF. The cable burial target depth will be informed by a CBRA and implemented through the CaP produced post-consent.

11.5.6 Data Gaps and Uncertainties

When undertaking the impact assessment, the following uncertainties have been identified:

- Entanglement of marine mammals with mooring lines and suspended inter-array cables:
  - Evidence of marine mammals becoming entangled in man-made marine materials exists, but records are almost entirely related to fisheries bycatch (Read *et al.,* 2005), with no available data on entanglement with floating offshore renewable energy infrastructure. It is assumed that taut and semi-taut mooring configurations would reduce the potential impacts associated with entanglement relative to mobile mooring systems (Harnois *et al.,* 2015; Maxwell et al., 2022);
  - Records of marine megafauna entanglement with passive fishing gears have generally been considered the most representative of the catenary mooring lines, which is one mooring solution being considered for the Offshore Development. In the UK, these passive gears include crustacean and shellfish creels and pots with floating buoys or markers. These gears are of particular concern to large baleen whales, including humpback and minke whales (Benjamins *et al.,* 2014; Garavelli, 2020). However, the applicability of fisheries entanglement records to the characterisation of entanglement risk from moored WTGs remains questionable. The work of Benjamins *et al.* (2014) has sought to better define entanglement risk associated with MRE mooring systems, but in the absence of any quantitative data, the characterisation of risk remains qualitative;
- Noise thresholds:
  - The levels of noise which could result in disturbance or injury to marine mammal species have been outlined in the Offshore EIAR (Volume 3): Technical Appendix 11.1: Underwater Noise Impact Assessment. Source sound pressure levels have been modelled against hearing thresholds which have been selected on a precautionary basis using the best available data. These data are modelled to identify the representative perceived sound levels at which the onset of a potential impact may occur. The results of this modelling cannot determine the specific source level at which significant effects will be observed. The assumptions and limitations of the underwater noise modelling impact assessment are detailed in the Offshore EIAR (Volume 3): Technical Appendix 11.1: Underwater Noise Impact Assessment. In short, these include:
    - Cumulative Permanent Threshold Shift (PTS);
    - The inability to model recovery between pulses or the changing characteristics of sound with distance from the source;
    - Limited empirical data available to confidently predict the extent to which animals may experience auditory damage or display responses to noise;
    - Uncertainty in the number of animals that experience PTS, with less than 20% of animals exposed to PTS-onset threshold levels expected to experience a PTS (see Section 3.3 of Offshore EIAR (Volume 3): Technical Appendix 11.1); therefore, assuming all animals within the modelled PTS-onset impact ranges is highly precautionary;

- Uncertainty in the density estimates used to predict the number of animals expected to experience impacts within proximity to the activities;
- Precaution in the population modelling, regarding the duration of non-foraging time, lack of density dependence, and level of environmental and demographic stochasticity;

o The hearing physiology of basking sharks is poorly understood for this elusive free-ranging species and captive testing is not possible. Basking sharks may be sensitive to noise and vibration from construction phase activities, such as pile driving and drilling. These activities are thought to have the potential to occur at frequencies which could fall within their hearing range (Corwin, 1981). However, all knowledge of basking shark auditory abilities has been inferred from studies on other elasmobranchs (Corwin, 1981; Casper and Mann, 2010; Popper et al., 2014). These data may not provide a realistic basis for the assessment of injury or disturbance from underwater noise to this species but have been used in the absence of other more definitive data sources;

> Barrier effects:

o Conservation legislation precludes tagging of cetaceans in UK waters, for scientific purposes or otherwise, due to the possible injury that tagging deployment may inflict. Consequently, data on the movement of marine megafauna around operational offshore wind developments are lacking. To date, the majority of movement data has focused on those marine megafauna species which can be tagged most readily – harbour and grey seals (McConnell *et al.,* 2012; Russell *et al.,* 2014) – or are recorded readily via passive acoustic methods – harbour porpoise (Lindeboom *et al.,* 2011; Schiedat *et al.,* 2011). Moreover, these studies have only considered movements around fixed-bottom offshore wind farms. Our current understanding of marine mammal movement around floating marine energy developments, whether wind, wave, or tidal, is lacking and relies heavily on simulations and modelling based on movement data around fixed devices (e.g., Sparling *et al.,* 2016). The characterisation of marine mammal and basking shark movement around floating offshore wind farms is thus limited to inference and approximation from the available data based on a few species and fixed energy developments;

> Long-term habitat change:

o Physical changes to the benthic and pelagic marine environment following the construction of marine energy developments have the potential to alter the abundance and distribution of marine species, including marine megafauna (Hemery, 2020). It is thought that habitat change resulting from floating offshore wind farms would be similar to that from other floating developments with surface and subsea components (e.g. MRE and oil and gas) (Hemery, 2020). However, data on habitat change from floating structures remain deficient and the majority of data come from the introduction of hard structures to the marine environment from fixed-bottom offshore wind farms (Causon and Gill, 2018). In the absence of empirical data on the colonisation of floating WTGs or MRE, it has been assumed that colonisation rates would be similar to, if not less than, those for fixed-bottom offshore wind farms, given the dramatic reduction in the within-water surface area provided by floating WTG foundations and their substructures. Rather, Causon and Gill (2018) propose the use of published data on buoys and deep-water oil rigs to characterise habitat change over the life-cycle of a floating offshore wind development and post-decommissioning;

o Additionally, the Predators and Prey Around Renewable Energy Developments (PrePARED) surveys, funded by Crown Estate Scotland and the Offshore Wind Evidence & Change programme, aim to improve the collective understanding of marine mammal responses to offshore wind farms, as well as changes to the distribution of their prey. The PrePARED surveys will collect data from offshore wind farms within the Firth of Forth and Moray Firth between 2022 and 2024. The results of these studies will inform the consenting of future activities within the Offshore Development, including management measures, such as the development of an effective Decommissioning Plan; and

- Whilst changes to the pelagic environment are most likely to directly impact animals which strictly utilise the water column, such as marine mammals and basking shark, indirect impacts to these species may also transpire if changes to the benthic environment result in changes to prey abundance and distributions. There is potential that the anchor piles and mooring components on the seabed may increase sedimentation which could impact benthic fish and shellfish populations through long-term habitat changes (Maxwell *et al.,* 2022). However, empirical data on floating WTG mooring systems are lacking, and it is assumed that scour and sedimentation rates would be comparable to those for traditional boat anchors (Maxwell *et al.,* 2022).

The uncertainties around these impact mechanisms have been considered when defining the sensitivity of a receptor and magnitude of impact.

11.6 Assessment of Potential Effects

11.6.1 Effects During Construction

11.6.1.1 Noise-related impacts to marine mammals, including the risk of physiological impacts, barrier effects, and displacement

During the construction phase, underwater noise emissions may impact marine mammals on an individual and population basis through physiological impacts which may result in injury, as well as barrier effects and/or displacement due to disturbance. The activities which have been identified as being possible sources of disturbance and/or injury include anchor pile installation; geophysical and UXO survey activities (including pre- and post-installation surveys); UXO clearance; and additional construction activities (i.e. vessel noise from installation works, cable laying, trenching, and rock placement, etc.). These activities have therefore been taken forward for a detailed quantitative Underwater Noise Impact Assessment (as detailed in the Offshore EIAR [Volume 3]: Technical Appendix 11.1) to understand the likelihood and magnitude of potential impacts on these protected species and their populations (SMRU Consulting, 2022). The impacts from the different noise-related construction activities will mainly occur in the PFOWF Array Area, and there is limited scope for noise impacts within the OECC when considering the worst case realistic scenarios for the construction phase of the Offshore Development.

It is worth noting that the desk-based UXO risk assessment undertaken by Ordtek (2021) has indicated that it will be possible to avoid any UXO identified during the UXO survey and, should further mitigation be required (i.e., clearance or detonation), this would be subject to separate assessment and applications. However, to provide a comprehensive assessment of potential worst case impacts associated with project activities, an initial assessment of noise-related impacts from UXO surveys and UXO clearance has been undertaken for the construction phase of the Offshore Development.

The Underwater Noise Impact Assessment (see Offshore EIAR [Volume 3]: Technical Appendix 11.1) characterises the risk of injury and disturbance to marine mammals from underwater noise and what effect those impacts may have on the species populations considered important within the Offshore Study Area. The report details the modelling approach and assessment methodologies used to identify impact significance and provides explanations of the assumptions and limitations of this assessment. This section summarises the results of the Underwater Noise Impact Assessment, clearly identifies any residual effects which might remain following the employment of the embedded mitigations (see Section 11.5.5) and provides recommendations for additional methods to further reduce those residual effects.

11.6.1.1.1 Quantitative assessment approach: Underwater noise propagation modelling

To estimate the underwater noise levels likely to be generated by the proposed construction activities, predictive noise modelling has been undertaken, based on best practice techniques described in Robinson *et al.* (2014). Impact piling forms the most important noise source, due to both the sound pressure levels generated and the duration of the activity; as such, it is the primary focus of the Underwater Noise Impact Assessment.

The modelling of impact piling sound was undertaken using the INSPIRE semi-empirical underwater noise propagation model (Version 5.1) which uses numerical modelling and measured source-level data as inputs. This model is designed to calculate the propagation of noise in shallow, mixed water, typical of the conditions around the UK and as such is very well suited to the region of the Pentland Firth. The model has been trained on 80 datasets of underwater noise propagation from monitoring during offshore piling activities. It provides estimates of unweighted peak sound pressure levels (SPL_{peak}), sound exposure levels with a soft-start (SEL_{ss}), and cumulative sound exposure levels over a 24-hour period (SEL_{cum}).

From these outputs, distances at which an individual animal would experience sound levels which would exceed the hearing thresholds for auditory injury can be identified.

Hearing thresholds for potential injury to cetacean and pinniped taxa are defined in Southall *et al.* (2019) and equate to the onset of a PTS in hearing levels. They have been derived from *in situ* measurements of audition in various marine mammal species and modelled to supply threshold levels representative of different taxa, based on their hearing sensitivities (Southall *et al.,* 2019). It is worth noting that sounds occurring at source pressure levels which meet the criteria for the onset of PTS do not necessarily equate to an injury in an animal. Rather, the hearing thresholds are used to conservatively estimate whether an injury *may* occur if an individual encounters it so that a conservative range of impact may be estimated.

As hearing thresholds are not defined for the more subjective issue of disturbance, which is behavioural response to perceived sound, several methods have been applied to characterise impact magnitude for the various construction activities based on available data and best practice.

Table 11.27 summarises the methods used to characterise injury and disturbance impacts to marine mammals and determine the range of impact (i.e., the distance from the noise source within which an impact is likely to occur) for each activity. Details on these methods are supplied in Offshore EIAR (Volume 3): Technical Appendix 11.1.

Table 11.27 Approach to the assessment of injury and disturbance to marine mammals from underwater noise sources

Injury			Disturbance			
Piling	**UXO**	**Other[1]**	**Geophysical Surveys**	**Other [1]**	**Piling**	**UXO**
SPL_{peak} and SEL_{cum} impact ranges for PTS-onset from Southall *et al.* (2019)			Evidence in the literature on disturbance ranges.		All cetacean species: Dose-response function[2] based on harbour porpoise responses to impact piling during the first phase of construction at the Beatrice wind farm, Moray Firth (Graham *et al.,* 2017). All seal species: Dose-response function[2] based on harbour seal responses to impact piling at the Lincs wind farm, Greater Wash area (Whyte *et al.,* 2020).	26-km effective deterrent range (EDR) for high-order detonation (JNCC, 2020) 5-km EDR for low-order deflagration (JNCC, 2020) Temporary Threshold Shift-onset as defined in Southall *et al.* (2019) has been used as a proxy

[1] 'Other' refers to the remaining construction activities that are proposed which will generate underwater noise levels which are audible to marine mammals (i.e., vessel noise from installation works, cable laying, trenching, rock placement, etc.)

[2] Dose-response functions are modelled relationships between received noise levels and a measure of animal responses based on empirical data, which provide estimates of the proportion of animals which will respond (from 1 to 0) at different noise levels. The function is combined with predicted noise level isopleths from the noise propagation modelling, to estimate the total number of animals that will respond (i.e. be disturbed).

11.6.1.1.2 Marine mammal sensitivity to underwater noise

Each species of marine mammal has a unique hearing range in which it has adapted to be most sensitive to perceived sounds; however, not all species' auditory abilities have been studied in sufficient detail to identify these ranges. In the absence of available data, species have been grouped based on taxonomy, hearing morphology, the frequencies characteristic of their noise emissions, and other similarities, to define 'functional hearing groups' (Southall *et al.,* 2019). Hearing sensitivity has been defined based on hearing groups for the marine mammal species of interest. In this way, the hearing sensitivities of bottlenose, white-beaked, common and Risso's dolphins have not been characterised separately, but rather as a delphinid hearing group.

Table 11.28 provides the relative sensitivity of the key marine mammal species and hearing groups to the underwater noise sources associated with construction activities at the Offshore Development; details on how these were defined are provided in Offshore EIAR (Volume 3): Technical Appendix 11.1.

Table 11.28 Sensitivity of marine mammal species to injury and disturbance from underwater noise sources

Species	Injury			Disturbance			
	Piling	UXO	Other[1]	Piling	Vessel	UXO	Other[1]
Harbour porpoise	Low	Low	Low	Low	Low	Low	Low
Dolphin species	Low	Low	Low	Low	Low	Low	Low
Minke whale	Low	Low	Low	Low	Low	Low	Low
Harbour seal	Low	Low	Low	Moderate	Negligible	Low	Negligible
Grey seal	Low	Low	Low	Negligible	Negligible	Low	Negligible

[1] 'Other' refers to the remaining construction activities that are proposed which will generate underwater noise levels which are audible to marine mammals (i.e., vessel noise from installation works, cable laying, trenching, rock placement, etc.)

All species exhibit a **low sensitivity** to injury from noise from the proposed Offshore Development activities (Table 11.28), based on the sensitivity definitions provided in Section 11.5.3.1. Moreover, all species of cetacean exhibit a **low sensitivity** to disturbance from the proposed activities. Grey and harbour seals are not considered sensitive to the continuous noises generated by vessels, or the intermittent and non-impulsive noises generated by other construction activities. However, they differ in that harbour seals have a **moderate sensitivity** to sounds generated during impulsive piling and grey seals are considered to have **negligible sensitivity** to this noise source (see Sections 2.3.7.7 and 2.3.7.8 of the Offshore EIAR [Volume 3]: Technical Appendix 11.1).

11.6.1.1.3 Results of the underwater noise propagation modelling

Geophysical and UXO surveys

Injury from geophysical and UXO surveys

Geophysical survey equipment has the potential to generate sound pressure levels which could induce injury in marine mammals. Indicative source pressure levels for the MBES and SSS equipment exceed the unweighted injury threshold for harbour porpoise and seals; however, the peak energy (as a function of pressure) is centred on frequencies which are outwith the hearing sensitivities for these species. Moreover, source frequencies are sufficiently high that sound pressure levels will rapidly attenuate to below threshold levels for PTS-onset in harbour porpoise within a few metres of the source.

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 MBES is necessary in shallow waters (<200 m) where the MBES used are of high frequencies (as they are planned to be here). EPS Guidance (JNCC et al. 2010) for use of 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).' An equivalent conclusion was reached by DECC (2011). Therefore, the risk of injury from MBES and SSS is concluded to be of **negligible magnitude**.

The source levels of ultra-short baseline (USBL) equipment are below the PTS-onset thresholds for all marine mammal species and therefore it is concluded that this survey equipment does not pose any risk of PTS onset to any marine mammals during survey activities.

Disturbance from geophysical and UXO surveys

For geophysical and UXO surveys, only the USBL beacon was assessed against disturbance impacts, as the proposed MBES and SSS will operate at frequencies above the hearing range of all functional hearing groups of marine mammals. Based on the disturbance criteria used by the National Marine Fisheries Service (NMFS) in the United States (NMFS, 2018), the assessment indicates that a marine mammal is not at risk of PTS-onset (considered Level A harassment). As the sound source levels will be at levels below which the onset of PTS is predicted to occur, it is concluded that there would be no risk of PTS-onset to any marine mammals from the use of USBL equipment. These surveys will be required within both the PFOWF Array Area and the OECC.

Disturbance from the USBL is only predicted to occur in close proximity (<6 m). Disturbance effects to marine mammals are therefore expected to be restricted to isolated, temporary, and short-lived effects upon low numbers of animals and, overall, to be negligible in magnitude. Using a highly conservative estimated survey area of the entire Offshore Site plus a 500 m buffer, which accounts for survey line turns and the propagation of disturbance-level noise beyond the edge of the survey area limits, a total disturbance area of 50.2 km^2 was calculated. This is not considered representative of the actual area which will be surveyed within the Offshore Site, but as the survey plans are yet to be determined, this estimate forms a cautionary worst case area of impact. Using this cautionary survey area, ≤1 animal was predicted to experience disturbance for all marine mammal species, with the exception of harbour porpoise (n = 10) and grey seals (n = 28), which exhibit greater absolute density within the Offshore Study Area and auditory sensitivity to USBL operational frequencies, respectively. Potential disturbance effects to marine mammals resulting from these activities are expected to be restricted to isolated, temporary, and short-lived effects upon low numbers of animals.

Disturbance from geophysical and UXO survey activities was limited to USBL deployment. The **sensitivity** of marine mammals to USBL disturbance has been assessed as **low** (see Offshore EIAR [Volume 3]: Technical Appendix 11.1) and the **magnitude** of impact from this impact pathway is **negligible**. For these reasons, this activity is considered to generate **negligible** effects, which is **not significant** in EIA terms.

UXO clearance

An initial desk-based UXO assessment undertaken by Ordtek (2021) has indicated a low likelihood of UXO being encountered in the Offshore Site and it is anticipated that during construction it will be possible to avoid any UXO identified during the UXO survey. Should the survey determine that UXO clearance or detonation is required, this would be subject to separate assessment and Licence applications. Nonetheless, to provide a comprehensive assessment of potential worst case impacts associated with Offshore Development activities, an initial assessment of noise-related impacts from UXO clearance has been undertaken. The inclusion of this potential, albeit unlikely, activity within this Offshore EIAR was specifically requested through consultation received during Scoping (see Table 11.3). Any UXO clearance identified as being required to proceed with the Offshore Development has the potential to take place within either the PFOWF Array Area or the OECC.

Injury from UXO clearance

UXO clearance has been identified as a possible noise source with the potential to impact marine mammals through the generation of underwater noise. 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.

Two scenarios of potential UXO clearance are assessed: (1) the worst case high-order detonation of a large 525 kilogram (kg) UXO plus donor charge, whereby the detonation of the donor charge causes a complete detonation of all explosive material in the 525 kg UXO; and, (2) the low-order detonation of any size of UXO using a small specialist donor charge (up to 500 grams) to vaporise the explosive material in the UXO in the absence of an explosion (deflagration) and therefore noise levels are proportional to the donor charge only. It is expected that if any UXO clearance is required, it would be undertaken using low-order clearance, however, the potential impact associated with a high-order detonation is provided here for context and to provide a realistic worst case assessment.

Table 11.29 summarises the outcomes of the impact assessment against UXO clearance. Full details of the underwater noise modelling and the resulting injury (PTS-onset) impact areas and ranges are provided in Offshore EIAR (Volume 3): Technical Appendix 10.1: Underwater Noise Modelling Report. It is important to remember that the predicted number of animals impacted assumes no mitigation, including no prior deterrence of animals from the impacted area. However, embedded mitigation measures (see below and Section 11.5.5) are considered in the assessment of the impact magnitude for injury (PTS) effects.

Table 11.29 Number of animals predicted to experience injury (PTS-onset) (in the absence of any mitigation measures) and resulting impact significance from high-order UXO detonation (525 kg + donor)

Species	Metric	Result[1]	Sensitivity	Magnitude[2]	Impact Significance
Minke whale	Range (km)	2.2	Low	Negligible	Negligible
	Area (km^2)	15.2			
	No. of animals	<1			
	% of population	<1			
Dolphin species[3]	Range (km)	0.73	Low	Negligible	Negligible
	Area (km^2)	1.7			
	No. of animals	<1			
	% of population	<1			
Harbour porpoise	Range (km)	13.0	Low	Negligible	Negligible
	Area (km^2)	530.9			
	No. of animals	81			
	% of population	North Sea: 0.02 West Scotland: 0.3			
Pinnipeds	Range (km)	2.5	Low	Negligible	Negligible
	Area (km^2)	19.6			
	No. of harbour seals	<1			
	% of harbour seal population	<1			
	No. of grey seals	12			
	% of grey seal population	0.03			

[1] The number of animals predicted to be impacted assumes no mitigation, including no prior deterrence of animals from the area impacted.

[2] Embedded mitigation measures (see Section 11.5.5) are considered in the assessment of impact magnitude.

[3] Considering the small size of the predicted impacted area (1.7 km^2) for dolphins (all high-frequency cetaceans), the low predicted density of each relevant species of dolphin (all < 0.2 individuals/km^2), and the size of all relevant Mus, the predicted < 1 animal and < 1% MU impacted applies to each relevant species of dolphin (bottlenose, white-beaked, Risso's and common).

The modelling results (Table 11.29) indicated that harbour porpoise will experience the greatest impact, with a predicted 81 harbour porpoises potentially experiencing noise levels sufficient to result in PTS-onset over a 13-km range. For minke whales and dolphin species, less than one individual will experience injury from high-order detonation using the maximum charge (525 kg + donor). For pinnipeds, grey seals will experience the greatest impact, with injury predicted to 12 individuals over a 2.5 km range.

The impact of PTS-onset is predicted to be of local spatial extent; however, since PTS is a permanent change in the hearing threshold, it is not recoverable. As part of any future consent for UXO removal, the Offshore Development will be required to implement a UXO-specific Marine Mammal Management Plan (MMMP) to ensure that the risk of PTS is reduced to negligible. The exact mitigation measures contained with the UXO MMMP are yet to be determined and will be agreed with Marine Scotland. However, multiple measures are available and have been implemented elsewhere for UXO clearance, such as the use of acoustic deterrent devices and scarer charges to displace animals to beyond the PTS-onset impact range, or noise abatement techniques where appropriate. Therefore, considering the embedded mitigation measures, the **magnitude** of this impact is considered to be **negligible**. It is also noted that the results likely represent an overestimate of PTS-onset impact ranges as they are calculated using conservative parameters (see Section 11.5.6).

The sound produced by these controlled explosions is low frequency with the main energy centred around 1 kHz (von Benda-Beckmann *et al.* 2015). For most marine mammal species considered here, the hearing sensitivity below 1 kHz is relatively poor and thus it is expected that a PTS at this frequency would result in a minor reduction in hearing sensitivity outside of the frequency of peak sensitivity, and therefore have little impact to vital rates. Therefore, the **sensitivity** of marine mammals to injury from noise generated during UXO clearance has been assessed as **low** for all of the key species.

Consequently, the overall **significance** of the potential impact of PTS from high-order UXO clearance is **negligible**, which is **not significant** in EIA terms.

Disturbance from UXO clearance

Empirical studies of marine mammal behavioural responses to UXO clearance are currently lacking, and there are no widely accepted noise thresholds for behavioural disturbance to apply to predicted noise levels. Therefore, three different approaches were used to assess the potential for behavioural disturbance in marine mammals from UXO detonations: a 26 km effective deterrence range for high-order detonations (as recommended in noise management guidance for harbour porpoise SACs in England, Wales and Northern Ireland (JNCC, 2020); 5-km effective deterrent range (EDR) for low-order detonations (as has recently been advised by JNCC with regard to porpoise SACs); and Temporary Threshold Shift (TTS)-onset thresholds (suggested as a proxy for significant behavioural disturbance by Southall *et al.,* [2019]).

Table 11.30 below summarises the worst case population-level impacts of behavioural disturbance due to both high-order and low-order UXO detonation and provides an assessment of species sensitivity, impact magnitude and impact significance for each of the marine mammal receptors.

Similarly, Table 11.31 provides estimates of the number of animals predicted to experience the onset of TTS from high-order UXO detonation, based on species-group auditory sensitivity, and the population-level consequences of this impact in terms of magnitude and significance.

Table 11.30 Number of animals predicted to experience behavioural disturbance from high-order (assuming 26-km EDR) and low-order (assuming 5-km EDR) UXO detonation and the resulting impact significance

Species	Population Abundance	Density (No. animals / km²)	High-order Detonation			Low-order Detonation			Sensitivity	Magnitude	Impact Significance
			Area (km²)	No. of Animals	% MU	Area (km²)	No. of Animals	% MU			
Harbour porpoise	346,601 (NS)	0.1520	995	151	0.04	79	12	<0.01	Low	Negligible	Negligible
	28,936 (WS)		485	74	0.25	0	0	0	Low	Negligible	Negligible
Bottlenose dolphin	224 (CES)	0.0037	1,478	5	2.44	79	<1	0.13	Low	Low	Minor
White-beaked dolphin	43,951	0.0210	1,478	118	0.27	79	6	0.01	Low	Negligible	Negligible
Risso's dolphin	12,262	0.0135	1,478	20	0.16	79	1	0.01	Low	Negligible	Negligible
Common dolphin	102,656	0.1168	1,478	18	0.02	79	1	<0.01	Low	Negligible	Negligible
Minke whale	20,118	0.0095	1,478	14	0.07	79	1	<0.01	Low	Negligible	Negligible
Harbour seal	1,951	Grid-cell specific	1,478	52	2.67	79	<1	0.05	Low	Low	Minor
Grey seal	35,979	Grid-cell specific	1,478	1,594	4.43	79	49	0.14	Low	Low	Minor

Table 11.31 Number of animals predicted to experience TTS-onset from high-order UXO detonation and the resulting impact significance

Species	Metric	Result	Sensitivity	Magnitude	Impact Significance
Minke whale	Range (km)	4.1	Low	Negligible	Negligible
	Area (km^2)	52.8			
	No. of animals	1			
	% of population	0.005			
Dolphin species[1]	Range (km)	1.3	Low	Negligible	Negligible
	Area (km^2)	5.3			
	No. of animals	<1			
	% of population	<1			
Harbour porpoise	Range (km)	23.0	Low	Negligible	Negligible
	Area (km^2)	1,193			
	No. of animals	181			
	% of population	NS MU: 0.04 WS MU: 0.19			
Pinnipeds	Range (km)	4.6	Low	Negligible	Negligible
	Area (km^2)	66.5			
	No. of harbour seals	<1			
	% of harbour seal population	<1			
	No. of grey seals	40			
	% of grey seal population	0.1			

[1] Considering the small size of the predicted impacted area (5.3 km^2) for dolphins (all high-frequency cetaceans), the low predicted density of each relevant species of dolphin (all <0.1 individuals/km^2), and the size of all relevant MUs, the predicted <1 animal and <1% MU impacted applies to each relevant species of dolphin (bottlenose, white-beaked, Risso's and common)

Using a 26-km EDR, it is predicted that high-order UXO clearance will have the greatest percentage impact on the grey seal NCO SMU, disturbing 40 individuals, or 4.43% of the MU, followed by 3.36% of the bottlenose dolphin CES MU, and 2.67% of the harbour seal NCO SMU (see Table 11.30). The conclusions of significance are based on impacts to MUs, not individuals. Thus, whilst a number of individuals may be affected, in the context of the populations of concern, these are small percentages of the population which would experience a temporary disturbance. Any such short-term changes to the presence of individuals from these populations within the study area are unlikely to be detectable against natural variation. Given the higher percentage of the relevant MUs predicted to experience disturbance, impacts to these three species are assessed as having a **low magnitude**, where effects may be detectable, but unlikely to be of a scale or duration to have a significant effect on the conservation status or integrity of the receptor in the short-term (i.e. one to five years). The potential for these disturbance effects to act cumulatively with those of other relevant projects is assessed in Section 11.7. The percentage of the MU predicted to be disturbed was significantly lower for all other species assessed (<0.25%) and, therefore, impacts to harbour porpoise, white-beaked dolphin, minke whale and Risso's dolphin are assessed as being of **negligible magnitude**.

Whilst high-order detonation represents the worst case scenario, low-order detonation (deflagration) represents the most likely scenario. The approach of assuming an EDR of 5 km has been used previously to support a Marine Licence Application (e.g., Sofia Offshore Wind Farm) and was, therefore, deemed an appropriate method to use for illustrative purposes for the Offshore Development. For all species, a low percentage of the MU is predicted to be disturbed (<0.15%), resulting in an equally low number of animals (<50) (see Table 11.30).

Given the low number of animals and percentage of each MU predicted to experience disturbance, the impact of disturbance from both high and low-order detonation, using their respective EDRs is predicted to be of relatively limited spatial extent, such that important changes in baseline conditions will not be encountered, and of short-term duration. Given the low number of animals and percentage of each MU predicted to experience disturbance, the impact pathway of disturbance from underwater noise from potential UXO clearance has been assessed as having a **low magnitude** of impact for bottlenose dolphins and harbour and grey seals, and **negligible magnitude** of impact for all other species. As all species have a **low** sensitivity to disturbance from UXO clearance, the impact **significance** is considered either **negligible** or **minor**, which is **not significant** in EIA terms.

An estimation of the extent of behavioural disturbance from UXO detonation can be based on the sound levels at which the onset of TTS is predicted to occur from impulsive sounds. The greatest TTS-onset impact area was predicted to occur for very high frequency cetaceans at 1,193 km^2, which also resulted in the greatest number of animals exposed to TTS-onset, with 181 harbour porpoises. For all high-order UXOs for both low-frequency and high-frequency cetaceans, it is anticipated that less than one animal within these impact areas would experience TTS-onset. For phocids (in water), the greatest TTS-onset impact area was estimated at 66.5 km^2. This resulted in TTS-onset to less than one harbour seal and 40 grey seals within this impact area.

The impact of TTS-onset, as a proxy for behavioural disturbance, is predicted to be of short-term duration, and likely to be associated with a one-off startle response or short-term aversive behaviour (see Table 11.31). Given the nature of these predicted impacts, combined with the low number of animals and percentage of each MU predicted to experience effects, impacts to all species have been assessed as being a **negligible magnitude**.

Taking into account the modelling results for all three metrics which were used to characterise disturbance impacts, the disturbance from UXO clearance has been assessed as having **negligible significance** for all marine mammal species, and this is considered **not significant** in EIA terms.

Anchor installation: Impact piles

<u>Injury from impact piling</u>

Under the worst-case scenario, it was calculated that instantaneous PTS-onset impact ranges are low for all groups, with a maximum area of 0.65 km for harbour porpoise (very high frequency cetaceans) and equating to less than one animal for all species. Therefore, this impact pathway is considered to be of **negligible magnitude**.

Cumulative PTS was also considered for impact piling and the maximum predicted impact was for minke whale (LF cetaceans) where the PTS-onset impact range was 27 km which equates to 10 minke whales and 0.047% of the MU. The cumulative PTS-onset impact range for harbour porpoise was 8.7 km which equates to 0.006% of the MU. For all other species, the cumulative PTS-onset impact range was <0.1 km equating to less than one animal. The modelled ranges for cumulative PTS-onset are highly precautionary and should be regarded as over-estimates (see Section 11.5.6), embedded mitigation such as the implementation of a piling MMMP will be applied, and the numbers of animals and percentage of the MU predicted to experience are low. Therefore, the probability of the PTS causing any changes in vital rates is expected to be very low and, as such, this impact pathway is considered to be **negligible** in **magnitude**.

As all species have been assessed as having a **low sensitivity** to PTS-onset from impact piling, the overall **significance** of PTS-onset under either scenario is considered to be **negligible**, which is **not significant** in EIA terms.

Disturbance from impact piling

For disturbance from impact piling, the results from the worst case scenario in Offshore EIAR (Volume 3): Technical Appendix 10.1: Underwater Noise Modelling Report are presented; these results consider the maximum possible pile size, piling durations, and blow energies associated with driven piling. It should be noted that a piling duration of eight hours per pile is anticipated to be well in excess of what will be required in practice during installation.

Table 11.32 details the predicted disturbance impact ranges for the realistic worst case parameters for impact piling activities and grades the overall impact significance for each marine mammal species. From the disturbance impact assessment, harbour porpoise, white-beaked dolphin, Risso's dolphin, common dolphin and minke whale were predicted to experience disturbance to <0.77% of their respective MUs. Given the low number of animals and percentage of each MU predicted to experience disturbance, alongside the limited number of total piling days (maximum 63 days), disturbance to these species have been assessed as **negligible magnitude**.

Table 11.32 Predicted disturbance impact ranges for impact piling and the resulting impact significance

Species	Density (No. indivs/km^2)	MU/SMU	No. of animals (95% CI)	% MU	Sensitivity	Magnitude[1]	Impact Significance
Harbour porpoise	0.152	NS	323	0.09	Low	Negligible	Negligible
		WS	318	1.10	Low	Negligible	Negligible
Bottlenose dolphin	0.0037	CES	6	2.57	Low	Low	Minor
		CWSH	4	7.88	Low	Low	Minor
		OW	4	0.1	Low	Negligible	Negligible
		GNS	2	0.11	Low	Negligible	Negligible
White-beaked dolphin	0.021	CGNS	337	0.77	Low	Negligible	Negligible
Risso's dolphin	0.0135	CGNS	57	0.46	Low	Negligible	Negligible
Common dolphin	0.1168	CGNS	8	0.01	Low	Negligible	Negligible
Minke whale	0.0095	CGNS	40	0.20	Low	Negligible	Negligible
Harbour seal	Grid-cell Specific	NC&O	116 (10 to 225)	5.93 (0.53 to 11.52)	Moderate	Negligible[1]	Minor
Grey seal	Grid-cell Specific	NC&O	1,890 (203 to 3,377)	5.03 (0.57 to 9.39)	Negligible	Negligible[1]	Negligible

[1] For bottlenose dolphin, harbour seal and grey seal, the conclusion of negligible magnitude considers the results of the additional assessment undertaken using the population modelling (iPCoD).

The impact contours from impact piling at the Offshore Development (using the harbour porpoise dose-response curve as a proxy in the absence of similar empirical data) are predicted to extend across four bottlenose dolphin MUs, so the disturbance predicted in each of these was modelled (see Table 11.32). The highest levels of response are expected within the CES (six animals; 2.57%) and CWSH (four animals; 7.88%). Despite these estimates being considered highly precautionary, to further assess whether this predicted level of disturbance would be sufficient to cause a population-level effect, the Interim Population Consequences of

Disturbance (iPCoD) model[ii] (version 5.2) was run. iPCoD uses an age-structure model of population dynamics to run a number of simulations of future population trajectory with and without the predicted level of impact (Harwood *et al.*, 2014; King *et al.*, 2015). Impact parameters are drawn from piling scenarios and associated number of animals impacted, and multiple repeated simulations allow estimation of the uncertainty in predictions based on uncertainty in various input parameters. The resulting predicted population trajectories can be compared to demonstrate the magnitude of the long-term effect of the predicted impact on the population.

Models were run for the two coastal bottlenose dolphin Mus separately. The demographic parameters used were those for the coastal east Scotland MU (Sinclair *et al.*, 2020). Two piling schedules were created: 'even spread' – with 63 piling days spread evenly across an indicative four-month piling window (April July); and, 'consecutive' – with 63 consecutive piling days centred on May-June. The results of the modelling showed that there was an extremely small or no predicted effect on most combinations of piling scenarios, Mus and time periods (see Offshore EIAR [Volume 3]: Technical Appendix 11.1 for full results). Predicted impacts were slightly greater for the CWSH MU and the consecutive piling schedule. Whilst the models for the CWSH MU suggest a slight decline at the 12-year simulation for an even spread piling schedule (corresponding to 1 individual), this is considered to be a highly unlikely scenario given that baseline data indicate a very low probability of bottlenose dolphin presence in the impact area, particularly those associated with the CWSH MU. This impact pathway is therefore assessed as being of **negligible magnitude**, where there is only a slight change from baseline that will have no effect on the conservation status or integrity of the receptor.

Additional assessment was also undertaken for harbour seals and grey seals based on the higher percentage of the MU predicted to experience disturbance (see Table 11.32). In harbour seals, disturbance was predicted to be 5.93% of the MU (CI: 0.53 to 11.52) per piling day, equating to 116 animals (CI: 10 to 225) and in grey seals disturbance is predicted to be 5.03% (CI: 0.57 to 9.39) of the MU equating to 1,890 animals (CI: 203 to 3,377). It is important to remember that the conclusions of significance are based on impacts to MUs, not individuals. In the context of the populations of concern, these are small percentages of the population which would experience a temporary disturbance and any short-term changes to the presence of individuals from these populations within the study area are unlikely to be detectable against natural variation.

For both species, to further assess whether this predicted level of disturbance would be sufficient to cause a population-level effect, the iPCoD model[iii] (version 5.2) was run. The results of the iPCoD modelling based on the worst case scenario (1 pile per day; 63 piling days) showed that there was no predicted impact on the seal population as a result of the piling activity from the Offshore Development. The impacted population was expected to remain the same as the unimpacted population (see Offshore EIAR [Volume 3]: Technical Appendix 11.1 for full results). This impact pathway is therefore assessed as having a **negligible magnitude** for both species of seal.

For grey seal, the **sensitivity** to disturbance from impact piling is assessed as **negligible** due to evidence of their limited responsiveness and life history characteristics which are relatively robust to the effects of disturbance resulting in any effects on vital rates (see Section 2.3.7.8 of Offshore EIAR [Volume 3]: Technical Appendix 11.1); therefore, the assessed impact significance for grey seal is **negligible**.

Harbour seals are considered more sensitive to disturbance from impact piling than grey seal due to evidence of wide-reaching, albeit temporary, behavioural responses, and less robust life history characteristics (see Offshore EIAR [Volume 3]: Technical Appendix 11.1); therefore, the assessed **sensitivity** of harbour seal to disturbance from impact piling is **moderate**, and the significance of effect is **minor**, which is **not significant** in EIA terms.

In summary, under the maximum design scenario for impact piling the **magnitude** of disturbance has been assessed as **negligible** for all species of marine mammal, and the **sensitivity** to disturbance from impact piling ranges between **negligible** and **moderate**. Therefore, the significance of disturbance from piling for is concluded to be of **negligible** or **minor** significance, which is **not significant** in EIA terms.

[ii] http://www.smruconsulting.com/products-tools/pcod/ipcod/.

[iii] http://www.smruconsulting.com/products-tools/pcod/ipcod/.

11.6.1.1.4 Other construction activities

A simple assessment of the noise impacts from other construction activities for the Offshore Development was provided in Offshore EIAR (Volume 3): Technical Appendix 10.1: Underwater Noise Modelling Report and is presented in Offshore EIAR (Volume 3): Technical Appendix 11.1: Underwater Noise Impact Assessment. Activities which were assessed include: cable laying, trenching, rock placement, and vessel noise. Modelling for cumulative PTS assumed the worst case scenario that all sources were operating for the entirety of each 24-hour period. Additional construction activities (cable laying, trenching, rock placement) and vessel noise will occur within both the PFOWF Array Area and OECC (e.g., associated with inter-array cable installation).

Injury from other construction activities

For all other construction activities, the injury-onset (PTS) impact ranges were calculated to be <100 m using the non-impulsive criteria from Southall *et al.,* (2019). These values mean that animals would have to stay within close proximity (<100 m) for 24 hours before they experienced injury, which is an extremely unlikely scenario given that any marine mammal within the injury zone is likely to move away from the vicinity of the vessel and the construction activity. Therefore, the **magnitude** of predicted PTS impact of non-piling construction noise is assessed to be **negligible**.

Disturbance from other construction activities

The literature available on the impacts of disturbance from other construction activities on marine mammals is limited but suggests that any potential displacement is likely to be of limited duration and on a local scale (see Offshore EIAR [Volume 3]: Technical Appendix 11.1) for a summary of the available literature). For example, a number of studies predicted dredging would result in a maximum avoidance of harbour porpoise of 400 m up to 5 km from the dredging site, although these results were considered highly conservative (Verboom (2014): source level 184 dB re 1 µPa at 1 m; McQueen *et al.* (2020): source level of 192 dB re 1 µPa). In seals, based on the generic threshold of behavioural avoidance of pinnipeds (140 dB re 1 µPa SPL) (Southall *et al.,* 2007), acoustic modelling of dredging demonstrated that disturbance could be caused to individuals between 400 m to 5 km from site (McQueen *et al.,* 2020).

For other noise sources such as rock placing and trenching, there is no information available in the literature on marine mammal responses. Modelling conducted for the Moray East impact assessment assessed the potential for disturbance to marine mammals from various construction activities, including cable laying, rock placing, trenching and vessels using two fixed noise thresholds defined by Nedwell *et al.,* (2005).

A 90 $dBht_{(Species)}$ threshold defined as a strong avoidance reaction by virtually all individuals; and 75 $dBht_{(Species)}$ threshold defined as mild behavioural avoidance (for further information about dBht frequency-weighted hearing thresholds, see Offshore EIAR [Volume 3]: Technical Appendix 11.1). From these noise thresholds, it was predicted that the impact ranges for cable laying are up to 220 m, up to 550 m for rock placement, up to 640 m for trenching and within 200 m for vessel-related noises. Table 11.33 summarises the modelled impact ranges for various non-impulsive construction-related activities.

Table 11.33 Predicted impact ranges (m) for disturbance from various construction activities (Note: Data obtained from the Moray East ES[iv])

Activity	Impact Range (m) Disturbance							
	Minke whale		Dolphins		Harbour porpoise		Seals	
	90 dB_{ht}	75 dB_{ht}	90 dB_{ht}	75 dB_{ht}	90 dB_{ht}	75 dB_{ht}	90 dB_{ht}	75 dB_{ht}
Cable laying	18	180	9	75	29	220	2	29
Rock placing	70	390	31	170	99	550	17	99
Trenching	59	390	81	350	140	640	12	87
Vessel noise	6	130	12	110	22	200	<1	11

[iv] Moray Offshore Renewables Ltd. Environmental Statement. Technical Appendix 7.3 A – Marine Mammals Environmental Impact Assessment (2012).

Relevant information on harbour porpoise responses to vessel activity associated with offshore wind farm construction is provided by a recent study in the Moray Firth (Benhemma-Le Gall *et al.*, 2021). Using a passive acoustic monitoring array and vessel tracking data, porpoise occurrence and foraging activity was investigated between different construction phases at the Beatrice and Moray East offshore wind farms from 2017 to 2019, including a quantification of porpoise responses to vessel activity. Importantly, the study differentiated between responses to periods of piling activity and periods of construction where no piling was taking place, but a variety of installation and support vessels were operating within the site and wider region. In addition to the key offshore service vessels used for impact piling and WTG installation, construction-related vessel traffic included fishing vessels working as guard vessels, passenger vessels for crew transfers and some port service craft or unassigned vessels.

The probability of detecting porpoise activity was positively related to the distance from the vessel and construction activities, and negatively related to levels of vessel pressure and background noise (Benhemma-Le Gall *et al.,* 2021). Overall, porpoise displacement was observed at up to 12 km from pile driving activities and up to 4 km from construction vessels. Across the wider construction site, a decrease in porpoise occurrence (-16.7%) was also observed between the baseline and the Beatrice turbine installation phase, which included jacket foundation, turbine and cable installation. Porpoise activity levels appeared to have recovered to baseline conditions between the temporally sequential activities of Beatrice turbine installation (ending 14th May 2019) and Moray East piling (commencing 20th May 2019), equating to several days. Comparable data for other species are not available, but it is expected that other cetacean species may be displaced to a similar extent.

These results, along with other studies of vessel disturbance (reviews in Erbe *et al.,* 2019) across multiple species, have contributed to the assessment of a **low sensitivity** for all relevant cetacean species and **negligible sensitivity** for grey and harbour seals to other construction activities (see Offshore EIAR [Volume 3]: Technical Appendix 11.1). Such findings, combined with modelling studies, and consideration of the planned activities associated with the Offshore Development, suggest that other construction-related activities will result in a relatively localised (i.e., up to 4 km), short-term, temporary reduction in marine mammals within the Offshore Development Area. These responses are unlikely to significantly affect marine mammal vital rates.

Therefore, the impact is assessed as **low magnitude** for all marine mammal species, resulting in a **negligible significance**, which is **not significant** in EIA terms.

11.6.1.2 Noise-related impacts to basking sharks from low-frequency sounds

Underwater noise generated during the construction phase of the Offshore Development has the potential to additionally impact basking sharks through the physical characteristics of vibrational sound as it moves through water. Due to the technical limitations of studying basking shark, the hearing physiology and audition in this species remains uncharacterised. Conclusions on basking shark hearing are generally drawn from knowledge of hearing in other elasmobranch species (Corwin, 1981; Casper and Mann, 2010; Popper *et al.,* 2014) and therefore should not be viewed as substantiated evidence of basking shark hearing sensitivity. Rather, the use of information on other elasmobranch species as a proxy for understanding hearing in basking sharks offers a provisional assessment of potential impacts from the proposed Offshore Development activities in the absence of actual data.

Elasmobranchs are typically sensitive to vibrational noise (commonly referred to as particle motion), which is the kinetic component of sound, rather than sound pressure, which is how we measure hearing in mammalian species (Corwin, 1981). Large sharks, such as the lemon shark (*Negaprion brevirostris*) and the scalloped hammerhead (*Sphyrna lewini*), have demonstrated an increased sensitivity to low-frequency sounds and can best discriminate between noise emissions on the very low end of the noise spectrum (e.g., 40 Hz to 800 Hz) (Corwin, 1981). The sharpnosed shark (*Rhisoprionodon terranovae*), for example, has shown the greatest hearing sensitivity to vibrational frequencies of 20 Hz (Casper and Mann, 2010).

Drilling noise has been reported to have the majority of its energy below 500 Hz to 1 kHz (Nedwell *et al.,* 2003; 2010; Kongsberg, 2012), which falls within the hearing sensitivity range for many of the shark species which have been studied. Based on this information, basking sharks may be able to hear and respond to noises generated during the installation of foundations and moorings from non-percussive drilling. In turn, there is potential for construction activities to elicit a disturbance response from basking sharks which encounter the PFOWF Array Area during mooring installation.

Such responses have the potential to impact the relative fitness of individuals and populations if they halt feeding behaviours or impinge upon courtship or mating. However, as detailed in the environmental baseline (see Section 11.4.4.3), the PFOWF Array Area does not serve as primary habitat for this species and the likelihood of encountering an individual, particularly one engaged in an important biological activity such as mating, is considered low.

Consequently, potential disturbance impacts are not anticipated to have negative implications for any populations or on the conservation status of the species. Nevertheless, uncertainties relating to basking shark hearing sensitivities place particular emphasis on the importance of monitoring during construction (through the embedded mitigations within the MMMP), including training in the Scottish Marine Wildlife Watching Code to ensure the potential for any such interaction is minimised.

Basking sharks are considered to be of **low sensitivity** to vibrational noise generated by anchor pile installation, via drilling, based on the hearing sensitivities of other large shark species. The majority of the drilling energy is likely to be expended at frequencies which are higher than those considered most sensitive for elasmobranchs, based on available data. Given the low likelihood of encountering basking sharks within the Offshore Development area and the nature of the activity, the impact of underwater noise on this species is defined as being of **low magnitude**.

Therefore, the overall effect to basking shark receptors is considered to be **minor**, which is **not significant** in EIA terms. Requirements for any additional licences covering potential disturbance to basking sharks from anchor pile installation will be discussed with the relevant stakeholders prior to construction.

11.6.1.3 Summary

A summary of the assessment of effects during Construction is provided in Table 11.34.

Table 11.34 Summary of significance of effects from construction impacts

Summary of Effect	Receptor	Sensitivity	Magnitude	Rationale	Consequence	Significance of Effect	Additional Mitigation Requirements*	Residual Effects
Noise-related impacts to marine mammals from all construction activities	Minke whales	Low	Negligible	A very low density of animals is predicted. UXO clearance: negligible risk of PTS and no more than one individual predicted to be disturbed. Piling: highly precautionary cumulative PTS predicted for 10 individuals and temporary, short-term disturbance to 20 individuals; both represent very small proportions of the MU. Other construction-related activities are predicted to result in no more than localised, short-term displacement of very low numbers of animals.	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
	Bottlenose dolphins	Low	Low	Negligible risk of PTS (<1 individual) from UXO clearance or piling. Impact magnitude has been assessed as low for disturbance from impact piling. Disturbance will be short-term, temporary, and to low numbers of individuals. The largest impacts predicted for piling disturbance are up to 7.88% of the CES MU; iPCoD modelling predicts no long-term population impacts. Other construction-related activities are predicted to result in no more than localised, short-term displacement of very low numbers of animals.	Minor Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
	Dolphin species	Low	Negligible	Negligible risk of PTS to all species (<1 individual) from UXO clearance or piling. Disturbance will be short-term, temporary, and to low numbers of individuals. The largest impacts predicted for piling disturbance of <1% of any species; iPCoD modelling predicts no long-term population impacts. Other construction-related activities are predicted to result in no more than localised, short-term displacement of very low numbers of animals.	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
	Harbour porpoise	Low	Negligible	A very low proportion of MU is predicted to experience PTS from UXO clearance or piling, and embedded mitigation will reduce risk to negligible. Disturbance effects to larger numbers of individuals, but short-term and to a low proportion of MU (<1%). Other construction-related activities are predicted to result in no more than localised, short-term displacement of very low numbers of animals.	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant	Not Significant
	Harbour seals	Moderate	Low	Negligible risk of PTS (<1 individual) from UXO clearance or piling. Greatest predicted effects (minor significance) are disturbance from piling, but iPCoD modelling predicted no impact on the population. Other construction-related activities are predicted to result in no more than localised, short-term displacement of very low numbers of animals.	Minor Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
	Grey seals	Low	Low	Greatest PTS impacts predicted for UC+XO clearance (12 individuals), but due to embedded mitigation to reduce risk and anticipated frequency and magnitude of PTS effect on hearing, very little impact on vital rates predicted. Greatest predicted effects (minor significance) are disturbance from UXO clearance, but <5% of MU and anticipated brief startle response is not predicted to impact vital rates. Other construction-related activities are predicted to result in no more than localised, short-term displacement of very low numbers of animals.	Minor Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant

Summary of Effect	Receptor	Sensitivity	Magnitude	Rationale	Consequence	Significance of Effect	Additional Mitigation Requirements*	Residual Effects
Noise-related impacts to basking sharks from low-frequency construction noise	Basking sharks	Low	Low	The majority of vibrational energy during drilling installation of anchor piles is likely to be expended at frequencies which are higher than those considered most sensitive for large sharks. Given the low likelihood of encountering basking sharks within the Offshore Site and the intermittent nature of the activity, the possible magnitude of impact from underwater noise is limited and baseline conditions are not anticipated to change.	Minor Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant

11.6.2 Effects During Operation and Maintenance

11.6.2.1 Noise-related impacts to marine mammals, including the risk of physiological impacts, barrier effects, and displacement

Noise-related impacts during the operation and maintenance phase are anticipated to be less than those assessed during the construction phase. Monitoring surveys will make use of geophysical survey equipment. However, it is unlikely that source levels will be as high or frequencies as low as those during the pre-installation phase of Offshore Development, as monitoring surveys do not seek to comprehensively characterise the seabed and its substrata, but rather aim to locate buried pieces of infrastructure. Similarly, vessel noise during the operations and maintenance phase will be reduced in comparison to the construction phase of the Offshore Development, as fewer, smaller vessels will be onsite, for shorter durations and on an *ad hoc* basis. Whilst a survey vessel may still be utilised, as well as possible guard and crew transfer vessels, a Service Operations Vessel is anticipated to replace the Construction Support Vessel, anchor handling, pre-lay grapnel run, and rock placement vessels utilised during the installation and commissioning of the Offshore Development. As such, the number of vessels working on site will be approximately halved for the operation and maintenance phase.

A potential additional source of noise introduced during the operation and maintenance phase is that of mooring line pinging. This is the term used for the noise made by the sudden re-tension in a cable following a period of slackness as a result of large amplitude and/or high-frequency surface motions (Liu, 1973). The potential for injury was assessed using noise measurements from the Hywind Demonstrator project which recorded on average less than 10 ping events per day which exceeded an SPLpeak of 160 dB re 1 µPa (Martin *et al.* 2011). The worst-case scenario modelling undertaken for the Hywind Scotland Pilot Park Project by Xodus Group Limited (2015) predicted a potential SEL_{cum} of up to 157 dB re 1 $\mu Pa^2 s$ over 24 hours at 150 m. This value is below the onset criteria for injury to marine mammals and, therefore, means that should any pinging noise occur it will not result in injury. In terms of disturbance from mooring line pinging, there are currently no reliable disturbance thresholds that would be recommended for the kind of intermittent/rare noise signals that would be generated from mooring line pinging. The best available assessment of marine mammal behavioural response to underwater sound, conducted by Southall *et al.* (2007), used the 140 dB re 1 µPa (rms) criterion for mild behavioural disturbance to marine mammals for impulsive sounds in its assessment and found that this would be exceeded up to approximately 250 m from each WTG. It is also important to note that it is not known whether mooring line pinging will occur at Offshore Development as currently, only one set of data from the Hywind Demonstrator project is available for analysis.

The potential effects that could transpire from noise generated by mooring line pinging are anticipated to be limited to the PFOWF Array Area and will not occur within the OECC. However, potential impacts from vessels have the possibility of occurring within either the PFOWF Array Area or the OECC.

Both injury and disturbance from mooring line pinging are assessed as having a **negligible magnitude**. As detailed in Offshore EIAR (Volume 3): Technical Appendix 11.1, the **sensitivity** of all marine mammals is considered **low** for PTS-onset from all categories of activity. The **sensitivity** to disturbance from vessels, which will dominate operation and maintenance noise sources, is assessed as **negligible** for grey and harbour seals and **low** for all cetacean species. The **sensitivity** of all marine mammal species to maintenance geophysical surveys (particularly USBL equipment) is assessed as **low**. Considering the proportionally lower level of vessel activity associated with the operation and maintenance activities relative to construction, the impact of underwater noise from operation and maintenance activities, other than mooring line pinging, is assessed as being of **negligible magnitude**.

Therefore, the impact significance for injury and disturbance is concluded to be **negligible**, which is deemed **not significant** in terms of the EIA regulations.

11.6.2.2 Risk of injury resulting from entanglement with mooring lines or cables, including secondary interactions with derelict fishing gears

Systems which utilise mooring lines and/or cables in the water column can introduce the potential for injury or death from entanglement to large marine megafauna. In the case of the Offshore Development, up to 5 km of the 110-kV dynamic inter-array cables will be present within the water column and up to 500 m of the Offshore Export Cable(s) will be dynamic at the point of connection to the first WTG. Additionally, each WTG will include a mooring system which introduces the additional potential for entanglement.

Entanglement occurs when an animal(s) incidentally comes into contact with a dynamic line (e.g., a freely moving rope, cable or mooring line which is attached to an object such as a mooring, buoy, or static fishing gear) in the water column causing their capture or restraint (Benjamins *et al.,* 2014). When an animal remains bound to the line for a prolonged period, the repercussions of an entanglement event can be fatal.

Additionally, fishing gears, particularly nets and gillnets, can unintentionally capture non-target species as bycatch whilst fishing. When those fishing gears are lost to sea or become derelict, they may continue incidentally capturing marine megafauna as bycatch through what is referred to as 'ghost fishing'. Derelict or freed gears can wrap around cables or mooring lines in the water column, creating an opportunity for indirect or secondary entanglement with the line, through adverse interactions between animals and the attached fishing gear(s) (Benjamins *et al.,* 2014).

The risk of direct entanglement with marine megafauna rests on the design characteristics of the infrastructure, whilst the risk of secondary entanglement rests on the maintenance of the infrastructure.

Baleen whales are considered particularly vulnerable to entanglement, based on decades of evidence from interactions with fishing gears and their associated ropes (Benjamins *et al.,* 2014; Copping *et al.,* 2020). Humpback and minke whales are two species found within the UKCS which are frequently recorded with evidence of entanglement (e.g., injuries, scarring, or entangled materials clinging to the animal) within the stranding records. In fact, entanglement has been attributed as the cause of death in roughly half of the baleen whale strandings in Scotland (Northridge *et al.,* 2010).

There is a large body of evidence for the bycatch of pinnipeds and small cetaceans (porpoise and dolphins) in fishing gears, though sublethal injuries from marine debris are regularly observed in global populations (Read *et al.,* 2006; Benjamins *et al.,* 2014). Whilst evidence of entanglement among pinnipeds in Scotland is lacking, there is potential that seal injury and mortality associated with ropes and marine debris remain underreported (Brownlow pers. comm., as referenced in Benjamins *et al.,* 2014).

Despite sparse evidence within the public domain (e.g., stranding records), basking sharks are also thought to experience an elevated risk of entanglement, due to their patterns of movement and behaviour whilst transiting and foraging (Benjamins *et al.,* 2014). Basking sharks have been found entangled with the ropes of static gears, both alive and as post-mortem strandings (Benjamins *et al.,* 2014).

The realistic worst case for entanglement risk based on modelling by Benjamins *et al.* (2014) and Harnois *et al.* (2015) is the proposed catenary mooring configuration, which has the largest swept water volume and least-taut lines. However, there is still thought to be too much tension on these lines to generate any loops which could entangle a large marine vertebrate (Garavelli, 2020).

Similar to the mooring systems employed by other marine renewables projects, the Offshore Development will be utilising chains and ropes in exceedance of 100 millimetres (mm) in diameter (Benjamins *et al.,* 2014), in this case with chains or cables of 175 mm diameter and synthetic ropes of 350 mm diameter. Fishing gears which pose the greatest entanglement risk to marine species typically falls between 1 mm to 7 mm in diameter (Wilcox *et al.,* 2015). Thus, marine mammals are more likely to be at risk from secondary entanglement from interactions with fishing gears than through direct entanglement with large, thick mooring components.

Secondary entanglement may cause physiological trauma leading to lifelong injury or mortality in marine megafauna; however, the magnitude of effect is dependent upon the characteristics of the material which have become entangled on the mooring lines (i.e., its thickness, length, number of loops, spread on the line, etc.) and the biological and behavioural traits of the individual animal which encounters them (i.e., how it moves, feeds, visual acuity, size, maturity, etc.).

As the WTG mooring systems do not have loose ends or sufficient slack to create an entangling loop, the risk of direct entanglement is considered to be of **negligible magnitude**. Rather, the risk of marine mammal or basking shark entanglement rests with the potential for derelict fishing gears to collect on mooring lines and cables and create static entangling gears which continue 'ghost fishing' within the PFOWF Array Area.

As a part of the embedded mitigations, mooring lines and floating inter-array cables will be inspected during the operation and maintenance phase using a risk-based adaptive management approach. Mooring line and cable inspections are expected to occur at a higher frequency initially and then reduce in frequency over a number of years, with changes to inspection periods based on evidence of risk garnered from the inspections. As such, the risk of secondary entanglement to marine mammals and basking sharks is also considered to be of **negligible magnitude**.

In light of this negligible pathway for impact against the perceived **moderate** to **high sensitivity** to entanglement exhibited by baleen whales and basking sharks, it is considered that the overall effect of the Offshore Development is **minor**, which is **not significant** in EIA terms**.**

Potential impacts to marine mammals and basking sharks associated with entanglement risk are not anticipated to occur and will not be detrimental to the maintenance of any populations of the species of concern across their biogeographic ranges. Nevertheless, a review of mitigation measures is recommended to increase awareness and response time, should an entanglement event occur.

11.6.2.3 Risk of injury resulting from collision of marine mammals or basking sharks with floating WTG foundations or substructures

During the operation and maintenance phase, the presence of the WTG substructures has the potential to increase the risk of injury to marine mammals and basking shark through collision with novel floating infrastructure. These potential impacts are limited to the PFOWF Array Area due to the location of these structures. No such impacts are expected to occur within the OECC as there will not be any relevant structures therein. As such, the OECC is not relevant to the assessment of collision risk to marine mammals and basking sharks.

To date, there is no evidence of marine mammal or basking shark collision with floating offshore wind infrastructure, nor fixed-bottom wind or floating MRE infrastructure, and the risk of adverse physical interactions remains poorly characterised for these technologies. The majority of research effort has been put towards characterising the risk of collision with marine energy infrastructure at or near the seabed or within the mid to lower water column. Explicitly, there are ongoing efforts to define both risk and impact magnitude for potential marine mammal collision with subsurface tidal energy developments (Copping *et al.,* 2020). This is likely a reflection of the overlap tidal arrays have with vertical habitat use for many marine mammal species, particularly during foraging activity (Bailey & Thompson, 2010; Thompson *et al.,* 2015; Maeda *et al.,* 2021). Floating surface and subsurface infrastructure generally occupy the upper limit of the water column, where marine mammals come to rest.

From a behavioural perspective, an animal which is giving chase to prey is potentially more likely to engage in risky behaviour, such as a near-field approach of moving or rotating infrastructure, because of the risk-reward outcomes if they subsequently capture the prey. Similarly, individuals may not recognise novel structures in the marine environment whilst focused on foraging, thereby increasing the likelihood of a near-field interaction with active tidal infrastructure. Some species, namely harbour seals, appear to forage specifically within tidally energetic areas which form corridors, potentially taking advantage of the currents as natural fish aggregates within narrow channels (Andrews and Hunt, 2011; Hastie *et al.,* 2016). The potential for an adverse interaction with moving infrastructure is likely to be elevated if both the receptor and the developer are exploiting the same features because of an increased spatiotemporal overlap. However, the PFOWF Array Area is not located within a tidally energetic 'habitat corridor' (Hastie *et al.*, 2016), but rather a highly exposed region which is not occluded in any way, which limits the potential for these types of interactions. Moreover, the Offshore Development has been designed to limit the movement of subsurface infrastructure and does not include any rotating infrastructure within the water column.

For the proposed Offshore Development, the semi-submersible is the floating substructure design which will have the greatest surface area within the water column and, therefore, the greatest potential for interaction with marine megafauna. Whilst the majority of the substructure will be above the water's surface (60%), there will still be a total of 25,625 square metres (m^2) of structure (per substructure) within the water column when considering the full array (i.e., seven WTGs and their substructures). This surface area will be within the upper 20 m of the water column where diving animals may be surfacing and/or resting between dives. Although, this is also where some species, such as minke whales and basking sharks, may be actively foraging for prey.

Collision risk to foraging animals is likely to be elevated, per the risk-reward reasoning, and may be highest for large filter-feeding species which lunge to capture prey (Friedlaender *et al.,* 2014) and are limited by monocular vision. There may be potential for individuals to collide with floating infrastructure whilst lunging to engulf krill and schooling fish. The likelihood of an adverse interaction taking place will be influenced by a receptor's ability to perceive the floating substructure and anticipate its movements.

Each semi-submersible has been designed to be up to 125 m in length and breadth, which is over ten times the length of the largest species under consideration (minke whale). So, the issue of limited awareness of the surrounding environment during foraging is eroded by the relative scale of the structure. All floating substructures will be fixed in place by taut, semi-taut, or catenary mooring systems, designed to dampen the movement of the WTGs, for the 30-year lifetime of the Offshore Development, or at least for the duration of the WTG's deployment within that period. During this time, it is considered very unlikely that any species would collide with the floating substructures, given their size and predictability within three-dimensional space. It is also reasonable to assume that the small array will become less novel to localised marine mammal populations, such as seals from nearby haul-outs, as they habituate to the presence of the infrastructure with the passage of time – further reducing the likelihood of a collision.

For these reasons, all marine mammal and basking shark receptors have been assessed as having **negligible sensitivity** to this impact pathway, and the impact **magnitude** is considered to be **negligible**.

The overall significance of collision risk as an impact pathway is, therefore, **negligible**, which is **not significant** in EIA terms.

11.6.2.4 Displacement or barrier effects resulting from the physical presence of array infrastructure

During the operation and maintenance phase, the physical presence of the array infrastructure, including substructures, mooring lines, and cables, introduces the potential for displacement or barrier effects to marine mammal and basking shark populations occurring across the Offshore Study Area. This impact pathway may result from the presence of multiple novel structures altering the movement patterns and/or behaviours of individuals or populations in such a way as to compromise their access to key habitats or inhibit their migratory movements.

Displacement in this instance refers to spatial displacement or the loss of access to the area comprising the Offshore Site due to the persistent presence of infrastructure during the possible 30-year operational timeline of the Offshore Development. Barrier effects focus less on the Offshore Site itself, but rather on the reduction in access to the areas surrounding it, due to the presence of infrastructure within the site.

Migratory species reliant on the utilisation of key pathways or seasonal habitats are particularly vulnerable to barrier effects from obstructions. Basking sharks and minke whales are migratory species which may be impacted by obstructions from large-scale engineering projects, such as offshore wind farm arrays, if they limit access to key seasonal sites for foraging and reproduction (i.e., the Sea of the Hebrides or the Southern Trench in the Moray Firth).

The majority of the Offshore Export Cable(s) will be buried or will include remedial cable protection where burial is not possible, and only a small portion will be suspended in the water column. As such, this infrastructure is not anticipated to limit the passage of animals across the OECC. Individuals will continue to move freely between locations to the east and west of the site, along the coastline to the south, and the islands in the north, by traversing the OECC or travelling around the PFOWF Array Area. It is therefore considered that there is limited scope for barrier effects to be introduced during the operation and maintenance phase. However, the PFOWF Array Area will have structures which will be maintained within the water column for the duration of the Offshore Development, and it is uncertain whether this would inhibit habitat use by particular species, so further consideration for potential displacement effects is required.

The PFOWF Array will consist of a maximum of seven WTGs separated by a minimum distance of 800 m and connected by a 5,000 m network of 300 mm inter-array cabling with a total below-sea surface area of 9,425 m^2. The semi-submersible design for the WTG substructure will introduce the greatest below-sea surface area (25,625 m^2) when considering a depth of 20 m and a square design. The semi-taut catenary mooring system design is anticipated to have the largest pelagic footprint of up to 33,075 m of line within the water column, giving a total surface area of 36,368 m^2 when considering the worst case scenario, synthetic rope (350 mm thickness), is used. This equates to a total maximum surface area of 0.074 km^2 of infrastructure which will be floating within the water column across the entirety of the 10 km^2 PFOWF Array Area (i.e., <1% of the PFOWF Array Area will have floating infrastructure).

When considering the scale of the infrastructure against the size of the animals in question (the largest being the minke whale, which can reach up to 9 m[v]), it is unlikely that 150 m to 350 mm diameter cables and lines, or a 125 m x 125 m substructure, would prevent the functional habitat use of any individuals across the site. Individuals would swim around the comparatively large substructures and, as the cabling and mooring lines between them predominate in the mid to low water column where they radiate outward to the mooring points, surface and near-surface movements are unlikely to be impacted in the areas between WTGs. Consequently, habitat use by marine mammal and basking shark populations in the upper water column is unlikely to be hindered by the physical presence of infrastructure during the operation and maintenance phase. Animals which spend more time at depth, such as Risso's dolphins (Arranz *et al.,* 2018) and grey seals (Thompson *et al.,* 1991), are more likely to be inhibited by the presence of infrastructure near or on the seabed. However, there is evidence that such infrastructure provides additional foraging opportunities to marine mammals which may act to negate displacement effects.

Fixed-bottom offshore wind farm structures have been recorded to function as fish aggregate devices, which introduces the potential for positive associations between predators and the prey aggregating infrastructure (Dergraer *et al.,* 2020). Some prey species could potentially benefit from the introduction of structures (i.e. as shelter), hard substrate (e.g. to feed on biofouling organisms), and/or reduced fishing pressure, with the potential for subsequent attraction of predators to exploit higher prey abundance in the vicinity of such structures (Clausen *et al.,* 2021). Grey and harbour seals have been recorded to target marine infrastructure during foraging trips (Farr *et al.,* 2021), including targeting the scour protection around infrastructure to capitalise on possible reef effects (Russell *et al.,* 2014). Similarly, increased harbour porpoise activity was recorded within the operational Egmond aan Zee offshore windfarms (Lindeboom *et al.,* 2011; Scheidat *et al.,* 2011), with the structures serving as either fish aggregates or as a respite from the high vessel activity surrounding the site (Defingou *et al.,* 2019). Whilst there are no such comparable studies to date for floating offshore wind infrastructure, these examples from fixed infrastructure provide evidence for several relevant species that displacement effects are unlikely.

To date, studies of marine mammal responses to wind farms have not concurrently addressed the potential for responses to prey occurrence, and how this may be driving marine mammal use of the site, with the potential for any displacement effects from the physical presence of infrastructure or operational activities. However, observations of seals foraging actively and selectively around submerged pipelines and wind turbine structures within less than a year of their installation (Russell *et al.*, 2014, Arnould *et al.*, 2015) and regular sightings and acoustic detections of porpoise close to oil and gas platforms (Todd *et al.*, 2009; Todd *et al.*, 2016; Delefosse *et al.*, 2018; Clausen *et al.*, 2021) suggests the ability of marine mammals to rapidly identify and utilise these artificial structures for foraging.

Given the scale of the infrastructure compared to the animals likely to be encountered, it is considered that individuals can readily move between and around the WTGs, substructures and cables and mooring lines. Moreover, the actual proportion of infrastructure which will be within the water column is low across the Offshore Site and there is ample available habitat for marine mammal and basking shark use which remains. Evidence suggests that the quality of the habitat, in terms of available biomass and foraging opportunities, may benefit from the introduction of the subsea infrastructure and this could lead to increased habitat use by certain species, rather than displacement. However, any such changes will be minor, as the Offshore Development includes embedded mitigations aimed at reducing the likelihood of the WTGs and associated array infrastructure acting as fish aggregates through the management of biofouling (see Chapter 9: Benthic Ecology).

For these reasons, the operation and maintenance phase is not expected to generate any displacement or barrier effects to marine mammals or basking sharks. The embedded mitigations and maximum design parameters of the seven WTG array will enable the minimisation of impacts, both positive and negative, on

[v] https://www.nature.scot/plants-animals-and-fungi/mammals/marine-mammals/minke-whale.

individuals. Moreover, the area comprising the Offshore Development does not form key habitat to any receptor species to make it preferable over the surrounding region. Given their extensive seasonal movements and wide-ranging habits, marine mammals and basking sharks are considered to have a **negligible sensitivity** to displacement from the Offshore Site. Any changes to individual behaviour during the operation and maintenance phase will not impact baseline conditions of the relevant population(s) for any species, thus making the impact **magnitude negligible**.

Therefore, the overall significance of displacement or barrier effects as an impact pathway to marine mammals and basking shark is considered **negligible**, which is **not significant** in EIA terms.

11.6.2.5 Long-term habitat change, including the potential for changes to habitat quality

Long-term habitat change during the operation and maintenance phase of the Offshore Development may be generated by reef effects, resulting from the accumulation of lower trophic organisms on the infrastructure, introduced by the development. With the build-up of these organisms, either as biofouling on floating infrastructure or as colonies forming on hard substrate, higher trophic species, such as fish and crustaceans, may be attracted to the site. In these instances, the infrastructure may be acting as a fish aggregation device which introduces an anthropogenic 'reef' to the area – concentrating biomass where it would not otherwise occur. Reef effects have the potential to attract predatory species, including marine mammals and basking sharks. Therefore, it is important to consider how this pathway may impact the distribution and abundance of marine mammals and megafauna over the 30-year lifetime of the Offshore Development and whether positive associations with the Offshore Site might have additional detrimental effects on those species.

Additionally, the presence of cabling within the marine environment introduces EMFs which have the potential to alter the behaviour and movement of fish species around the Offshore Site such that marine mammals and basking sharks alter their habitat use in response. Potential impacts of EMFs on fish and shellfish species have been assessed in Chapter 10: Fish and Shellfish Ecology. The assessment has concluded that EMF effects on fish and shellfish receptors as a result of the Offshore Development will be not significant.

11.6.2.5.1 Long-term habitat change from the physical presence of mooring lines

Floating offshore wind arrays have the potential to generate more sedimentation from scouring around anchors and other related elements compared to fixed-bottom wind infrastructure. Mooring components will be susceptible to similar impacts from currents and wave motion that vessel anchors are subject to and those components at the seabed may generate sedimentation levels which could impact benthic species present in the PFOWF Array Area.

A catenary mooring configuration may be used, in which nylon ropes or chains will be connected to the seabed. This configuration allows for some movement of the floating structure from hydrographic processes. Movement of the ropes/chains along the seabed due to currents or tension on the lines is expected to locally abrade the seabed surface and increase sedimentation repeatedly in response to environmental conditions over the structure's lifetime. The maximum temporary footprint from the lateral movement of the maximum number of catenary mooring lines will be 2,205,000 m^2. However, any increases in sedimentation will be highly localised (i.e., a sediment plume of 1 m to 3 m in height with limited spread) and temporary in duration, with particles falling out of suspension likely within hours (see Chapter 9: Benthic Ecology).

Sedimentation from the movement of mooring lines may also have a secondary impact of releasing contaminants from the benthos into the water column, should these be present, which could additionally impact benthic species (Maxwell *et al.*, 2022). Sediment contaminant levels are low within the PFOWF Array Area and it is considered highly unlikely that important concentrations of contaminants will be released during any of the proposed activities which would negatively impact benthic organisms (Chapter 9: Benthic Ecology). As such, negative effects on higher trophic levels, such as fish and apex predatory species, through the bioaccumulation of contaminants is considered to be extremely unlikely (Sham *et al.,* 2020).

As none of the key marine megafauna receptors are susceptible to long-term impacts from mooring line presence within the marine environment, both receptor **sensitivity** and the **magnitude** of impact is considered **negligible** for this impact pathway.

The overall impact significance has been defined as **negligible** for long-term habitat change due to the presence of mooring lines, and this is **not significant** in EIA terms.

11.6.2.5.2 Long-term habitat change from the introduction of hard substrate

Marine mammals have been recorded to utilise offshore structures (e.g., pipelines, fixed-bottom wind, and MRE infrastructure) as fish aggregation devices, exploiting the opportunities for safety and sustenance they provide to lower trophic species. The introduction of artificial hard substrate to the marine environment will potentially alter the structure of benthic communities within the Offshore Site, which could in turn attract species which rely upon the benthos (Hemery *et al.,* 2020). The introduction of these new habitats and any associated species is noted to have either neutral or positive effects on biomass, from previous studies looking at marine renewable structures as artificial reefs (Kraus *et al.,* 2019). However, any long-term change to the biomass of benthic species may have ecosystem-wide implications for the marine mammals and basking sharks which share their habitat.

The use of anchors will be a permanent change to the marine habitat in the PFOWF Array Area. The maximum permanent seabed footprint of the gravity anchors (including scour protection) will be up to 55,755 m^2. The addition of remedial protection across a maximum of 50% of the inter-array cables will introduce approximately 70,000 m^2 of hard substrate to the seabed.

The WTG substructures also introduce hard substrate into the marine environment. The semi-submersible substructure design is the largest within the project envelope in terms of surface area which could be colonised by organisms. For the seven WTGs in the array, this design equates to a maximum below-sea surface area of 179,375 m^2 within the PFOWF Array Area.

Furthermore, the addition of remedial protection across a maximum of 50% of the buried Offshore Export Cable(s) will introduce approximately 87,500 m^2 of hard substrate to the seabed encompassing the OECC.

Due to the dynamic nature of the WTGs and the position of the substructures within the water column, as well as the non-porous materials used in their construction, it is unlikely that a significant biomass of biofouling will build up on these substructures. The substructure materials are fairly uniform and smooth, exhibiting low structural complexity, which does not promote colonisation. Moreover, the burial of cables and anchor design reduces the surface area of introduced hard substrates on the seabed which could be colonised. Finally, the embedded mitigation of using anti-fouling paint will further reduce the potential for significant biofouling of subsurface infrastructure. However, as the anchors and remedial protection are fixed on the seabed and are not subject to regular maintenance like the surface infrastructure and substructures, there is a greater chance that biofouling could accumulate on them.

A long-term study looking at offshore wind farm structures was conducted to determine the impacts of introducing hard substrates from offshore wind farm structures on the species richness compared to the surrounding areas (Degraer *et al.,* 2020). This study indicated three succession stages to the hard structures with the climax stage being dominated by mussels and anemones. Offshore oil and gas platforms have also been observed to be dominated by these types of species between depths of 15 m and 50 m (Degraer *et al.,* 2020).

Therefore, the potential biofouling in this region would likely move through three stages as it does on fixed offshore wind foundations and oil and gas platforms:

- Stage 1: 0 to 2 years for the pioneering stage;
- Stage 2: 3 to 5 years for the intermediate stage; and
- Stage 3: 6 or more years for the climax stage.

Biofouling on the Offshore Development infrastructure is not expected to surpass the pioneering stage, due to the low complexity of the communities present in this area (Degraer *et al.,* 2020). It would take approximately three to six years of biomass accumulation for the presence of biofouling organisms to begin to have an impact on fish distributions (Degraer *et al.,* 2020).

Therefore, habitat change resulting from the addition of novel hard substrate across the Offshore Site is not anticipated to result in important changes to the abundance of benthic flora or fauna which would result in more than a minor shift from baseline conditions (Chapter 9: Benthic Ecology). As habitat complexity is not expected to be markedly different due to the introduction of a finite amount of hard substrate, ecological changes to the community composition of the benthos are not anticipated. Should the build-up of biofouling occur within the Offshore Development, then the embedded mitigation of checking and cleaning of marine organisms from the floating infrastructure may help prevent the formation of large colonies which could result in the aggregation of fish species (see Chapter 9: Benthic Ecology). This should significantly reduce the time taken for these changes to be recovered and therefore the **magnitude** of impact will be **low**.

Consequently, there is not anticipated to be any propagation of change up the trophic levels. Important 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 Development. For these reasons, both marine mammals and basking sharks are considered to have a **negligible sensitivity** to long-term habitat change associated with the addition of novel hard substrate.

The overall impact significance is, therefore, considered **negligible**, which is **not significant** in EIA terms.

11.6.2.5.3 Long-term habitat change due to emission of EMFs

Electricity transfer via alternating and direct current (AC and DC) submarine cables generates EMFs which are comprised of an electric (E) field component (measured in Volts per m) and a magnetic (B) field component (measured in Telsa units, T). The presence of subsea cabling within the Offshore Site introduces EMFs to the marine environment which may alter the behaviour and distributions of species which rely on electric and/or magnetic signals for navigation and hunting. This may include marine mammals and basking sharks and the fish species which are preyed upon by them. Long-term impacts to the marine environment from the presence of EMF-generating cables will be fundamentally related to the sensitivity of the species occupying that habitat (Copping *et al.,* 2020).

Marine mammals are considered to have **negligible sensitivity** to EMFs, whereas basking sharks are thought to possess similar electroreceptive capabilities to other species of Elasmobranchs (i.e., sharks, rays, skates and sawfish*)* (Copping *et al.,* 2020). Elasmobranchs are known to be electro-sensitive species, possessing specialised electro-receptors within their skin to aid in identifying minute changes in current flows around them (Copping *et al.,* 2020). Sharks are also known to respond to magnetic stimuli, but it has been difficult to differentiate whether this is a true B-field response or if they are responding to an induced E-field (iE-field) generated by their movement through the B-field (Copping *et al.,* 2020). Elasmobranchs do not appear to have sophisticated magneto-receptor organs and are therefore considered to possess a **low sensitivity** to magnetic fields and a **moderate sensitivity** to electrical fields.

Diadromous fish are thought to be magneto-sensitive, using the earth's magnetic field to aid in navigating whilst undertaking extensive migrations (see Chapter 10: Fish and Shellfish Ecology). Therefore, these fish species, which include the *Salmonids* and eels, are potentially sensitive to anthropogenically-induced EMFs (Copping *et al.*, 2021). A variety of fish species utilise the Pentland Firth, but herring, whiting, and sandeels are the species most commonly preyed upon by marine mammals in the UK (BEIS, 2022). However, the Offshore Site is not located in key spawning or nursery habitat for herring or sandeels, thereby limiting the sensitivity of populations of these species to impacts therein (Chapter 10: Fish and Shellfish Ecology).

Laboratory testing and *in situ* testing of wild populations have indicated that the movements and behaviours of some diadromous and anadromous migratory fish species may be influenced by the presence of EMFs. However, it is unlikely that small-scale behavioural changes, such as an avoidance response, would impact the large-scale, migratory movements of these fish populations, particularly given the **low sensitivity** of these species to weak magnetic fields (i.e., falling at or below that of the earth) (Copping *et al.,* 2020; *see also* Chapter 10: Fish and Shellfish Ecology).

Within the PFOWF Array Area, there will be a maximum of 5 km of 110 kV High Voltage Alternating Current (HVAC) inter-array cabling with a 300 mm diameter floating in the water column until touch down point, where there will be a maximum of 20 km of cabling buried to a minimum depth of 0.6 m, or where burial is not possible, covered by remedial cable protection (to a height of 1 m). This will create a 9,425 m^2 lateral surface area from the inter-array cables within the water column which are likely to be generating EMFs. It is worth noting that, although 110 kV is the preferred cabling option, the 66 kV inter-array cabling option (as set out in Chapter 5: Project Description) forms the realistic worst case scenario, in terms of EMF emissions (Chapter 10: Fish and Shellfish Ecology).

Additionally, up to two 12.5 km 110-kV HVAC Offshore Export Cable(s), separated by a minimum distance of 20 m, will be installed within the OECC. As with the inter-array cables, the majority of the Offshore Export Cable(s) will be buried to a minimum depth of 0.6 m and remedial cable protection (to a height of 1 m) will be used where the targeted burial depth is not achieved; only a small portion of the Offshore Export Cable(s) will be in the water column. It is expected that remedial protection will account for up to 50% of the length of the Offshore Export Cable(s).

Initial modelling undertaken by Prysmian (2022) of predicted EMFs (based on a worst case voltage of 66 kV as discussed in Chapter 5: Project Description) associated with the inter-array and offshore export cables indicate that the EMF effects of the cables will be highly localised (undetectable beyond 5 m) (Prysmian, 2022). The two offshore export cables, with a minimum separation of 20 m, will not act cumulatively with one another in terms of EMF effects over this distance (see Chapter 10: Fish and Shellfish Ecology). Moreover, cable burial will reduce the EMFs generated by the inter-array and offshore export cables (17.1 μT) (Prysmian, 2022) to levels well below those from the earth's magnetic field (predicted to be 50.7±0.14 μT within the Offshore Site) (NOAA, 2021). Consequently, fish and shellfish are unlikely to detect any change in EMFs from the baseline of the surrounding environment, particularly if burial of 0.6 m achieved or remedial cable protection measures are applied (see Chapter 10: Fish and Shellfish Ecology).

Inter-array or offshore export cable lengths which remain in the water column will be protected via insulation, sheathing and armouring to reduce power loss to the surrounding environment. This will additionally act to reduce EMF emissions within the water column to undetectable within 5 m (Prysmian, 2022). Details of the cable protection measures for the floating portions of the inter-array and Offshore Export Cable(s) will be developed within the Cable Plan and CBRA post-consent.

As all EMF emissions will decay rapidly with minimal distance from the source, effects on the behaviours of individual animals are expected to be limited to very close contact with the cables (see Chapter 10: Fish and Shellfish Ecology; Copping *et al.,* 2020). In light of these design elements, the **magnitude** of effect on basking sharks and migratory fish species due to the introduction of EMFs from the use of submarine cables for the Offshore Development is considered **low**. Effects of EMFs on all other fish species and on all marine mammals are of **negligible magnitude**.

The overall **significance** of effect of EMF presence to basking shark receptors is considered to be **minor**, which is **not significant** in EIA terms. The overall significance of effect of EMFs on marine mammal receptors is considered **negligible**, which is also **not significant** in EIA terms.

As migratory fish are not key prey species to the marine megafauna receptors considered in this Chapter, and the overall **significance** of effect of EMFs on non-migratory fish species is considered **negligible**, the overall **significance** of effect to these receptors as predators is considered **negligible**. There will be no impact to marine mammals or basking sharks due to long-term habitat impacts on their prey species and any effects are **not significant** in EIA terms.

11.6.2.6 Summary

A summary of the assessment of effects during Operation and Maintenance is provided in Table 11.35.

Table 11.35 Summary of significance of effects from operation and maintenance impacts

Summary of Effect	Receptor	Sensitivity	Magnitude	Rationale	Consequence	Significance of Effect	Additional Mitigation Requirements	Residual Effects
Noise-related impacts to marine mammals from operation and maintenance activities	Minke whales	Low	Negligible	Lesser impacts than the construction phase due to fewer vessels and no high amplitude impulsive noise such as piling or UXO clearance. Negligible risk of PTS from any activities. Disturbance will be limited to localised, temporary, and intermittent displacement from vessels, which is expected to impact very low numbers of individuals and have no impact on vital rates.	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
	Dolphin species	Low	Negligible	Lesser impacts than the construction phase due to fewer vessels and no high amplitude impulsive noise such as piling or UXO clearance. Negligible risk of PTS from any activities. Disturbance will be limited to localised, temporary, and intermittent displacement from vessels, which is expected to impact very low numbers of individuals and have no impact on vital rates.	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
	Harbour porpoise	Low	Negligible	Lesser impacts than the construction phase due to fewer vessels and no high amplitude impulsive noise such as piling or UXO clearance. Negligible risk of PTS from any activities. Disturbance will be limited to localised, temporary, and intermittent displacement from vessels, which is expected to impact very low numbers of individuals and have no impact on vital rates.	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
	Harbour seals	Low	Negligible	Lesser impacts than the construction phase due to fewer vessels and no high amplitude impulsive noise such as piling or UXO clearance. Negligible risk of PTS from any activities. Any disturbance effects from vessels are predicted to be highly localised and temporary. No evidence relating decreasing seal populations with high levels of co-occurrence between vessel traffic and seals.	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
	Grey seals	Low	Negligible	Lesser impacts than the construction phase due to fewer vessels and no high amplitude impulsive noise such as piling or UXO clearance. Negligible risk of PTS from any activities. Any disturbance effects from vessels are predicted to be highly localised and temporary. No evidence relating decreasing seal populations with high levels of co-occurrence between vessel traffic and seals.	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
Entanglement risk to marine mammals and basking sharks	Minke whales	High	Negligible	The potential for direct entanglement with floating mooring and cable infrastructure is considered to be negligible due to the proposed design parameters. Whilst minke whales are considered very sensitive to injury and mortality impacts from secondary entanglement, the risk of such an impact occurring is considered negligible due to the embedded mitigations regarding the inspection and removal of debris from floating lines and cables.	Minor Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
	Basking sharks	Moderate	Negligible	The potential for direct entanglement with floating mooring and cable infrastructure is considered to be negligible due to the proposed design parameters. Whilst basking sharks are considered particularly sensitive to injury and mortality impacts from secondary entanglement, the risk of such an impact occurring is considered negligible due to the embedded mitigations regarding the inspection and removal of debris from floating lines and cables.	Minor Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant

Summary of Effect	Receptor	Sensitivity	Magnitude	Rationale	Consequence	Significance of Effect	Additional Mitigation Requirements	Residual Effects
	All other marine mammals	Moderate	Negligible	Small marine mammals are considered to have a moderate sensitivity to secondary entanglement with derelict fishing gears. However, the risk of such an impact occurring is considered negligible due to the embedded mitigations regarding the inspection and removal of debris from floating lines and cables.	Minor Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
Collision risk to marine mammals and basking sharks	Marine mammals and basking sharks	Negligible	Negligible	All floating substructures will be fixed in place by taut or semi-taut mooring systems for the 30-year lifetime of the Offshore Development. During this time, it is considered very unlikely that any marine megafauna species would collide with the floating substructures, given their size and predictability within three-dimensional space.	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
Displacement or barrier effects	Marine mammals and basking sharks	Negligible	Negligible	The embedded mitigations and maximum design parameters of the seven WTG array will enable the minimisation of impacts, both positive and negative, on marine mammals and basking sharks and any individual behavioural changes will not impact baseline conditions for relevant populations.	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
Long-term habitat change – physical presence of mooring lines	Marine mammals and basking sharks	Negligible	Negligible	Habitat change from the long-term presence of mooring lines will not generate important changes to the benthic habitat through sedimentation or contamination. Any such negative effects will be limited both spatially and temporally and will not impact marine mammals or basking sharks.	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
Long-term habitat change – introduction of hard substrate	Marine mammals and basking sharks	Negligible	Low	When considered against the spatial scale of the impact and the quality of the habitat being impacted, it is concluded that habitat change from the addition of hard substrate will be of negligible magnitude. Lower trophic species are not predicted to be significantly impacted by habitat change, particularly when considering embedded mitigations. Marine mammals are considered to have negligible sensitivity to the minor changes at lower trophic levels, and therefore have negligible sensitivity to long-term habitat changes resulting from the addition of hard substrate. Therefore, the overall effect to marine mammal and basking shark receptors is considered to be negligible and not significant.	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 and within Chapter 9: Benthic Ecology as it was concluded that the impact was not significant.	Not Significant
Long-term habitat change – emissions of EMFs	Basking sharks	Moderate	Low	Elasmobranchs such as basking sharks have electro-receptive organs which give them a moderate sensitivity to electrical fields and a low sensitivity to magnetic fields, potentially due to the induced electrical field they generate when moving through them. As there will be some EMFs which are generated within the water column due to the presence of floating cables over the lifetime of the Offshore Development, the magnitude of impact is considered to be low. Therefore, the overall effect to basking shark receptors is considered to be minor and not significant.	Minor Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 and within Chapter 9: Benthic Ecology as it was concluded that the impact was not significant.	Not Significant
Long-term habitat change – emissions of EMFs	Marine mammals	Negligible	Low	Marine mammals are not known to possess electro- or magneto-receptive organs like other marine species and are not considered to be sensitive to EMF emissions. Therefore, whilst the magnitude of impact is considered low due to the duration of the project's lifetime, the overall effect to marine mammal receptors is considered to be negligible and not significant.	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 and within Chapter 9: Benthic Ecology as it was concluded that the impact was not significant.	Not Significant

11.6.3 Effects During Decommissioning

Decommissioning will involve the dismantling and removal of the seven WTGs and associated floating substructures, anchoring systems and the removal of the dynamic and seabed laid cables (unless there is compelling evidence to leave the buried sections *in situ*). Scour protection may also be left *in situ* as it may not be practical or desirable to remove, and anchor piles may also be cut to a depth of 1 m below the seabed and left *in situ*. Detail on the decommissioning of the Offshore Development infrastructure is limited at this time as this will occur after the 30-year operational life of the Offshore Development. A Decommissioning Programme will be developed pre-construction to address the principal decommissioning measures for the Offshore Development. This will be developed in accordance with applicable guidance and detail the management, environmental management, and schedule for decommissioning. The decommissioning programme will be reviewed and updated throughout the lifetime of the Offshore Development to account for changing best practices.

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 phase. Therefore, the magnitudes of impact assigned to long-term impacts to marine mammal and basking shark receptors during the construction stage are also applicable to the decommissioning stage. It is also assumed that the receptor sensitivities will not materially change over the lifetime of the Offshore Development. Therefore, the decommissioning effects are not expected to exceed those assessed for construction.

11.6.3.1 Long-term habitat change, including the potential for changes to habitat quality

The only infrastructure that will be considered to be left *in situ* is that which is stably buried: the scour protection around the anchors as well as the piles (if this anchor solution is used) which may be cut to 1 m below the seabed. As such, the assessment focuses on these two structural components and the long-term habitat changes that their physical presence may generate.

Similar to the long-term habitat change generated by the addition of hard substrate during the construction phase of the Offshore Development, the decommissioning phase will include a seabed footprint which will last for decades. Long-term changes to the benthos may arise from leaving the driven anchor piles *in situ* (albeit 1 m below seabed), which would generate a permanent footprint of up to 1,235 m^2 with an additional footprint of 47,880 m^2 from the associated scour protection.

The man-made anchors are not structurally complex and will continue to break down over the decades, post-decommissioning, making it less likely to generate long-term habitat change through varied community composition. If the anchor piles are cut to a depth of up to 1 m below the seabed and left *in situ* during decommissioning, the permanent seabed footprint of this infrastructure is likely to be reduced through backfilling by surrounding sediments over time. Furthermore, the benthic communities which characterise the Study Area have low complexity and any biofouling on the decommissioned infrastructure is not expected to surpass the pioneering stage (Degraer *et al.,* 2020). This leaves a limited potential for the formation of new habitat which could increase the biomass of benthic fauna or alter its composition in such a way as to concentrate fish species which are targeted by marine mammals and basking sharks. For these reasons, it is considered that there will be no change in the habitat quality associated with the Offshore Site from the perspective of marine megafauna receptors.

In the absence of mitigations regarding the removal of biofouling, this pathway is thought to generate a **low magnitude** of impact from the permanent addition of hard substrate from the cut piles and surrounding scour protection within the PFOWF Array Area. As there are not expected to be any important ecological implications from the decommissioning of anchor piles *in situ*, marine mammals and basking shark populations are considered to have **negligible sensitivit**y to this impact pathway. Any effects resulting in habitat change will be tolerated without impacts to marine megafauna receptor individuals or population.

As a result, the overall impact significance is considered **negligible**, which is **not significant** in EIA terms.

11.6.3.2 Summary

A summary of the assessment of effects during Decommissioning is provided in Table 11.36.

Table 11.36 Summary of significance of effects from decommissioning impacts

Summary of Effect	Receptor	Sensitivity	Magnitude	Rationale	Consequence	Significance of Effect	Additional Mitigation Requirements	Residual Effects
Long-term habitat change	Marine mammals and basking sharks	Negligible	Low	The base case for the decommissioning of the Offshore Development is to remove all surface and subsurface infrastructure unless there is compelling evidence to leave the buried sections *in situ*. On this basis, the area of impact will be very small, but permanent. Regardless, there will be limited change to the quality of the habitat from the perspective of marine megafauna. It is considered unlikely that any habitat change would have important implications for the marine megafauna species which use it, either as individuals or as a population.	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant

11.7 Assessment of Cumulative Effects

11.7.1 Introduction

The consideration of projects which could result in potential cumulative effects is based on the results of the Offshore Study Area specific impact assessment, together with the expert judgement of specialist consultants.

Developments with construction periods that overlap with the Offshore Development will be considered quantitatively where there is sufficient information available to do so. This information may not be available for offshore wind farms in EU waters, in which case a 26-km EDR has been assumed.

Activities associated with oil and gas and carbon capture and storage (CCS) assets in the North Sea have been considered qualitatively, as the key noise source associated with these developments comes from seismic survey activities.

Projects that overlap the Offshore Study Area, which is receptor species-specific, comprising the relevant cetacean and seal MUs (as detailed in Section 11.4.1) are considered to have the potential to result in cumulative effects for marine mammals. The Offshore Study Area for basking sharks considers the UKCS; however, projects which have the potential to impact basking sharks cumulatively with the Offshore Development are limited to the seismic survey activity which regularly occurs in the North Sea and long-term habitat changes.

Cumulative effects which may compound any long-term habitat changes generated by the Offshore Development have been considered over the spatial scale supplied in Chapter 9: Benthic Ecology (i.e., 20 km), which was defined through quantitative analysis (see Section 11.7.3.4).

The approach to the assessment of projects includes:

- Quantitative assessment of projects submitted to Scoping up to six months prior to PFOWF application submission;
- Qualitative assessment of projects submitted to Scoping up to five months prior to PFOWF application submission; and
- Acknowledgement of projects submitted to Scoping between five and two months prior to PFOWF application submission.

This approach was shared with MS-LOT and the agreement was confirmed via email on 6th December 2021.

The approach to the cumulative assessment is set out in Offshore EIAR (Volume 3): Appendix 6.1. The approach and list of cumulative projects screened into the assessment were provided to MS-LOT and consultees and comments were received on 16th May 2022. These comments have been taken into account within this assessment and all relevant responses and actions in association with cumulative comments in relation to marine mammals and basking sharks are discussed in Section 11.3.

There are limited project details for offshore wind farm sites awarded Option Agreements within the ScotWind leasing round or for Offshore Wind Leasing Round 4 Projects in English waters. As noted above, the cut-off date for a qualitative assessment of projects in the Scoping stage was February 2022, therefore, the ScotWind Projects and Offshore Wind Round 4 Projects are acknowledged but no assessment has been conducted. The sites with the greatest potential to act cumulatively with the Offshore Development include the West of Orkney Windfarm (within the N1 Plan Option [PO]) as well as other sites along the north, northeast and east coasts of Scotland (e.g., those sites within the N2, N3, NE2, NE3 and NE4 POs). These projects will undertake a detailed cumulative assessment against the Offshore Development to support their development consent application.

It is additionally noted that the West of Orkney Windfarm submitted a Scoping Report in March 2022, and therefore, is not included in the assessment of cumulative effects below. However, it is envisaged that there will be no overlap with the Offshore Development activities due to Project schedules.

Projects considered for the cumulative impact assessment are listed in Table 11.37 and are illustrated in Figure 11.11 below alongside the Offshore Development.

Table 11.37 List of projects considered for the marine mammal and basking shark cumulative impact assessment

Development Type	Project Name	Status	Location	Distance (km) (in-water not straight-line distance)	Rationale for Including in Cumulative Project List
Cable	SHE Transmission Orkney-Caithness project	Consented	Pentland Firth	0	Operational timeline of the Offshore Development will overlap with this development, which crosses the OECC, meaning there is the potential for cumulative impacts which may generate long-term habitat change.
Dredge disposal site	Scrabster Extension	Open / Active	Northeast Scotland	18	Operational timeline of the Offshore Development will overlap with this development, meaning there is the potential for cumulative impacts which may generate long-term habitat change.
Offshore wind farm	Green Volt (floating wind)	Pre-consent (Scoping)	Northeast Scotland	220	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
Offshore wind farm	Rampion 2	Pre-consent (Preliminary Environmental Information Report [PEIR])	English Channel	1,135	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
Offshore wind farm	Erebus (floating wind)	Pre-consent (application stage)	Celtic Sea	935	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
Offshore wind farm	Blyth Offshore Demonstrator – Phase 2 (floating wind)	Consented	Northeast coast of England (Blyth)	468	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
Offshore wind farm	Dogger Bank C	Consented	East coast of England (adjacent to the UK Exclusive Economic Zone [EEZ] boundary)	574	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
Offshore wind farm	Sofia	Consented	East coast of England (adjacent to the UK EEZ boundary)	564	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
Offshore wind farm	Hornsea Three	Consented	East coast of England (Humber / the Wash)	695	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
Offshore wind farm	Hornsea Four	Pre-consent (application stage)	East coast of England (Humber / the Wash)	640	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
Offshore wind farm	Norfolk Vanguard	Consented	East coast of England (Norwich)	812	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
Offshore wind farm	Norfolk Boreas	Consented	East coast of England (Norwich)	800	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
Offshore wind farm	Dudgeon extension and Sheringham Shoal Extension Projects	Pre-consent (PEIR)	East coast of England (Humber / the Wash)	744	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
Offshore wind farm	East Anglia One North	Pre-consent (application stage)	East coast of England (Norwich)	876	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
Offshore wind farm	East Anglia Two	Pre-consent (application stage)	East coast of England (Norwich)	885	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
Offshore wind farm	East Anglia Three	Consented	East coast of England (Norwich)	849	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
Offshore wind farm	Awel y Môr	Pre-consent (PEIR)	North coast of Wales	744	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.

Development Type	Project Name	Status	Location	Distance (km) (in-water not straight-line distance)	Rationale for Including in Cumulative Project List
Offshore wind farm	Offshore wind farms in EU waters	Pre-consent and consented	Ireland, France, Germany, Denmark and Sweden	>500	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
Interconnector	Scotland England Green Link 1	Pre-consent (scoping)	East Lothian (Scotland) to County Durham (Northeast England)	386	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
Interconnector	Scotland England Green Link 2	Pre-consent (scoping)	Peterhead (Scotland) to North Yorkshire (Northeast England)	206	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
Interconnector	NorthConnect	Pre-consent (consented in UK but not in Norway)	Peterhead to Norway	202	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
Interconnector	Celtic Interconnector	Pre-consent (application stage)	North France (La Matrye) to South of Ireland (Ballyadam)	987	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
Interconnector	French-Alderney-Britain (FAB) Link	Under Construction	East Devon (Southeast England) to Brittany (France)	1,315	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
CCS	Acorn	Pre-consent	Northeast Scotland	154	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions. Impacts from underwater noise emissions associated with this project are limited to those from seismic surveys. As such, this is captured in the ‘Seismic Surveys’ development type listed below and would constitute one of the four seismic surveys per annum to potentially overlap the activities of the Offshore Development.
Jetty	Faray slipway extension and landing jetty	Consented	Orkney Islands (Faray island)	95	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions.
Deep water quay	Scapa Deep Water Quay	Pre-application	Orkney Islands (Burn of Deepdale, Scapa Flow)	65	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions. Potential cumulative impact for marine mammals and basking sharks from long-term habitat change over the Offshore Development’s life-cycle.
Pier extension and reclamation	Hatston Pier Proposed Extension and Reclamation	Pre-application	Orkney Islands (Mainland, Kirkwall)	90	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions. Potential cumulative impact for marine mammals and basking sharks from long-term habitat change over lifetime of the project, including post-decommissioning.
Oil and gas field developments and decommissioning projects	North Sea oil and gas assets	Pre-consent and Consented projects, and projects undergoing Decommissioning	Various locations throughout the Celtic and Greater North Seas	>100	Potential for construction timelines of the Offshore Development to overlap with this development, meaning there is the potential for cumulative impacts from underwater noise emissions. Potential cumulative impact for marine mammals and basking sharks from long-term habitat change over lifetime of the project, including post-decommissioning.
Seismic Surveys	Seismic surveys for oil and gas and CCS developments	Ongoing	Various locations throughout the Celtic and Greater North Seas	TBD	Potential cumulative impact for marine mammals and basking sharks if underwater noise generated by seismic surveys overlaps with the construction period for the Offshore Development.

Development Type	Project Name	Status	Location	Distance (km) (in-water not straight-line distance)	Rationale for Including in Cumulative Project List
Tidal energy array	MeyGen Limited	Operational[6]	North Coast of Scotland	39	Potential cumulative impact for marine mammals and basking sharks from the risk of collision and entanglement due to overlap in operational timelines.
Wave energy device testing site – Archmedes Waveswing technology	European Marine Energy Centre (EMEC) Scapa Flow	Operational	Orkney Islands (Mainland, Kirkwall)	61	Potential cumulative impact for marine mammals and basking sharks from the risk of collision and entanglement due to overlap in operational timelines.
Tidal energy device testing site	EMEC Fall of Warness	Operational	Orkney Islands (Eday)	92	Potential cumulative impact for marine mammals and basking sharks from the risk of collision and entanglement due to overlap in operational timelines.
Wave energy device testing site	EMEC Billia Croo	Operational	Orkney Islands (Mainland, Stromness)	41	Potential cumulative impact for marine mammals and basking sharks from the risk of collision and entanglement due to overlap in operational timelines.

[6] The MeyGen tidal project currently has four 1.5 MW turbines deployed, as well as a subsea hub for the existing turbines which was installed in 2020. In 2017, Meygen Limited were granted permission to deploy a further four turbines (Phase 1b) however no construction activity for this phase has taken place to date, and there is very limited publicly available information on their construction timelines for this phase. The project has restrictions on the consent for phased development (under the deploy and monitor approach) and cannot proceed to subsequent phases without application and further consultation. On 7th July 2022, Meygen Limited was successful in the Contracts for Difference (Cfd) Allocation Round 4, for Phase 1c (28MW). Whilst the results announcement by the Department for Business, Energy and Industrial Strategy indicates that MeyGen aim to install this phase in 2026/27, a new separate application will need to be made to Marine Scotland for this phase under their phased consent condition. As the CfD announcement was made less than one month prior to submission of the application for the Offshore Development (i.e. beyond the six month cut-off agreed upon with MS-LOT), and there is no further information available on MeyGen's plans or construction timelines for any of these works, only the existing operational projects have been considered in the cumulative assessment for PFOWF.

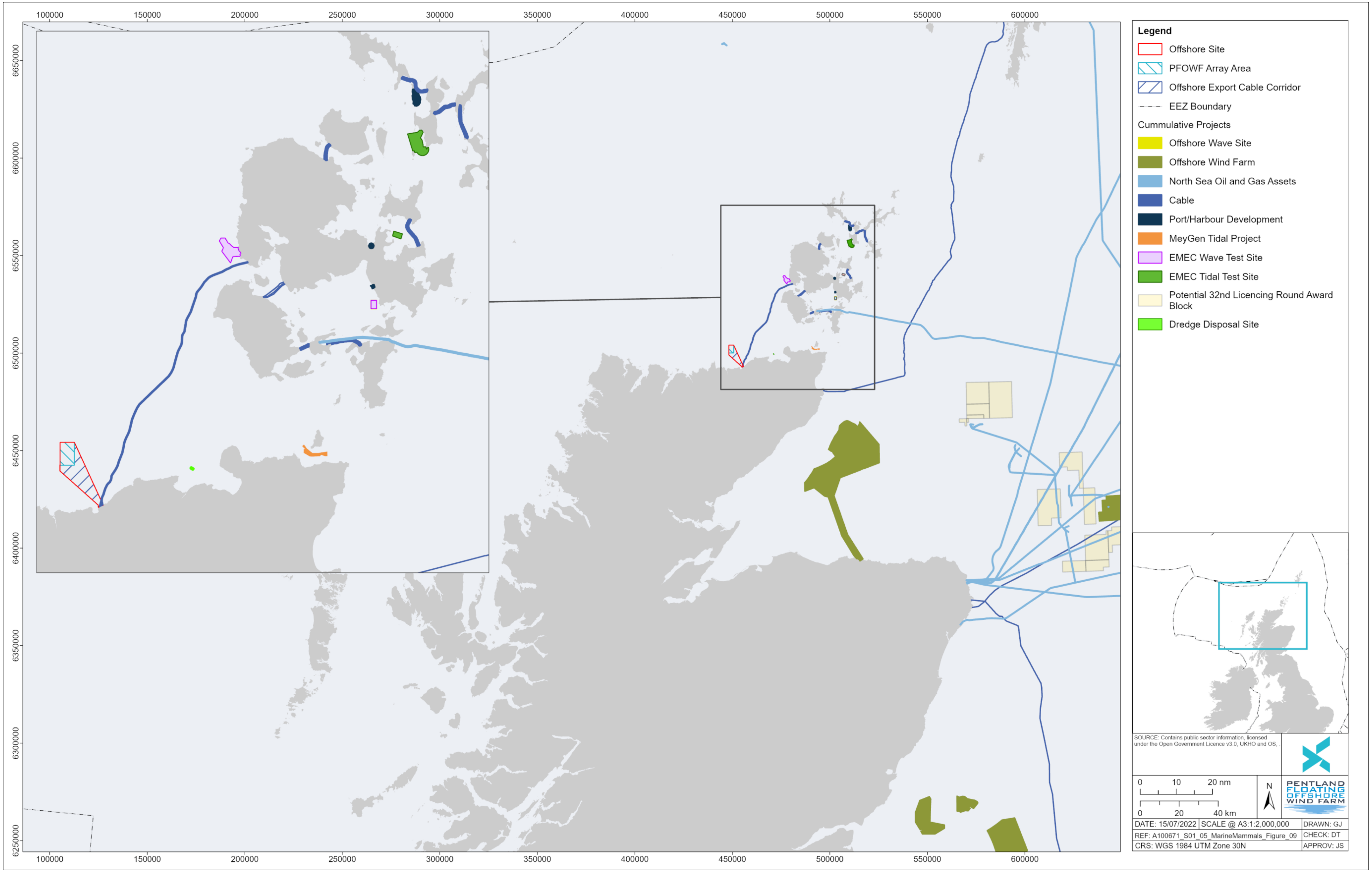

Figure 11.11 Map of the projects considered for cumulative effects to marine mammals and basking sharks within the Offshore Study Area

Construction of the Offshore Development is planned to take place over two seven-month construction stages over the spring and summer months in 2025 (Stage 1) and 2026 (Stage 2)[7]. The subsequent 30-year operational lifetime of the Offshore Development will be followed by a finite, albeit as yet undefined, decommissioning phase. Key impact pathways which have been identified with the potential to contribute to cumulative effects with other projects include noise-related impacts to marine mammals and basking shark, risk of injury from entanglement and collision, barrier and displacement effects, and long-term habitat change.

The following sections summarise the nature of the potential cumulative impacts for each Offshore Development phase.

11.7.2 Cumulative Construction Effects

11.7.2.1 *Noise-related impacts to marine mammals*

This section of the cumulative effects assessment provides a summary of the full quantitative cumulative impact assessment for underwater noise from construction activity, presented in Offshore EIAR (Volume 3): Technical Appendix 11.1.

Certain noise impacts assessed for the Offshore Development alone are not considered in the marine mammal cumulative assessment due to:

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

For these reasons, the following noise impacts are screened out of the marine mammal cumulative impact assessment:

- Auditory injury: Where PTS may result from activities such as pile-driving and UXO clearance, suitable mitigation will be put in place to reduce injury risk to marine mammals to negligible levels (as a requirement of EPS legislation);
- Disturbance from vessels: Highly localised and negligible significance. In addition, it is expected that all offshore projects will employ a vessel management plan or follow best practice guidance to reduce the impact of disturbance; and/or
- Barrier effects / operational noise: Highly localised and negligible significance.

Therefore, the only impact associated with the Offshore Development that is considered in the marine mammal cumulative impact assessment is the potential for disturbance from underwater noise during construction activities.

A variety of assessment methods were used, depending on the project type and whether or not an EIA was available. Additionally, the report details the precautions/ conservatisms inherent in this cumulative assessment of disturbance from underwater noise, which results in the estimated effects being highly precautionary. For example, assumptions of overlapping construction schedules, no spatial overlap in the impact footprints of nearby projects (such that they cover a greater area within each MU), and worst case piling parameters.

The cumulative impact assessment methods for underwater noise impacts are summarised in Table 11.38 and presented in detail in Offshore EIAR (Volume 3): Technical Appendix 11.1.

[7] It is noted that HDD at landfall is proposed to commence in 2024. However, this activity has been scoped out from further assessment for marine mammals and basking shark, based on the justifications provided in Section 11.5.2.

Table 11.38 Approach used for the underwater noise impact assessment to marine mammals from different project types in the cumulative effects assessment

Activity	Projects Considered	Approach
Floating wind projects in the planning phase	Green Volt, Erebus, Blyth Offshore Demonstrator – Phase 2	The primary impact pathway for floating offshore wind farms is underwater noise produced by anchor pile installation during the construction phase. For projects with an EIA available: The maximum number of animals disturbed per piling day presented in the EIA has been carried into the assessment. For floating offshore wind projects with no EIA available: A 15-km EDR was assumed based on JNCC *et al.,* (2020) and a worst case scenario that pin piles may be required to anchor the mooring lines.
Fixed-bottom offshore wind projects in the planning phase	Rampion 2, Dogger Bank C, Sofia, Hornsea Three, Hornsea Four, Norfolk Vanguard, Norfolk Boreas, Dudgeon extension and Sheringham Shoal Extension Projects, East Anglia ONE North, East Anglia Two, East Anglia Three, Awel y Môr, and Offshore wind farms in EU waters	The primary impact pathway for fixed offshore wind farms is underwater noise produced by piling during the construction phase. For projects with an EIA available: The maximum number of animals disturbed per piling day presented in the EIA has been carried into the assessment. For fixed-bottom offshore wind projects with no EIA available: A 26-km EDR was assumed, based on JNCC *et al.,* (2020) and a worst case scenario of driven monopiles without noise abatement (JNCC *et al.,* 2020).
Seismic surveys	Seismic surveys for oil and gas and carbon capture and storage developments	The potential number of seismic surveys that could be undertaken is unknown, so a precautionary approach was adopted, assuming up to four seismic airgun surveys could occur in the CGNS at any one time (to account for concurrent surveys in the northern and southern North Sea in both UK waters and those of neighbouring North Sea nations). The impact area was calculated following the approach used in Business Energy and Industrial Strategy (2020) where it was assumed that a seismic survey vessel travelling at 4.5 knots (8.3 km/h) could, in theory, survey a total of 199 km of survey line in a single 24-hour period and therefore impact an area of 5,228 km^2/day.
Cables and pipelines	Scotland England Green Link 1, Scotland England Green Link 2, NorthConnect, Celtic Interconnector, French-Alderney-Britain (FAB) Link	The primary impact pathway for cables and pipeline is underwater noise produced during the construction phase by pre-laying activities, such as trenching, and cable laying activities, including vessel noise. For projects with an EIA available: The maximum predicted disturbance range presented in the EIA was used. For projects with no EIA available: A precautionary 5-km EDR has been assumed.
Coastal developments (jetties, piers, port infrastructure)	Faray slipway extension and landing jetty, Scapa Deep Water Quay, Hatston Pier Proposed Extension, and Reclamation	The primary impact pathway for offshore wind farms is underwater noise produced by construction activities such as pile driving. For projects with an EIA available: The maximum predicted disturbance range presented in the EIA was used. For projects with no EIA available: A 15-km EDR has been assumed to account for impact piling of pin piles or sheet piles.

The outcomes of the cumulative impact assessment for each of the key species identified are as follows:

- **Harbour porpoise:** No relevant projects were identified in addition to PFOWF with the potential to impact the West Scotland MU; therefore, the assessment focuses on the North Sea MU, within which all projects that are expected to be under construction in 2025/26 were considered for harbour porpoise. The worst case scenario assumes that in 2025, disturbance to the harbour porpoise MU is caused by the Offshore Development together with 11 other offshore wind farm construction activities, three cable/pipeline projects, three coastal developments and four seismic surveys (see Table 9.1 in Offshore EIAR [Volume 3]: Technical Appendix 11.1: Underwater Noise Impact Assessment). In this scenario, assuming all projects construct simultaneously without mitigation, the overall impact is to 20,9217 animals (9.2% of the MU) when seismic surveys are included. It should be noted that this is an exceptionally unlikely scenario, where all construction activities would overlap and proceed as worst case scenarios without any mitigation of disturbance impacts, alongside the protections afforded to marine mammals in UK waters (see Section 11.2). The majority of the impact is predicted to come from the four seismic surveys, pile-driving at the Hornsea Projects, Dudgeon & Sheringham Shoal Extensions, the Norfolk Projects, the Dogger Bank Projects, and the East Anglia Projects.

  The proportion of the overall disturbance impact that is attributable to the proposed activities is minimal (2% or 1% of the total disturbance area, depending on whether seismic surveys are included). Therefore, even in the extremely unlikely scenario that all projects are constructed in 2025, and that they construct without mitigation, the overall **magnitude** of impact is assessed as being **low** since it is not expected that the combined impacts would result in an effect on the conservation status or integrity of the species. This assessment of a **low magnitude**, combined with a l**ow sensitivity** to disturbance from construction noise (Table 11.28), generates an overall cumulative impact significance of **minor**, which is **not significant** in EIA terms.

- **Bottlenose dolphins:** No projects were identified in the cumulative shortlist within the bottlenose dolphin CWSH MU; therefore, the assessment is limited to those projects that are within (or adjacent to) the CES MU. Considering that the population is considered to be largely restricted to shallow, near-shore waters, no disturbance is considered from seismic survey activity. The worst case scenario assumes that in 2025 and 2026, disturbance to the bottlenose dolphin CES MU is caused by the Offshore Development together with offshore export cable construction activity with one other offshore wind farm (Green Volt; landfall near Peterhead), three cable/pipeline projects, and three coastal developments, with a total of 14 dolphins (6.3% of the CES MU) predicted to be disturbed per activity day. A population model was run on this scenario, resulting in an extremely small predicted impact, with impacted populations predicted to be 99.1%, 99.3%, and 99.7% of unimpacted populations at 1, 6 and 12 years following the disturbance, respectively, which is not considered to represent a significant effect on the conservation status or integrity of the population. Therefore, the **magnitud**e of impact has been assessed as **low.** Bottlenose dolphins have been assessed as having **low sensitivity** to construction noise disturbance, and the cumulative impact of disturbance has been assessed as **low magnitude.** Therefore, the overall cumulative impact of underwater noise on bottlenose dolphin is assessed as **minor** significance, which is considered **not significant** in EIA terms.

- **White-beaked dolphins:** Whilst a large number of projects were screened into the marine mammal cumulative assessment for the white-beaked dolphin Celtic and Greater North Sea (CGNS) MU, most projects concluded that white-beaked dolphins were not common enough at the site to be screened into the project specific impact assessment. As a result, there is little impact predicted to the white-beaked dolphin MU (see Table 9.3 in Offshore EIAR [Volume 3]: Technical Appendix 11.1: Underwater Noise Impact Assessment). The worst case scenario assumes that in 2025, disturbance to the white-beaked dolphin MU is caused by the Offshore Development together with four other offshore wind farm construction activities, two cable/pipeline projects, three coastal developments and four seismic surveys. Assuming these projects are all constructed at the same time, this results in disturbance to 1,174 white-beaked dolphins (2.7% MU) per day. Even in the extremely unlikely scenario presented in this cumulative assessment, the overall impact is assessed as being of **low magnitude** since it is not expected that the combined impacts would result in an effect on the conservation status or integrity of the species. White-beaked dolphins have been assessed as of **low sensitivity** to construction noise disturbance, and the cumulative impact of disturbance has been assessed as **low magnitude.** Therefore, the overall cumulative impact of underwater noise on white-beaked dolphin is assessed as **minor** significance, which is **not significant** in EIA terms.

- **<u>Risso's dolphin:</u>** Whilst a large number of projects were screened into the marine mammal cumulative assessment for the Risso's dolphin CGNS MU, most projects concluded that Risso's dolphins were not common enough at the site to be screened into the project-specific impact assessment. As a result, there is little impact to the Risso's dolphin MU predicted (see Table 9.4 in Offshore EIAR [Volume 3]: Technical Appendix 11.1: Underwater Noise Impact Assessment). The worst- ase scenario assumes that in 2025-2026, disturbance to the Risso's dolphin MU is caused by the Offshore Development, together with three other offshore wind farm construction activities and four seismic surveys. Assuming these projects are constructed at the same time, this results in disturbance to 242 Risso's dolphins (2.0% MU) per day. Risso's dolphins have been assessed as of **low sensitivity** to construction noise disturbance. Even in the extremely unlikely scenario presented in this cumulative assessment, the overall impact of cumulative noise disturbance to Risso's dolphins is assessed as being of **low magnitude** since it is not expected that the combined impacts would result in an effect on the conservation status or integrity of the species. Therefore, the overall cumulative impact of underwater noise on Risso's dolphin is assessed as **minor** significance, which is **not significant** in EIA terms.

- **<u>Common dolphin:</u>** Whilst a large number of projects were screened into the marine mammal cumulative assessment for the common dolphin CGNS MU, most projects, including all North Sea wind farm projects, concluded that common dolphins were not common enough at the site to be screened into the project specific impact assessment. As a result, there is little impact to the common dolphin MU predicted (see Table 9.5 in Offshore EIAR [Volume 3]: Technical Appendix 11.1: Underwater Noise Impact Assessment). The worst case scenario assumes that in 2026, disturbance to the common dolphin MU is caused by the Offshore Development together with two other offshore wind farm construction activities (Rampion 2 and Erebus), one coastal development and four seismic surveys. Assuming these projects are constructed at the same time, this results in disturbance to 2,150 common dolphins (2.1% MU) per day, the vast majority of which is attributable to seismic survey activity. Common dolphins have been assessed as of **low sensitivity** to construction noise disturbance. Even in the extremely unlikely scenario presented in this assessment, the overall impact of cumulative noise disturbance to common dolphins is assessed as being of **low magnitude** since it is not expected that the combined impacts would result in an effect on the conservation status or integrity of the species. Therefore, Therefore, the overall cumulative impact of underwater noise on common dolphin is assessed as **minor** significance, which is **not significant** in EIA terms.

- **<u>Minke whale:</u>** The worst case scenario assumes that in 2026, disturbance to the minke whale MU is caused by the Offshore Development together with eight other offshore wind farm construction activities, two cable/pipeline projects, three coastal developments and four seismic surveys (see Table 9.6 in Offshore EIAR [Volume 3]: Technical Appendix 11.1: Underwater Noise Impact Assessment). Assuming these projects are constructed at the same time, this results in disturbance to 770 minke whales (3.8% MU) per day. Minke whales have been assessed as of **low sensitivity** to construction noise disturbance. Even in the extremely unlikely scenario presented in this cumulative impact assessment, the overall impact of cumulative noise disturbance to minke whales is assessed as being of **low magnitude** since it is not expected that the combined impacts would result in an effect on the conservation status or integrity of the species. Therefore, the overall cumulative impact of underwater noise on minke whale is assessed as **minor** significance, which is considered to be **not significant** in EIA terms.

- **<u>Harbour and grey seals:</u>** The worst case scenario assumes that in 2025 to 2026, disturbance to harbour and grey seal of the North Coast and Orkney MU is caused by the Offshore Development, together with three other coastal developments scheduled to construct around this time. Assuming these projects construct at the same time, this results in disturbance to 162 harbour seals (8.3% MU) and 2,698 grey seals (7.5% MU) per day (see Table 9.7 in Offshore EIAR [Volume 3]: Technical Appendix 11.1: Underwater Noise Impact Assessment). To assess whether the predicted level of disturbance would be sufficient to cause a population level effect on grey seals, the iPCoD model was run, with results predicting no impact on the harbour or grey seal population as a result of the cumulative disturbance activity (impacted population were the same size as unimpacted populations). Therefore, this impact was assessed of **negligible magnitude**. Harbour and grey seals have been assessed as of **moderate** and **negligible sensitivity** to construction noise disturbance, respectively. Even in the extremely unlikely scenario presented in this cumulative impact assessment, the overall impact of cumulative noise disturbance to both harbour and grey seal is assessed as being of **negligible magnitude** as assessment results predict that changes will be barely detectable, approximating to the 'no change' situation, and will not affect the conservation status or integrity of the receptor. Therefore, the overall cumulative impact of underwater noise is assessed as **minor** significance for harbour seals, and **negligible** significance for grey seals, both of which are considered to be **not significant** in EIA terms.

11.7.2.2 Noise-related impacts to basking sharks

This section of the cumulative effects assessment provides a summary of the qualitative impact assessment for noise-related impacts to basking sharks.

Cumulative noise-related impacts to basking sharks associated with the proposed construction activities will be limited to impacts from projects associated with seismic surveys using equipment operating within the hearing sensitivity range of elasmobranchs. For this reason, the following cumulative impact assessment strictly considers low and ultra-low frequency seismic surveys (i.e., those undertaken during geophysical surveys for subsea oil and gas reservoirs for oil and gas development or CCS).

Table 11.39 summarises the project type and assessment methods used in the cumulative impact assessment.

Table 11.39 Approach used for the underwater noise impact assessment to basking sharks from different project types in the cumulative effects assessment

Activity	Projects Considered	Approach
Seismic surveys	Seismic surveys for oil and gas and carbon capture and storage developments	The potential number of seismic surveys that could be undertaken is unknown, so a precautionary approach was adopted, assuming up to four seismic airgun surveys could occur in the CGNS at any one time (to account for concurrent surveys in the northern and southern North Sea in both UK waters and those of neighbouring North Sea nations). The impact area was calculated following the approach used in Business Energy and Industrial Strategy (BEIS) (2020) where it was assumed that a seismic survey vessel travelling at 2.3 metres per second (4.5 knots) could, in theory, survey a total of 199 km of survey line in a 24 hours and therefore impact an area of 5,228 km^2 per day. For low-frequency seismic survey impacts to basking sharks, it is uncertain whether individuals would be attracted to or deterred by impulsive sounds within their hearing range, thus a qualitative assessment has been undertaken.

Available data on elasmobranch hearing suggests basking sharks are most sensitive to ultra-low or low-frequency sounds (i.e., in the order of a few Hz to several tens of Hz). There are no planned construction activities with the capacity to produce sounds at these very low frequencies. However, as a part of standard survey methods for oil and gas exploration, seismic airgun arrays can be used to generate sounds under 100 Hz to penetrate the seafloor and gather information about subsea reservoirs (Chelminksi *et al.,* 2019).

The potential number of seismic surveys which may take place concurrently with construction activities cannot be determined at present; thus, a conservative estimate of four surveys taking place within the North Sea at any given time has been adopted. It remains unlikely that four separate seismic survey campaigns will be running concurrently with one another, much less with the construction of the PFOWF Array Area. Moreover, the scope for cumulative noise effects is limited by the spatial separation between projects and the topography of the Offshore Development's surrounding environment, with the Orkney Isles acting as a barrier for far-reaching low and ultra-low noise emissions.

Low and ultra-low frequency seismic surveys for oil and gas development and CCS are expected to occur many tens to several hundreds of kilometres offshore in the central northern North Sea, where such development is actively being sought. The Acorn CO_2 Storage Site, for example, is located approximately 153 km to the southeast by sea from the Offshore development, whilst the nearest 32nd Licensing Round Award Blocks for oil and gas development are located over 100 km by sea from the Offshore Development, all of which are offshore of the outer Moray Firth (Figure 11.11). It is worth noting that, whilst ultra-low frequency sounds can travel hundreds of kilometres within the marine environment, as has been shown in communication experiments (e.g., Frietag *et al*., 2015), the vast majority of the acoustic energy for seismic surveys is directed downward into the seabed, not horizontally into the water column. As such, sound loss (i.e., attenuation) over the horizontal plane is expected to be dramatic, limiting important underwater noise to the survey area (Offshore EIAR [Volume 3]: Technical Appendix 11.1: Underwater Noise Impact Assessment).

Additionally, precaution has been applied in the absence of an evidence base for disturbance effects of underwater sounds on basking sharks. Research on the effects of underwater sounds, including low and ultra-low frequency sounds (i.e., <1.5 kHz), on shark behaviour suggests that animals may be attracted to the noise source or repelled by it and elicited behaviours are likely to be species-dependent (Chapuis *et al.*, 2019). As such, it has been assumed that basking sharks would be repelled by the noise, acting out a disturbance response rather than an attraction response, though with limited potential for significant effects to individual or population vital rates. Thus, **sensitivity** to underwater sound has been cautiously assessed as **low** for this species.

As seismic surveys are a mobile sound source, any basking sharks which may encounter an actively surveying vessel will only do so for a short period, as the survey vessel will be moving at a speed of roughly 2.3 metres per second (4.5 knots) (BEIS, 2020). Basking sharks have been recorded to reach a top speed of 5.1 metres per second (Emmett *et al.*, 2018), which means that a fleeing individual could rapidly move away from this sound source in any direction without the risk of it re-encountering the sound because it had caught up. Within a matter of minutes, the animal could be a kilometre away from the survey vessel if travelling at this speed.

Impacts generated by seismic surveys operating equipment at low and ultra-low frequencies are considered to be **negligible** in **magnitude**, with the area of impact largely limited to the temporary survey area. Therefore, there is limited scope for those projects to act cumulatively with the activities of the Offshore Development. Consequently, there will be **no change** to the **low magnitude** of impact from the project alone, which considered the effects of noise from drilled mooring anchor installation on basking sharks. Therefore, the overall cumulative effect of noise-related impacts to basking sharks is assessed as **minor** and **not significant.**

11.7.3 Cumulative Operation and Maintenance Effects

11.7.3.1 Risk of injury from entanglement

This section of the cumulative effects assessment provides a summary of the qualitative cumulative impact assessment of the risk of injury from entanglement to marine mammals and basking sharks during the operation and maintenance phase of the Offshore Development.

Projects which have been considered are limited to floating MRE and wind projects which have operational timelines which will overlap that of the Offshore Development, as the addition of novel floating infrastructure within the Offshore Study Area may increase the magnitude of effect for this impact pathway. Additionally, commercial fishing forms a key activity which has the potential to generate secondary entanglement impacts within the Offshore Site, and which may be a source of primary entanglement for receptors within the Offshore Study Area.

Table 11.40 summarises the approach used to assess the cumulative risk of injury from entanglement to marine mammals and basking sharks.

Table 11.40 Approach used for the entanglement risk assessment from different project types in the cumulative effects assessment

Activity	Projects Considered	Approach
Wave energy projects in the operational phase	EMEC Scapa Flow, EMEC Billia Croo	The primary impact pathway for wave energy projects is the risk of injury from entanglement during the operational phase. The impact area considers all projects which overlap the Offshore Study Area.
Tidal energy projects in the operational phase	MeyGen Limited, EMEC Fall of Warness	The primary impact pathway for tidal energy projects is the risk of injury from entanglement during the operational phase. The impact area considers all projects which overlap the Offshore Study Area.

Activity	Projects Considered	Approach
Floating wind projects in the operational phase	Green Volt, Erebus, Blyth Offshore Demonstrator – Phase 2	The primary impact pathway for floating wind projects is the risk of injury from entanglement during the operational phase. The impact area considers all projects which overlap the Offshore Study Area.
Commercial fisheries	Static and Active Gear Fisheries	The key impact pathway for commercial fisheries is the risk of injury or mortality from primary entanglement with static gears (lines from creels and pots) and secondary entanglement with various derelict gears. The assessment considers International Council for the Exploration of the Sea (ICES) rectangles 46E5, 46E6, 47E5, and 47E6 (Chapter 10:Fish and Shellfish Ecology). The Offshore Site does not directly overlap ICES rectangles 46E5, 47E5, and 47E6; however, is it acknowledged that certain impacts from the Offshore Development may extend into surrounding ICES rectangles.

As described in Section 11.6.2.2, minke whales are considered to have a **high sensitivity** to injury from entanglement, whilst the remaining marine mammal species and basking sharks have a **moderate sensitivity** to this impact pathway.

The sections below detail the risk of primary (or direct) entanglement between projects and marine mammal and basking shark receptors, as well as the risk of secondary entanglement due to the fouling of that infrastructure with marine debris.

11.7.3.1.1 Primary entanglement risk

The potential risk of primary entanglement with floating offshore wind and MRE projects is considered very low for marine mammals and basking sharks due to the design considerations for the infrastructure within the water column. For the Offshore Development, all mooring configurations will be under some level of tension that will maintain the position of the floating WTGS and the floating portions of the inter-array and offshore export cables are extremely thick (300 mm) (see Chapter 5: Project Description) relative to other sources of marine entanglement, such as fishing lines and nets (see Section 11.6.2.2). These design parameters make it highly unlikely that there will be enough ductility or slack in the cables or mooring lines to generate an 'entangling loop' around marine mammals and basking sharks. It is highly plausible that other floating offshore wind infrastructure would utilise similar anchoring design parameters, including the level of tension and the thickness of the mooring chains or cables, to maintain the position of the WTGs within the energetic marine environment and under the force of the wind power they are extracting. Consequently, it is considered that other floating offshore wind projects which are anticipated to be operational during the operation and maintenance phase of the Offshore Development will not alter the **negligible magnitude** of effect for primary entanglement risk.

Wave and tidal stream energy projects which are located within the water column (i.e., rather than those utilising stationary turbines affixed to the seabed or coastline) have the potential to introduce primary entanglement risk, though only if their mooring or cabling infrastructure design differs dramatically from the Offshore Development. The closest floating MRE project to the Offshore Development is the European Marine Energy Commission (EMEC) Billia Croo wave energy test site, located 41 km north by sea. This site has five deep-water berths for device deployment which are all grid-connected via protected subsea export cables which are on the seabed. As such, entanglement risk within this site is largely limited to mooring lines and any small lengths of cable within the water column, connecting the devices to the subsea export cables. Many of the device types anticipated to occupy the EMEC Billia Croo wave energy test site will utilise fixed foundations, and those devices with moorings are restricted to 100 tonnes of synthetic mooring material per device to limit risks to humans and the marine environment. The maximum footprint of the collective mooring systems at Billia Croo, including those which are not associated with wave energy devices, is estimated at 0.073 km^2, which is very small compared to the footprint generated by commercial fisheries activities (Xodus Group, 2019). Although a variety of mooring configurations may be deployed at Billia Croo, the Environmental Appraisal conducted for this site concluded that the likelihood of a primary entanglement event occurring within this site is extremely low (Xodus Group, 2019), given its maximum footprint and location in respect to sensitive marine megafauna receptors.

Consequently, there is **no change** to the **negligible magnitude** of effect from primary entanglement risk to marine mammals or basking sharks cumulatively with activities at this site.

The other EMEC test sites include the Scapa Flow wave energy test site (61 km north) and EMEC Fall of Warness tidal test site (92 km north). EMEC Scapa Flow is a scale test site which is not grid connected. This site gives developers the opportunity to test individual devices in the relatively benign waters of the Harbour Authority Limits. Recently, the Archimedes Waves Swing (AWS) technology has been undergoing initial testing within this site, in which the 50-tonne AWS device was moored to a gravity base anchor via a single tension tether. The risk of primary entanglement associated with this particular device is considered to be of **negligible magnitude**, with no potential to alter the vital rates of any receptor species. Whilst other mooring configurations may be used onsite in future, the limited number of devices which will be in the water for temporary testing at any one time is extremely small for this 0.4 km by 0.9 km test site, and therefore the **magnitude** of effect remains **negligible** for primary entanglement within this site.

The EMEC Fall of Warness tidal test site is grid-connected, with seven cabled tidal test births situated in waters between 20 m and 50 m in depth. Currently, the Orbital O2 floating tidal turbine is anchored at this site. It has four taut mooring lines, which consist of thick chains, and a small length of cable within the water column connecting it to the offshore export cable. This configuration precludes primary entanglement with marine mammals or basking sharks, and therefore there is **no change** to the **negligible magnitude** of effect cumulatively with activities at this site.

For these reasons, the impact pathway of primary entanglement with marine megafauna is not anticipated to be generated by the Offshore Development or any other operational floating wind, wave or tidal energy developments. All projects are considered to have a **negligible magnitude** of effect, which constitutes a **negligible** significance of effect for the Offshore Development cumulatively with these projects, which is **not significant** in EIA terms.

The remaining source of primary entanglement within the Offshore Study Area comes from commercial fishing activities, namely through the use of creels (Benjamins *et al.*, 2014; MacLennan *et al.*, 2021). Creel fishing effort is moderate to high in the waters encompassing the Offshore Development, compared to other regions of the United Kingdom (Northridge *et al.*, 2010). However, the relative risk of entanglement for minke whales (and other baleen whales) is considered very low along the North Coast of Scotland, due to the limited potential for overlap between minke whales and creel effort, based on sightings data on this species (Northridge *et al.*, 2010). In recent years, support from the creel fishing industry on this marine wildlife conservation issue has grown, with the development of the Scottish Entanglement Alliance (SEA) – an industry-led partnership with research and conservation organisations initiated by the Scottish Creel Fishermen's Federation (MacLennan *et al.*, 2021). The SEA has highlighted the issue of marine megafauna entanglement to Scottish creel fishermen and, in partnership with the IWC Global Whale Entanglement Response Network, was able to provide the first disentanglement training workshop for fishermen in Europe.

Whilst the SEA project has no doubt made a positive impact to the future conservation outcomes within the Scottish creel fishing industry, this issue remains a concern for the conservation of baleen whales in Scottish waters. There is evidence that entanglement events in Scotland are sufficiently frequent and consequential to impact localised populations of marine mammals, including the conservation and recovery of minke whale populations. Adverse impacts to the vital rates of minke whale populations cannot, therefore, be ruled out and the **magnitude** of effect against this particular species is considered **high.** However, as the impact **magnitude** for primary entanglement for the project alone is **negligible**, there is no potential for the Offshore Development to generate cumulative effects for this impact pathway. Consequently, there is **no change** to the impact **magnitude**, regardless of the assessment against potential impacts from commercial fisheries.

The overall significance of effect due to primary entanglement with marine mammals and basking sharks cumulatively with other offshore projects is **minor**, which is **not significant** in EIA terms.

11.7.3.1.2 Secondary entanglement risk

The risk of secondary entanglement between offshore infrastructure with marine debris, including derelict fishing gears, forms the basis of the cumulative effects assessment for this impact pathway.

As covered in Section 11.7.3.1.1, the footprint of the floating infrastructure surrounding the Offshore Development is collectively small, with all proposed large-scale floating energy projects located over 200 km from the Offshore Site. This minimises the potential for marine debris to become fixed on infrastructure within the water column, generating a potential secondary entanglement risk. Moreover, as covered in Section 11.6.2.2, the waters encompassing the Offshore Site do not form key habitat to minke whales or basking sharks, further limiting the potential for adverse interactions between floating MRE and wind infrastructure with these species through the pathway of secondary entanglement. Nonetheless, commercial fisheries do operate within the Offshore Study Area and it is important to characterise their effort and area use to fully glean an understanding of risk due to derelict fishing gears fouling existing or proposed floating infrastructure.

Overall fishing intensity within the Offshore Study Area is low relative to surrounding waters (Scottish Government, 2022b) and is dominated by demersal trawling and scallop dredging, with some creeling as well (see Chapter 10: Fish and Shellfish Ecology) (MMO, 2020). Scallop dredging does not introduce any entanglement risk to marine mammals or basking sharks, because dredge gears do not include lines or nets in the water column, but rather dragging a towed metal-framed net with dredge 'teeth' across the seabed to extract buried scallops. There is the potential for derelict trawl nets and untethered lines from creel pots to foul floating marine infrastructure in such a way as to increase the risk of secondary entanglement with marine mammals and basking sharks. However, it is worth noting that such losses of gears are expensive to fishing fleets and fishermen are expected to minimise the potential for such losses because of the potential impacts it may have on their commercial income.

Similar to the Offshore Development, it is anticipated that other floating wind energy and floating MRE developments will include monitoring and maintenance of cables and lines in the water as a part of their infrastructure management practices during the operation and maintenance phase. Monitoring is a necessary component to maintaining floating offshore infrastructure and ensuring the functionality and integrity of the devices is not compromised by external sources. It can therefore be safely assumed that akin to the Offshore Development, other projects will aim to reduce the risk of fouling to their floating infrastructure through best practice management during the operation and maintenance phase.

Consequently, it is considered that there will be **no change** to the **magnitude** of effect, which was originally assessed as **negligible** for secondary entanglement. Therefore, potential impacts from secondary entanglement with minke whale receptors, which have a **high sensitivity** to entanglement effects, are still considered to be of **negligible magnitude**, making the overall significance of effect **minor** which is **not significant** in EIA terms.

All other species of marine mammal and basking sharks are considered to have a **moderate sensitivity** to entanglement, based on the likelihood of injury or mortality resulting from an entanglement interaction. Given there is **no change** anticipated for the **magnitude** of impact based on the above information, the overall significance of effect for the remaining receptor species remains **negligible**, which is **not significant** in EIA terms.

11.7.3.2 Risk of injury from collision

This section of the cumulative effects assessment provides a summary of the qualitative cumulative impact assessment of risk of injury from collision to marine mammals and basking sharks during the operation and maintenance phase of the Offshore Development.

Projects which have been considered are limited to floating and fixed MRE and floating wind projects which have operational timelines which will overlap that of the Offshore Development, as the addition of novel floating infrastructure within the Offshore Study Area may increase the magnitude for this impact pathway.

Table 11.41 summarises the approach used to assess the cumulative risk of injury from collision to marine mammals and basking sharks.

Table 11.41 Approach used for the collision risk assessment from different project types in the cumulative effects assessment

Activity	Projects Considered	Approach
Wave energy projects in the operational phase – floating	EMEC Scapa Flow, EMEC Billia Croo	The primary impact pathway for wave energy projects is the risk of injury from collision. The impact area considers all projects which overlap the Offshore Study Area.

Activity	Projects Considered	Approach
Tidal energy projects in the operational phase – fixed and floating	MeyGen Limited, EMEC Fall of Warness	The primary impact pathway for tidal energy projects is the risk of injury from collision. The impact area considers all projects which overlap the Offshore Study Area.
Floating wind projects in the operational phase	Green Volt, Erebus, Blyth Offshore Demonstrator – Phase 2	The primary impact pathway for floating wind projects is the risk of injury from collision. The impact area considers all projects which overlap the Offshore Study Area.

As described in Section 11.6.2.3, marine mammals and basking sharks are considered to have a **negligible sensitivity** to collision risk with the WTG substructures, based on the realistic worst case design parameters. However, there is potential that the introduction of additional novel floating infrastructure from other floating wind and fixed or floating MRE developments may increase the risk of collision within the Offshore Study Area.

The closest of these types of projects is the MeyGen Limited tidal energy array, which is 39 km to the east of the Offshore Development. The MeyGen tidal energy project has four fixed 1.5 megawatts (MW) turbines and a subsea hub in operation currently and this is considered further below. However, as future expansion remains uncertain, this has not been considered within the cumulative effects section. There are also the EMEC test sites for wave and tidal energy scattered around the Orkney Islands, which will berth floating and fixed MRE devices. The nearest of these is the EMEC Billia Croo wave energy device testing site, which is 41 km north by sea. All floating offshore wind farms are located over 200 km from the Offshore Site.

The MeyGen tidal project, which has been operational since 2017, is most likely to impact marine mammals which utilise the site as a part of their primary foraging area (Thompson *et al.,* 2015; Maeda *et al.,* 2021; Bailey & Thompson, 2010), for example, harbour and grey seals from nearby haul-outs at Gills Bay or Stroma (see Section 11.4.4.4.2). These tidal turbines have sensors and are well monitored, as there is an industry-wide commitment to characterising and managing the issue of collision risk with tidal energy devices. The MeyGen tidal project has had no reported cases of marine mammal collisions since its installation in 2017, and a total of four marine mammal sightings have occurred within 100 m of a MeyGen turbine (Sparling *et al.,* 2020).

The other tidal energy site under consideration, the EMEC Fall of Warness tidal energy test site, was granted a generating capacity of up to 10 MW, which may be achieved through a maximum of 12 devices with up to 18 rotors in total. Similar to MeyGen, this site sits within an area of elevated at-sea density for seal species (Figure 11.5), due to its proximity to important haul-outs and breeding sites (see Figure 11.10). Currently, the world's most powerful tidal turbine, the Orbital O2, is berthed at EMEC Fall of Warness and undergoing continued testing. There are no reported collisions with any marine megafauna species at this site.

Small cetacean and seal species occur in the greatest densities in the surrounding environment of these tidal energy projects and are most likely to experience serious injury or mortality if a collision were to occur (due to their size). As such, they are considered most at risk for adverse interactions with a tidal energy device. However, the behaviour of these species around the devices limits the potential for adverse interactions.

Behavioural data demonstrates that small marine mammals generally exhibit evasive behaviour around tidal turbines, particularly during operational periods, thereby reducing the risk of collision (Gillespie *et al.,* 2021; Palmer *et al.,* 2021; Onoufriou *et al.*, 2021). Research on harbour seal behaviour around tidal energy devices noted a change in transiting behaviour during operation, such that tagged individuals exhibited localised avoidance at a distance of 250 m from the operating device (Sparling *et al.*, 2016). Similarly, there is evidence that harbour seals may avoid tidal energy devices within the audible range of the operating turbines (Onoufriou *et al.*, 2021). Similarly, studies of harbour porpoise movements around the MeyGen tidal turbines suggests avoidance at a distance of 140 m from operational turbines and assessed the risk of collision for this species as low (Gillespie *et al.*, 2021).

Therefore, it is considered that there will be **no change** to the magnitude of effect due to collision risk generated by tidal energy projects. As such, the **magnitude** of impact is still considered to be **negligible**, making the overall significance **negligible**, which is **not significant** in EIA terms.

Harbour seals and other marine mammals may also actively avoid wave energy converters which generate operational noise similar to those of tidal turbine devices. Underwater noise recordings of the Wavestar wave energy converter in Denmark, a hydraulic point absorber device, showed that noise levels from this device were so low that they were unlikely to be detectable by marine mammals against ambient noise levels (Tougaard, 2015). Similarly, measurements of another point absorber device from the Lysekil Project in Sweden indicated that the operational device would only be audible within a range of 20 m for marine mammals (Haikonen *et al.*, 2013). These observations are likely an artefact of the design of hydraulic point absorbers which, like other classes of wave energy converters (Esteban *et al.*, 2017), do not introduce moving parts into the water column, such as rapidly rotating turbines which shear the flow of water, as do tidal stream energy devices.

It is possible that the various wave energy devices to be deployed at the EMEC Billia Croo and Scapa Flow wave energy test sites will generate very low levels of underwater noise, making them difficult for marine mammals to detect against ambient noise levels. However, some classes of wave energy devices have no external moving parts, while others have very limited, predictable movement within the water column. Moreover, the design of many wave energy devices sees the bulk of the device sitting on or near the surface of the water, where light penetration and visibility will be greatest. This further reduces the likelihood of a collision event because the upper water column is where marine mammals come to rest, so overall swim speeds will be slower than at depth where hunting occurs. Based on these design parameters, it is logical to conclude that wave energy devices introduce an even lower risk of collision to marine megafauna than tidal energy devices do.

Those wave energy devices which are deployed in deeper waters will still be within the bounds of the EMEC Billia Croo test site, and therefore must prepare a Project Environmental Monitoring Plan (PEMP) prior to commencement of works as a condition of the Marine Licence (Xodus Group, 2019). The PEMP will be developed in consultation with Marine Scotland and will contain a plan for monitoring, which may include focal studies on the behaviour of receptor species around devices, as well as appropriate mitigation measures. Under these licence conditions, no significant effects to marine mammals or basking sharks are anticipated within the Billia Croo test site due to any adverse interactions with devices.

Given that there have been no records of marine mammal or basking shark collision with any tidal or wave energy developments to date, it is considered that there will also be **no change** to the magnitude of effect due to collision risk with wave energy projects. As such, the **magnitude** of impact remains **negligible**, making the overall significance of effect **negligible** and **not significant** in EIA terms.

Other offshore floating wind projects, such as the Green Volt, Erebus, and Blyth Offshore Demonstrator projects, will be deploying WTGs of a similar scale as the Offshore Development, which will use floating foundations that are an order of magnitude larger than the longest marine megafauna receptor (the minke whale). It is unrealistic to believe that marine mammals and basking sharks would be unable to avoid such large-scale floating infrastructure as those in development or currently deployed by the floating wind energy industry.

In alignment with the assessment for the Offshore Development in isolation, it is considered that there will be **no change** to the **magnitude** of effect due to collision risk generated by floating offshore wind projects. As such the **magnitude** of impact is still considered to be **negligible**, making the overall significance **negligible** and **not significant** in EIA terms.

11.7.3.3 *Displacement or barrier effects*

This section of the cumulative effects assessment provides a summary of the qualitative cumulative impact assessment of barrier and displacement effects to marine mammals and basking sharks during the operation and maintenance phase.

Projects which have been considered are limited to floating MRE and wind projects which have operational timelines which will overlap that of the Offshore Development, as the addition of novel floating infrastructure within the Offshore Study Area may increase the magnitude for this impact pathway. Fixed-bottom wind and oil and gas developments have not been considered for non-noise-related barrier and displacement effects because animals have shown the ability to recognise and move around static infrastructure in the marine environment and must regularly do so in increasingly crowded seas.

Table 11.42 summarises the approach used to assess the cumulative risk barrier and/or displacement effects on marine mammals.

Table 11.42 Approach used for the barrier and/or displacement effects assessment from different project types in the cumulative effects assessment

Activity	Projects Considered	Approach
Wave energy projects in the operational phase	EMEC Scapa Flow, EMEC Billia Croo	The primary impact pathway for wave energy projects is the risk of displacement and/or barrier effects. The impact area considers all projects which overlap the Offshore Study Area.
Tidal energy projects in the operational phase	MeyGen Limited, EMEC Fall of Warness	The primary impact pathway for tidal energy projects is the risk of displacement and/or barrier effects. The impact area considers all projects which overlap the Offshore Study Area.
Floating wind projects in the operational phase	Green Volt, Erebus, Blyth Offshore Demonstrator – Phase 2	The primary impact pathway for floating wind projects is the risk of displacement and/or barrier effects during the operational phase. The impact area considers all projects which overlap the Offshore Study Area.

As described in Section 11.6.2.4, marine mammals and basking sharks identified are considered to have a **negligible sensitivity** to barrier effects and displacement impacts from the presence of infrastructure within the PFOWF Array Area during the operation and maintenance phase. This is because animals will be able to move completely around and within the PFOWF Array Area during its operation. None of the other projects screened into the cumulative impact assessment are located in an area which would generate barriers to marine mammal or basking shark movement locally, regionally or across their biogeographic range cumulatively with the Offshore Development. Moreover, should displacement from the 10 km^2 PFOWF Array Area occur for any species, this would still result in a **negligible** impact **magnitude**. This is because the Offshore Site is not considered a particularly important habitat to any receptor species, nor is it considered to differ from the available habitat surrounding the project.

The footprint of the device arrays of the other floating wind and MRE projects may be greater than that of the PFOWF Array Area. However, devices will still require spacing of several hundreds of meters to minimise risk to the infrastructure, and the collective footprints of the WTG and MRE devices will be small compared to the overall array areas for these projects. This means that, like the Offshore Development, these projects are not likely to limit the movement of animals, which are several metres in length, within the project areas, when considering the scale of their infrastructure.

Accordingly, there will be **no change** to the project-specific **magnitude** of impact, which is **negligible**, when considering other projects cumulatively. This means the overall significance of effect remains **negligible**, which is **not significant** in EIA terms.

11.7.3.4 *Long-term habitat change*

This section of the cumulative effects assessment provides a summary of the qualitative cumulative impact assessment of long-term habitat change to marine mammals and basking sharks during the operation and maintenance phase.

The impact area for cumulative long-term habitat change considers all projects within a 20 km zone of influence of the Offshore Site, based on the zone of influence used to assess cumulative changes to the benthic habitat defined in Chapter 9: Benthic Ecology. The application of this zone of influence was guided by modelling undertaken in Chapter 7: Marine Physical Processes, which concluded the maximum lateral excursion of suspended sediment would fall within 3.7 km from the Offshore Development. Therefore, a 20-km zone of influence was applied to support a highly conservative assessment of cumulative impacts to benthic receptors.

Projects which have been considered are those which: introduce hard substrate onto the seabed; have the potential to generate scour; and/or have the potential to modify habitat use by prey species, such that habitat quality in terms of prey availability is affected. Floating infrastructure associated with MRE and wind technology has not been considered for long-term habitat change because these technologies are unlikely to experience extensive biofouling, due to their limited surface area within the water column and on the seabed, and the fact that they are non-static structures and movement hinders colonisation (Hemery, 2020). Moreover, there are no fixed-bottom wind, oil and gas, or coastal developments (jetties, piers, ports or harbours) within the 20 km zone of influence identified for this impact pathway.

These projects have been assessed for long-term impacts to the benthic habitat in Chapter 9: Benthic Ecology and to fish and shellfish distributions in Chapter 10: Fish and Shellfish Ecology. The findings of the cumulative impact assessment against long-term habitat change in terms of changes to these receptors, which are indicative of habitat quality, have been carried forward into the discussion below.

Table 11.43 summarises the approach used to assess the cumulative risk of long-term habitat change.

Table 11.43 Approach used for the long-term habitat change assessment from different project types in the cumulative effects assessment

Activity	Projects Considered	Approach
Cables	SHE Transmission Orkney-Caithness project	The primary impact pathway for cable projects is the risk of long-term habitat change through scour and the addition of hard substrate. The impact area considers all projects within a 20 km zone of influence from the Offshore Site.
Dredge disposal sites	Scrabster Extension	The primary impact pathway for dredge disposal sites is the risk of long-term habitat change through increased suspended sediment concentrations. The impact area considers all projects within a 20 km zone of influence from the Offshore Site.

Potential long-term habitat changes are anticipated to occur within the PFOWF Array Area due to the presence of WTG infrastructure and also within the OECC, should remedial protection be required for the Offshore Export Cable(s). These impacts could potentially act cumulatively with long-term habitat change from other subsea cables and dredge disposal sites, if they alter the quality of available habitat within the Offshore Site, including in terms of prey availability.

The assessment of cumulative impacts to benthic habitat was undertaken in Chapter 9: Benthic Ecology. The assessment focused on the colonisation of subsea infrastructure, scour protection and support structures, as well as habitat change from scour around subsea infrastructure. The only other project which falls within the Offshore Site is the SHE Transmission Orkney-Caithness project, which has the potential to act cumulatively with the Offshore Development for all of these impact pathways. However, it is assumed that the transmission cable will be buried where possible, reducing the likelihood of colonisation by marine epifauna. As such, it is expected that there will be **no change** to the **magnitude** of the impact, and it is therefore still considered to be **low** for this impact pathway. Therefore, the overall significance of effect is **minor**, which is **not significant** in EIA terms.

The potential introduction of scour and abrasion is considered to primarily relate to the PFOWF Array Area, due to the presence of anchors, mooring lines and inter-array cables at this location. Due to the intervening distance between the PFOWF Array Area and the SHE Transmission Orkney-Caithness project and Scrabster Extension dredge disposal site, there are not anticipated to be any cumulative impacts to habitat quality from seabed scouring. This is reinforced by project-specific embedded mitigations for the Offshore Development to reduce the potential for scour occurring by installing appropriate levels of scour protection during the construction phase of the Offshore Development. For these reasons, it is expected that there will be **no change** to the impact **magnitude** and it is therefore still considered to be **low** for this impact pathway.

The assessment of cumulative impacts to fish and shellfish species in Chapter 10: Fish and Shellfish Ecology considered the SHE Transmission Orkney-Caithness project, which overlaps the OECC, for impacts to the spawning and nursery grounds of sandeels and herring across the Offshore Site from the addition of hard substrate. Dredging sites are consented on the basis that they will not have an adverse impact upon spawning and nursery areas and associated habitats. Therefore, no cumulative impact on spawning grounds is expected to occur with the Scrabster Extension dredge disposal site. Per the baseline description, harbour porpoise and minke whales in particular target sandeels and herring as an integral component of their diet. Data from Ellis *et al.* (2012) suggests that the Offshore Site only overlaps with low-intensity herring and sandeel nursery grounds and low-intensity sandeel spawning grounds. Moreover, because of the fairly uniform composition of sediments in the Pentland Firth, nursery and spawning grounds for these sensitive species are widely available in the surrounding waters. The cumulative impacts of both the SHE Transmission Orkney-Caithness project and Offshore Development will be highly localised and are therefore considered to be of **low magnitude**.

As described in Section 11.6.2.5 above, marine mammals and basking sharks are considered to have **negligible sensitivity** to long-term habitat changes across the Offshore Site, making the overall effect against these **low magnitude** long-term habitat changes of **negligible** significance, which is **not significant** in EIA terms.

11.7.4 Cumulative Decommissioning Effects

11.7.4.1 Long-term habitat change

This section of the cumulative effects assessment provides a summary of the qualitative cumulative impact assessment to marine mammals and basking sharks during the decommissioning phase of the Offshore Development.

Long-term habitat change from activities associated with the decommissioning phase of the Offshore Development alone will be of **low magnitude**. The base case position, in the absence of a full Decommissioning Programme, is to remove all surface and within-water infrastructure but to potentially leave the scour protection around the anchors and possibly the piles cut 1 m below seabed *in situ*. This results in a very small area of seabed habitat which will experience residual impacts from the Offshore Development through the alteration of substrate. Any such change will be exceptionally small when considering the wider available habitat and is not anticipated to generate any detectable changes to the baseline environment within the zone of influence or the wider Offshore Study Area.

As there are not expected to be any important ecological implications from the decommissioning of anchor piles *in situ*, marine mammals and basking shark populations are considered to have **negligible sensitivity** to this impact pathway. For this reason, it is considered that there is no mechanism through which activities from other projects could act cumulatively with those of the Offshore Development to generate long-term habitat changes which could impact marine mammal or basking shark receptors within the Offshore Study Area. Therefore, there will be **no change** to **magnitude** of impact and as such the **magnitude** of impact is still considered to be **low**, making the overall significance of effect **negligible** and **not significant** in EIA terms.

11.8 Assessment of Transboundary Effects

Impacts on marine mammals and basking sharks from the construction, operation and maintenance, and decommissioning of the Offshore Development will be localised to the extent of the Offshore Study Area and its immediate surroundings, which are all within UK waters. The Offshore Study Area is approximately 308 km from the UK to Norway Median Line, which is the nearest international boundary which could be crossed.

Whilst several of the cetacean species are part of MUs with ranges which extend into international waters (i.e., harbour porpoise, common dolphins, Risso's dolphins and minke whales; see Figure 11.3), and basking sharks in the UKCS are known to travel hundreds of kilometres down the western European coastline (Drewery, 2011), none of these populations will be significantly impacted by any of the proposed activities during any phase of the Offshore Development. Moreover, it is highly unlikely that there will be any adverse impacts on marine mammals as qualifying features of protected sites in European waters due to their distance from the Offshore Development (> 500 km). Overall, the limited and localised nature of the impacts anticipated from the Offshore Development precludes them from generating transboundary effects.

11.9 Assessment of Impacts Cumulatively with the Onshore Development

The Onshore Development components are summarised in Chapter 5: Project Description. These Offshore Development aspects have been considered in relation to the impacts assessed in this Chapter.

The Onshore Development will undertake HDD operations from above MHWS, with an HDD exit point(s) occurring approximately 600 m offshore. The impacts from the installation of the Offshore Export Cable(s) (including the landfall activities) have been assessed in full in Section 11.6. It is not anticipated that there will be any additional impacts from the Onshore Development on Marine mammal and basking shark receptors as all other activities from the Onshore Development are fully terrestrial.

11.10 Mitigation and Monitoring Requirements

With consideration of the embedded mitigation measures for the Offshore Development, the assessment has concluded no significant impacts to any marine mammal species or basking sharks, and therefore there is no requirement for additional mitigation over and above the embedded measures.

It is anticipated that any monitoring that may be proposed by HWL to support the EIA conclusions and provide supporting information for future floating offshore wind farm developments will be established through consent conditions and the development of a PEMP in consultation with relevant stakeholders. All qualifying activities (i.e., those generating low-frequency impulsive noise) will be submitted to the Marine Noise Registry.

11.11 Inter-relationships

Interrelated effects describe the potential interaction of multiple Offshore Development impacts upon one receptor which may interact to create a more significant impact on a receptor than when considered in isolation. Interrelated effects may have a temporal or spatial element and may be short-term, temporary, or longer-term over the lifetime of the Offshore Development.

In line with the Scoping Opinion and Scoping Opinion Addendum received, this Chapter has assessed all impacts that are relevant to marine mammal and basking shark receptors during the construction, operation and maintenance, and decommissioning phases of the Offshore Development. Therefore, it is considered that the assessment and conclusions presented in Section 11.6 provide a complete and robust assessment of all potential impacts relevant to marine mammals and basking sharks. The assessment has also considered the potential for inter-related effects in relation to marine mammals and basking sharks, and no additional inter-related effects beyond those presented in Section 11.6 have been identified.

Where the assessment contained in this Chapter is considered within other assessment chapters, a summary of these inter-relationships is presented below in Table 11.44.

Table 11.44 Inter-relationships identified with marine mammals and basking sharks and other receptors in this Offshore EIAR

Receptor	Impacts	Description
Water and Sediment Quality	Indirect impacts to marine mammals and basking sharks from disturbance of contaminants and radioactive particles resulting in changes to water quality which may affect prey species.	Changes in water quality can adversely impact the benthos and influence the distribution of fish species. Impacts to habitat quality, particularly in terms of prey availability, may alter habitat use by marine megafauna receptors. Impacts to water quality, including those resulting from increased sedimentation, are discussed in Chapter 7: Water and Sediment Quality. The impacts these changes have on benthic ecology are discussed in Chapter 9: Benthic Ecology, whilst impacts on fish distributions are discussed in Chapter 10: Fish and Shellfish Ecology As described in Section 11.6.2.5, marine mammals and basking sharks are considered to have **negligible sensitivity** to long-term habitat changes across the Offshore Site.

Receptor	Impacts	Description
Benthic Ecology	Indirect impacts to marine mammals and basking sharks through long-term benthic habitat change, including the potential for changes to habitat quality.	Long-term changes to benthic habitats can indirectly impact marine megafauna due to changes in the availability of prey species. Fish species which exploit benthic habitats may be impacted by loss or disturbance of that habitat and this can impact habitat use in higher trophic species, such as seals and certain species of dolphins, which rely on those fish species as prey resources. Direct impacts to benthic habitats from the Offshore Development are assessed in Chapter 9: Benthic Ecology, whilst impacts on fish distributions are discussed in Chapter 10: Fish and Shellfish Ecology. Impacts on marine mammals and basking shark from long-term habitat changes are assessed in Sections 11.5.1, 11.6.2.5, 11.6.3.1, and 11.7.
Fish and Shellfish Ecology	Indirect impacts to marine mammals and basking sharks through long-term habitat change which may result in changes to prey availability in terms of fish and shellfish abundance and distribution.	Long-term changes to habitat quality may influence the abundance and distribution of fish and shellfish, and consequently the marine megafauna species which prey upon them. Impacts to fish and shellfish from the Offshore Development are assessed in Chapter 10: Fish and Shellfish Ecology. Impacts on marine mammals and basking sharks as a function of long-term habitat change, including changes to prey availability, are assessed in Sections 11.6 and 11.7
Commercial Fisheries	In-direct impacts on marine mammals and basking sharks associated with entanglement from secondary interactions with derelict fishing gears	There is potential for derelict fishing gears to become entangled with infrastructure within the PFOWF Array Area, which introduces the risk of secondary entanglement with marine mammals and basking sharks. Information about commercial fishing effort and gear types used are integral to characterising the risk of this indirect impact between marine megafauna and the Offshore Development. These data are characterised in Chapter 14: Commercial Fisheries. Impacts on marine mammals due to entanglement risk are assessed in Sections 11.6 and 11.7.

11.12 Summary of Residual Effects

Table 11.45 summarises the residual effects on marine mammal and basking shark receptors through the construction, operation and maintenance, and decommissioning phases of the Offshore Development. The residual effects of potential cumulative impacts are also considered.

Table 11.45 Summary of residual effects for marine mammal and basking shark receptors

Predicted Effect	Receptor	Assessment Consequence	Significance	Mitigation Identified	Significance of Residual Effect
Construction					
Noise-related impacts to marine mammals from all construction activities	Minke whales	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
	Bottlenose dolphins	Minor Effects	Not Significant		Not Significant
	Other dolphin species	Negligible Effects	Not Significant		Not Significant
	Harbour porpoise	Negligible Effects	Not Significant		Not Significant
	Harbour seals	Minor Effects	Not Significant		Not Significant
	Grey seals	Minor Effects	Not Significant		Not Significant
Noise-related impacts to basking sharks from low-frequency construction noise	Basking sharks	Minor Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
Operation and Maintenance					
Noise-related impacts to marine mammals from operation and maintenance activities	Minke whales	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
	Dolphin species	Negligible Effects	Not Significant		Not Significant
	Harbour porpoise	Negligible Effects	Not Significant		Not Significant
	Harbour seals	Negligible Effects	Not Significant		Not Significant
	Grey seals	Negligible Effects	Not Significant		Not Significant

Predicted Effect	Receptor	Assessment Consequence	Significance	Mitigation Identified	Significance of Residual Effect
Entanglement risk to marine mammals and basking shark	Minke whales	Minor Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
	Basking sharks	Minor Effects	Not Significant		Not Significant
	All other marine mammals	Minor Effects	Not Significant		Not Significant
Collision risk to marine mammals and basking shark	Marine mammals and basking sharks	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
Displacement or barrier effects	Marine mammals and basking sharks	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
Long-term habitat change – physical presence of mooring lines	Marine mammals and basking sharks	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
Long-term habitat change – introduction of hard substrate	Marine mammals and basking sharks	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 and within Chapter 9: Benthic Ecology as it was concluded that the impact was not significant.	Not Significant

Predicted Effect	Receptor	Assessment Consequence	Significance	Mitigation Identified	Significance of Residual Effect
Long-term habitat change – emissions of EMFs	Basking sharks	Minor Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 and within Chapter 9: Benthic Ecology as it was concluded that the impact was not significant.	Not Significant
	Marine mammals	Negligible Effects	Not Significant		Not Significant
Decommissioning					
Long-term habitat change	Marine mammals and basking sharks	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
Cumulative - Construction					
Noise-related impacts to marine mammals	Harbour porpoise	Minor Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
	Bottlenose dolphins	Minor Effects	Not Significant		Not Significant
	White-beaked dolphins	Minor Effects	Not Significant		Not Significant
	Risso's dolphins	Minor Effects	Not Significant		Not Significant
	Common dolphin	Minor Effects	Not Significant		Not Significant
	Minke whales	Minor Effects	Not Significant		Not Significant
	Harbour and grey seals	Minor Effects	Not Significant		Not Significant

Predicted Effect	Receptor	Assessment Consequence	Significance	Mitigation Identified	Significance of Residual Effect
Noise-related impacts to basking sharks	Basking sharks	Minor Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
Cumulative – Operation and Maintenance					
Risk of injury from entanglement	Minke whales	Minor Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
	All other marine mammals and basking sharks	Negligible Effects	Not Significant		Not Significant
Risk of injury from collision	Marine mammals and basking sharks	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
Displacement or barrier effects	Marine mammals and basking sharks	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant
Long-term habitat change	Marine mammals and basking sharks	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant

Predicted Effect	Receptor	Assessment Consequence	Significance	Mitigation Identified	Significance of Residual Effect
Cumulative – Decommissioning					
Long-term habitat change	Marine mammals and basking sharks	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this impact above and beyond the embedded project mitigation listed in Section 11.5.5 as it was concluded that the impact was not significant.	Not Significant

11.13 References

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