Pentland floating offshore wind farm

Volume 2: Offshore EIAR

Chapter 9: Benthic Ecology

OFFSHORE EIAR (VOLUME 2): MAIN REPORT

CHAPTER 9: BENTHIC ECOLOGY

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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.

ACRONYMS AND ABBREVIATIONS

BGS	British Geological Survey
BWM Convention	Ballast Water Management Convention
CEMP	Construction Environmental Management Plan
cm	centimetre
CMS	Construction Method Statement
DSRL	Dounreay Site Restoration Limited
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EMF	Electromagnetic Fields
EU	European Union
EUNIS	European Union Nature Information System
FEPA	Food and Environment Protection Act
HDD	Horizonal Directional Drilling
HWL	Highland Wind Limited
INNS	Invasive Non-Native Species
IUCN	International Union for Conservation of Nature and Natural Resources
km	kilometre
km^2	kilometre squared
LEDS	Liquid Effluent Diffuser System
LOD	Level of Detection
OECC	Offshore Export Cable Corridor
Offshore EIAR	Offshore Environmental Impact Assessment Report
m	metre
m^2	Square metre
m^3	Cubic metre
MarLIN	The Marine Life Information Network
MHWS	Mean High Water Springs
MPA	Marine Protected Area
mm	millimetre
MS-LOT	Marine Scotland Licencing Operations Team
MSS	Marine Scotland Science
nm	nautical mile
OEMP	Operational Environmental Management Plan
OSPAR Convention	The Convention for the Protection of the Marine Environment of the North East Atlantic
PAH	Polycyclic Aromatic Hydrocarbons

PCB	Polychlorinated Biphenyl
PFOWF	Pentland Floating Offshore Wind Farm
PMF	Priority Marine Feature
ROV	Remotely Operated Vehicles
SAC	Special Area of Conservation
SBL	Scottish Biodiversity List
SEPA	Scottish Environment Protection Agency
THC	The Highland Council
UK	United Kingdom
UKBAP	UK Biodiversity Action Plan
μT	microtesla
WTG	Wind Turbine Generator

9 BENTHIC ECOLOGY

9.1 Introduction

The potential effects of the Pentland Floating Offshore Wind Farm (PFOWF) Array and Offshore Export Cable(s), hereafter referred to as the 'Offshore Development', during construction, operation and maintenance, and decommissioning on Benthic Ecology receptors are assessed in this chapter. This chapter also includes a review of the potential cumulative effects with other relevant projects. Physical conditions such as sediments, water quality and physical processes are considered in Chapter 7: Marine Physical Processes and Chapter 8: Water and Sediment Quality.

Xodus Group Limited has drafted and carried out the impact assessment. Further competency details of the Project Team, 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 9.1 below provides a list of all the supporting studies which relate to the Benthic Ecology impact assessment. All supporting studies are appended to this Offshore EIAR.

Table 9.1 Supporting studies

Details of Study	Locations of Supporting Studies
Environmental Baseline Report – MMT Pentland Floating Offshore Wind Farm, Geophysical & Environmental Survey 2021- 103760-HWL-MMT-SUR-REP-ENVEBSRE.	Offshore EIAR (Volume 3): Appendix 9.1

9.2 Legislation, Policy, and Guidance

The following relevant legislation, policies, and guidance relating to Benthic Ecology were consulted in preparing this chapter:

9.2.1 Legislation

> Nature Conservation (Scotland) Act 2004 (as amended): Ensures public bodies in Scotland have a duty to further the conservation of biodiversity;

> Habitats (Scotland) Regulations 1994 (as amended): Implements species protection requirements of the European Union (EU) Habitats Directive (as detailed in Chapter 2: Policy and Legislative Context) in Scotland, on land and inshore waters up to 3.7 kilometres (km) (12 nautical miles [nm]);

> Offshore Marine Conservation (Natural Habitats &c) Regulations 2017 (as amended): Implements the requirements of the EU Habitats Directive in the United Kingdom (UK) offshore marine area (beyond 3.7 km [12 nm]);

> The International Convention for the Control and Management of Ships' Ballast Water and Sediments: Aims to prevent the spread of harmful aquatic organisms from one region to another, by establishing standards and procedures for the management and control of ships' ballast water and sediments;

> UK Biodiversity Action Plan (UKBAP): The UK Government's response to the Convention on Biological Diversity, which called for the development and enforcement of national strategies and associated action plans to identify, conserve, and protect existing biological diversity and enhance it wherever possible; and

> The Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR Convention): The relevant annexes to benthic ecology include Annex III: Prevention and elimination of pollution from offshore sources, Annex IV: Assessment of the quality of the marine environment, and Annex V: On the protection and conservation of the ecosystems and biological diversity of the maritime area.

9.2.2 Policy

> Scotland's National Marine Plan (Marine Scotland, 2015): Sets out policies and objectives requiring marine planners and decision-makers to consider the potential impacts of development on benthic ecology and is useful to identify some of the key concerns and issues that should be addressed in any impact assessment. Policies under General Polices GEN 9 and GEN 10 are considered relevant to Benthic Ecology.

Guidance

> Scotland's Biodiversity Strategy: A route map to 2020 (Scottish Government, 2015); and

> Pilot Pentland Firth & Orkney Waters Marine Spatial Plan, July 2016 (Scottish Government, 2016).

9.3 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 and the Scoping Opinion Addendum specific to Benthic Ecology provided by Marine Scotland Licensing Operations Team (MS-LOT), Marine Scotland Science (MSS), NatureScot, Scottish Environment Protection Agency (SEPA), and The Highland Council (THC) are summarised in Table 9.2 below, which provides a high-level response on how these comments have been addressed within this Offshore EIAR.

Table 9.2 Summary of consultation responses specific to Benthic Ecology

Consultee	Comment / Issue Raised	Offshore Development Approach and Section ID
Scoping Opinion		
MS-LOT (on behalf of Scottish Ministers)	*The Scottish Ministers advise that the Developer must consider the potential impacts of the Offshore Proposed Development on species and habitats listed as Priority Marine Features ("PMFs") in the EIA Report. Both NatureScot and MSS agree that PMFs are an important consideration as part of the assessment of potential impacts on benthic ecology. The Scottish Ministers further advise that key Annex I habitats of conservation importance should be considered in the EIA Report, per the NatureScot representation.*	PMF species and habitats and Annex I habitats identified have been outlined within Section 9.4.4. The impacts on PMF have been assessed within Section 9.6.
MS-LOT (on behalf of Scottish Ministers)	*The Scottish Ministers broadly agree with the Developer on the impacts proposed to be scoped in however, advise that additional impacts must also be scoped in. Firstly, the Scottish Ministers agree with NatureScot and MSS that the introduction of marine non-native species must be considered and assessed in the EIA Report. The Scottish Ministers further recommend that proposed mitigation measures and monitoring should also be considered in the EIA Report in relation to marine invasive non-native species. The Scottish Ministers highlight the MSS recommendation that an assessment of the risk of marine non-native species while adhering to the protocols provided in the International Convention for the Control and Management of Ships' Ballast Water and Sediments is undertaken.*	The potential impact associated with the introduction of marine Invasive Non-Native Species (INNS) has been scoped in (see Sections 9.6.1.4 and 9.6.2.2). Section 9.5.5 summarises the protocols provided in the International Convention for the Control and Management of Ships' Ballast Water and Sediments which will be adhered to.
MS-LOT (on behalf of	*With regards to the impact of colonisation of subsea infrastructure, scour protection and support structures,*	The potential impact of colonisation of subsea infrastructure, scour protection,

Consultee	Comment / Issue Raised	Offshore Development Approach and Section ID
Scottish Ministers)	*the Scottish Ministers advise that this must be scoped in. The Scottish Ministers highlight the importance of this when considering the spread of marine invasive non-native species and direct the Developer to the specific comments in the NatureScot and MSS representations on this. The Scottish Ministers agree that the long-term effects of the introduction of hard structures must be carefully considered in the EIA Report. The Scottish Ministers highlight the NatureScot recommendation to use a more targeted placement method where protective material cannot be avoided and minimising the amount of hard substrate material used during the operations and maintenance. The Scottish Ministers agree with NatureScot that a worst case quantity should be included and assessed for the lifetime of the Offshore Proposed Development in the EIA Report and further agree with both MSS and NatureScot that consideration is given to the choice of materials and how they can be recovered during decommissioning.*	and support structures and the long-term effect of the introduction of hard structures have been scoped in (see Section 9.6.2.3).
MS-LOT (on behalf of Scottish Ministers)	*The Scottish Ministers further advise that impacts to benthic communities from any thermal load or electromagnetic field ("EMF") arising from the cable during operation are scoped in. The Scottish Ministers agree with MSS advice that impacts of thermal load or EMF should be considered for cables when buried in addition to those that are not buried, for example free-hanging or surface-laid cables, and direct the Developer to the specific comments from MSS on what the EIA Report should include in this regard. In addition, the Scottish Ministers advise that increased sedimentation and smothering on benthic infauna and epifauna impacts must also be scoped into the EIA Report and should be assessed specifically for benthic habitats and species found within the vicinity of the Offshore Proposed Development. This view is supported by the MSS advice.*	The potential impacts associated with EMFs and thermal load have been scoped in (see Section 9.6.2.5.1). The potential impacts of increased sedimentation and smothering on benthic infauna and epifauna have also been scoped in (see Section 9.6.1.2).
MS-LOT (on behalf of Scottish Ministers)	*With regards to the method of assessment for benthic ecology, the Scottish Ministers highlight key questions recommended by NatureScot to be answered by the pre-construction baseline surveys. The Scottish Ministers agree with NatureScot that the EIA Report must clearly present the main biotopes identified within the site of the Offshore Proposed Development and that a biotopes/habitat map should be used by the Developer to inform the finalised design.*	Site-specific surveys have been completed across the Offshore Site, as outlined in Section 9.4.3. Biotypes are outlined in Section 9.4.4 and a biotopes map is provided in Offshore EIAR (Volume 3): Appendix 9.1. Embedded mitigations are outlined in Section 9.5.5.
MS-LOT (on behalf of Scottish Ministers)	For the avoidance of doubt, all impacts listed during the construction phase, including the additional impacts recommended above should also be scoped in during the decommissioning phase. The Scottish Ministers advise that both MSS and NatureScot's recommendations are fully addressed within the EIA Report.	All impacts considered in the construction phase have also been considered for the decommissioning phase (see Sections 9.6.1 and 9.6.3).
MS-LOT (on behalf of Scottish Ministers)	*The Scottish Ministers highlight the RSPB Scotland representation that the EIA Report should consider the overall carbon payback period for the Proposed Development, including any impacts on "blue carbon" from habitats affected by the Proposed Development.*	Blue carbon habitats that may be present within the Offshore Site are identified in Section 9.4.4.4.

Consultee	Comment / Issue Raised	Offshore Development Approach and Section ID
	The Scottish Ministers agree and advise that this must be considered in the EIA Report.	Key blue carbon habitats are listed in Table 9.4. Impacts on blue carbon habitats are assessed within Section 9.6 and further considered in Chapter 20: Climate Change and Carbon.
MSS	*Under section 8.2.2 MSS recommend including species and habitats listed as Priority Marine Features (PMF; Scotland's National Marine Plan). The ocean quahog Arctica islandica for example is a PMF found in this region of the Pentland Firth (Moore 2015).* *MSS broadly agree with Highland Wind on those impacts that are scoped out and agree with NatureScot's comments on the additional impacts that should be scoped in. MSS have provided more detail on reasoning for scoping these aspects in.*	PMF species and habitats and Annex I habitats have been outlined within Section 9.4.4.
MSS	*Introduction of marine non-native species (NNS): A new structure provides an opportunity for colonisation without competition from the indigenous population (Tyrrell & Byers 2007). NNS can arrive by numerous different vectors (Drake et al. 2007; Ashton et al. 2006; Coolen et al. 2006). Therefore even when precautions are taken to reduce likelihood of NNS, it is still possible they may colonise these structures. Research in the Southern North Sea points to the intertidal zone of windfarm turbines and those wind farms that are closer to shore as being important for colonisation by NNS (Coolen et al. 2016; Kerckhof et al. 2015). Literature such as Adams et al. (2014) describes how NNS can spread to natural habitats. MSS recommend an assessment of the risk of NNS while adhering to the protocols provided in the International Convention for the Control and Management of Ships' Ballast Water and Sediments. MSS recommend that regular monitoring of structures is carried out by trained observers, particularly of high risk areas (such as the splash zone), in order that management action can be taken swiftly should NNS be found.*	The potential impact associated with the introduction of marine INNS has been scoped in (see Sections 9.6.1.4 and 9.6.2.2). Section 9.5.5 summarises the protocols provided in the International Convention for the Control and Management of Ships' Ballast Water and Sediments. As set out in Section 9.5.5, the substructures will be designed to accommodate marine growth; however, growth levels will be inspected regularly which will include inspection for INNS. Subsequent removal of this growth will be undertaken using water jetting tools if substantial accumulation is in evidence.
MSS	*Colonisation of subsea infrastructure, scour protection and support structures: Subsea structures are likely to be colonised by species with a preference for hard substrates. As this is a largely soft sediment environment, the introduction of subsea infrastructure presents an opportunity for colonisers, representing a change in the natural soft sediment ecosystems present in the area. From the perspective of benthic ecology, MSS recommend burial of cables over the addition of cable protection. Where cable / scour protection is necessary, MSS recommend where possible, minimising the amount that is installed in order to reduce the deposition of hard substrate structures on the soft sediment habitats. Consideration should be given to the choice of cable protection with a view to firstly, minimise the introduction of plastics contained within the rock*	The potential impact of colonisation of subsea infrastructure, scour protection, and support structures has been scoped in (see Section 9.6.2.3). Multiple forms of remedial protection are under consideration for the Offshore Development, including rock placement and concrete mattresses. Different forms of protection may be used across the Offshore Site. The final selection at each specific location will depend on various factors, including ground conditions, level of protection afforded, recoverability, etc. Cable protection materials will also be considered, and this will be detailed in the Construction Method Statement (CMS)

Consultee	Comment / Issue Raised	Offshore Development Approach and Section ID
	mattresses and secondly, to use a type of cable protection that can be removed during decommissioning.	and cable plans for the Offshore Development should consent be granted.
MSS	*NS advise that impact to benthic communities from any thermal load or electromagnetic field (EMF) arising from the cable during operation are scoped in, particularly for inter-array cables (dynamic and static). Further to this, MSS advise that impacts of EMF should be considered for cables when buried in addition to those that are free-hanging or surface-laid.*	The potential impacts associated with EMFs and thermal load have been scoped in (see Section 9.6.2.5).
MSS	***Thermal load*** *There is evidence that thermal emissions occur from high voltage subsea cables, which can be detectable within the sediment surrounding a cable (Meißner 2006; Taormina et al. 2018). MSS recommend that the developer considers how thermal emissions might affect benthic species in the vicinity of subsea cables both within the sediment (for buried cables) and in the sediment and water column (for non-buried).*	The potential impacts associated with EMFs and thermal load have been scoped in (see Section 9.6.2.5).
MSS	***Electromagnetic fields*** *As raised in the Marine Fish and Diadromous Fish sections in this response, MSS advise MS-LOT that there is a need to consider potential impact of EMF on sensitive species or taxa. MSS advise that impact of buried cables is important in addition to those that are free-hanging or surface-laid. Recent research demonstrates that both the magnetic field and the induced electric field may still be detectable by electro-sensitive and magneto-sensitive organisms even after burial. Literature such as Hutchison et al. (2020) describes how cable burial increases the distance from the source of the EMF but it does not shield it, while research such as Formicki et al. (2019), Newton et al. (2018) and Hutchison et al. (2020) demonstrate that EMF is perceivable at levels that are biologically relevant for sensitive species. MSS acknowledge that research on many Scottish species are lacking however. Similarly, MSS is not aware of work specifically addressing EMF emissions from free-hanging or surface-laid cables but as there is no separation from the seabed or water column, it is expected that an animal could experience the full emission of EMF when adjacent to the cable.*	The potential impacts associated with EMFs and thermal load have been scoped in (see Section 9.6.2.5).
MSS	*MSS advise that the EIAR should include:* *- A section detailing the models used to calculate EMF emissions for the various types of cables used, i.e. a buried DC export cable and free-hanging/surface-laid AC inter-array cables, together with the interaction with the local natural electromagnetic environment.* *A qualitative evaluation of the potential behavioural and physiological effects from EMF for the various species / taxa for which there is evidence (examples in Scott et al. 2018; Cresci et al. 2019; Hutchison et al. 2020; Gill and Desender 2020; Taormina et al. 2020), giving particular*	The potential impacts associated with EMFs and thermal load have been scoped in (see Section 9.6.2.5). This includes details of the modelling used to calculate EMFs (see Section 9.6.2.5).

Consultee	Comment / Issue Raised	Offshore Development Approach and Section ID
	consideration to those that are known to occur within the vicinity of this site.	
MSS	*Potential impacts during decommissioning: Note that all impacts listed during the construction phase should be scoped in, including the additional impacts recommended by NS and MSS.*	All of the impacts considered for the construction phase have been scoped into the decommissioning phase (see Sections 9.6.1 and 9.6.3).
MSS	*MSS advise that increased sedimentation / smothering on benthic infauna and epifauna is scoped in. The process of open-cut trenching for cable installation and introduction of structures on the seabed will temporarily increase sediment concentrations in the water column and may result in smothering. Impacts should be assessed specifically for habitats and species found in the vicinity of the site.*	Increased sedimentation and potential smothering are covered within Section 9.6.1.2.
NatureScot	***Assessment Approach*** *The EIAR should consider the impact of all phases of the proposed development on the receiving environment, including effects from pre-construction activities and decommissioning as well as the construction and operation phases. Increasingly, there is a need to understand potential impacts holistically at a wider ecosystem scale in addition to the standard set of discrete individual receptor assessments. This assessment should focus on potential impacts across key trophic levels particularly in relation to the availability of prey species. This will enable a better understanding of the consequences (positive or negative) of any potential changes in prey distribution and abundance from the development of the wind farm on seabird and marine mammal (and other top predator) interests and what influence this may have on population level impacts.*	Potential impacts across key trophic levels particularly in relation to the availability of prey species are considered in each of the biodiversity chapters of this Offshore EIAR (Volume 2): Main Report in Chapter 9: Benthic Ecology, Chapter 10: Fish and Shellfish Ecology, Chapter 11: Marine Mammals and Other Megafauna and Chapter 12: Marine Ornithology. This allows for a better understanding of the consequences (positive or negative) of any potential changes in prey distribution and abundance from the Offshore Development on receptors, including on a population level.
NatureScot	***Benthic interests*** *Advice on benthic interests is provided in Appendix C. Assessment of any potential impacts to Priority Marine Features both within the wind farm site and along the cable corridor route will be important to consider. The introduction of hard structures will also require consideration.*	The potential impact of colonisation of subsea infrastructure, scour protection, and support structures has been scoped in (see Section 9.6.2.3).
NatureScot	***Key species and habitats*** *Consideration should be given to Priority Marine Features (PMFs)[i] and key Annex 1 habitats of conservation importance.*	PMF species and habitats and key Annex I habitats have been outlined within Sections 9.4.4 and 9.4.6.
NatureScot	***Key impact pathways to consider*** *We broadly agree with the potential impacts outlined in Table 8.1 and provide the following advice below.* *- Introduction of marine non-natives* *We advise that the introduction of marine non-natives is scoped in. Although the Dounreay Tri EIA assessed this*	The potential impact associated with the introduction of marine INNS has been scoped in (see Sections 9.6.1.4 and 9.6.2.2). Section 9.5.5 summarises the protocols provided in the International Convention for the Control and Management of Ships'

[i] https://www.nature.scot/professional-advice/protected-areas-and-species/priority-marine-features-scotlands-seas.

Consultee	Comment / Issue Raised	Offshore Development Approach and Section ID
	impact as minor, the proposed development is larger with a variety of different types of infrastructure proposed.	Ballast Water and Sediments which will be adhered to.
NatureScot	***Colonisation of hard structures*** *This is important in considering the potential spread of marine invasive non-native species and ensuring appropriate mitigation is embedded to combat this, both of which may differ depending on the type of substructures and anchors to be used. This will also be of use from an engineering perspective - depending on the hard structure in question, removal of encrusted growth may be necessary throughout the lifetime of the wind farm development, and if so, should be factored in.*	The potential impact of colonisation of subsea infrastructure, scour protection, and support structures has been scoped in (see Section 9.6.2.3). As set out in Section 9.5.5, the substructures will be designed to accommodate marine growth; however, growth levels will be inspected regularly which will include inspection for INNS. Subsequent removal of this growth will be undertaken using water jetting tools if substantial accumulation is in evidence.
NatureScot	*The introduction of hard structure (e.g. floating substructures, scour protection and cable protection) could also result in a change in community type from species typical of sedimentary habitats to those typical of hard substrata. We recognise that the long-term effect of such introduction is not fully understood at present, and that this change may provide positive and/or negative effects for different receptors and as such should be carefully considered. This will also help inform how any local increase in species diversity may influence prey species availability.*	The potential impact of colonisation of subsea infrastructure, scour protection, and support structures has been scoped in (see Section 9.6.2.3).
NatureScot	*Where protective material cannot be avoided, we recommend using a more targeted placement method e.g. fall pipe vessel rather than using vessel-side discharge methods. We also recommend that consideration is given to minimise the amount of hard substrate material used during the operations, and maintenance, of the wind farm and that the worst case quantity is assessed for the lifetime of the project. Where materials have to be used we also encourage that consideration is given to choice of materials (composition and size) and their ability to be recovered during decommissioning.*	The installation of protective material will be minimised as far as possible. Worst case scenarios have been outlined in Section 9.5.4 and assessed in Section 9.6. A range of cable protection materials has been considered. The final choice of cable protection materials will be detailed in the CMS and cable plans for the Offshore Development should consent be granted.
NatureScot	***Approach to impact assessment*** *Table 8.2 provides information on impact assessment methodologies for benthic interests. Pre-construction baseline surveys should seek to answer the following:* *- Are there any benthic habitats or species of note present (i.e. Priority Marine Features[ii] rare, protected or invasive)?* *- What is the spatial distribution and abundance of these species?* *- How will these habitats or species be affected by the development?*	Species and habitats of note, including PMFs, have been outlined within Section 9.4.4. Biotypes are outlined in Section 9.4.4 and a biotopes map is provided in Offshore EIAR (Volume 3): Appendix 9.1.

[ii] www.snh.gov.uk/protecting-scotlands-nature/safeguarding-biodiversity/priority-marine-features/.

Consultee	Comment / Issue Raised	Offshore Development Approach and Section ID
	- What would be the significance or implications of any loss incurred? *We advise that the EIAR presents clear information on, and identification of, the main biotopes found within the proposed development site. The biotopes / habitat map should be used by the applicant to inform their finalised mooring location and cable route.*	
NatureScot	*In relation to Benthic Ecology, you advised that key Annex 1 habitats of conservation importance are considered; however, in the scoping report the Developer has considered that Annex 1 habitats are not within the Proposed Development site. Could you please clarify your advice on this point. Do you wish a consideration of Annex 1 habitats in the vicinity of the Proposed works in the EIA Report? Is this a comment on the proposed study area – should it be widened etc (if so, by how much)?* *As we have yet to see the results from the geophysical and benthic surveys from the proposed study area, we recommend that Annex 1 habitats are scoped in.*	PMF species and habitats and key Annex I habitats have been scoped in and are outlined within Sections 9.4.4 and 9.4.6.
THC	*The EIAR should provide a baseline survey of the ecology present on the site (onshore and offshore) to determine the presence of any rare or threatened species.*	In terms of the baseline surveys of the marine environment and the identification of rare or threatened species, these are presented and summarised in Section 9.4.4.3. The full Environmental Baseline Report for the marine environment is provided in Offshore EIAR (Volume 3): Appendix 9.1.
THC	*The EIAR should address the likely impacts on the nature conservation interests of all the designated sites in the vicinity of the proposed development. It should provide proposals for any mitigation that is required to avoid these impacts or to reduce them to a level where they are not significant.* *NATURESCOT can also provide specific advice in respect of the designated site boundaries for SACs and SPAs and on protected species and habitats within those sites. The potential impact of the development proposals on other designated areas such as SSSI's should be carefully and thoroughly considered and, where possible, appropriate mitigation measures outlined in the EIAR. NATURESCOT provide advice on the impact on designated sites. You should also note the representations from RSPB and take this into consideration in preparing your EIAR.*	This Offshore EIAR addresses the potential impacts on the nature conservation interests of all the designated sites in the vicinity of the Offshore Development, embedded mitigation measures are also considered within the assessment of significance of effects. Where residual significant effects occur, additional mitigation measures may be proposed to avoid or reduce these effects to not significant levels. Designated Sites with benthic ecology interests are presented in Section 9.4.4.3.
Scoping Opinion Addendum		
NatureScot	*The new worst case parameters include potentially up to 12 moorings and anchors per wind turbine, a spread radius of up to 1,250m, and potentially up to 12 driven piles per wind turbine with each pile being approximately 8m in diameter. Although we agree the potential impacts that may result from these increases are not new impacts from those presented in the Scoping Report, and the*	The Offshore Development has been refined since the Scoping Report Addendum Report was submitted. The PFOWF Array Area has been reduced in size, the number of WTGs has decreased from 10 to seven, and the number of mooring lines and anchors or piles per

Consultee	Comment / Issue Raised	Offshore Development Approach and Section ID
	approach to assessing them will not alter, the new worst case parameters will result in a much greater area of the seabed being impacted. This should be considered in the EIA Report in terms of disturbance and loss of benthic habitat and habitat supporting fish and shellfish.	WTG has been reduced to nine. These refinements decrease the Offshore Development's seabed footprint from what was proposed in the Scoping Report Addendum. The new worst case scenarios for the impact assessments, based on these refined parameters, are detailed in Section 9.5.4.
MSS	*Benthic ecology* *The potential increase in number of anchors per turbine could lead to a greater spatial footprint of the project on benthic features. However, this does not change our previous advice on the impact pathways to be screened in for further assessment in the benthic section of the EIAR.*	Noted, no response required.
Cumulative Project List		
The Highland Council (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 EIAR for the project noted no significant effects on benthic ecology during operations, there is no potential for a cumulative impact with the Offshore Development with respect to Benthic Ecology receptors. The Space Hub Sutherland project is considered in Chapter 18: Other Users of the Marine Environment.
Additional Consultation		
SEPA	*Ongoing discussions were held with SEPA regarding requirements for sampling in the FEPA Zone.*	HWL were granted an Environmental Authorisations (Scotland) Regulations (EASR) permit which allows for the handling and transfer of radioactive waste recovered during sampling activities.

9.4 Baseline Characterisation

The purpose of this section is to provide a description of the marine benthic ecology in the vicinity of the Offshore Development. A discussion of the key sensitivities and potential ecological impacts arising from the Offshore Development during the construction, operation and maintenance, and decommissioning phases has been carried out and the findings are presented.

9.4.1 Study Area

The focus of the assessment is the potential impacts on benthic ecology within the Offshore Site. The following areas are referred to in this impact assessment:

> Offshore Site: The area encompassing the PFOWF Array and the Offshore Export Cable Corridor (OECC), as defined;

- Benthic Ecology Study Area: Potential impacts to Benthic Ecology receptors are expected to be localised to within the Offshore Site. Therefore, the Benthic Ecology Study Area covers the area from the intertidal environment within the OECC out to and including the PFOWF Array Area; and
- Suspended Sediment Buffer Area: An additional 4-km buffer has been added to the Offshore Site and the PFOWF Array Area to account for maximum excursion of suspended sediments as per Chapter 7: Marine Physical Processes. The 4-km buffer takes into account the maximum excursion on a spring flood tide, which is around 3.7 km to the east, before the tide turns and around 2.6 km to the south-west.

The study and buffer areas are shown below in Figure 9.1.

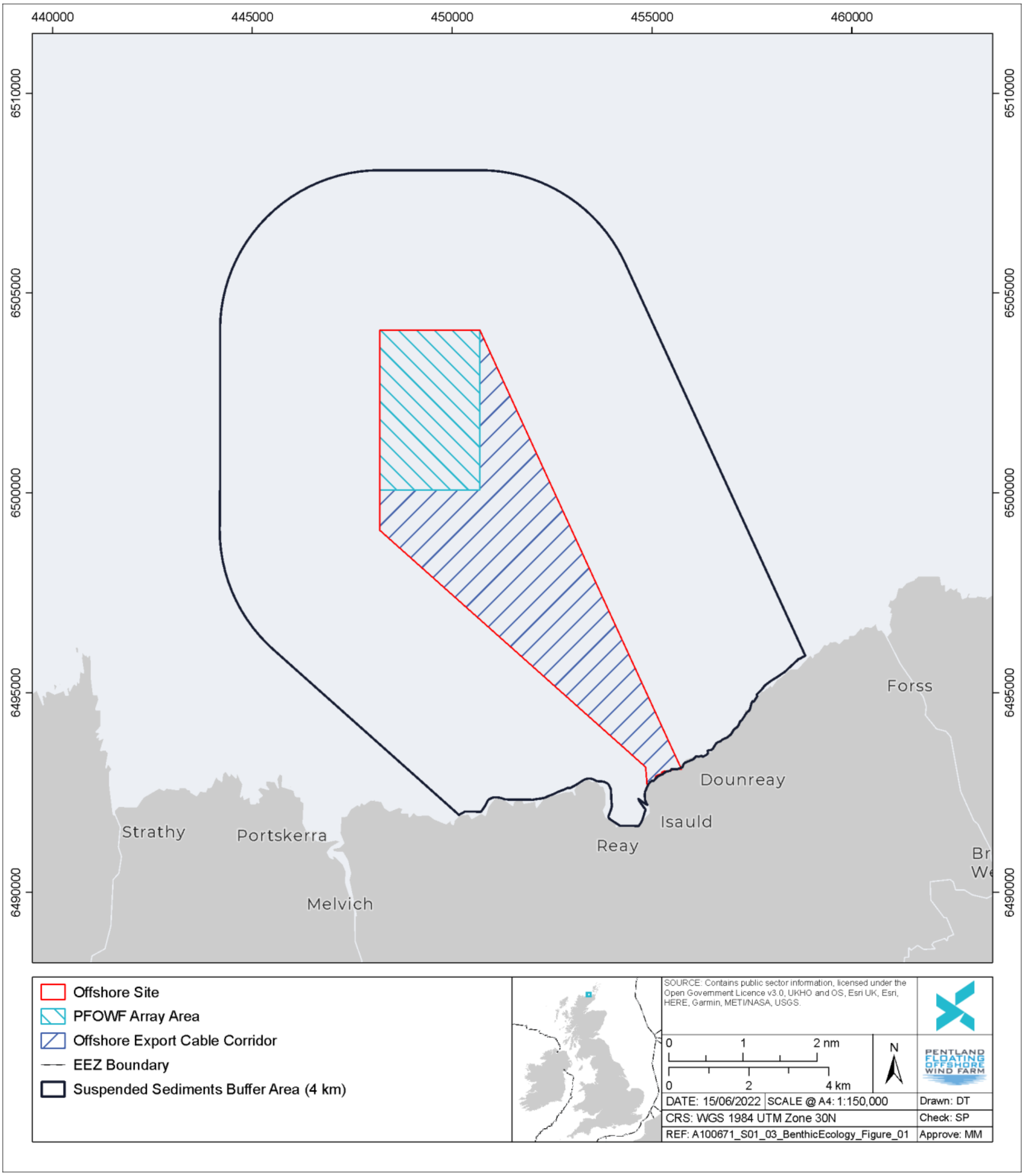

Figure 9.1 Benthic Ecology study and buffer areas

9.4.2 Sources of Information

A review was undertaken of the literature and data relevant to this assessment and was used to give an overview of the existing environment. The primary data sources used in the preparation of this chapter are listed below in Table 9.3 .

Table 9.3 Summary of key sources of information pertaining to Benthic Ecology

Title	Source	Year	Author
Spatial data relating to benthic ecology on National Marine Plan Interactive: NatureScot (2018). Ocean Quahog Mapping European Seabed Habitat (MESH) project data.	https://marinescotland.atkinsgeospatial.com/nmpi/ http://marine.gov.scot/node/12704 http://www.marine.gov.scot/data/mapping-european-seabed-habitats-mesh	2021	NMPi
Marine Scotland Science Farr Point Bathymetry Survey	https://marine.gov.scot/maps/544	2014	MMS
Seabed Habitat – Borad-scale Predictive Habitat Map – EUNIS Classification full detail	https://www.emodnet-seabedhabitats.eu/access-data/launch-map-viewer/	2019	EMODnet
UKSeaMap	https://jncc.gov.uk/our-work/marine-habitat-data-product-ukseamap/	2018	JNCC
LT17 Orkney – Mainland HVAC 220 kV Subsea Link Environmental Appraisal, Non-Technical Summary	http://marine.gov.scot/sites/default/files/06889_-_environmental_appraisal_non-technical_redacted.pdf	2019	Xodus Group
Biological analyses of underwater video from research cruises in marine protected areas and renewable energy locations around Scotland in 2014. Scottish Natural Heritage Commissioned Report No. 819	https://www.nature.scot/naturescot-commissioned-report-819-biological-analyses-underwater-video-research-cruises-marine	2015	Moore, C.G
North-West Orkney MPA	https://jncc.gov.uk/our-work/north-west-orkney-mpa/	2018	JNCC
The Marine Life Information Network	https://www.marlin.ac.uk/	2021	MarLIN
Feature Activity Sensitivity Tool	http://www.marine.scotland.gov.uk/FEAST/	2013	Marine Scotland
Sectoral Marine Plan for Offshore Wind Energy	https://www.gov.scot/publications/sectoral-marine-plan-offshore-wind-energy/documents/	2020	Scottish Government

Title	Source	Year	Author
British Geological Survey carbonate content of surficial sediment	http://mapapps2.bgs.ac.uk/geoindex_offshore/home.html	2021	BGS GeoIndex Offshore

9.4.3 Site-specific Surveys

9.4.3.1 MMT 2021 benthic surveys

MMT, on behalf of Highland Wind Limited (HWL), conducted geophysical and environmental surveys covering the PFOWF Array Area and OECC from June to July 2021.

The purpose of the survey was to provide information on the environmental conditions within the Offshore Site. Geophysical data were acquired via multibeam echo sounder, side scan sonar, sub-bottom profiler, 2D multi-channel sparker (offshore), single channel boomer (nearshore), and single magnetometer.

A total of 21 sampling sites were chosen for photo documentation and grab sampling. All the sampling sites were successfully photographed with good quality photos acquired. Seven standalone video transects were successfully performed with good quality video acquired. Grab sample sites S003 and S021 comprised insufficient sample volume for faunal analysis and were excluded from further statistical analyses. No faunal samples were retrieved at grab sites S004 due to coarse sediments. Grab sample site S013 was not sampled due to the presence of a rocky reef. Grab sampling was successfully performed at the remaining sites. The grab sample sites and video transects are shown in Figure 9.2.

At each of the grab sample sites, prior to the collection of samples, imagery was acquired and four still images were selected for further analysis. At each grab sampling site, three samples were retrieved. Two samples were dedicated for taxonomic analysis and one for physio-chemical and radioactivity analyses. The primary grab sampler utilised was a Dual Van Veen (2 square metres [m^2] x 0.1 m^2) and the secondary grab sampler was a Hamon grab (0.1 m^2). Upon retrieval, samples were checked for adequate sample volume and samples covering less than 0.1 m^2 of bottom surface sediment were deemed unacceptable. A minimum penetration depth of 5 centimetres (cm) in sands (7 cm in fine sediments / mud) measured in the Dual Van Veen was considered acceptable. For the Hamon grab a volume of 7 litres was considered to be an acceptable sample.

The faunal samples were sorted from sediment residue, and the fauna was identified to the most detailed level possible (mainly species) and then counted and weighed. When the species could not be identified, the specimen was grouped into the nearest identifiable taxon of a higher rank (i.e. genus or family, etc.).

The geophysical interpretation combined with the environmental data was used as the basis for the European Union Nature Information System (EUNIS) habitat classifications and assessments of potential areas and species of conservation importance. Habitats were classified to the lowest hierarchic level possible and based on interpretations that combine biotope descriptions of species abundance, diversity, depth and seabed features from grab samples, video and photos acquired at each sample site.

Physio-chemical and radioactivity analysis was undertaken on the grab samples for metals, hydrocarbons (Total Hydrocarbons and Polycyclic Aromatic Hydrocarbons), organics (Loss of Ignition, Total Organic Carbon and Fractioned Organic Carbon), Polychlorinated Biphenyls (PCBs), and gamma spectrometry for radioactivity. The samples were analysed against varying environmental quality standards and guidelines.

Further information on the survey methodology and the findings of the surveys are provided in Offshore EIAR (Volume 3): Appendix 9.1. A summary of these findings is detailed within Section 9.4 below.

9.4.3.2 Additional supporting surveys

A Phase 1 Habitat Intertidal survey was undertaken on 12th October 2015 in an area covering the rocky habitat between the eastern flank of Sandside Bay to the western side of the Dounreay Site Restoration Limited (DSRL) site (Fox, 2015). The survey was undertaken to identify and map the biotypes present within the Dounreay intertidal study area, identify and map the presence of any rare or protected species, and provide target notes for each biotype and any rare or protected species encountered (Fox, 2015). The survey area was approximately 0.9 km long and varied in width (up to 100 m), due to variable substrate and tidal conditions (Fox, 2015).

Additionally, the Farr Point (2014) multi-beam survey was undertaken in 2014 by the MSS vessel, the *MRV Scotia,* and covered the north coast of Scotland between the Kyle of Tongue and 13 km west of Thurso (MSS, 2014). Video-based monitoring of the benthic environment located in the same area was also conducted in 2014 (MSS, 2014; Moore, 2015) (see Figure 9.2).

In 2016, Hexicon AB commissioned Horizon Geosciences Limited to complete a geophysical survey at the site from 1st to 17th October 2016, followed by a geotechnical survey in June 2017 (Horizon Geosciences, 2016) (see Figure 9.2). The survey objectives were to map the sub-surface geology up to a depth of 20 metres (m) or more, including identifying the presence of bedrock, interpret the shallow structures within the bedrock, acquire accurate bathymetry, detect seabed debris and seabed / sub-seabed cemented material, identify sub-seabed lithologies and structures such as channelling, and identify potential geohazards, including the identification of boulders within the glacial materials across the site (Horizon Geosciences, 2016).

The survey locations are shown in Figure 9.2.

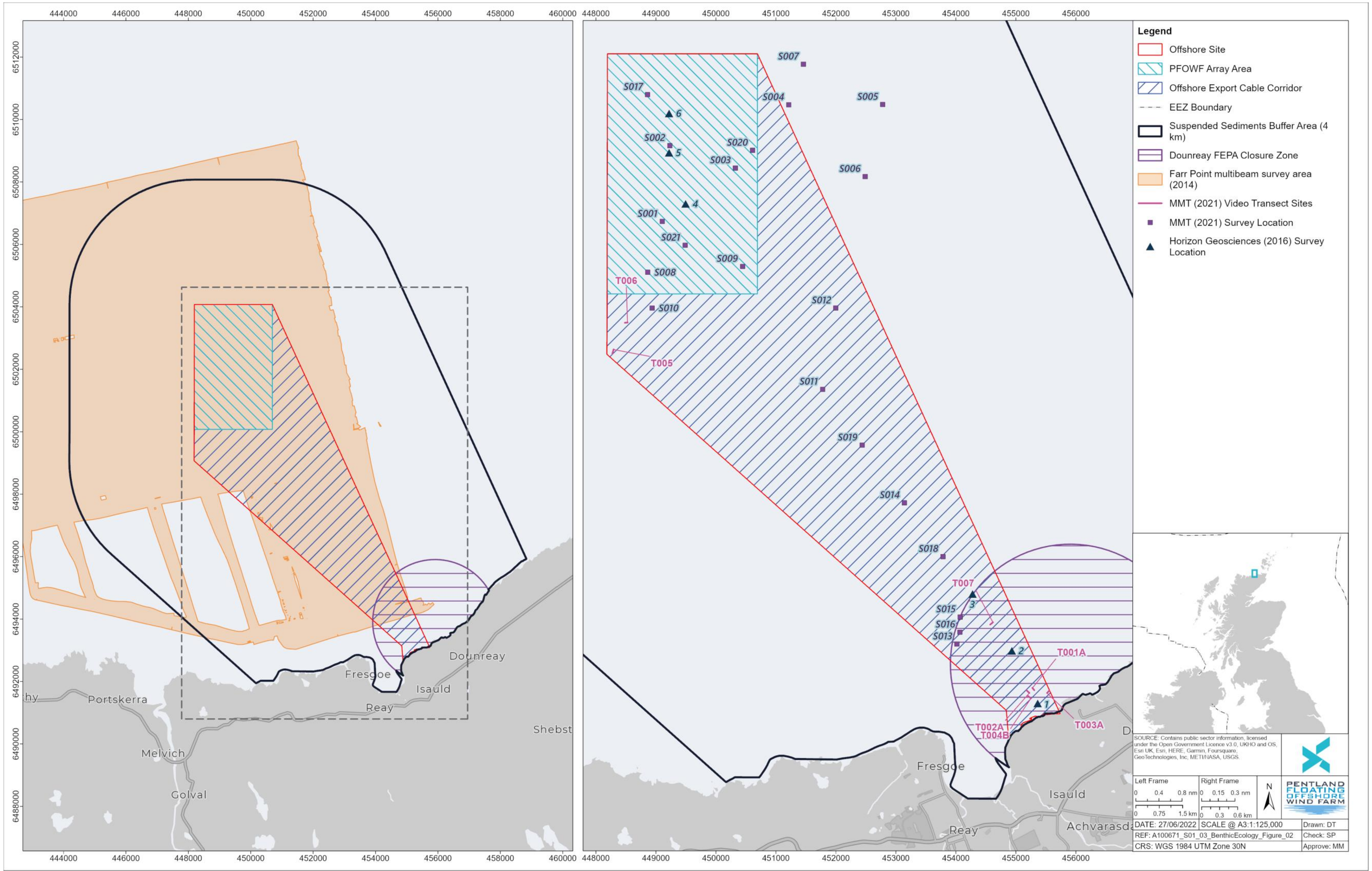

Figure 9.2 Survey locations at the Offshore Development

9.4.4 Baseline Description

9.4.4.1 PFOWF Array Area and Suspended Sediment Buffer Area

The PFOWF Array Area is within water depths ranging from 66 m to 102 m. At the closest point, the PFOWF Array Area is located 7.5 km from the northern coastline of Scotland. The predicted EUNIS 2007 classification for the PFOWF Array Area and Suspended Sediment Buffer Area is predominantly A5.27-Deep circalittoral sand. To the west of the Suspended Sediment Buffer Area, there are small patches of A5.14-Circalittoral coarse sediment and A.15-Deep circalittoral coarse sediment (Figure 9.3).

Three main types of sediment classification were observed during the 2016 survey conducted by Horizon Geosciences for the Offshore Site including slightly gravelly fine sand, gravelly sand with occasional boulders, and coarse sand and gravel with numerous boulders (Horizon Geosciences, 2016).

The dominant habitat type observed within the 2014 MSS survey was slightly rippled fine sand, which is consistent with the predicted EUNIS classifications identified. Patches of scattered gravel, pebbles, cobbles, and occasional boulders on sand were also observed, mainly in the south-western sector of the PFOWF Array Area.

This is also consistent with the recent MMT 2021 survey where sand was the dominating sediment fraction in all samples (see Offshore EIAR [Volume 3]: Appendix 9.1). The survey also showed the distribution of the sediments was consistent with the predicted EUNIS classifications, with the dominant sediment type of the PFOWF Array Area classified as A5.2-Circalittoral fine sand and A5.27-Deep circalittoral sand, with stills from all sampled locations showing the seabed comprised mostly clean sand with sparse visible fauna (see Offshore EIAR [Volume 3]: Appendix 9.1).

A number of discrete sediment classifications in the PFOWF Array Area were also identified during the MMT 2021 survey (see Offshore EIAR [Volume 3]: Appendix 9.1), these were:

> A5.45-Deep circalittoral mixed sediments (identified at grab sample site S009 and S021 (in the PFOWF Array area) and S004 and S007 (within the Suspended Sediment Buffer Area); and

> A5.15 / A5.27-Deep circalittoral coarse sediment / Deep circalittoral sand (identified at grab sample site S003 within the PFOWF Array Area).

The faunal analyses showed that the phyletic composition, regarding both the total number of taxa and abundance, was dominated by annelids, whereas the biomass was dominated by molluscs (see Offshore EIAR [Volume 3]: Appendix 9.1).

In addition, as identified in Chapter 7: Marine Physical Processes, there is the potential for relatively thin (approximately 2 m thick) peat deposits at depths of 4 m to 8 m below the seabed across the PFOWF Array Area. The presence of this unit means that there is the potential for it to be released to the seabed, through seabed disturbance.

9.4.4.2 OECC and Suspended Sediment Buffer Area

The predicted EUNIS classification for the OECC and Suspended Sediment Buffer Area, below the MHWS, is predominantly A5.25-Circalittoral fine sand or A5.26-Circalittoral muddy sand with areas of A3.2-Atlantic and Mediterranean moderate energy infralittoral rock and A5-Sublittoral sediment as the OECC approaches the coastline (EUSeaMap, 2019).

Four main sediment types were observed during the Horizon (2016) survey for the OECC, including muddy very fine sand, gravelly find sand / muddy fine sand, coarse sand, and gravel with numerous boulders and rugged, and high relief seafloor dominated by outcrops with pinnacles (Horizon Geosciences, 2016).

The recent MMT 2021 survey found within all grab samples and video surveys, except for S015 where gravel dominated the sample, that sand was the dominating sediment fraction in the OECC (see Offshore EIAR [Volume 3]: Appendix 9.1). The survey also showed the distribution of the sediments was consistent with the predicted EUNIS classification with the majority of the OECC attributed to A5.252-Abra prismatica, Bathyporeia elegans, and polychaetes in circalittoral fine sand and A5.27-Deep circalittoral sand.

A discrete area of A4.13-Mixed faunal turf communities on circalittoral rock was also identified in the OECC, below the south-west corner of the PFOWF Array Area. The seabed comprised rock dumps and boulders with intrusions of silty sediment and is assessed to meet the criteria for Annex I (1170) - Stony Reefs (identified at video transects T005 (Medium Grade Stony Reef) and T006 (High Grade Stony Reef) (see Offshore EIAR [Volume 3]: Appendix 9.1). A discrete area of A5.15-Deep circalittoral coarse sediment comprising clean sands with shell gravel was also identified at grab sample site S010, immediately south of the PFOWF Array Area.

Additionally, the following EUNIS habitats were found within the OECC on approach to the coast during the MMT 2021 surveys (see Offshore EIAR [Volume 3]: Appendix 9.1):

- A5.25-Circalittoral fine sand (identified at grab sample sites S014, S018, and S019, 0.75 km to 1.4 km from the coast);
- A5.14-Circalittoral coarse sediment (identified at grab sample sites S015 and S016, 1.4 km to 2 km from the coast);
- A5.44-Circalittoral mixed sediments (very isolated patch at 1.4 km to 1.42 km from the coast);
- A4.13-Mixed faunal turf communities on circalittoral rock (assessed to meet the criteria for Annex I [1170] – Stony Reefs, Medium Grade) at (identified at video transect T007 and grab sample S013, 1.5 km to 2 km from the coast); and
- A5.451-Polychaete-rich deep Venus community in offshore mixed sediments (2 km to 2.2 km from the coast).

In the nearshore, on direct approach to the landfall, the MMT 2021 survey video transects showed the seabed consisted predominantly of sand and high-energy outcropping bedrock out to 0.75 km. The bedrock feature that extends across the width of the survey corridor closest to shore is classified as A3.115-*Laminaria hyperborea* with dense foliose red seaweeds on exposed infralittoral rock. Moving slightly further offshore, a narrow band (approximately 50 m) of A3.125-Mixed kelps with scour-tolerant and opportunistic foliose red seaweeds on scoured or sand-covered infralittoral rock is present. Habitat complex A3.115 / A3.125 was assessed as meeting the criteria for Annex I (1170)-Bedrock Reefs (see Offshore EIAR [Volume 3]: Appendix 9.1).

Video footage collected within the OECC (Moore, 2015) also coincides with the findings of the MMT (2021) surveys and indicate a gradual increase in the proportion of coarser sediment types as water depth decreases towards the coast and areas of rocky seabed are present. Emergent tubes, polychaete casts, and bivalve siphons, most of which resembled those of the ocean quahog (*Arctica islandica),* were observed in the sandy sediments (Moore, 2015). In areas where hard substrates were present, encrusting communities of soft corals, bryozoans, and hydroids were observed (Moore, 2015).

9.4.4.3 Habitats and species of conservation interest

There are no Marine Protected Areas (MPAs), Special Areas of Conservation (SACs), or Potential Annex I habitats within the PFOWF Array Area. The nearest MPA is North-West Orkney MPA, located 33 km to the north of the PFOWF Array Area, designated for its importance to biodiversity (sandeels [Ammodytes sp.]) and geodiversity (marine geomorphology of the Scottish Shelf Seabed, including sandbanks and sand and sediment wave fields) (JNCC, 2018).

The following mobile species of conservation importance were identified within the OECC: sandeel, ling (*Molva molva),* skate (*Dipturus sp* complex), and European plaice (*Pleuronectes platessa)*. These species are all categorised as species of least concern (IUCN, 2022). The fish species identified in the MTT (2021) surveys are discussed further in Chapter 10: Fish and Shellfish Ecology.

Two ocean quahog individuals were previously recorded within the Benthic Ecology Study Area. Additionally, 12 records of ocean quahog are located within a 10-km radius of the Benthic Ecology Study Area (NMPi, 2018). Ocean quahogs were also identified at 10 of the MTT (2021) survey sample sites within the Offshore Site and Suspended Sediment Buffer Area at: S019 (see Offshore EIAR [Volume 3]: Appendix 9.1). Ocean quahogs are listed on the OSPAR Convention's List of Threatened and/or Declining Species and Habitats (OSPAR, 2008) and also as a PMF species.

One of the most abundant species identified during the survey was *Alcyonium digitatum*, belonging to the broad subclass Octocorallia; these were identified at 14 of the grab sample sites across the Offshore Site and Suspended Sediment Buffer Area at S001 to S009, S013, S016, S017, S020, and S021, as well as along transects T001A, T002A, T004B, T005, and T006 (see Offshore EIAR [Volume 3]: Appendix 9.1). *A. digitatum* is a member of the Octocorallia, a broad group including some rare soft corals and sea pens and is listed in the Scottish Biodiversity List (SBL). *A. digitatum* is widely distributed, found on all British and Irish coasts, and does not hold further protected status; therefore, it is not considered further in this assessment.

Three habitats of conservation importance were identified within the Offshore Site during the MMT 2021 surveys (see Offshore EIAR [Volume 3]: Appendix 9.1):

- Annex I habitat 1170 Reefs (subtype 'Stony Reef' and 'Bedrock Reefs');
- Kelp beds; and
- Subtidal sands and gravels.

These habitats and their conservation status are discussed below.

9.4.4.3.1 Stony and Bedrock Reefs

Annex I habitat *1170 Reefs* were recorded within the OECC and immediately south-west of the PFOWF Array Area (within the OECC) during the MMT 2021 surveys (see Offshore EIAR [Volume 3]: Appendix 9.1) at S013 and video transects T006, T005, T007, T001A, T002A, T003A, and T004B. These comprised both stony and bedrock reef types. An area of medium-grade stony reef (T007 and S013) was recorded in the southern extent of the OECC. One small area of medium-grade stony reef, located in an area of mixed sediments, details a mostly epifaunal-dominated community and variable density of cobbles and boulders and a small area of high-grade stony reef, formed from two manmade rock dumps (T006), detailed an epifaunal dominated community and densely stacked boulders; these were located in the north-west corner of the OECC. These small areas were dominated by A4.13 Mixed faunal turf communities on circalittoral rock and A5.141-Pomatoceros triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles.

The bedrock formation within the OECC is 'sandstone dominate cyclic sequence with siltstone and calcareous (fish bed) laminated limestone' (BGS GeoIndex Offshore, 2021). This habitat type may be characterised by differing types of communities / assemblages because it encompasses various structural and substrate typologies that are characterised by different physical, chemical, and hydrographic factors.

The Phase 1 Intertidal Survey (2015) reported nine biotypes associated with the rocky habitat present in the OECC. These were: *Pelvetia canaliculata* and barnacles on moderately exposed littoral fringe rock, *Semibalanus balanoides* on exposed to moderately exposed or vertical sheltered eulittoral rock, *Fucus spiralis* on full salinity exposed to moderately exposed upper eulittoral rock, Fucoids and kelp in deep eulittoral rockpools, Green seaweeds (*Enteromorpha spp.* and *Cladophora* spp.) in shallow upper shore rockpools, *Corallina officinalis*, coralline crusts and brown seaweeds in shallow eulittoral rockpools, Lichens or small green algae on supralittoral rock, *Fucus serratus* and under-boulder fauna on lower eulittoral boulders, and *Laminaria digitata* on moderately exposed sublittoral fringe rock (Fox, 2015). These biotopes are associated with the Annex I rocky reef habitat but are not individually designated as Annex I habitats.

Intertidal boulder communities are a functional habitat and are in decline in the UK. They are also a habitat for which the UK has international obligations for conservation (Council Directive 92/43/EEC). Additionally, dog whelk (*Nucella lapillus)* was found on most of the intertidal rock and is an OSPAR Convention-listed species (OSPAR, 2008) (Fox, 2015).

9.4.4.3.2 Kelp beds

An area of kelp beds was located in the nearshore zone on the approach to landfall within the OECC, observed within video transects at T001A, T002A, T003A, and T004B (see Offshore EIAR [Volume 3]: Appendix 9.1).

The North Scotland coastline is composed of A3.1-Atlantic and Mediterranean high-energy infralittoral rock interspersed with sandy beaches of A5.23-Infralittoral fine sand or A5.23-Infralittoral fine sand (EUSeaMap, 2019). Areas of high-moderate energy infralittoral rock are likely to provide conditions suitable for the development of kelp forest / park habitats. Kelp beds are classified as a PMF habitat under the A3.115-*Laminaria hyperborea* with dense foliose red seaweeds on exposed infralittoral rock classification and were identified on the exposed bedrock classification.

9.4.4.3.3 Subtidal sands and gravels

The SBL and PMF habitat Subtidal sands and gravels, classified as A5.14-Circalittoral coarse sediment, A5.15-Deep circalittoral coarse sediment, A5.23-Infralittoral fine sand, A5.25-Circalittoral fine sand, and A5.27-Deep circalittoral sand, was identified throughout the majority of the survey areas (S001 to S003, S005 to S008, S010 to S012, and S014 to S020). Sand and gravel sediments are the most common subtidal habitat around the coast of the British Isles and are abundant in the offshore waters of Scotland. This broad habitat type is included in the SBL as it was identified in the wider 2007 UK Biodiversity Action Plan (UKBAP).

9.4.4.4 Blue carbon

Blue carbon refers to the ability of coastal or marine habitats to capture and store atmospheric carbon dioxide. Plants, calcifying organisms, and sediments can sequester and store carbon, in both the short term (i.e. plants) and long term (i.e. reefs and deep-sea sediments). The principal threat to long-term carbon storage is any process or work that disturbs the top layers of sediment (including activities relating to the placement of sub-sea export cables or piling of the anchors). The key habitats that support blue carbon storage and sequestration include:

- Kelp forest;
- Intertidal macroalgae;
- Subcanopy algae;
- Maerl beds;
- Burrowed mud;
- Seagrass beds;
- Saltmarshes;
- Horse mussels (*Modiolus modiolus*);
- Flame shell (*Lamaria hians*);
- Sabellaria reefs;
- Lophelia pertusa reefs;
- Tubeworm (*Serpula vermicularis*) reef;
- Brittlestar beds; and
- Blue mussel (*Mytilus edulis*).

Of the above habitats, kelp beds are the only habitat identified as present within the Benthic Ecology Study Area that supports blue carbon storage or sequestration.

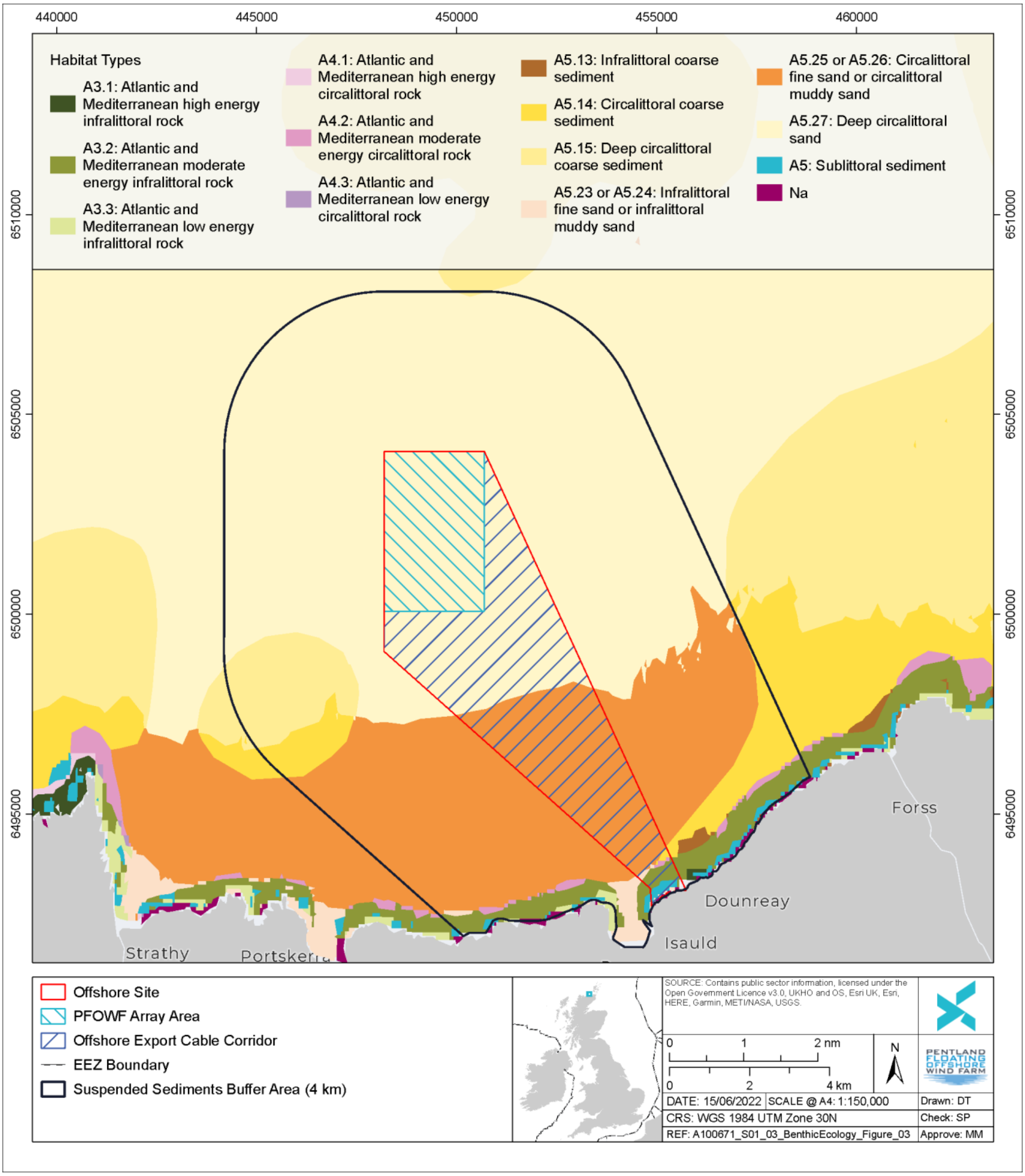

Figure 9.3 Sediment types in the vicinity of the Offshore Development

9.4.4.5 Non-native species

Within the MTT (2021) environmental surveys, the non-native polychaete *Goniadella gracilis* was recorded in the grab samples collected at sample sites S010, located to the south-east of the PFOWF Array Area, and S016 located within the northern section of the OECC (see Offshore EIAR [Volume 3]: Appendix 9.1). The first British records of this non-native species are from 1970 in Liverpool Bay (Eno, Clark, & Sanderson, 1997). This non-native species is listed as having an unknown impact on native ecology meaning that the status of this species becoming invasive is unknown (ADAS, 2008). No other non-native species have been identified as present within the Benthic Ecology Study Area.

9.4.4.6 Sediment quality analysis

Specific results for the contaminant analysis across the sediment sampled sites during the 2021 MMT Environmental Surveys are set out in Chapter 8: Water and Sediment Quality. This chapter also provides an assessment of these findings. A summary of these results and conclusions of the sediment quality assessment are provided below.

Across the sampled sites, metal concentrations were generally below threshold values throughout the assessed locations. Concentrations of hydrocarbons (Total Hydrocarbons and PAH) varied across the sites at low concentrations. As a result of the low concentrations across the sampled sites, both Total Hydrocarbons and PAH contaminants are not considered to be of concern to the proposed Offshore Development. Concentrations of PCBs across the sampled sites show that the majority of PCBs were below the level of detection (LOD) across these sites. Therefore, this set of contaminants is not considered to be of concern to the proposed Offshore Development.

It is noted that a portion of offshore export cable installation will be undertaken on the seabed within the Dounreay Food and Environment Protection Act (FEPA) closure cone (as shown in Figure 9.2). This is an area of sea, of 2-km radius centred on the Dounreay historic Liquid Effluent Diffuser System (LEDS), where fishing is prohibited to prevent the possibility of radioactive particles present on the seabed within this location. In line with the OECC overlapping the Dounreay FEPA closure zone, sediment samples were analysed for radioactivity by gamma spectrometry. The analysis was completed for a range of radionuclides, including gross alpha and gross beta (MMT, 2021). In general, the radioactivity of the sediment varied across the surveyed area but based on the classification used to define the potential relative harm, the levels were very low (NUVIA, 2021a; 2021b).

Overall, sediment sampling and chemical analyses undertaken across the Offshore Site demonstrate a low to negligible occurrence of contaminants and radioactive particles. It is therefore unlikely that any significant chemical contamination or radioactive particles would be encountered within the Offshore Site.

9.4.5 Future Baseline

In the absence of the Offshore Development, the future benthic ecology environment at the Offshore Site is likely to primarily experience changes associated with the effects of climate change. Climate change is leading to increases in ocean temperature, changes to ocean chemistry, sea-level rise, changing salinities and oceanographic patterns and increased extreme events including storminess and marine heatwaves (Stocker, 2013).

A description of the future baseline of the Offshore Site in terms of climate change and the potential effects from climate change to the biological environment, including Benthic Ecology receptors, are discussed in Chapter 20: Climate Change and Carbon.

9.4.6 Summary of Baseline Environment

Table 9.4 summarises the key receptors reviewed in Section 9.4.4. The sensitivities provided are as per the Marine Evidence-based Sensitivity Assessment as published on the Marine Life Information Network website.

Potential receptors and impacts scoped into the assessment and impacts scoped out are provided in Section 9.5 along with justification.

Table 9.4 Key sensitive receptors within the Benthic Ecology Study Area

Receptor	Designation(s)	Location (PFOWF Array Area, OECC, Suspended Sediment Buffer Area)	Sensitivity	Recoverability
Kelp beds	> PMF under A3.115 - *Laminaria hyperborea* with dense foliose red seaweeds on exposed infralittoral rock > Blue carbon habitat	OECC	> High sensitivity to habitat change; > Medium sensitivity to abrasion / disturbance of the surface of the substratum or seabed; > Not sensitive to light smothering, and low sensitivity to heavy smothering; and > High sensitivity to introduction or spread of INNS (MarLIN, 2022a).	> No resistance and very low resilience to habitat change; > Medium resilience and low resistance to abrasion / disturbance of the surface of the substratum or seabed; > High resilience and resistance to light smothering and medium resilience and high resistance to heavy smothering; and > Low resistance and very low resilience to introduction or spread of INNS (MarLIN, 2022a).
Ocean quahog	> OSPAR Convention's List of Threatened and/or Declining Species and Habitats > PMF species	All	> High sensitivity to physical change (to another sediment type); > High sensitivity to habitat structure changes - removal of substratum (extraction); > High sensitivity to abrasion / disturbance of the surface of the substratum or seabed; > Not sensitive to light or heavy smothering; and	> Low resistance and very low resilience to physical change (to another sediment type); > No resistance and very low resilience to habitat structure changes - removal of substratum (extraction); > Low resistance and very low resilience to abrasion / disturbance of the surface of the substratum or seabed;

Receptor	Designation(s)	Location (PFOWF Array Area, OECC, Suspended Sediment Buffer Area)	Sensitivity	Recoverability
			> No evidence of sensitivity level to the introduction or spread of INNS (MarLIN, 2022b).	> High resilience and resistance to light and heavy smothering; and > No evidence of resistance to the introduction or spread of INNS (MarLIN, 2022b).
Offshore subtidal sands and gravels	> PMF > SBL	OECC and PFOWF Array Area	> High sensitivity to physical change (to another sediment type); > Low sensitivity to increase in suspended sediment; > Low sensitivity to abrasion and physical disturbance; and > Low to medium sensitivity to light and heavy smothering (MarLIN, 2022c).	> No resistance and very low resilience to physical change (to another sediment type); > Medium resistance and high resilience to increase in suspended sediment; > Medium resistance and high resilience to abrasion and physical disturbance; and > Medium resistance and high to medium reliance to light and heavy smothering (MarLIN, 2022c).
Stony / Bedrock Reef Habitats				
Channelled wrack *(Pelvetia canaliculata)* and barnacles on moderately exposed	> Biotope of Habitat Directive Annex I reef	OECC	> Not sensitive to increase in suspended sediment; > Medium sensitivity to abrasion and physical disturbance; and > Medium sensitivity to light and heavy smothering (MarLIN, 2022d).	> Medium resistance and medium resilience to light smothering; > Low resistance and medium resilience to abrasion and physical disturbance; and

Receptor	Designation(s)	Location (PFOWF Array Area, OECC, Suspended Sediment Buffer Area)	Sensitivity	Recoverability
littoral fringe rock				> Low resistance and medium resilience to heavy smothering (MarLIN, 2022d).
Semibalanus balanoides on exposed to moderately exposed or vertical sheltered eulittoral rock	> Biotope of Habitat Directive Annex I reef UKBAP	OECC	> High sensitivity to physical change (to another seabed type); > Medium sensitivity to abrasion / disturbance of the surface of the substratum or seabed; and > Medium sensitivity to light and heavy smothering (MarLIN, 2022e).	> No resistance and very low resilience to physical change (to another seabed type); > Low resistance and medium resilience to abrasion / disturbance of the surface of the substratum or seabed; > Low resistance and medium resilience to light smothering; and > No and medium resilience to heavy smothering (MarLIN, 2022e).
Fucus spiralis on full salinity exposed to moderately exposed upper eulittoral rock	> Biotope of Habitat Directive Annex I reef	OECC	> Physical changes to another sediment type are not relevant for bedrock biotypes; > Medium sensitivity to abrasion / disturbance of the surface of the substratum or seabed; and > Low sensitivity to light smothering and medium sensitivity to heavy smothering (MarLIN, 2022f).	> Low resistance and medium resilience to abrasion / disturbance of the surface of the substratum or seabed; > Medium resistance and high resilience to light smothering; and > Low resistance and medium resilience to heavy smothering (MarLIN, 2022f).

Receptor	Designation(s)	Location (PFOWF Array Area, OECC, Suspended Sediment Buffer Area)	Sensitivity	Recoverability
Fucoids and kelp in deep eulittoral rockpools	> Biotope of Habitat Directive Annex I reef > Blue carbon habitat	OECC	> Physical changes to another sediment type are not relevant for bedrock biotypes; > Medium sensitivity to abrasion / disturbance of the surface of the substratum or seabed; and > Medium sensitivity to light and heavy smothering (MarLIN, 2022g).	> Medium resistance and medium resilience to abrasion / disturbance of the surface of the substratum or seabed; > Medium resistance and medium resilience to light smothering; and > Low resistance and medium resilience to heavy smothering (MarLIN, 2022g).
Green seaweeds *(Enteromorpha spp*. and *Cladophora spp*.) in shallow upper shore rockpools	> Biotope of Habitat Directive Annex I reef	OECC	> Physical changes to another sediment type are not relevant for biotypes which occur in tidepools on bedrock; > Low sensitivity to abrasion / disturbance of the surface of the substratum or seabed; and > Low sensitivity to light and heavy smothering (MarLIN, 2022h).	> Medium resistance and high resilience to abrasion / disturbance of the surface of the substratum or seabed; and > Low resistance and high resilience to light and heavy smothering (MarLIN, 2022h).
Mixed faunal turf, *P. triqueter*, barnacles and bryozoan crusts	> Biotope of Habitat Directive Annex I reef	OECC	> High sensitivity to physical change (to another seabed type); > Low sensitivity to heavy smothering; and > Low sensitivity to abrasion and physical disturbance (MarLIN, 2022i).	> No resistance and very low resilience to physical change (to another seabed type); > Medium resistance and high resilience to heavy smothering; and > Medium resistance and high resilience to abrasion and physical disturbance (MarLIN, 2022i).

Receptor	Designation(s)	Location (PFOWF Array Area, OECC, Suspended Sediment Buffer Area)	Sensitivity	Recoverability
Dog whelk (*Nucella lapillus)*	> OSPAR Convention's List of Threatened and/or Declining Species and Habitats	OECC	> Not sensitive to smothering; and > Not sensitive to an increase in suspended sediment (MarLIN, 2022j).	> High tolerance and immediate recoverability to smothering; and > High tolerance and immediate recoverability to increase in suspended sediment (MarLIN, 2022j).

9.4.7 Data Gaps and Uncertainties

The MTT (2021) survey works included two faunal replicates to be acquired at each grab sample site which was conducted in compliance with the survey Scope of Work. However, following demobilisation and transfer of samples to the taxonomic laboratory the replicate material at each of the grab sample sites was pooled to provide a single faunal analysis with no replicates. Due to this, each grab sample site has been effectively represented by an abundance per 0.2 m^2 with biomass expressed as faunal group weight per 0.2 m^2 (see Offshore EIAR [Volume 3]: Appendix 9.1).

This deviation is not expected to have a significant effect on the impact assessment as the variability analysis between stations still holds. However, for any future monitoring, the macrofaunal data at each station may not be statistically comparable and the level of precision to detect change may have been reduced.

No grab sampling was performed in the nearshore areas. The nearshore environmental survey consisted only of drop-down camera operations.

9.5 Impact Assessment Methodology

9.5.1 Impacts Requiring Assessment

This assessment covers all impacts identified through 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 phases of the Offshore Development.

Table 9.5 below indicates all of the direct and indirect impacts assessed with regards to Benthic Ecology and indicates the Offshore Development Phases to which they relate. Cumulative impacts are discussed in Section 9.7.

Table 9.5 Impacts requiring assessment

Impact	Description
Construction	
Damage from placement of infrastructure (cables, moorings, anchors) on the seabed	The installation of the Offshore Export Cable(s), horizontal direction drilling (HDD) exit point(s), dynamic cables, anchors, mooring lines, clump weights, and scour protection on the seabed will result in some direct loss of sedimentary habitat in the vicinity of the Offshore Development. An assessment of this impact is provided in Section 9.6.1.1.
Suspension of sediments from the installation of subsea infrastructure	The installation of subsea infrastructure, such as the Offshore Export Cable(s), HDD exit point(s), dynamic cables, anchors, mooring lines, clump weights, and scour protection, is likely to result in a temporary increase in suspended sediments resulting in the potential smothering of species located within the installation zones. An assessment of this impact is provided in Section 9.6.1.2.
Disturbance of contaminated sediments	The planned OECC route is located on the border of the Dounreay Nuclear Facility and passes through the Dounreay FEPA closure zone. It is known that there are small numbers of radioactive particles present in the offshore and intertidal sediments as a result of activities at Dounreay Nuclear Facility. These may be released into the wider environment as a result of direct disturbance from installation activities. Sediment samples collected for contaminant analysis in the wider Offshore Site are also used to assess any potential impacts associated with the disturbance of the seabed in the PFOWF Array Area and OECC. This assessment is provided in Section 9.6.1.3.
Introduction of marine invasive non-native species (INNS)	Marine INNS can be introduced to, or transferred in, the marine environment through vessel movements, particularly those vessels working within an international market such as anchor handler vessels and cable installation vessels. This can happen through biofouling (e.g. attachment of organisms to boat hulls) or release of ballast water. INNS can have a detrimental effect on the benthic ecology through predation on existing wildlife or outcompeting for prey and habitat. This can result in biodiversity changes in

Impact	Description
	the existing habitats present in the Offshore Site. An assessment of this impact is provided in Section 9.6.1.4.
Deposition of drill cuttings	As described in Chapter 7: Marine Physical Processes, the drilling activities for the anchor piles may result in drill cuttings piles within the PFOWF Array Area. This could result in habitat loss or smothering of slow-moving or sessile species, potentially resulting in injury or mortality.
Operation and Maintenance	
Hydrodynamic changes leading to scour and abrasion around subsea infrastructure (including mooring cables which move with waves and tides)	Scour and abrasion caused by the presence of anchors, mooring lines, dynamic cables and export cable protection has the potential to directly change habitats, exclude some species from the immediate area and increase the number of scour-resistant species. Scour results from turbulent flow, which has the ability to suspend and redistribute sediment and is induced by the presence of structures (anchors and cables) on the seabed. The movement of infrastructure on the seabed (mooring lines and dynamic cables) may locally abrade the surface of the seabed under more extreme wave conditions. An assessment of this impact is provided in Section 9.6.2.1.
Introduction of marine INNS	As described above, INNS can be introduced to, or transferred in, the marine environment through vessel movements, as well as via infrastructure acting as stepping-stone habitats. This can result in biodiversity changes in the existing habitats present in the Benthic Ecology Study Area. An assessment of this impact is provided in Section 9.6.2.2.
Colonisation of subsea infrastructure, scour protection, and support structures	Whilst epifaunal colonisation of subsea infrastructure can be considered to be beneficial in terms of localised increases in biodiversity and net productivity, this is dependent on the colonising community composition which may include non-native species and may have secondary impacts on the native biota of the receiving environment. An assessment of this impact is provided in Section 9.6.2.3.
Impact to benthic communities from any EMFs and thermal load arising from the cable during operation	EMFs have the potential to alter the behaviour of marine organisms that are able to detect electric or magnetic fields. When electric energy is transported, a certain amount gets lost as heat energy. This increases the temperature of the cable surface and potentially increases the temperature of the surrounding environment. An assessment of these impacts is provided in Section 9.6.2.5.
Decommissioning	
As per construction	Potential impacts arising during the decommissioning phase are expected to be similar to and not exceed those arising during the construction phase.

9.5.2 Impacts Scoped Out

The following impact was scoped out of the assessment during EIA Scoping:

9.5.2.1 Damage to habitats or species due to pollution from routine and accidental discharges.

The accidental release of pollutants is limited to oils and fluids contained within the WTGs and vessels. For WTGs, 12.8% of the fluid constituents are oils and grease, which, as an example, total approximately 11,300 litres for a 16-megawatt WTG. However, as per the embedded mitigations for the Offshore Development (as detailed in Section 9.5.5), the nacelle, tower, and rotor will be designed and constructed to contain leaks thereby reducing the risk of spillage into the marine environment. Therefore, the potential for a full inventory release from any individual WTG is considered extremely remote, requiring a catastrophic unplanned event (e.g. vessel collision with WTG). Additionally, routine service inspection, maintenance and monitoring of the WTGs will be carried out in accordance with best practices and service requirements provided by the WTG manufacturer to ensure any machinery fault which could cause a leak will be remedied as soon as practicable. Emergency response procedures will be in place for the Offshore Development, including pollution control and spillage response plans secured through the Construction Environmental Management

Plan (CEMP) and Operational Environmental Management Plan (OEMP). For these reasons, impacts to benthic ecology from any accidental release of pollutants are not considered further.

9.5.3 Assessment Methodology

The EIA process and methodology are described in detail in Chapter 6: EIA Methodology.

Project-specific criteria have been developed for the sensitivity and vulnerability of the receptor, based on the sensitivity and recoverability criteria set out in Table 9.4, and the likelihood and magnitude of impact as detailed below.

9.5.3.1 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 9.6.

Table 9.6 Impact magnitude criteria

Magnitude	Criteria
High	The impact occurs over a large spatial extent resulting in widespread, long-term, or permanent changes in baseline conditions or affecting a large proportion of receptor population. The impact is very likely to occur and/or will occur at a high frequency or intensity.
Moderate	The impact occurs over a local to medium extent with a short- to medium-term change to baseline conditions or affects a moderate proportion of a receptor population. The impact is likely to occur and/or will occur at a moderate frequency or intensity.
Low	The impact is localised and temporary or short-term, leading to a detectable change in baseline conditions or a noticeable effect on a small proportion of a receptor population. The impact is unlikely to occur or may occur but at low frequency or intensity.
Negligible	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 a receptor population. The impact is very unlikely to occur; if it does, it will occur at a very low frequency or intensity.
No Change	No change from baseline conditions.
Note: The magnitude of an impact is based on a variety of parameters. The definitions provided above are for guidance only and may not be appropriate for all impacts. For example, an impact may occur in a very localised area but at a very high frequency / intensity for a long period of time. In such cases, expert judgement is used to determine the most appropriate magnitude ranking as explained through the narrative of the assessment.	

9.5.3.2 Receptor sensitivity

Determining receptor sensitivity is part of the significance of effects assessment. Receptor sensitivity is defined as 'the degree to which a receptor is affected by an impact'.

Overall receptor sensitivity is determined by considering a combination of value, adaptability, tolerance, and recoverability. This is achieved by applying known research and information on the status and sensitivity of the receptor under consideration coupled with professional judgement and past experience.

The ability of a receptor to adapt to change, tolerate, and/or recover and the timing for recovery from potential impacts is key in assessing its vulnerability to the impact under consideration. Table 9.7 details the criteria used to define sensitivity in terms of adaptability and recoverability.

Table 9.7 Sensitivity of receptor (ability to recover and adaptability)

Receptor Sensitivity	Definition
Very high	The receptor has no capacity to accommodate a particular effect and no ability to recover or adapt.
High	The receptor has a very low capacity to accommodate a particular effect with a low ability to recover or adapt.
Moderate	The receptor has a low capacity to accommodate a particular effect with a low ability to recover or adapt.
Low	The receptor has some tolerance to accommodate a particular effect or will be able to recover or adapt.
Negligible	The receptor is generally tolerant and can accommodate a particular effect without the need to recover or adapt.

Receptor value considers whether, for example, the receptor is rare, has protected or threatened status, importance at the local, regional, national, or international scale. In the case of biological receptors, it also considers whether the receptor has a key role in the ecosystem function. Based on this, receptor value has been defined for Benthic Ecology receptors in Table 9.8 below to aid the overall assessment of receptor sensitivity.

Table 9.8 Criteria for value of Benthic Ecology receptor

Value of Receptor	Definition
Very high	The receptor is of very high importance or rarity, e.g. species that are globally threatened e.g. those listed on the OSPAR Convention's List of Threatened and Declining Species, International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species (the 'Red List') including those listed as endangered or critically endangered and/or a significant proportion of the international population (> 1%) is found within the Offshore Site. The receptor has no capacity to avoid or adapt to an effect, tolerate, or absorb an effect, or recover to baseline conditions.
High	The receptor is of high importance or rarity, such as species on the OSPAR Convention's List of Threatened and Declining Species and listed as near-threatened or vulnerable on the IUCN Red List. The species is listed on Annex IV of the EU Habitats Directive as a European Protected Species and/or is a qualifying interest of a SAC and a significant proportion of the national population (> 1%) is found within the Offshore Site. The receptor has very little capacity to avoid or adapt to an effect, tolerate, or absorb an effect, or recover to baseline conditions.
Medium	The receptor is of least concern on the IUCN Red List, listed as a breeding species on Schedule 1 of the Wildlife and Countryside Act 1981, from a cited interest of a Site of Special Scientific Interest, is listed in the UK BAP, PMF, SBL, and a significant proportion of the regional population (> 1%) is found within the Offshore Site. The receptor has a medium capacity to avoid or adapt to an effect, tolerate, or absorb an effect, or recover to baseline conditions.

Value of Receptor	Definition
Low	Any other species of conservation interest (e.g. Birds of Conservation Concern [BOCC] Amber-listed species). The receptor has limited capacity to avoid or adapt to an effect, tolerate, or absorb an effect, or recover to baseline conditions.
Negligible	The receptor is of very low importance, such as those which are generally abundant around the UK with no specific value or conservation concern. The receptor has the capacity to avoid or adapt to an effect, tolerate, or absorb an effect, or recover to baseline conditions.

The overall sensitivity for Benthic Ecology receptors is thus defined based on professional judgement in line with the above criteria.

9.5.3.3 Evaluation to determine significance of effect

The significance of an effect is determined by correlating the magnitude of the impact and the sensitivity of the receptor whilst utilising professional judgement and 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 (see Table 9.9). Importantly, latitude for professional judgement in the application of this matrix is permitted where deemed appropriate.

Table 9.9 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 9.10. For this Offshore EIAR, any effect with a significance of moderate or greater is generally considered 'significant' in EIA terms and additional mitigations may be required. Effects identified as minor or negligible are generally considered to be 'not significant' in EIA terms.

Table 9.10 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 population. Such adverse 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 population are not disrupted. Such adverse 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 or hardship or impair the function and value of the receptor. Such adverse effects are typically not contentious and generally will not 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. Such 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

9.5.4 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, known as the 'realistic worst case scenario'. The realistic worst case scenario represents, for any given receptor and potential impact on that receptor, various options in the Design Envelope that would result in the greatest potential for change to the receptor in question.

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 9.11 presents the realistic worst case scenario for potential impacts on Benthic Ecology during construction, operation and maintenance, and decommissioning phases of the Offshore Development.

In terms of Benthic Ecology, the realistic worst case scenario has been derived by ensuring that the maximum parameters of components for the Offshore Development with the potential to interact with Benthic Ecology receptors are considered to enable, for example, that the maximum seabed disturbance area from the placement of subsea infrastructure, to be assessed.

Where there are a number of options for the various Offshore Development components e.g. both tension-leg Platforms (TLP) and semi-submersible platforms are currently being explored for the floating substructures, the option which has the largest potential impact on Benthic Ecology receptors has been assessed at the maximum parameters identified, i.e. in this case the semi-submersible parameters have been assessed for colonisation impacts as they are the largest substructure and therefore have the maximum potential for colonisation of a floating structure.

For seabed disturbance impact, for example, a number of anchoring options are being explored, however, gravity anchors have the largest footprint and therefore represent the worst case anchor solution in terms of seabed disturbance and potential effects on Benthic Ecology receptors. Similarly, catenary mooring lines, although not the only mooring line option, have also been identified as the worst case in terms of seabed disturbance and therefore the associated maximum parameters have been assessed.

Hammer pile anchors have been assessed for impacts resulting from scour as they have the largest scour protection volume in comparison to other anchoring options being considered.

The Offshore Development components which have been identified as resulting in the worst case scenarios for each potential impact on Benthic Ecology receptors are detailed below.

Table 9.11 Design parameters specific to Benthic Ecology receptor impact assessment

Potential Impact	Design Envelope Scenario Assessed
Construction Phase	
Damage to the seabed from placement of infrastructure (cables, moorings, anchors) on the seabed	**Offshore Export Cable(s)** > A maximum of two offshore export cables which will run from the PFOWF Array Area to landfall; > The maximum total combined length of cable is approximately 25 km; > Maximum trench width of 3 m; > The maximum width of the OECC is 15 m (seabed disturbance, not trench width). Seabed preparation, including boulder removal, seabed levelling, etc., will take place within the OECC; > Maximum percentage of seabed requiring preparation: 100%; > A maximum seabed preparation footprint of 375,000 m^2; > The total duration of offshore activities is approximately four months in spring / summer in Stage 1 or Stage 2 of the construction phase; and > Up to 50% of the offshore export cables may not reach the target burial depth of 0.6 m and will require remedial protection; therefore, the maximum length of remedial cable protection will be 6.25 km per cable (12.5 km in total). Cable protection height and width of 1 m and 7 m, respectively. A total area of 87,500 m^2. **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 from MHWS. The water depth range in this region is between 15 m to 40 m; > The maximum offshore HDD length is 700 m; > The maximum bore diameter is 750 millimetres (mm); and > The total duration of offshore activities is approximately seven months in spring / summer of the year prior to Stage 1 (2024). **Inter-array cables** > A maximum of seven inter-array cables; > The maximum combined length of the cable is 25 km (all cables combined); > The maximum length of cable on the seabed is 20 km (all cables combined); > Maximum percentage of cable requiring seabed preparation (levelling, boulder removal): 100%; > A maximum seabed preparation footprint (all cables) of 300,000 m^2; > A maximum of 14 gravity anchors (two per inter-array cable, 20 m^2 per anchor);

Potential Impact	Design Envelope Scenario Assessed
	> A total cable protection footprint for all inter-array cables of 70,000 m^2; > It is assumed that 5,000 m of cable will be in the water column. These cables will be 300 mm in diameter (9,425 m^2 lateral surface area in the water column); and > The total duration of offshore activities is approximately three months in summer / autumn of Stage 2 of the construction phase. **Trench and burial methods for the offshore export cables and inter-array cables:** A combination of the following methods may be used, depending on the ground conditions: > Pre-lay trenching using a displacement plough to create a pre-lay trench which the cable is then installed into. A separate backfill plough may then be used to push the spoil heaps created by trenching over the cable, thus creating the required cable cover. > Post-lay trenching using a variety of tools including: o Jet trenchers (either self-propelled or mounted as skids onto ROVs) which inject water at high pressure into the sediment surrounding the cable. The seabed is temporarily fluidised and the cable is lowered to the required depth. Displaced material is suspended in the water and then resettles over the cable. This process is controlled, to ensure that sediment is not displaced too far from the cable; o Mechanical trenchers which bury the cable by lifting the laid cable whilst excavating a trench below, and then replacing the cable at the base of the trench and allowing the soil to naturally backfill behind the trencher; o Non-displacement ploughs which simultaneously lift a share of seabed whilst depressing the cable into the bottom of the trench. As the plough progresses, the share of the seabed is replaced on top of the cable; and > Simultaneous cable lay and burial, using a jet trencher or non-displacement plough. **Moorings: Catenary** > The maximum number of moorings is nine per substructure / WTG; > Maximum length of mooring that may come into contact with the seabed: 1,485 m per line (90% of total length); > A maximum lateral movement of 0.035 square kilometres [km^2] (assuming the full length of mooring line on seabed [i.e.1,485 m per mooring line]); > A maximum mooring line seabed footprint of 93,555 m^2; > A maximum temporary footprint from lateral movement of 2,205,000 m^2; and > The total duration of offshore activities is approximately four months during summer of Stage 1 of the construction phase (for the single WTG) and six months during spring / summer of Stage 2 of the construction phase. **Anchors: Gravity** > Up to nine anchors per WTG; > A maximum permanent seabed footprint of 625 m^2 per anchor; > A maximum seabed footprint of scour protection per anchor of 590 m^2; > A maximum area of seabed preparation (levelling) of 900 m^2 per anchor;

Potential Impact	Design Envelope Scenario Assessed
	> A maximum temporary total anchor footprint of 56,700 m^2; > A maximum seabed footprint of scour protection per anchor of 260 m^2; > A maximum permanent total anchor and scour protection footprint of 55,755 m^2; and > The total duration of offshore activities is approximately six months during spring / summer of Stage 1 of the construction phase.
Suspension of sediments from the installation of subsea infrastructure	Same parameters as above.
Disturbance of contaminated sediments	**Offshore Export Cable(s)** > A maximum of two offshore export cables which will run from the PFOWF Array Area to landfall; > The maximum total combined length of cable is approximately 25 km; > Maximum trench width of 3m; > The maximum width of OECC is 15 m (seabed disturbance, not trench width). Seabed preparation, including boulder removal, seabed levelling etc., will take place within the OECC; > Maximum percentage of seabed requiring preparation: 100%; > A maximum seabed preparation footprint of 375,000 m^2; > A maximum cable remedial protection footprint of 87,500 m^2; > The total duration of offshore activites is approximately four months over spring / summer of Stage 1 and Stage 2 of the construction phase; and > Up to 50% of the offshore export cables may not reach the target burial depth of 0.6 m and will require remedial protection; therefore, the maximum length of remedial cable protection will be 6.25 km per cable (12.5 km in total). Cable protection height and width of 1 m and 7 m, respectively. Total area of 87,500.
Introduction of marine INNS	A maximum number of 30 vessels will be used during the construction phase.
Deposition of drill cuttings	As discussed in Chapter 7: Marine Physical Processes, the radius of the cuttings mound, if drilled piles were selected as the optimum anchoring solution, would be approximately 21 m and cover an area of approximately 1,424 m^2.
Operational and Maintenance Phase	
Hydrodynamic changes leading to scour around subsea infrastructure (including mooring lines as a result of movement with waves and tides);	**Offshore Export Cable(s)** > A maximum of two offshore export cables which will run from the PFOWF Array Area to landfall; and > Maximum cable remedial protection footprint: 87,500 m^2. **Inter-array cables** > A maximum of seven inter-array cables; > A maximum combined length of the cable of 25 km (all cables combined); > A maximum length of cable on the seabed of 20 km (all cables combined);

Potential Impact	Design Envelope Scenario Assessed
	> Maximum of 14 gravity anchors (two per inter-array cable, 20 m^2 per anchor): 280 m^2; and; > Total cable protection footprint for all inter-array cables: 70,000 m^2. **Moorings: Catenary** > A maximum number of moorings is nine per substructure / WTG; > The maximum length of mooring that may come into contact with the seabed is 1,485 m per line (90% of total length); > A maximum lateral movement of 0.035 km^2 (assuming the full length of mooring line on seabed [1,485 m per mooring line]); > Seabed footprint of 1,485 m^2 per mooring line; and > A maximum mooring line seabed footprint of 93,555 m^2. **Anchors: Gravity** > Up to nine anchors per WTG; > A maximum seabed footprint of 625 m^2 per anchor; > A maximum seabed footprint of scour protection per anchor of 260 m^2; and > A maximum permanent total anchor and scour protection footprint of 55,755 m^2.
Introduction of marine INNS	> Offshore Export Cable(s) remedial protection and moorings (catenary) dimensions as above as worst case novel habitat; **Inter-array cables** > A maximum of seven inter-array cables; > A maximum combined length of the cable of 25 km (all inter-array cables combined); > A maximum length of cable on the seabed of 20 km (all inter-array cables combined); > A maximum of 500 m per inter-array cable could be in the water column. > A maximum of 14 gravity anchors (two per inter-array cable, 20 m^2 per anchor): 280 m^2; and > A total cable protection footprint for all inter-array cables of 70,000 m^2; and > A total cable protection volume for all inter-array cables of 35,000 cubic metres (m^3). **Floating Substructure: Semi-Submersible** > The overall surface area below water (per substructure): 25,625 m^3; and > For seven floating foundations, a maximum of 179,375 m^3 of available surface below water. **Anchors: Gravity** > Up to nine anchors per WTG; > A maximum seabed footprint of 625 m^2 per anchor;

Potential Impact	Design Envelope Scenario Assessed
	> A maximum seabed footprint of scour protection per anchor of 260 m^2; and > A maximum permanent total anchor and scour protection footprint of 55,755 m^2.
Colonisation of subsea infrastructure, scour protection, and support structures	**Floating Substructure: Semi-submersible** > Overall surface area below water (per substructure): 25,625 m^2; and > For seven floating foundations a maximum of 179,375 m^3 of available surface below water. **Offshore Export Cable(s)** > A maximum of two offshore export cables which will run from the Offshore Development to landfall; > A maximum total combined length of cable is approximately 25 km; and > A maximum volume of cable protection of 43,750 m^3. **Inter-array cables** > A maximum of seven inter-array cables; > A maximum combined length of the cable of 25 km (all inter-array cables combined); > A maximum length of cable on the seabed of 20 km (all inter-array cables combined); > A maximum of 14 gravity anchors (two per inter-array cable, 20 m^2 per anchor): 280 m^2; > Up to 50% inter-array cables requiring cable protection (10,000 m in total). Cable protection height and width of 1 m and 7 m, respectively. A total area of 70,000 m^2; and > A total cable protection volume for all inter-array cables of 35,000 m^3. **Anchors: Gravity** > Up to nine anchors per WTG; > A maximum seabed footprint of 625 m^2 per anchor; > A maximum seabed footprint of scour protection per anchor of 260 m^2; and > A maximum permanent total anchor and scour protection footprint of 55,755 m^2. **Drilled piles** > As discussed in Chapter 7: Marine Physical Processes, the radius of the cuttings mound, if drilled piles were selected as the optimum anchoring solution, would be approximately 21 m and cover an area of approximately 1,424 m^2.
Impact to benthic communities from any EMFs or thermal load arising from the cable during operation.	**Offshore Export Cable(s)** > A maximum of two (High Voltage Alternating Current [HVAC]) offshore export cables which will run from the Offshore Development to landfall; and > A maximum voltage of 110 kV. However, for EMF calculations, 66 kV is the worst case and is the basis for the assessment, as explained in Chapter 5: Project Description.

Potential Impact	Design Envelope Scenario Assessed
	Inter-array Cables > Maximum of seven inter-array with a maximum voltage of 110 kV. However, for EMF calculations, 66 kV is the worst case and is the basis for the assessment, as explained in Chapter 5: Project Description; > The maximum proportion of cable on the seabed is 20 km; and > A maximum of 500 m per inter-array cable could be in the water column.
Decommissioning	
Same as installation	In the absence of detailed information regarding decommissioning works, the implications for benthic ecology 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 now 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 the buried sections *in situ*. The only exceptions to this is scour protection and piled foundations, the latter of which may be cut off at 1 m below the seabed, as they may not be practical to recover. It may also 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 rock 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. It will be drafted 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. 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.

9.5.5 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 Benthic Ecology receptors (see Table 9.12). As there is a commitment to implementing 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.

Table 9.12 Embedded Mitigation Measures and Management Plans specific to Benthic Ecology for the Offshore Development

Embedded Mitigation Measures and Management Plans	Justification
Management Plans	
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. The CEMP will include an INNS Management Plan. Adopting these protocols will reduce risk in relation to the spread of INNS across all phases of the Offshore Development.
Marine Pollution Contingency Plan	Consent conditions will require a Marine Pollution Contingency Plan to outline procedures in the event of an accidental pollution event arising from activities associated with the Offshore Development. The Plan provides guidance to personnel and contractors on the action and reporting requirements. Adopting these protocols will reduce risk in relation to the spread of INNS across all phases of the Offshore Development.
Construction Method Statement	A CMS will be developed in accordance with the CEMP detailing how project activities and plans identified within the CEMP will be carried out and highlighting any possible dangers / risks associated with particular project activities.
Operational Environmental Management Plan	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 Management Plan. Adopting these protocols will reduce risk in relation to the spread of INNS across all phases of the Offshore Development.
Embedded Mitigations	
Nacelle, Tower, and Rotor Design	The nacelle, tower, and rotor are designed and constructed to contain leaks thereby reducing the risk of spillage into the marine environment.
Micrositing of WTGs and associated offshore infrastructure including cable routes	The final Project layout will be presented within the Cable Plan and Design Specification and Layout Plan, conditions of Section 36 and/or Marine Licence consents. These will include any micrositing of infrastructure to avoid sensitive habitats or features. Where possible, the offshore export cable route(s) should aim to avoid more sensitive habitats and where this is not possible, the route should take the shortest distance possible through the sensitive areas.
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 benthic ecology receptors, 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.

Embedded Mitigation Measures and Management Plans	Justification
Reducing habitat loss	Localised habitat loss during the installation phase is an unavoidable consequence of the Offshore Development. Best practices will be followed to ensure that potential habitat loss is reduced (e.g. micrositing and reducing the benthic footprint of the Offshore Development). The amount of rock armour, grout bags, and concrete mattresses used to protect the Offshore Export Cable(s), anchor, and mooring lines will be kept to a minimum where possible.
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 if substantial accumulation is in evidence.
Application of scour protection	Scout protection will be installed around the anchor installations within the PFOWF Array Area, where required, based on the detailed design of the final anchor option selected and supporting assessments. This will therefore negate the introduction of scour during the operation and maintenance phase.
Adherence with the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 (BWM Convention)	Aims to prevent the spread of harmful aquatic organisms from one region to another, by establishing standards and procedures for the management and control of ships' ballast water and sediments. Measures will be adopted to ensure that the risk of marine INNS introduction during construction, operation and maintenance, and decommissioning is reduced.

9.5.6 Data Gaps and Uncertainties

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

- EMF: There is little species-specific research on the effects of EMFs on many Scottish benthic taxa. Recent research focuses on EMF effects on fish and shellfish species, and this is considered in Chapter 10: Fish and Shellfish Ecology. There is also a lack of research specifically addressing EMF emissions from free-hanging cables;
- Heat generation and thermal loading from cables: There has been limited research into this effect and the potential impact of thermal loading on the benthic community is therefore largely unknown.

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

9.6 Assessment of Environmental Effects

9.6.1 Effects during Construction

9.6.1.1 Placement of infrastructure (cables, moorings, anchors) on the seabed

Existing seabed habitats and communities may be temporarily and, in some cases, permanently changed due to the introduction of the infrastructure outlined above. For example, cable protection and surface-laid infrastructure are likely to permanently change benthic communities locally via the provision of novel habitat, whereas buried infrastructure and levelling activities will only result in a temporary disturbance. In areas where the Offshore Export Cable(s), inter-array cables, and anchors are buried, and the horizontal directional drilling (HDD) exit point(s) is located, the opportunity for benthic community re-establishment would begin immediately after completion of the construction operations.

The installation of the inter-array cables, anchors, mooring lines, and scour protection on the seabed within the PFOWF Array Area will result in some loss of sedimentary habitat. As per Table 9.11, the combined permanent footprint of the infrastructure associated with the PFOWF Array Area is 219,590 m^2 and the temporary disturbance, resulting from trenching and seabed levelling activities is 356,700 m^2.

As per Table 9.11, the permanent footprint of the Offshore Export Cable(s) and associated infrastructure within the OECC is 87,500 m^2 with a temporary footprint of 375,000 m^2. Additionally, a maximum of two HDD exit point(s) will be located in the subtidal zone, within the OECC, with a borehole diameter of 750 millimetres (mm). The cable duct will be pushed through the hole from the landward side or pulled through from the offshore side, and then capped and temporarily protected, using a highly localised spread of remedial placement until cable installation commences. Temporary habitat loss resulting from these activities has been considered within the Offshore Export Cable(s) footprint. The HDD will extend from the onshore area, below the intertidal, and breach the seabed in the subtidal. As such, no impacts to intertidal receptors are expected.

Ocean quahog

There is a possibility that some low-mobility species such as the PMF ocean quahog could be lost as a result of the placement of infrastructure across the PFOWF Array Area and OECC. The MTT (2021) survey sample sites (see Offshore EIAR [Volume 3]: Appendix 9.1) and MSS survey data (Moore *et al*., 2015) showed that ocean quahog was widespread across the survey area though at low abundances. According to the OSPAR Commission (2009a), the range of ocean quahog covers the entire British and Irish coasts and offshore waters. The European range extends from Norway to the Bay of Biscay. The OSPAR Commission also reports that the spawning season is June to October. The installation period is planned to take place within the spring / summer months of Stage 1 and/or Stage 2 of the construction phase (April to September). However, the small size of the area of habitat disturbance in relation to the wide range of ocean quahog and availability of suitable habitat means that any impact to ocean quahog is not likely to result in a population level effect.

Ocean quahog are considered to be a **high-value** receptor, because of its protection status under the OSPAR Convention's List of Threatened and Declining Species and are considered to have **high** sensitivity to physical change in sediment type (MarLIN, 2022b)**.** However, there will only be a localised spatial and temporal change in habitat, and a low frequency of construction / installation events. Although the construction period is likely to be within the ocean quahog's spawning season, the embedded mitigation measures, such as micrositing to avoid sensitive habitats or aggregations of ocean quahog and reducing localised habitat loss, result in impacts of a **negligible** magnitude.

Therefore, the overall effect to ocean quahog is considered to be **minor** and **not significant.**

Offshore subtidal sands and gravels

Offshore subtidal sand and gravel habitats were identified throughout the OECC and PFOWF Array Area. Sand and gravel sediments are the most common subtidal habitat around the coast of the British Isles and are abundant in the offshore waters of Scotland. Similarly, the associated EUNIS biotope A5.451-Polychaete-rich deep Venus community in offshore mixed sediments (SS.SMx.OMx.PoVen) was identified within the OECC. As less than 1% of the regional habitat extent is located within the Benthic Ecology Study Area, this PMF habitat is broadly considered as a **low-value** receptor.

Placement of infrastructure and protective materials on the seabed would result in abrasion and disturbance to the epifauna and infauna characteristic of this sediment type, however, the receptor does have some tolerance to accommodate disturbance and abrasion and so is considered to have **low** sensitivity. Based on localised spatial and temporal disturbance compared to their highly widespread distribution, and low frequency of construction / installation events, any impacts are unlikely to affect the long-term functioning of the wider habitat and associated biotopes. The impact is thus defined as being of **low** magnitude.

Therefore, the effect to subtidal sand and gravel habitats is considered to be **minor** and **not significant.**

Stony and bedrock reefs

Within the OECC, a number of Annex I rocky reef habitats were identified and are considered to be a **high-value** receptor. Biotopes identified in the nearshore area of the OECC include Channelled wrack *Pelvetia canaliculata* and barnacles on moderately exposed littoral fringe rock, *Semibalanus balanoides* on exposed to moderately exposed or vertical sheltered eulittoral rock, *Fucus spiralis* on full salinity exposed to moderately exposed upper eulittoral rock, *Fucoids* and kelp in deep eulittoral rockpools, and green seaweeds (*Enteromorpha spp.* and *Cladophora spp.)* in shallow upper shore rockpools. In the offshore area of the OECC, two small areas of rocky reef are characterised primarily by mixed faunal turf and encrusting species. These habitats are widespread throughout the coastal regions of the UK.

Placement of cable infrastructure and protective materials across the reef habitats however would result in abrasion and disturbance to the epifauna inhabiting the reef habitat to which the faunal components have **moderate** sensitivity. Based on highly localised spatial and temporal disturbance compared to the widespread distribution of this habitat type, and the low frequency of construction / installation events, any impacts are unlikely to affect the long-term functioning of the wider habitat. With the implementation of embedded mitigation measures, such as micrositing to avoid sensitive habitats and reducing localised habitat loss, the impact is defined as being of **low** magnitude.

Therefore, the effect to reef habitats outlined above is considered to be **minor** and **not significant.**

Kelp beds

Within the OECC, kelp beds were found in a small area in the vicinity of the landfall and therefore could be impacted by offshore export cable installation activities. Kelp beds are found within water depths of 0 m to 20 m (MarLIN, 2022a); therefore, they will only be affected by the nearshore offshore export cable installation activities related to seabed preparation and remedial protection placement on the approach to landfall. Kelp beds are a PMF and are listed under ‘A3.115-*Laminaria hyperborea* with dense foliose red seaweeds on exposed infralittoral rock’. In addition, kelp beds are considered to be blue carbon habitats. Kelp beds are widely distributed along the UK coast, and therefore only an extremely small proportion of this habitat will be impacted by offshore export cable installation activities.

Kelp beds are considered to be a **high-value** receptor, listed in Annex I of the Habitats Directive and a PMF. Kelp beds are considered to have **high** sensitivity to changes in habitat type (MarLIN, 2022a). However, based on the highly localised spatial extent of the activities, and the low frequency of cable construction / installation events, any impacts are unlikely to affect long-term functioning of the wider kelp bed habitat. With the implementation of embedded mitigation measures such as micrositing to avoid sensitive habitats and reducing localised habitat loss, the impact is defined as being of **negligible** magnitude.

Therefore, the overall effect to kelp beds is considered to be **minor** and **not significant.**

9.6.1.2 Suspension of sediments from installation of subsea infrastructure

Existing seabed habitats and communities may be temporarily disturbed by the suspension of sediments during the installation of subsea infrastructure outlined in Table 9.11. For example, the Offshore Export Cable(s), HDD exit point(s), inter-array cables, anchors, mooring lines, and scour protection are likely to result in a temporary increase in suspended sediments resulting in the potential smothering of species and habitats located within the installation zones. The composition of the seabed is mainly gravels and sands, along with an occasional small percentage of silts. The average ratio of gravel:sand:silt is 13:84:3. The maximum amount of silts in any sample is 5%. The installation of subsea infrastructure such as the inter-array cables, anchors, mooring lines, clump weights, and scour protection on the seabed within the PFOWF Array Area will result in a temporary disturbance during installation. As per Table 9.11, the combined worst case temporary disturbance footprint resulting from anchors and inter-array cables is 356,700 m^2.

As per Table 9.11, the temporary footprint of the Offshore Export Cable(s) and associated infrastructure within the OECC is 375,000 m^2. Additionally, a maximum of two HDD exit points will be located in the subtidal zone, within the OECC, with a borehole diameter of 750 mm. The cable duct will be pushed through the hole from the landward side or pulled through from the offshore side, and then capped and temporarily protected using a highly localised spread of remedial placement until cable installation commences. Temporary habitat loss resulting from these activities has been considered within the offshore export cable footprint. The HDD will extend from the onshore area, below the intertidal, and breach the seabed in the subtidal. As such, no impacts to intertidal receptors are expected.

There is a risk to subtidal benthic receptors from water-based drilling mud (i.e. bentonite) which will be used as a lubricant during the HDD process. A limited volume of drilling mud will be discharged at the point where the bore exits the seabed in the subtidal zone. However, the volume of fluids released will be small and quickly dispersed in the high-energy conditions of the marine environment. As such, impacts are not expected for any intertidal receptors.

All construction activities operate close to the seabed, with the ceiling height of any disturbance from the seabed being a controlling influence on the time required for silts to settle out and the opportunity to be carried away by flows in the form of a sediment plume. The disturbance and potential increase in suspended sediments (including potentially contaminated sediments) have been modelled within Chapter 7: Marine Physical Processes. The Marine Physical Processes assessment considered representative ceiling heights between 1 m to 3 m and assessed the associated spread of any sediment plume based on near-bed flow measurements. The maximum plume transit on a spring flood tide release is around 3.7 km to the east before the tide turns and a further 2.6 km to the south-west. All silt material is expected to settle out within a few hours, depending on the ceiling height of any disturbance. The time-limited effects of any single plume are therefore short-term (Chapter 7: Marine Physical Processes). To assess this impact, the Suspended Sediment Buffer Area (an additional 4-km buffer around the Benthic Ecology Study Area) has been considered.

The spread of silts is expected to remain near-bed with elevated concentrations of suspended sediment not influencing the water column above. Concentrations would rapidly reduce from the source, due to horizontal spreading of the plume and material settling out. The theoretical depth of deposition onto the seabed is minimal from <10 mm close to the point of disturbance to <0.1 mm within a kilometre travelled (Chapter 7: Marine Physical Processes).

Ocean quahog

PMF species, including ocean quahog, are found throughout the Offshore Site in both the OECC and the PFOWF Array Area, and within the 4-km Suspended Sediments Buffer Area.

Ocean quahog are considered to be a **high-value** receptor, because of its protection status under the OSPAR Convention's List of Threatened and Declining Species. Ocean quahog are not sensitive to light or heavy smothering. Studies have shown that ocean quahog are able to burrow to the surface from depths of up to 41 cm in sandy sediment types with no effect on growth or population structure (MarLIN, 2022b). As such, ocean quahog individuals are considered to have **negligible** sensitivity to smothering**.** Based on localised spatial (<10 mm of sediment) and temporal change (a few hours) in habitat, the low frequency of construction / installation events and the low abundance of the species, and with the implementation of embedded mitigation measures such as micrositing to avoid sensitive habitats or aggregations of ocean quahog and reducing localised habitat loss, the impact is defined as being of **negligible** magnitude**.**

Therefore, the overall effect to ocean quahog is considered to be **negligible** and **not significant.**

Offshore subtidal sands and gravels

Offshore subtidal sand and gravel habitats were identified throughout the OECC and PFOWF Array Area. Sand and gravel sediments are the most common subtidal habitat around the coast of the British Isles and are abundant in the offshore waters of Scotland. Similarly, the EUNIS biotope A5.451-Polychaete-rich deep Venus community in offshore mixed sediments (SS.SMx.OMx.PoVen) was identified within the OECC. As less than 1% of the regional habitat extent is located within the Benthic Ecology Study Area, this PMF habitat is broadly considered as a **low-value** receptor.

The biotopes associated with this benthic habitat, including the SS.SMx.OMx.PoVen, have a **low** sensitivity to increases in suspended sediments and light to heavy smothering. Based on the localised spatial and temporal disturbance of increases in suspended sediment and the resulting potential for smothering across the full installation area, compared to their highly widespread distribution both regionally and around the UK, and the low frequency of construction / installation events, any impacts are unlikely to affect long term functioning of the wider habitat and associated biotopes. The impact is thus defined as being of **low** magnitude.

Therefore, the effect to subtidal sand and gravel habitats is considered to be **minor** and **not significant.**

Stony and bedrock reefs

A number of potential Annex I rocky reef habitats were identified within the Benthic Ecology Study Area. Biotopes identified in the nearshore area of the OECC include Channelled wrack *Pelvetia canaliculata* and barnacles on moderately exposed littoral fringe rock, *Semibalanus balanoides* on exposed to moderately exposed or vertical sheltered eulittoral rock, *Fucus spiralis* on full salinity exposed to moderately exposed upper eulittoral rock, *Fucoids* and kelp in deep eulittoral rockpools, and green seaweeds (*Enteromorpha spp.* and *Cladophora spp.)* in shallow upper shore rockpools. In the offshore area, two small areas of rocky reef were characterised primarily by mixed faunal turf and encrusting species. These habitats are widespread throughout the coastal regions of the UK.

These habitats have a **moderate** sensitivity to increases in suspended sediments. Due to the medium and high reefiness of the observed habitats, they are considered a **high-value** receptor. Based on the localised spatial and temporal change in suspended sediments and low frequency of construction / installation events any impacts are unlikely to affect the long-term functioning of the wider habitat. With the implementation of embedded mitigation measures such as micrositing to avoid sensitive habitats and reducing localised habitat loss, the impact is defined as being of **negligible** magnitude.

Therefore, the effect to stony and bedrock reefs outlined above is considered to be **minor** and **not significant.**

Kelp beds

PMF species kelp beds under 'A3.115-*Laminaria hyperborea* with dense foliose red seaweeds on exposed infralittoral rock' were only found to be very localised at the landfall site within the OECC.

Kelp beds are not sensitive to light smothering and have low sensitivity to heavy smothering (MarLIN, 2022a). Light smothering is considered to be up to 5 cm of sediment deposited on the habitat. If the sediment was to remain on the habitat for long periods, it may inhibit the growth of the kelps bed. However, this habitat occurs in areas where there is high wave exposure and, therefore, deposits of sediment are unlikely to remain for more than a few tidal cycles, except in the deepest of rock pools. Therefore, the effects of depositing 5 cm of fine sediment would only last for a short period (MarLIN, 2022a).

Kelp beds are considered to be a **high-value** receptor, because of their protection status under Annex I of the Habitats Directive and as they are also blue carbon habitats, however, kelp beds are considered to have **low** sensitivity to smothering (MarLIN, 2022a). Based on localised spatial (<10 mm of sediment) and temporal change (a few hours) and low frequency of construction / installation events any impacts are unlikely to affect the long-term functioning of the wider kelp bed habitat. With the implementation of embedded mitigation measures such as micrositing to avoid sensitive habitats and reducing localised habitat loss, the impact is defined as being of **negligible** magnitude.

Therefore, the effect to kelp beds is considered to be **negligible** and **not significant.**

9.6.1.3 Disturbance of contaminated sediments

Fragments of irradiated nuclear fuel were discharged to sea at the Offshore Site as a result of reprocessing of nuclear fuels at the Dounreay Site (former nuclear facility) during the 1960s and 1970s (DSRL, 2015). Studies have shown that the most hazardous particles are clustered on the seabed in a radioactive plume running parallel to the coast from south-west to north-east, within the immediate vicinity of the historic LEDS point, located to the north of the facility approximately 0.5 km to the north-east of the OECC. There is a possibility that construction and installation activities could disturb any remaining radioactive particles, resulting in their release to the wider environment. These particles would be damaging if consumed by benthic fauna.

With respect to radioactive particles, an extensive programme of remediation activity has been undertaken by DSRL to detect and retrieve hazardous particles from a 0.6-km^2 area of seabed near the outfall using Remotely Operated Vehicles (ROVs), clean-up vehicles, and divers. Sandside Bay is also routinely monitored for particles and other contamination (DSRL, 2014). This remediation work is currently ongoing on land and is expected to be remediated by 2032 (Construction Management, 2020); however, seabed monitoring has now ceased. Based on the reported survey results (PRAG-D, 2011; DSG, 2014; SEPA, 2015) there is no evidence to suggest that potentially significant particles (with activities of greater than 1 million becquerels) would be encountered within PFOWF Array Area or the OECC. SEPA also undertook a survey of radioactive particles present in shellfish such as crabs, winkles and mussels in the Dounreay area (SEPA, 2015) and found no significant levels of radioactive particles.

Routine marine monitoring included seafood sampling (including crabs, mussels and winkles, seawater, sediment, and seaweed) around the Dounreay historic LEDS, and other materials further afield from the outfall, as well as the measurement of beta and gamma dose rates. Seafood samples are collected from within the Dounreay FEPA closure zone, as shown in Figure 9.2, which prohibits the harvesting of seafood within a 2-km radius of the historic LEDS. Sediment samples collected in 2018 recorded a maximum gamma dose rate of 0.14 µGy h-1 (microgray per hour) at 1 m over the substrate at Oigin's Geo, immediately east of the Dounreay Site. Seawater samples collected in 2018 from Brims Ness and Sandside Bay did not result in the detection of radioactive contaminants above laboratory LOD (Environment Agency *et al.,* 2019).

Based on the Nuvia (2021a) Radiation Risk Assessment Report undertaken for the Offshore Development, it is very unlikely that radioactivity contamination will arise and spread due to the installation work within the Offshore Site during construction. The assessment completed for the Water and Sediment Quality topic (Chapter 8: Water and Sediment Quality) concluded that there has been no evidence of the spread of radioactive contamination associated with the previous recovery of particles from the shoreline (Nuvia, 2021a; 2021b), and the contamination of equipment during construction activities is not expected to be an issue. Furthermore, the radioactive particle footprint, which was monitored by the extensive seabed ROV surveys undertaken up to 2012, was demonstrated to be within 1 km from the historic LEDS point. The larger-sized particles, which were more likely to be 'significant' in activity had not travelled far (a few hundred metres) from the diffuser where they were emitted. Smaller particles had been transported eastwards, with a very small proportion travelling westwards towards Sandside Bay. There is no evidence available of whether any particles had been transported further offshore.

Results of contaminant analyses presented in Chapter 8: Water and Sediment Quality highlighted the limited occurrence of contaminants across the Offshore Site. From the analysed grab samples, there were isolated and localised occurrences of metal contaminants, including arsenic (three sites), copper (two sites), and nickel (three sites), which exceeded environmental quality thresholds. Hydrocarbons and PCBs were mainly below laboratory LOD. For the identified contaminants across the Offshore Site, the highest occurrence was in relation to arsenic identified in a sample beyond the extent of the PFOWF Array Area and is therefore unlikely to be encountered during construction activities. Gamma spectrometry was also completed for samples across the Offshore Site. The results of alpha and beta dose rates were mainly below laboratory LOD and there were no occurrences of radioactive particles above minor levels. In the very unlikely event that any contaminants or radioactive particles are disturbed during construction activities, the maximum extent will be within the applied Suspended Sediment Buffer Area of 4 km. However, it is considered extremely unlikely that such contaminants would be encountered, and that benthic fauna would ingest contaminated sediment.

In addition, many benthic faunae are filter feeders and are therefore resilient to the consumption of a wide range of toxins. As a result of these factors, the sensitivity of Benthic Ecology receptors, including ocean quahog and reef epifauna, to contaminated sediments is considered to be **low**. Based on localised spatial and temporal change and the low likelihood of construction / installation events disturbing areas of contaminated sediment, the impact is defined as being of **negligible** magnitude. Any impacts are unlikely to affect long-term functioning of the benthic receptors.

Therefore, the overall effect to benthic receptors is considered to be **negligible** and **not significant.**

9.6.1.4 Introduction of marine invasive non-native species

There is potential for marine invasive non-native species (INNS) to be introduced or transferred by construction and operation and maintenance vessels, particularly those vessels working within an international market such as anchor handler vessels and cable installation vessels. This can happen through biofouling (e.g. attachment of organisms to boat hulls) or release of ballast water. Another potential pathway for the INNS is the towing of floating WTGs to the Offshore Site introducing or transferring marine INNS.

INNS can have a detrimental effect on the benthic ecology through predation on existing wildlife or outcompeting for prey and habitat. This can result in biodiversity changes in the existing habitats present in the Benthic Ecology Study Area. Depending on the INNS species introduced, this could potentially lead to complete loss of certain species and may result in new habitats forming (e.g. reef-forming species).

There will be approximately 30 vessels used during the construction campaign. The following vessels are likely to be used: Construction Support Vessels, Anchor Handling Tug Supply vessels, ROVs and survey vessel(s). Vessels will be sourced locally where possible. The maximum number of vessels that will be present at the Offshore Site at any one time is 10.

Ocean quahog

Ocean quahog are considered to be a **high-value** receptor, because of its protection status under the OSPAR Convention's List of Threatened and Declining Species. No evidence suggests that ocean quahog populations are particularly sensitive to the introduction of INNS (MarLIN, 2022b). As such, ocean quahog are considered to have a **low** sensitivity to INNS.

Any impacts could affect the long-term functioning of the ocean quahog populations. Nonetheless, based on the localised workings of the vessels and the temporary nature of the activities and embedded mitigation for INNS impacts through the CEMP, such as the INNS Management Plan and the routine removal of marine growth, the impact is defined as being of **negligible** magnitude.

Therefore, the overall effect to ocean quahog is considered to be **negligible** and **not significant.**

Offshore subtidal sands and gravels

Offshore subtidal sand and gravel habitats were identified throughout the OECC and PFOWF Array Area. Sand and gravel sediments are the most common subtidal habitat around the coast of the British Isles and are abundant in the offshore waters of Scotland. As less than 1% of the regional habitat extent is located within the Benthic Ecology Study Area, this PMF habitat is broadly considered as a **low-value** receptor. Similarly, the EUNIS biotope A5.451-Polychaete-rich deep Venus community in offshore mixed sediments (SS.SMx.OMx.PoVen) was identified within the OECC.

The sediments characterising this biotope are likely to be too mobile or otherwise unsuitable for most of the recorded invasive non-indigenous species currently recorded in the UK. However, colonisation or establishment of INNS would likely change the biotope classification(s) and characterising species may be prey items for invasive mobile species. As such, the biotopes associated with this benthic habitat, including the SS.SMx.OMx.PoVen, are considered to have a **high** sensitivity to INNS. The introduction and establishment of INNS to the Offshore Site could result in long-term changes to the native biotopes. Nonetheless, based on the localised workings of the vessels and the temporary nature of the installation activities and when considering embedded mitigation for INNS impacts through the CEMP, such as the INNS Management Plan, and the routine removal of marine growth, the impact is defined as being of **negligible** magnitude.

Therefore, the impact to subtidal sand and gravel habitats is considered to be **minor** and **not significant.**

Stony and bedrock reefs

Within the OECC, a number of potential Annex I rocky reef habitats were identified. Biotopes associated with bedrock reef were identified in the nearshore, including Channelled wrack *Pelvetia canaliculata* and barnacles on moderately exposed littoral fringe rock, *Semibalanus balanoides* on exposed to moderately exposed or vertical sheltered eulittoral rock, *Fucus spiralis* on full salinity exposed to moderately exposed upper eulittoral rock, *Fucoids* and kelp in deep eulittoral rockpools, and green seaweeds (*Enteromorpha spp.* and *Cladophora spp.)* in shallow upper shore rockpools. In the offshore area, two small areas of rocky reef were characterised primarily by mixed faunal turf and encrusting species. These habitats are widespread throughout the coastal regions of the UK.

Due to the medium and high reefiness of the observed habitats, they are considered a **high-value** receptor. There is no evidence regarding known invasive species that may pose a threat to the rocky reef biotopes identified (Marlin, 2022c to h). There is little evidence available on the sensitivity of these rocky reef habitats to INNS and when considering the established epifaunal coverage of the reef habitats also reduces the attachment potential for INNS introduced during construction activities, they are considered to have **low** sensitivity.

Habitats along the OECC are likely to be subjected to a relatively low risk of INNS introduction as only the export cables will be installed along the OECC, which will be buried where possible, removing the infrastructure from the possibility of colonisation and the use of cable protection materials will be reduced as far as practicable. Likewise, the vessel activity required during construction and installation activities along the OECC will be limited, temporary and dispersed over a large area. Any impact is predicted to be of local spatial extent, though if INNS do become established the impact would be long-term and irreversible. It is predicted that the impact would affect the receptors indirectly. Based on the localised spatial and temporal change and low frequency of construction / installation events any impacts are unlikely to affect the long-term functioning of the wider habitat. With the implementation of embedded mitigation measures for INNS impacts through the CEMP such as the INNS Management Plan, the impact is defined as being of **negligible** magnitude.

Therefore, the effect to benthic habitats outlined above is considered to be **negligible** and **not significant.**

Kelp beds

Kelp beds are considered to be a **high-value** receptor, because of their protection status under Annex I of the Habitats Directive and as a PMF in Scottish seas. Kelp beds have high sensitivity to INNS (MarLIN 2020a). They are particularly sensitive to the invasive kelp *Undaria pinnatifida* that has been found to outcompete native UK kelp bed habitats. This species is typically found in the French Mediterranean, North and south Brittany, Atlantic coast of Spain (MarLIN, 2022k). As a result of these factors, the sensitivity of the kelp receptor is considered to be **high** sensitivity.

Any impacts could affect the long-term functioning of the kelp populations. However, based on the localised workings of the vessels and the temporary nature of the activities and embedded mitigation for INNS impacts through the CEMP such as the INNS Management Plan, the impact is defined as being of **negligible** magnitude.

Therefore, the overall effect to kelp beds is considered to be **minor** and **not significant.**

9.6.1.5 Deposition of drill cuttings

As described in Chapter 7: Marine Physical Processes, the drilling activities for the anchor piles would result in drill cuttings being flushed from the drilled pile hole onto the seabed where finer material has the potential to disperse more widely and coarser material would quickly settle out to form a cuttings mound. On the conservative assumption of 100% coarse grains (i.e. sands and gravels), this material is expected to settle around the drilled pile to form a cuttings mound. The alternative assumption is of 100% fine grains (silts), in which case this material could be widely dispersed.

The worst case increase to suspended sediment concentrations, resulting in the development of a plume for the PFOWF Array Area, is associated with the seabed levelling operations for gravity anchors and is discussed in Section 9.6.1.2. Cone penetration testing of the sub-surface sediment across the PFOWF Array Area identified the potential for organic / peat deposits occurring at depths between 4 m and 8 m below the seabed with a maximum thickness of less than 2 m. Peat is plant material which is partially decomposed and has accumulated in waterlogged conditions The peat deposits are not widely distributed across the PFOWF Array Area but were observed mainly in the south of the PFOWF Array Area (see Chapter 7: Marine Physical Processes for further details). As the peat deposits are interpreted as relative thin deposits (<2 m), the volume of peat would be approximately 4% of the total sediment released. It is assumed that this organic material will behave similar to the fine grains (silts) and is therefore not assessed within this section.

Assuming a 3-m wide anchor pile reaching a target depth of 49.5 m, each resulting cuttings mound would have a volume of 350 cubic metres (m^3) (approximately 22,000 m^3 in total). The worst case scenario in terms of seabed footprint assumes the cutting mounds are formed of coarse sediments and are 1 m high, each covering 1,424 m^2 (89,712 m^2 in total) (Chapter 7: Marine Physical Processes).

Over time, any formed cuttings mound would be incorporated into the sediment transport regime across the Pentland Firth. The small volume of peat and the eventual integration into the sediment transport regime means that its presence is unlikely to alter the seabed character in the long term.

As the deposition of drilled cuttings is confined to the PFOWF Array Area, only habitats and species within this area of the Offshore Site are assessed (i.e. ocean quahog and offshore subtidal sands and gravels).

Ocean quahog

PMF species including ocean quahog are found throughout the PFOWF Array Area. The worst case scenario assessed for this receptor is the deposition of a cuttings mound formed of primarily coarse grains.

Ocean quahog are considered to be a **high-value** receptor, because of its protection status under the OSPAR Convention's List of Threatened and Declining Species. Ocean quahog are not sensitive to light or heavy smothering, however, mortality or physical injury resulting from deposition of the cuttings material may occur. Studies have shown that ocean quahog are able to burrow to the surface from depths of up to 1 m in course sediment types with no effect on growth or population structure (MarLIN, 2022b). As such, ocean quahog individuals are considered to have **negligible** sensitivity to burial under the cuttings mound**.** Based on the highly localised impact, the low abundance of the species across the PFOWF Array Area, and the implementation of embedded mitigation measures such as micrositing to avoid sensitive habitats or aggregations of ocean quahog, the impact is defined as being of **low** magnitude**.**

Therefore, the overall effect to ocean quahog is considered to be **negligible** and **not significant.**

Offshore subtidal sands and gravels

Offshore subtidal sand and gravel habitats were identified throughout the PFOWF Array Area. Sand and gravel sediments are the most common subtidal habitat around the coast of the British Isles and are abundant in the offshore waters of Scotland. Similarly, the EUNIS biotope A5.451-Polychaete-rich deep Venus community in offshore mixed sediments (SS.SMx.OMx.PoVen) was identified within the OECC. As less than 1% of the regional habitat extent is located within the Benthic Ecology Study Area, this PMF habitat is broadly considered as a **low-value** receptor.

At the point of construction, the biotopes within the cuttings mound footprint would be expected to be lost through rapid burial and severe physical disturbance. However, the faunae that comprise this biotope include opportunist species that rapidly colonise disturbed habitats and increase in abundance, as well as species that are larger and longer-lived and that may be more abundant in an established, mature assemblage (MarLIN, 2022c). Due to the ability of this biotope to recover following disturbance, they are considered to have **low** sensitivity to potential habitat loss or smothering that would be expected to result from the drill cutting mounds. Based on the localised spatial potential for habitat loss or smothering resulting from the drill cutting mounds across the installation area, compared to their highly widespread distribution both regionally and around the UK, and the low frequency of construction / installation events, any impacts are unlikely to affect long term functioning of the wider habitat and associated biotopes. The impact is thus defined as being of **low** magnitude. Therefore, the effect to subtidal sand and gravel habitats is considered to be **minor** and **not significant.**

9.6.1.6 Summary of effects during construction

A summary of the assessment of effects during construction is provided in Table 9.13.

Table 9.13 Summary of significance of effects from construction impacts

Summary of Effect	Receptor	Sensitivity	Magnitude of Impact	Rationale	Consequence	Significance of Effect	Additional Mitigation Requirements	Significance of Residual Effect
Damage from placement of infrastructure (cables, moorings, anchors) on the seabed	Offshore subtidal sands and gravels	Low	Low	Offshore subtidal sand and gravel habitats have a low sensitivity to abrasion and disturbance, with a low magnitude of impact in consideration of the very widespread distribution. The impact to this habitat type is considered to be minor and not significant.	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant
	Stoney and Bedrock Reef Habitats	Moderate	Low	As detailed in the sections above these habitats have **moderate** sensitivity to this impact. The impact is however defined as being of **low** magnitude. Therefore, the effect to reef habitats outlined above is considered to be **minor** and **not significant.**	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant
	Kelp beds - A3.115 - *Laminaria hyperborea* with dense foliose red seaweeds on exposed infralittoral rock	High	Negligible	Kelp beds have **high** sensitivity to changes in habitat type. The impact is defined as being of **negligible** magnitude. Therefore, the effect to kelp beds is considered to be **minor** and **not significant.**	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant
	Ocean quahog	High	Negligible	Ocean quahog are considered to have **high** sensitivity to physical change in sediment type**.** The impact is defined as being of **negligible** magnitude. Therefore, the overall effect to ocean quahog is considered to be **minor** and **not significant.**	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant
Suspension of sediments from installation of subsea infrastructure	Offshore subtidal sands and gravels	Low	Low	Biotopes associated with this habitat type are considered to have low sensitivity to increases in suspended sediments and smothering. The impact is defined as being of low magnitude. Therefore, the overall effect to the impacted biotopes is minor and not significant.	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant
	Stoney and Bedrock Reef Habitats	Moderate	Negligible	This is a **high** value receptor which is considered to have a **moderate** sensitivity to increases in suspended sediments. The impact is defined as being of **negligible** magnitude. Therefore, the effect to reef habitats outlined above is considered to be **minor** and **not significant.**	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant
	Kelp beds - A3.115 - *Laminaria hyperborea* with dense foliose red seaweeds on exposed infralittoral rock	Low	Negligible	Kelp beds are considered to have **low** sensitivity to smothering. The impact is defined as being of **negligible** magnitude. Therefore, the effect to kelp beds is considered to be **negligible** and **not significant**	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant
	Ocean quahog	Negligible	Negligible	Ocean quahog are considered to have **negligible** sensitivity smothering**.** The impact is defined as being of **negligible** magnitude. Therefore, the overall effect to ocean quahog is considered to be **negligible** and **not significant.**	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant

Summary of Effect	Receptor	Sensitivity	Magnitude of Impact	Rationale	Consequence	Significance of Effect	Additional Mitigation Requirements	Significance of Residual Effect
Disturbance of contaminated sediments	Benthic habitats (including ocean quahog and reef epifauna)	Low	Negligible	These habitats are considered to have **low** sensitivity to contaminated sediments. The impact is defined as being of **negligible** magnitude. Therefore, the overall effect to benthic receptors is considered to be **negligible** and **not significant**.	Negligible Effects	Not Significant	No mitigation or additional measures have been identified for this effect.	Not Significant
Introduction of marine INNS	Offshore subtidal sands and gravels	High	Negligible	The biotopes associated with this habitat have high sensitivity to INNS. Considering the widespread distribution of this habitat and embedded mitigation, the magnitude of impact is negligible. Therefore, the effect to subtidal sand and gravel habitats is considered to be minor and not significant.	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant
	Stoney and Bedrock Reef Habitats	Low	Negligible	These habitats have a **low** sensitivity to the introduction of INNS. The impact is defined as being of **negligible** magnitude. Therefore, the effect to reef habitats outlined above is considered to be **negligible** and **not significant.**	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant
	Kelp beds - A3.115 - *Laminaria hyperborea* with dense foliose red seaweeds on exposed infralittoral rock	High	Negligible	Kelp beds have a **high** sensitivity to INNS. The impact is defined as being of **negligible** magnitude. Therefore, the overall effect to kelp is considered to be **minor** and **not significant.**	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant
	Ocean quahog	Low	Negligible	Ocean quahog are considered to have a **low** sensitivity to INNS. The impact is defined as being of **negligible** magnitude. Therefore, the overall effect to ocean quahog is considered to be **negligible** and **not significant.**	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant
Deposition of dill cuttings	Ocean quahog	Negligible	Low	Ocean quahog are considered to have a **negligible** sensitivity to burial under the cuttings mound. The impact is defined as being of **low** magnitude. Therefore, the overall effect to ocean quahog is considered to be **negligible** and **not significant.**	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant
	Offshore subtidal sands and gravels	Low	Low	Offshore subtidal sands and gravels have **low** sensitivity to potential habitat loss or smothering that would be expected to result from the drill cutting mounds. The impact is defined as being of **low** magnitude. Therefore, the overall effect to offshore subtidal sands and gravels is considered to be **minor** and **not significant.**	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant

9.6.2 Effects during Operation and Maintenance

9.6.2.1 Hydrodynamic changes leading to scour and abrasion

9.6.2.1.1 Scour around seabed structures

Scour around seabed structures such as anchors, mooring lines, cables, and cable protection results from turbulent flow, which has the ability to suspend and redistribute sediment away from the structure. This can change habitats, exclude some species from the immediate area and attract scour-resistant species. Particularly, scour has the potential to change the habitat within the sandy / soft sediment areas within the Offshore Site and impact those species which depend on these habitats, in this case, ocean quahog.

The assessment within Chapter 7: Marine Physical Processes has determined that the development of scour is considered to primarily relate to the PFOWF Array Area, due to the presence of anchors. As such, this assessment is limited to the area of seabed where scour is likely to occur. Therefore, rocky reef biotopes and other hard substrates and kelp beds within the nearshore area of the OECC have not been considered.

Scour protection will be installed around each anchor, as required, and as informed by scour studies (Table 9.12). This will negate scour development and as such no scour is anticipated, therefore the magnitude of impact of scour development is assessed as **negligible.**

Ocean quahog

Ocean quahog are found in both the PFOWF Array Area and the OECC. They are considered to be a **high-value** receptor, because of its protection status under the OSPAR Convention's List of Threatened and Declining Species. Although ocean quahog are highly tolerant of smothering and siltation rate changes, they are highly sensitive to significant changes in sediment type equivalent to one Folk class, for example, alteration of the baseline sediment to fine muds or mixed sediments dominated by gravels. Changes of this extent however are unlikely, and so the overall sensitivity of this low mobility species to scour effects is considered to be **low**. As described above, scour development is unlikely to occur due to the planned installation of scour protection and therefore the magnitude of impact is considered to be **negligible**.

Therefore, localised scour effects to the ocean quahog population are considered to be **minor** and **not significant.**

Offshore subtidal sands and gravels

Offshore subtidal sand and gravel habitats were identified throughout the OECC and PFOWF Array Area. Sand and gravel sediments are the most common subtidal habitat around the coast of the British Isles and are abundant in the offshore waters of Scotland. The EUNIS biotope A5.451-Polychaete-rich deep Venus community in offshore mixed sediments (SS.SMx.OMx.PoVen) was only identified within the OECC. As less than 1% of the regional habitat extent is located within the Benthic Ecology Study Area, this PMF habitat is broadly considered as a **low-value** receptor.

As described for construction activity impacts, this receptor does have some tolerance to accommodate disturbance and abrasion as could be expected from localised scour and abrasion and so is considered to have **low** sensitivity. As described above, scour development is unlikely to occur due to the embedded mitigation of installation of scour protection, as required, and compared to the widespread distribution of this habitat type, any impacts are unlikely to affect the long-term functioning of the wider habitat and associated biotopes. The impact is thus defined as being of **negligible** magnitude.

Therefore, the effect to subtidal sand and gravel habitats is considered to be **negligible** and **not significant.**

9.6.2.1.2 Scour (abrasion) resulting from lateral movement of mooring lines and inter-array cables

Abrasion caused by the lateral movement of subsea infrastructure has the potential to physically disturb and damage surface seabed habitats and species. For example, mooring lines and dynamic cables can move laterally in the subsea environment. This can vary depending on the weather conditions and selected mooring and cable configurations. This impact is therefore confined to the PFOWF Array Area and thus kelp and reef habitats restricted to the OECC will not be impacted by the lateral movement of infrastructure.

As per Table 9.11, within the PFOWF Array Area there will be a maximum lateral movement of 0.035 square kilometres (km^2) per line resulting in an overall temporary disturbance area of 2,205,000 m^2. This movement is considered to be highly conservative as, if the catenary mooring line configuration is selected, there will be a maximum of 40 clump weights per mooring line which will reduce the movement of the mooring lines and thus significantly reduce the potential for scour. Additionally, inter-array cables within the PFOWF Array Area will be buried to a minimum depth of 0.6 m where possible. If burial is not achieved, remedial protection will be required. This will prevent lateral movement and thus remove the potential for scour during operation.

Ocean quahog

Ocean quahog are present in the PFOWF Array Area and have **high** sensitivity to abrasion. Ocean quahog are considered to be a **high-value** receptor because of its protection status under the OSPAR Convention's List of Threatened and Declining Species. Considering the low frequency of such events, and the localised area of abrasion possible, the impact is defined as **negligible** magnitude. Any impacts are unlikely to affect the long-term functioning of the ocean quahog population.

Therefore, the overall effect is considered to be **minor** and **not significant.**

Offshore subtidal sands and gravels

Offshore subtidal sand and gravel habitats were identified throughout the OECC and PFOWF Array Area. Sand and gravel sediments are the most common subtidal habitat around the coast of the British Isles and are abundant in the offshore waters of Scotland. The EUNIS biotope A5.451-Polychaete-rich deep Venus community in offshore mixed sediments (SS.SMx.OMx.PoVen) was only identified within the OECC and as such is removed from this impact pathway. As less than 1% of the regional habitat extent is located within the Benthic Ecology Study Area, this PMF habitat is broadly considered as a **low-value** receptor.

As described for construction activity impacts, this receptor does have some tolerance to accommodate disturbance and abrasion as could be expected from localised scour and abrasion and so is considered to have **low** sensitivity. Based on the highly localised spatial disturbance resulting from scour impacts compared to the widespread distribution of this habitat type any impacts are unlikely to affect the long-term functioning of the wider habitat and associated biotopes. The impact is thus defined as being of **negligible** magnitude.

Therefore, the effect to subtidal sand and gravel habitats is considered to be **negligible** and **not significant.**

9.6.2.2 Introduction of marine INNS

Impacts associated with the introduction of marine INNS from vessels during operation and maintenance are expected to be lower to that during construction. As such these effects are assessed as a worst case in Section 9.6.1.4.

Once installed, the infrastructure within the PFOWF Array Area and OECC, including floating foundations, mooring lines, inter-array cables and remedial protection materials could act as a stepping-stone for INNS with pelagic larvae that move passively under the influence of currents, such as barnacles, gastropods, and algae. For these species, the PFOWF Array Area may provide new habitat, consisting of artificial surfaces in addition to new natural substrate in anti-scouring protection. In this situation, the novel habitat provided by offshore structures could play a role in providing stepping-stones, by which geographical barriers to species dispersal might be passed (Adams et al., 2014). However, there is mixed evidence from post-construction monitoring undertaken to date to suggest that the hard structures associated with offshore wind farms provide new or unique opportunities for INNS which could facilitate their introduction (e.g. Linley *et al.,* 2007).

During operation and maintenance, the cables, anchors, mooring lines, clump weights, and scour protection on the seabed within the PFOWF Array Area and OECC will provide a long-term provision of novel hard substrate for INNS to potentially colonise the structures. As per Table 9.11, the combined permanent footprint of the infrastructure associated with the PFOWF Array Area is 219,590 m^2.

This effect is considered most likely in the PWOWF Array Area due to the provision of novel hard substrate in the water column. The placement of protective material will be minimised as far as possible and marine growth will be minimised and removed as required. The maximum surface area of the floating substructures below water available for colonisation could be up to 179,375 m^2 when considering a semi-submersible foundation option (as per Table 9.11). In addition, the inter-array cables within the water column provide an additional 9,425 m^2 of cable surface area that can potentially be colonised.

Similarly, as per Table 9.11, the permanent footprint of the remedial cable protection for the Offshore Export Cable(s) within the OECC is 87,500 m^2; this will also provide a surface for INNS to potentially colonise the area. As such potential for a stepping-stone effect is assessed.

As described previously in Section 9.6.1.4, INNS can have a detrimental effect on the benthic ecology through predation on existing wildlife or outcompeting for prey and habitat, with resultant changes to localised biodiversity (Inger *et al.,* 2009).

Offshore subtidal sands and gravels

Offshore subtidal sand and gravel habitats were identified throughout the OECC and PFOWF Array Area. Sand and gravel sediments are the most common subtidal habitat around the coast of the British Isles and are abundant in the offshore waters of Scotland. As less than 1% of the regional habitat extent is located within the Benthic Ecology Study Area, this PMF habitat is broadly considered as a **low-value** receptor. Similarly, the EUNIS biotope A5.451-Polychaete-rich deep Venus community in offshore mixed sediments (SS.SMx.OMx.PoVen) was identified within the OECC.

The sediments characterising this biotope are likely to be too mobile or otherwise unsuitable for most of the recorded invasive non-indigenous species currently recorded in the UK. However, colonisation or establishment of INNS would likely change the biotope classification(s) and characterising species may be prey items for invasive mobile species. As such, the biotopes associated with this benthic habitat, including the SS.SMx.OMx.PoVen, are considered to have a **high** sensitivity to INNS. The long-term presence of installed infrastructure would only be expected to provide attachment potential for epilithic species. The sediments characterising this biotope are likely to be too mobile or otherwise unsuitable for most of the recorded invasive non-indigenous species currently recorded in the UK (MarLIN, 2022c). As such it is unlikely that INNS will be able to colonise the sandy gravelly sediments of this habitat and outcompete or heavily predate the native species, thus removing the potential for alterations to the mobile sediment habitat and biotopes. With the implementation of embedded mitigation measures for INNS impacts through the OEMP such as the INNS Management Plan, as such, the magnitude of impact is defined as being **negligible**.

Therefore, the impact to subtidal sand and gravel habitats is considered to be **minor** and **not significant.**

Stony and Bedrock Reefs

Within the OECC, a number of Annex I rocky reef habitats were identified and are considered a **high-value** receptor. Biotopes identified in the nearshore area of the OECC include Channelled wrack *Pelvetia canaliculata* and barnacles on moderately exposed littoral fringe rock, *Semibalanus balanoides* on exposed to moderately exposed or vertical sheltered eulittoral rock, *Fucus spiralis* on full salinity exposed to moderately exposed upper eulittoral rock, *Fucoids* and kelp in deep eulittoral rockpools, and green seaweeds (*Enteromorpha spp.* and *Cladophora spp.)* in shallow upper shore rockpools. In the offshore area, two small areas of rocky reef are characterised primarily by mixed faunal turf and encrusting species. These habitats are widespread throughout the coastal regions of the UK.

There is no evidence regarding known invasive species that may pose a threat to the rocky reef biotopes identified (Marlin 2022 c-h). Habitats along the OECC are likely to be subjected to a relatively low risk of INNS introduction, as only the Offshore Export Cable(s) will be installed within the OECC. Up to 87,500 m^2 remedial cable protection would provide colonisation potential and thus a stepping-stone for epilithic INNS. However, the vessel activity required during operation and maintenance activities along the OECC will be very limited, temporary and non-continuous. Any impact is predicted to be of local spatial extent though if INNS do become established the impact would be long-term and irreversible. It is predicted that the impact would affect the rocky reef receptors indirectly. The magnitude is therefore considered to be **negligible**. There is little evidence available on the sensitivity of these rocky reef habitats to INNS and considering the established epifaunal coverage of the existing reef habitats also reduces the attachment potential for INNS they are considered to have **low** sensitivity. Based on localised spatial and temporal change and low frequency of operation and maintenance activities, any impacts are unlikely to affect the long-term functioning of the wider habitat. With the implementation of embedded mitigation measures for INNS impacts through the OEMP such as the INNS Management Plan, the impact is defined as being of **negligible** magnitude.

Therefore, the effect to reef habitats outlined above is considered to be **negligible** and **not significant.**

Ocean quahog

Ocean quahog are known to populate soft sediment habitats within the PFOWF Array Area and the OECC. Soft sediment habitats are considered more sensitive to impacts from the introduction of INNS as the installation of hard surfaces will essentially introduce a new type of habitat to the predominantly soft sediments of the area. As such, there will only be a limited local epifaunal community which will be able to colonise the new habitat resource, therefore any introduced INNS will face minimal competition and will be more likely to establish local populations.

There is no evidence that suggests ocean quahog populations are currently sensitive to INNS (MarLIN, 2022b). The area taken up by the Offshore Development infrastructure represents only a very small proportion of the wider area and therefore there will be habitat areas remaining for ocean quahog to colonise. For this assessment, **high-value** ocean quahog are thus assumed to have **low** sensitivity. Based on the soft sediment habitat of the species, with no competition potential with epilithic colonisers, and with the implementation of embedded mitigation measures for INNS impacts through the OEMP such as the INNS Management Plan, the magnitude of impact is considered **negligible**.

Therefore, the overall effect to ocean quahog is considered to be **negligible** and **not significant**.

Kelp beds

Kelp beds are considered to be a **high-value** receptor, because of their protection status under Annex I of the Habitats Directive. Kelp beds have high sensitivity to INNS (MarLIN 2020a). They are particularly sensitive to the invasive kelp *Undaria pinnatifida* that has been found to outcompete native UK kelp bed habitats. This species is typically found in the French Mediterranean, North and south Brittany, Atlantic coast of Spain (MarLIN, 2022k). As a result of these factors, the sensitivity of the kelp receptor is considered to be **high sensitivity**.

Any impacts could affect the long-term functioning of the kelp populations. However, based on the localised workings of the vessels and the temporary nature of the activities and embedded mitigation for INNS impacts through the OEMP such as the INNS Management Plan, the impact is defined as being of **negligible** magnitude.

Therefore, the overall effect to kelp is considered to be **minor** and **not significant.**

As it is anticipated that there will be a minor and not significant impact on benthic ecology from the introduction of marine INNS, it is not expected that the long-term provision of novel hard substrate will result in the impact propagating up the food chain. This is due to there not being a significant increase in habitat complexity or changes to trophic levels. Therefore, there will not be a significant long-term, indirect impact to prey species, such as fish and shellfish species, marine mammals, and seabirds.

9.6.2.3 Colonisation of subsea infrastructure, scour protection, and support structures

Throughout the life of the Offshore Development, the presence of mooring lines, anchors, scour protection, and cable protection installed on soft sediment seabed all provide novel hard substrate for colonisation by epilithic species. New species with a preference for hard substrates are expected to colonise the installed structures, typically increasing the biodiversity of the local area.

The installation of the inter-array cables (and associated remedial protection), anchors, mooring lines, clump weights, and scour protection on the seabed within the PFOWF Array Area will provide potential surfaces for colonisation. As per Table 9.11, the combined permanent seabed footprint of the infrastructure associated with the PFOWF Array Area is 219,590 m^2. The inter-array cables will be buried where possible to reduce the footprint. In addition, the submerged exterior surface of the floating foundations within the PFOWF Array Area will provide additional colonisable surface. The total surface area coverage of the floating foundations below sea level is 179,375 m^2. Although these surfaces are not on the seabed, they may provide new benthic habitat.

As per Table 9.11, the permanent footprint of the Offshore Export Cable(s) due to remedial protection within the OECC is 87,500 m^2.

These structures are all likely to be colonised by significant amounts of encrusting epifauna typical of local bedrock and cobbles including hydroids, bryozoans, and tunicates. Their lack of structural complexity makes it unlikely that highly diverse communities will develop, however, all biofouling represents additional food supply within the local ecosystem. It is unlikely that this will significantly increase the productivity of the local area or attract significant numbers of foraging species to the area given the size of the Offshore Development. In addition, it is expected that the floating substructures will be painted in a low-toxicity anti-fouling paint and will also be fitted with cathodic (anode) protection to reduce the risk of corrosion of the steel structures. Substructures will be regularly inspected, and subsequent removal of marine growth will be undertaken using water jetting tools if substantial accumulation is in evidence. The exact protection measures to be employed will be developed during detailed design and set out within the OEMP that will be submitted for approval prior to construction, should consent be granted.

The sensitivity of the benthic receptors broadly is considered to be **moderate**. The total area of potential new habitat is small, based on the wider area, but still represents a minor shift away from baseline conditions. Based on localised spatial extent, the impact is defined as being of **low** magnitude**.** Any impacts are unlikely to affect the long-term functioning of the baseline benthic receptors.

Therefore, the overall effect to benthic receptors is considered to be **minor** and **not significant.**

As it is anticipated that there will be a minor and not significant impact on benthic ecology from colonisation of subsea infrastructure, it is not expected that the long-term provision of novel hard substrate will result in the impact propagating up the food chain. This is due to there not being a significant increase in habitat complexity or changes to trophic levels. Therefore, there will not be a significant long-term, indirect impact to prey species such as fish and shellfish species, marine mammals and seabirds.

9.6.2.4 Colonisation of cutting mounds

As described in Chapter 7: Marine Physical Processes, the drilling activities for the anchor piles may result in drill cutting mounds within the PFOWF Array Area, each with a volume of 350 m^3. The worst case scenario in terms of seabed footprint assumes the cutting mounds are formed of coarse sediments, similar to baseline conditions, and are 1 m high, each covering 1,424 m^2 (89,712 m^2 in total). The cutting mounds provide an opportunity for benthic fauna to re-colonise the area.

Interpretation of penetration and resistance from Cone Penetration Tests across the PFOWF Array Area also suggests a limited occurrence of organic soils (peat deposits). The peat deposits occur as relatively thin units of around 2-m thick, at depths of between 4 m to 8 m below the seabed. The peat deposits are not widely distributed across the PFOWF Array Area and are observed mainly in the south of the PFOWF Array Area (as detailed within Chapter 7: Marine Physical Processes). On the conservative assumption that the peat material is retained within the cuttings pile, this would constitute a very small proportion of the material (approximately 4%) and would not be considered sufficient to alter the composition of the colonising community.

As the sediment type introduced by the cutting mounds will largely be the same as before, it is anticipated that the mounds will be colonised by epifauna and infauna recruited from the surrounding seabed, rather than promoting colonisation by new species. Recolonisation would be reasonably expected to include ocean quahog (**high-value** receptor) as well as the more opportunistic species associated with the widespread EUNIS biotope A5.451-Polychaete-rich deep Venus community in offshore mixed sediments (SS.SMx.OMx.PoVen (low-value receptor) indicating **negligible** sensitivity. Furthermore, in time, the cutting mounds, limited in spatial extent relative to the receiving environment, would be incorporated into the sediment transport regime across the Pentland Firth resulting in a **low** magnitude of impact.

Therefore, it is expected that the affected area will return to the baseline conditions in the medium term and as such the overall effect is considered to be **negligible** and **not significant.**

9.6.2.5 *Impact to benthic communities from any electromagnetic fields or thermal load arising from the cables during operation.*

9.6.2.5.1 EMF

Electromagnetic fields (EMFs) have the potential to alter the behaviour of marine organisms that are able to detect electric (E field) or magnetic (B field) components of the fields. Both B field and E fields dissipate rapidly from the source. Up to two Offshore Export Cable(s) will be installed as part of the Offshore Development, each with a maximum length of 12.5 km. The inter-array cabling configuration adds a further 25 km total length of cable.

Where seabed conditions allow, within the OECC, the Offshore Export Cable(s) will be buried to a minimum depth of 0.6 m or, where this cannot be achieved, remedial cable protection measures will be employed. Similarly, as an estimated maximum of 5 km of the 25 km of inter-array cabling could be present in the water column across the PFOWF Array Area, therefore a maximum of 20 km will be situated on the seabed and buried to a minimum depth of 0.6 m or, where this cannot be achieved, remedial cable protection measures will be employed. As both export and inter-array cables will either be buried or covered with remedial cable protection, they are assessed together here. EMFs produced by cables suspended in the water column are considered in Chapter 10: Fish and Shellfish Ecology.

Burial of the cable is effective at moving the source away from the water / seabed interface; however, the B field still propagates through the sediment. As a result, burial may reduce the proportion of the water column affected by EMFs and confines the effects on species living in or on the sediment to a local area of seabed surrounding the cables.

Up to two 110-kV Offshore Export Cable(s) (HVAC) will be installed as part of the Offshore Development, each with a maximum length of 12.5 km. Although a maximum voltage of 110 kV is proposed, the worst case is the lower 66 kV option (as set out in Chapter 5: Project Description). Where seabed conditions allow, the Offshore Export Cable(s) will be buried to a depth of a minimum of 0.6 m, with the aim of burying up to 100% of the cable to this minimum target depth. Remedial protection will be used where burial is not achieved to a height of 1 m, and it is expected that remedial protection will account for up to 50% of the cable length as a worst case scenario.

Up to seven 110-kV inter-array cables will be installed as part of the Offshore Development. For this benthic ecology assessment, only those sections which are buried have been considered; the maximum length of the inter-array cables to be buried for the Offshore Development is 20 km. Although a maximum voltage of 110 kV is proposed the worst case in terms of EMFs is the lower 66-kV option (as set out in Chapter 5: Project Description).

HWL has commissioned an initial modelling exercise of the predicted EMFs from both the inter-array and offshore export cables to determine the realistic worst case EMF potential based on the worst case EMF potential (i.e. the 66-kV option). The modelling demonstrates that EMF effects will be below the natural variation of the earth’s magnetic field for both seabed buried or protected cables and in-water dynamic cables. Should two offshore export cables be installed, the anticipated separation distance between cables (20 m) means there will be no potential interaction between EMF effects (Prysmian, 2022)

9.6.2.5.1.1 *Buried / protected cable sections*

Although the burial of cables and other protective measures such as placement of remedial protection are not considered to be effective ways to mitigate magnetic emissions into the marine environment entirely, burial separates the most sensitive species from the source of the emissions (Copping *et al*., 2020). In addition, design parameters and installation methods are expected to conform to industry standard specifications, which include shielding technology to reduce the direct emission of EMFs.

The results of the study are shown in Table 9.14 for the various protection heights or burial depths assessed. It is assessed that an EMF strength of approximately 17.7 microtesla (μT) would be produced by the buried inter-array and offshore export cables at the seabed if 0.6 m burial is achieved (Prysmian, 2022). This rapidly dissipate when assuming 1 m burial or protection and no EMFs are experienced at 5 m from the source.

The earth's magnetic field intensity is known to vary between 25 μT to 65 μT (NOAA, 2021a). For context, a reference magnitude of the earth's magnetic field at a particular location can be estimated from models publicly available (NOAA, 2021b). For the Offshore Site, from sea level to maximum water depth, the geomagnetic total field is estimated as 50.7±0.14μT. As such, even without burial, the magnetic field produced by a 66-kV cable would be less than the value associated with the earth's magnetic field at the Offshore Site. As such, Benthic Ecology receptors are unlikely to detect any notable change from EMFs produced by a 66-kV cable, particularly if the proposed 0.6m burial can be achieved for the inter-array and offshore export cables.

Table 9.14 EMF levels at various distance from buried cables

Component	5 m (μT)	1 m (μT)	Seabed (cable buried by a minimum of 0.6 m) (μT)
Offshore Export Cable(s) / buried inter-array cables	≈ 0	0.73	17.1

The effects of EMFs on benthic communities are not well understood, however, recent studies suggest that benthic communities growing along cables route are similar to those in nearby baseline areas, and where species are not found this is likely due to the physical presence of the cable and surface properties, rather than an EMF effect (Copping and Hemery, 2020). EMF impacts on fish and shellfish species are covered within Chapter 10: Fish and Shellfish Ecology.

There will be remedial protection used on the portions of the cables that are not buried but in contact with the seabed. If the protection placed on top of the cables extends beyond the limits of the generated EMFs, epifaunae are unlikely to have increased exposure.

There is insufficient data to reach a conclusion on the effect of EMFs on any particular benthic invertebrate species. In particular, there is limited evidence on the effects of EMFs on the PMF species ocean quahog (MarLIN, 2022b) and EMF effects are not considered to be relevant to the PMF habitat *Laminaria hyperborea* with dense foliose red seaweeds on exposed infralittoral rock. The literature indicates that the greatest effect will be on fish species that use electroreception for benthic prey detection (see Chapter 10: Fish and Shellfish Ecology). The outcome of limited benthic EMF research appears to place benthic species in a category of least concern.

The EMF emissions from the Offshore Development inter-array and offshore export cables are likely to be much smaller than those predicted by modelling studies. Therefore, the sensitivity of the benthic receptors is considered to be **low** sensitivity. As a result of this, the impact is defined as being of **low** magnitude**.** A **high-value** receptor – ocean quahog – is present within the Benthic Ecology Study Area. This species is of high value because of its protection status under the OSPAR Convention's List of Threatened and Declining Species. However, any impacts are unlikely to affect the long-term functioning of the ocean quahog population or other benthic receptors within the Benthic Ecology Study Area.

Therefore, the overall effect to Benthic Ecology receptors is considered to be **minor** and **not significant.**

9.6.2.5.2 Thermal load

When electric energy is transported, a certain amount dissipates as heat energy. This increases the temperature of the cable surface and potentially increases the temperature of the surrounding environment (OSPAR, 2009a). There will be heat released from the inter-array and offshore export cables which has the potential to increase the temperature in the surrounding sediment and water (Boehlert & Gill, 2010). There is evidence that this heat (also known as thermal emissions) can occur from high voltage subsea cables and is detectable within the surrounding sediments (Meißner 2006; Taormina *et al*. 2018).

The Nysted offshore wind array looked at thermal radiation produced by two alternating current cables of 33 kV and 132 kV that were buried in a medium sand sediment at an approximate burial depth of 1 m. The results demonstrated a maximal temperature increase of about 2.5ºC at 50 cm directly below the cable (Meißner, 2006). The maximum cable voltage for the inter-array and offshore export cables associated with the Offshore Development is 110 kV. Therefore, it is anticipated that the temperature increase will be comparable to or lower than these findings.

An increase in sediment temperature can alter the physical and chemical properties of the substratum, for example, the oxygen concentration. It can also indirectly result in the development of microorganism communities (Rhoads and Boyer, 1982; OSPAR Commission, 2008). Although there are limited studies on thermal radiation impacts on benthic receptors there have been studies looking at the de-oxygenation impacts on ocean quahog, which are highly tolerant to severe hypoxia and anoxia (Theede et al., 1969, Diaz & Rosenberg, 1995; MarLIN, 2022b). Particularly severe increases in temperature may affect the spawning levels in Ocean Quahog, but juveniles can survive in temperatures as high as 20°C and adults 16°C (Merrill et al., 1969; Cargnelli et al., 1999; MarLIN, 2022b), far above the temperature increases predicted as a result of the installed cables. There has been limited research into this effect and the potential impact on the benthic community is therefore largely unknown (Boehlert & Gill, 2010; Taormina et al. 2018).

Although there has been limited research into the impacts of thermal loading as it relates to subsea cables, based on available evidence, the sensitivity of the benthic receptors is considered to be **low** sensitivity and the impact is defined as being of **low** magnitude**.** A **high-value** receptor – ocean quahog – is present within the Benthic Ecology Study Area; however, this species has been found to have high tolerance to oxygen alterations and a medium tolerance to temperature changes. Any impacts are therefore unlikely to affect the long-term functioning of the ocean Quahog population or other benthic receptors within the Benthic Ecology Study Area. Therefore, the overall effect to Benthic Ecology receptors is considered to be **minor** and **not significant.**

9.6.2.6 Summary of effects during Operation and Maintenance

A summary of the assessment of effects during Operation and Maintenance is provided in Table 9.15.

Table 9.15 Summary of significance of effects from operation and maintenance impacts

Summary of Effect	Receptor	Sensitivity	Magnitude of Impact	Rationale	Consequence	Significance of Effect	Additional Mitigation Requirements	Significance of Residual Effect
Hydrodynamic changes leading to scour around subsea infrastructure (including mooring lines as a result of movement with waves and tides)	Ocean quahog	High	Negligible	Ocean quahog are considered to have high sensitivity to abrasion and **low** sensitivity to scour. The impact is defined as **negligible** magnitude. Any impacts are unlikely to affect the long-term functioning of the ocean quahog population. Therefore, the overall effect is considered to be **minor** and **not significant**.	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant
	Offshore subtidal sands and gravels	Low	Negligible	Subtidal sand and gravel habitats have **low** sensitivity to abrasion and scour. The impact is considered to have **negligible** magnitude. Therefore, the overall effect is considered to be **negligible** and **not significant**.	Negligible Effect	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant
Introduction of marine non- native species (INNS)	Offshore subtidal sands and gravels	High	Negligible	Subtidal sand and gravel habitats have high sensitivity to INNS. The impact is considered to have **negligible** magnitude as colonising species are expected to be epilithic. Therefore, the overall effect is considered to be **minor** and **not significant**.	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant
	Stoney and Bedrock Reef habitats	Low	Negligible	Habitats assessed have a **low** sensitivity to the introduction of INNS. the impact is defined as being of **negligible** magnitude. Therefore, the effect to benthic habitats outlined above is considered to be **negligible** and **not significant**.	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant
	Ocean quahog	Low	Negligible	Ocean quahog are considered to have **low** sensitivity. The magnitude of impact is considered to be **negligible**. Therefore, the overall effect to ocean quahog is considered to be **negligible** and **not significant**.	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant
	Kelp beds	High	Negligible	The sensitivity of the kelp receptor is considered to be **high** sensitivity. The impact is defined as being of **negligible** magnitude. Therefore, the overall effect to kelp beds is considered to be **minor** and **not significant**.	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant
Colonisation of subsea infrastructure, scour protection and support structures	Benthic Receptors	Moderate	Low	Benthic receptors are considered to be **moderately** sensitive to colonisation. The impact is defined as being of **low** magnitude. Therefore, the overall effect to benthic receptors is considered to be **minor** and **not significant**.	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant
Colonisation of cutting mounds	Benthic Receptors	Negligible	Low	Benthic receptors are considered to be indicating **negligible** sensitivity. The impact is defined as being of **low** magnitude. Therefore, the overall effect is considered to be **negligible** and **not significant**.	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant
Impact to benthic communities from any EMFs or thermal load arising from the cable during operation.	Benthic Receptors	Low	Low	EMF - The sensitivity of the benthic receptors is considered to be **low** sensitivity. The impact is defined as being of **low** magnitude. Therefore, the overall effect to benthic receptors is considered to be **minor** and **not significant**. Thermal Load -The sensitivity of the benthic receptors is considered to be **low** sensitivity and the impact is defined as being of **low** magnitude. Therefore, the overall effect to benthic receptors is considered to be **minor** and **not significant**.	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded project mitigation listed in Section 9.5.5 as it was concluded that the effect was not significant.	Not Significant

9.6.3 Effects during Decommissioning

Decommissioning will involve the dismantling and removal of the seven WTGs and associated floating substructures and anchoring systems along with the removal of the dynamic and seabed laid cables (unless there is compelling evidence to leave the buried sections *in situ*). Scour protection may be left *in situ* as it may not be practical 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. It will be drafted 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 Benthic Ecology receptors during the construction phase are also applicable to the decommissioning phase. 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.

9.7 Assessment of Cumulative Effects

9.7.1 Introduction

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

Projects within 20 km of the Benthic Ecology Study Area are considered for the cumulative effects assessment for Benthic Ecology. A 20-km zone of influence was initially applied to inform the cumulative projects list to try and capture overlapping maximum excursion extents. Modelling undertaken within Chapter 7: Marine Physical Processes has shown that the maximum lateral excursion of suspended sediments would be 3.7 km from the Offshore Development and as such the application of a 20-km zone of influence is considered highly conservative. The projects that will be considered for the cumulative impact assessment are listed in Table 9.16 and illustrated in Figure 9.4.

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 EIA (Volume 3): Appendix 6.1. The approach and list of cumulative projects screened into the assessment was provided to MS-LOT and consultees and comments were received on 16th May 2022. These comments have been taken into account within this assessment. All relevant responses and actions in association with cumulative comments in relation to Benthic Ecology receptors are discussed in Section 9.3.

Table 9.16 List of projects considered for the Benthic Ecology cumulative impact assessment

Development Type	Project Name	Status	Phase	Distance (km) to Offshore Site	Data Confidence	Relevant Receptors
Cable	Scottish Hydro Electric (SHE) Transmission Orkney-Caithness Cable project	Consented	Construction (construction timelines unknown)	0 (overlap with OECC)	Medium	All
Dredge disposal site	Scrabster Extension dredge disposal site	Open	Active	18	High	All

Figure 9.4 Cumulative projects identified for Benthic Ecology within 20 km of the Offshore Development

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

The following impacts have been taken forward for the cumulative assessment:

- Construction / Decommissioning:
    - Damage from placement of infrastructure (cables, mooring, anchors) on the seabed;
    - Suspension of sediments from the installation of subsea infrastructure;
    - Disturbance of contaminated sediments;
    - Introduction of marine INNS; and
    - Burial of seabed from cutting piles.
- Operation and Maintenance:
    - Hydrodynamic changes leading to scour around subsea infrastructure (including mooring lines as a result of movement with waves and tides);
    - Introduction of marine INNS;
    - Colonisation of subsea infrastructure, scour protection, and support structures; and
    - Impacts to the benthic community from any EMFs or thermal load arising from the cables during operation.

9.7.2 Cumulative Construction Effects

9.7.2.1 Damage from placement of infrastructure (cables, mooring, anchors) on the seabed

As described above, within the Benthic Ecology Study Area kelp beds and Ocean Quahog have been identified as **highly** sensitive receptors. Offshore subtidal sands and gravels are assessed as having low sensitivity and Stony and Bedrock Reefs are assessed as having a moderate sensitivity to damage from placement of infrastructure.

The magnitude of impact for the Offshore Development from placement of infrastructure was assessed as **negligible** magnitude for ocean quahog and kelp beds and **low** magnitude for Stony and Bedrock Reefs and Offshore subtidal sands and gravels.

The SHE Transmission Orkney-Caithness project is the only project that overlaps geographically with the Benthic Ecology Study area (within the OECC). However, the construction timelines for this project are uncertain; therefore, it is not possible to ascertain if there will be a cumulative impact from the placement of the SHE Transmission Orkney-Caithness project infrastructure with the installation of the Offshore Export Cable(s) for the Offshore Development. Nonetheless, the SHE Transmission Orkney-Caithness project only covers a small proportion of widely available habitat.

Given the small spatial extent of the impacts associated with the SHE Transmission Orkney-Caithness project, there will be **no change** to the magnitude of impact and the magnitude of the impact of both projects is considered to be **negligible** for ocean quahog and kelp beds and **low** for Stony and Bedrock Reefs and Offshore subtidal sands and gravels. Therefore, the overall effect is **minor** and **not significant**.

The Scrabster Extension dredge disposal site does not overlap with the Benthic Ecology Study Area, and therefore no cumulative impacts are anticipated.

9.7.2.2 Suspension of sediments from installation of subsea infrastructure

As described above, within the Benthic Ecology Study Area, Stony and Bedrock Reefs have a **moderate** sensitivity to suspension of sediments, whilst kelp beds and Offshore subtidal sands and gravels have a **low** sensitivity**,** and ocean quahog have a **negligible** sensitivity to suspended sediments.

The magnitude of impact for the Offshore Development from the installation of infrastructure was assessed as **low** magnitude for Offshore subtidal sands and gravels and **negligible** for Stony and Bedrock Reefs, ocean quahog, and kelp beds.

The SHE Transmission Orkney-Caithness project is the only project that overlaps geographically with the Benthic Ecology Study area (within the OECC). However, the construction timelines for this project are uncertain and therefore it is not possible to ascertain if there will be a cumulative impact from the installation of the SHE Transmission Orkney-Caithness project infrastructure with the installation of the Offshore Export Cable(s) for the Offshore Development. Assuming both projects were constructed in tandem, there is the potential that the installation of these cables could result in an increase in suspended sediments and ceiling heights of the plume. However, it is likely, given the similar nature of the SHE Transmission Orkney-Caithness project cable installation, that the lateral extent of any sediments in suspension would still be similar to that caused by the Offshore Development (e.g. within a couple of kilometres [a maximum of 3.7 km modelled for the Offshore Development]). even when considered cumulatively, furthermore, as these would be the same sediments in suspension, it is likely that they would also settle out within a matter of hours to a shallow depth (<10 mm modelled for the Offshore Development).

Given the small spatial and temporal extent of the impacts likely associated with the SHE Transmission Orkney-Caithness project, the magnitude of impact of both projects is conservatively considered to increase marginally to **low** for Stony and Bedrock Reefs, ocean quahog, and kelp beds, and **moderate** for offshore subtidal sands and gravels. Therefore, the overall effect is **minor** and **not significant.**

The Scrabster Extension dredge disposal site does not overlap with the Benthic Ecology Study Area and is also 14 km beyond the 4-km Suspended Sediment Buffer Area for the Offshore Development. The disposal site is active, so there is the potential for plume development during dredge disposal operations within the Scrabster Extension dredge disposal site. As the dredge disposal site is at an appreciable distance (14 km) from the Suspended Sediment Buffer Area, the potential for the coalescence of sediment plumes from the dredge disposal site and the Offshore Development is low, but it would be primarily dependent on the dredged material and disposal operations at the dredge disposal site. Should the Offshore Development construction activities (i.e. within the PFOWF Array Area or OECC) coincide with dredge disposal activities rapid dilution of suspended sediment concentrations can be expected to reduce the potential for the coalescence of sediment plumes from each independent activity.

Given the intervening distance of the dredge disposal site and the small-scale temporal change anticipated from any suspended sediments from these projects, there will be **no change** to the magnitude of impact and the impact of both projects is still considered to be **low** for offshore subtidal sands and gravels and **negligible** for Stony and Bedrock Reefs, ocean quahog, and kelp beds. Therefore, the overall effect is **minor** and **not significant.**

9.7.2.3 Disturbance of contaminated sediments

As described above, this impact is only relevant to the OECC as this is where there is potential to disturb contaminated sediments. The sensitivity of benthic receptors, including ocean quahog and reef epifauna, to the disturbance of contaminated sediment is **low.**

The magnitude of impact assessed for the potential to disturb contaminated sediment from the Offshore Development was assessed as being of **negligible** magnitude.

The SHE Transmission Orkney-Caithness project is the only project that overlaps geographically with the Offshore Development (within the OECC). However, the construction timelines for this project are uncertain and therefore it is not possible to ascertain if there will be a cumulative impact with the installation of the Offshore Export Cable(s) for the Offshore Development. The HDD operations for the offshore Development at the landfall could take place in the year prior to Stage 1 (anticipated in 2024), but the actual disturbance from this will be very limited and localised to the exit point, with a maximum release of 264 m^3 of fluid. There is a potential for the SHE Transmission Orkney-Caithness project installation periods to overlap, however, the disturbance of potentially contaminated sediment will be very localised and the potential for the occurrence of contaminated sediment is low. Therefore, there will be **no change** to the magnitude of impact and the impact of both projects is defined as being of **negligible** magnitude. Therefore, the overall effect is **negligible** and **not significant**.

The Scrabster Extension dredge disposal site does not overlap with the Benthic Ecology Study Area or areas of potentially contaminated sediment, so no cumulative impacts are anticipated.

9.7.2.4 Introduction of marine INNS

As described above, within the Benthic Ecology Study Area, offshore subtidal sands and gravels and kelp beds were identified as having a **high** sensitivity to INNS. Ocean quahog and Stony and Bedrock Reefs were identified as having **low** sensitivity to INNS.

The magnitude of impact for the Offshore Development for the introduction of INNS was assessed as being of **negligible** magnitude.

The SHE Transmission Orkney-Caithness project is the only project that overlaps geographically with the Offshore Development (within the OECC). However, the construction timelines for this project are uncertain and therefore it is not possible to ascertain if there will be a cumulative impact with the installation of the Offshore Export Cable(s) for the Offshore Development. As there is potential for the construction periods of the two projects to overlap, there is the potential for a temporary increase in the number of vessels in the area that have the potential to introduce INNS. However, it is assumed that all vessels will adhere to embedded mitigation industry standards, including the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 (BWM Convention). Therefore, there will be **no change** to the magnitude of impact and the magnitude of impact is still defined as being of **negligible** magnitude, and the overall effect will be **minor** and **not significant**

The Scrabster Extension dredge disposal site does not overlap with the Benthic Ecology Study Area, however, due to the increase in vessel traffic during the construction period of the Offshore Development, there is an increased potential of introducing marine INNS. Assuming that all vessels are adhering to the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 (BWM Convention), there will be **no change** to the magnitude of the impact and as such the magnitude of impact is still considered to be **negligible**. Therefore, the overall effect is **minor** and **not significant**.

9.7.2.5 Deposition of drill cuttings

As described above, within the PFOWF Array Area, offshore subtidal sands and gravels were identified as having **low** sensitivity to potential habitat loss or smothering that would be expected to result from the drill cutting mounds. Ocean quahog were identified as having **negligible** sensitivity.

The magnitude of impact for the PFOWF Array Area for the potential habitat loss or smothering that would be expected to result from the drill cutting mounds was assessed as being of **low** magnitude.

There are no projects with anticipated drill cutting mounds that intersect the Benthic Ecology Study Area. Therefore, there will be **no change** to the magnitude of impact and the impact of the Offshore Development cumulatively with these two projects is defined as being of **negligible** magnitude. Therefore, the overall effect is **negligible** and **not significant**.

9.7.3 Cumulative Operation and Maintenance Effects

9.7.3.1 Hydrodynamic changes leading to scour around subsea infrastructure (including mooring lines as result of movement with waves and tides)

As described above, within the Benthic Ecology Study Area, ocean quahog have a **high** sensitivity to abrasion and a **low** sensitivity to scour around subsea infrastructure resulting from hydrodynamic changes**.** Offshore subtidal sands and gravels have a **low** sensitivity to abrasion and a **low** sensitivity to scour.

The magnitude of impact for the Offshore Development from the development of scour and impacts from abrasion was assessed as being of **negligible** magnitude**.**

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 sites, there are not anticipated to be any cumulative impacts.

This is further reinforced by the application of scour protection, where necessary, to negate the development of scour.

Therefore, there will be **no change** to the magnitude of the impact due to the intervening distance of both these projects and as such the magnitude of impact is still considered to be **negligible**. Therefore, the overall effect is **minor** and **not significant**.

9.7.3.2 Introduction of marine INNS

As described above, within the Benthic Ecology Study Area, offshore subtidal sands and gravels and kelp beds were identified as having a **high** sensitivity to INNS, whilst ocean quahog and Stony and Bedrock Reefs were identified as having **low** sensitivity to INNS.

The magnitude of impact for the Offshore Development from the introduction of INNS during the operational phase was assessed as being of **negligible** magnitude.

Considering the overlap with the SHE Transmission Orkney-Caithness project there is the potential for cumulative impacts to occur. Under the SHE Transmission Orkney-Caithness project's Marine Licence and installation approval plans, SHE Transmission will be required to bury the cables to a sufficient burial depth where possible or, where burial is not possible, remedial protection measures will be applied. Therefore, there will be minimal additional subsea infrastructure which non-native species can colonise. Therefore, there will be **no change** to the magnitude of impact. The impact of both these projects is defined as being of **negligible** magnitude, and the overall effect is **minor** and **not significant.**

The Scrabster Extension dredge disposal site does not overlap with the Benthic Ecology Study Area; however, the site has the potential to introduce non-native species and the Offshore Development could potentially act as a steppingstone. Assuming that appropriate biofouling management practices are implemented at the dredge site, and that the risk of introduction of non-natives from sedimentary material is reduced in comparison to rock, there is a low risk of the Offshore Development infrastructure acting as a stepping stone for non-native species dispersed from the dredge site. Therefore, there will be **no change** to the magnitude of impact and the impact of both these projects is defined as being of **negligible** magnitude, making the overall effect **minor** and **not significant.**

9.7.3.3 Colonisation of subsea infrastructure, scour protection, and support structures

As described above within the Benthic Ecology Study Area, the sensitivity of benthic receptors is broadly considered to be **moderate** to colonisation of the Offshore Development's subsea infrastructure, scour protection, and support structures**.**

The magnitude of impact for the Offshore Development from potential colonisation during the operational phase was assessed as being of **low** magnitude**.**

Considering the overlap with the SHE Transmission Orkney-Caithness project, there is the potential for cumulative impacts to occur. However, it is assumed that the cable will be buried where possible, reducing the likelihood of colonisation of significant levels of biomass of epifauna. As such, there will be **no change** to the magnitude of the impact and as such the magnitude of impact is still considered to be **low**. Therefore, the overall effect is **minor** and **not significant**.

The Scrabster Extension dredge disposal site does not overlap with the Benthic Ecology Study Area, therefore, no cumulative impacts are anticipated.

9.7.3.4 Colonisation of cutting mounds

As described above, within the PFOWF Array Area, benthic receptors were identified as having **negligible** sensitivity to the introduction of drill cutting mounds and colonisation of the cutting piles.

The magnitude of impact for the PFOWF Array Area for the drill cutting mounds and colonisation of the cutting mounds was assessed as being of **low** magnitude.

There are no projects with anticipated drill cutting mounds that intersect the Benthic Ecology Study Area. Therefore, there will be **no change** to the magnitude of impact and the impact of the Offshore Development cumulatively with these two projects is defined as being of **negligible** magnitude. Therefore, the overall effect is **negligible** and **not significant**.

9.7.3.5 *Impact to benthic community from any EMFs or thermal load arising from the cables during operation*

As described above within the Benthic Ecology Study Area, overall Benthic Ecology receptors have a **low** sensitivity to EMFs or thermal load arising from the cables during operation.

The magnitude of impact for the Offshore Development from potential EMFs during the operational phase was assessed as being of **low** magnitude**.**

Considering the overlap with the SHE Transmission Orkney-Caithness project there is the potential for cumulative impacts to occur. Under the SHE Transmission Orkney-Caithness project's Marine Licence and installation approval plans, SHE Transmission will be required to bury the cables to a sufficient burial depth where possible or, where burial is not possible, remedial cable protection measures will be applied to reduce the effects of EMFs. Therefore, there will be **no change** to the magnitude of the impact and as such the magnitude of impact is still considered to be **low**. Therefore, the overall effect is **minor** and **not significant**.

No cumulative effects regarding EMFs or thermal load will occur with the Scrabster Extension dredge disposal site as there are no cables present at the site.

9.7.4 Cumulative Decommissioning Effects

There is limited information on cumulative projects applicable to the decommissioning phase of the Offshore Development. As there is limited information on the decommissioning of the Offshore Development and that of other projects, it is not possible to provide a meaningful cumulative assessment. However, the cumulative impacts are expected to be less than or equal to the construction phase and decommissioning of multiple other projects would not be expected to occur at the same time as the decommissioning phase 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 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 practices.

9.8 Assessment of Transboundary Effects

Impacts on Benthic Ecology receptors will be localised to the extent of the Benthic Ecology Study Area, within UK waters. Given the intervening distance to neighbouring European Economic Area states, there is no potential for transboundary impacts and resultant effects to occur.

9.9 Assessment of Impacts Cumulatively with the Onshore Development

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

The Onshore Development will undertake HDD operations above MHWS, with the HDD exit point(s) occurring between 400 m and 700 m offshore. The impacts of the HDD exit point(s) on Benthic Ecology receptors have been assessed in full in Section 9.6. It is not anticipated that there will be any additional impacts from the Onshore Development on Benthic Ecology receptors as all other activities from the Onshore Development are fully terrestrial.

9.10 Mitigation and Monitoring Requirements

There is no requirement for additional mitigation over and above the embedded measures for the Offshore Development proposed in Section 9.5.5.

9.11 Inter-relationships

Inter-related effects describe the potential interaction of multiple project impacts upon one receptor which may interact to create a more significant impact on a receptor than when considered in isolation. Inter-related 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 Benthic Ecology receptors during construction, operation and maintenance, and decommissioning phases of the Offshore Development. Therefore, it is considered that the assessment and conclusions presented in Section 9.6 provide a complete and robust assessment of all potential impacts relevant to Benthic Ecology receptors. The assessment has also considered the potential for inter-related effects in relation to Benthic Ecology receptors, and no additional inter-related effects beyond those presented in Section 9.6 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 9.17.

Table 9.17 Inter-relationships identified with Benthic Ecology and other receptors in this Offshore EIAR

Receptor	Impacts	Description
Marine Physical Processes	Indirect impacts on benthic habitats and benthic species from suspended sediments.	Changes in marine physical processes could lead to the suspension of sediments which may indirectly result in the smothering of benthic habitats and benthic species which depend on these habitats. These impacts are discussed in Section 9.6.1.2.
	Indirect impacts on benthic habitats and benthic species from changes to hydrodynamics.	Changes in hydrodynamics could lead to increased scour and abrasion which may indirectly result in the loss or disturbance of benthic habitats and benthic species. These impacts are discussed in Section 9.6.2.1.
Water and Sediment Quality	Indirect impacts on benthic habitats and benthic species from changes in water and sediment quality.	Changes in water and sediment quality can result in indirect impacts to benthic habitats which are sensitive to contamination and toxins. These impacts are discussed in Section 9.6.1.3.
Fish and Shellfish Ecology	Indirect impacts to fish and shellfish ecology from changes to spawning and nursery ground habitats from loss / disturbance of benthic ecology habitats.	Changes in benthic habitats can lead to an indirect impact on fish spawning and nursery grounds which rely on these habitats. Direct impacts to benthic habitats from the Offshore Development are assessed within this chapter. Habitat loss of spawning and nursery grounds due to the presence of the Offshore Development infrastructure are assessed within Chapter 10: Fish and Shellfish Ecology.
	Indirect impacts to fish and shellfish fish aggregation from changes to the colonisation of benthic habitats and species.	Colonisation of benthic habitats and species may occur as a result of the Offshore Development infrastructure and scour. These impacts are assessed within Section 9.6.2.3. This can indirectly impact fish species through an increase in reefs and food availability resulting in fish aggregations around these structures. These impacts are assessed in Chapter 10: Fish and Shellfish Ecology.

Receptor	Impacts	Description
Marine Mammals and Other Megafauna	Indirect impacts to marine mammals and other megafauna through long-term benthic habitat change, including the potential for changes to habitat quality.	Changes in benthic habitats can lead to an indirect impact on marine mammals and other megafauna due to changes in prey availability of fish, which may be impacted due to loss / disturbance of the benthic habitat on which they rely. Direct impacts to benthic habitats from the Offshore Development are assessed within this chapter. Impacts on marine mammals and other megafauna from long-term habitat changes are assessed within Chapter 11: Marine Mammals and other Megafauna.
Marine Ornithology	Indirect impacts to Marine Ornithology from potential change in benthic habitat and prey availability.	Changes in benthic habitats can lead to an indirect impact on marine ornithology due to changes in prey availability of fish, which may be impacted due to loss / disturbance of the benthic habitat on which they rely. Direct impacts to benthic habitats from the Offshore Development are assessed within this chapter. Impacts on marine ornithology from potential change in benthic habitat and prey availability are assessed within Chapter 12: Marine Ornithology.
Climate Change and Carbon	Indirect impacts on benthic ecology from climate change in combination with the Offshore Development activities.	Indirect impacts from climate change and the Offshore Development combined, such as increased rainfall in combination with the Offshore Development activities, may result in increased concentrations of suspended solids in the water column leading to the smothering of benthic habitats and species. Climate change impacts in combination with the Offshore Development activities such as changes in temperature, salinity, oxygen and pH also have the potential to effect Benthic Ecology receptors. These indirect impacts on benthic ecology are assessed within Chapter 20: Climate Change and Carbon.
	Direct effects on blue carbon habitats.	Loss or disturbance of blue carbon habitats such as kelp beds may occur due to direct habitat loss or disturbance of these blue carbon habitats. These impacts on benthic ecology (kelp beds) are assessed within Chapter 20: Climate Change and Carbon.

9.12 Summary and Residual Effects

Table 9.18 summarises the effects for all impacts assessed.

Table 9.18 Summary of residual effects for Benthic Ecology

Predicted Effect	Receptor	Assessment Consequence	Significance	Mitigation Identified	Significance of Residual Effect
Construction					
Damage from placement of infrastructure (cables, moorings, anchors) on the seabed	Offshore subtidal sands and gravels	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in Table 9.12 as it was concluded that the effect was not significant.	Not Significant
	Stoney and Bedrock Reef Habitats	Minor Effects	Not Significant		Not Significant
	Kelp beds - A3.115 - *Laminaria hyperborea* with dense foliose red seaweeds on exposed infralittoral rock	Minor Effects	Not Significant		Not Significant
	Ocean quahog	Minor Effects	Not Significant		Not Significant
Suspension of sediments from the installation of subsea infrastructure	Offshore subtidal sands and gravels	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in Table 9.12 as it was concluded that the effect was not significant.	Not Significant
	Stoney and Bedrock Reef Habitats	Negligible Effects	Not Significant		Not Significant
	Kelp beds - A3.115 - *Laminaria hyperborea* with dense foliose red seaweeds on exposed infralittoral rock	Negligible Effects	Not Significant		Not Significant
	Ocean quahog	Negligible Effects	Not Significant		Not Significant
Disturbance of contaminated sediments	Benthic habitats (including ocean quahog and reef epifauna)	Negligible Effects	Not Significant	No mitigation or additional measures have been identified for this effect.	Not Significant

Predicted Effect	Receptor	Assessment Consequence	Significance	Mitigation Identified	Significance of Residual Effect
Introduction of marine INNS	Offshore subtidal sands and gravels	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in Table 9.12 as it was concluded that the effect was not significant.	Not Significant
	Stoney and Bedrock Reef Habitats	Negligible Effects	Not Significant		Not Significant
	Kelp beds - A3.115 - *Laminaria hyperborea* with dense foliose red seaweeds on exposed infralittoral rock	Minor Effects	Not Significant		Not Significant
	Ocean quahog	Negligible Effects	Not Significant		Not Significant
Deposition of drill cuttings	Ocean quahog	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in Table 9.12 as it was concluded that the effect was not significant.	Not Significant
	Offshore subtidal sands and gravels	Minor Effects	Not Significant		Not Significant
Operation and Maintenance					
Hydrodynamic changes leading to scour around subsea infrastructure (including mooring lines as result of movement with wave and tides)	Ocean quahog	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in Table 9.12 as it was concluded that the effect was not significant.	Not Significant
	Offshore subtidal sands and gravels	Negligible Effects	Not Significant		Not Significant
Introduction of marine INNS	Offshore subtidal sands and gravels	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded	Not Significant
	Stoney and Bedrock Reef habitats	Negligible Effects	Not Significant		Not Significant

Predicted Effect	Receptor	Assessment Consequence	Significance	Mitigation Identified	Significance of Residual Effect
	Ocean quahog	Negligible Effects	Not Significant	mitigation listed in Table 9.12 as it was concluded that the effect was not significant.	Not Significant
	Kelp beds	Minor Effects	Not Significant		Not Significant
Colonisation of subsea infrastructure, scour protection, and support structures	Benthic Receptors	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in Table 9.12 as it was concluded that the effect was not significant.	Not Significant
Colonisation of cutting mounds	Benthic Receptors	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in Table 9.12 as it was concluded that the effect was not significant.	Not Significant
Impact to benthic communities from any EMFs or thermal load arising from the cable during operation.	Benthic Receptors	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in Table 9.12 as it was concluded that the effect was not significant.	Not Significant
Decommissioning					
Decommissioning effects on Benthic Ecology receptors are not expected to exceed those assessed for the construction phase.					
Cumulative – Construction					
Damage from placement of infrastructure	Offshore subtidal sands and gravels	Minor Effects	Not Significant	No additional mitigation measures have	Not Significant

Predicted Effect	Receptor	Assessment Consequence	Significance	Mitigation Identified	Significance of Residual Effect
(cables, moorings, anchors) on the seabed	Stoney and Bedrock Reef Habitats			been identified for this effect above and beyond the embedded mitigation listed in Table 9.12 as it was concluded that the effect was not significant.	
	Kelp beds - A3.115 - *Laminaria hyperborea* with dense foliose red seaweeds on exposed infralittoral rock				
	Ocean quahog				
Installation of subsea infrastructure	Offshore subtidal sands and gravels	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in Table 9.12 as it was concluded that the effect was not significant.	Not Significant
	Stoney and Bedrock Reef Habitats				
	Kelp beds - A3.115 - *Laminaria hyperborea* with dense foliose red seaweeds on exposed infralittoral rock				
	Ocean quahog				
Disturbance of contaminated sediments	Benthic habitats (including ocean quahog and reef epifauna)	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in Table 9.12 as it was concluded that the effect was not significant.	Not Significant
Introduction of marine INNS	Offshore subtidal sands and gravels	Minor Effects	Not Significant	No additional mitigation measures have	Not Significant

Predicted Effect	Receptor	Assessment Consequence	Significance	Mitigation Identified	Significance of Residual Effect
	Stoney and Bedrock Reef Habitats			been identified for this effect above and beyond the embedded mitigation listed in Table 9.12 as it was concluded that the effect was not significant.	
	Kelp beds - A3.115 - *Laminaria hyperborea* with dense foliose red seaweeds on exposed infralittoral rock				
	Ocean quahog				
Deposition of drill cuttings	Ocean quahog	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in Table 9.12 as it was concluded that the effect was not significant.	Not Significant
	Offshore subtidal sands and gravels				
Cumulative – Operation and Maintenance					
Hydrodynamic changes leading to scour around subsea infrastructure (including mooring lines as a result of movement with drillwaves and tides)	Ocean quahog	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in Table 9.12 as it was concluded that the effect was not significant.	Not Significant
	Offshore subtidal sands and gravels				
Introduction of marine INNS	Offshore subtidal sands and gravels	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in Table 9.12 as it was concluded that the effect was not significant.	Not Significant
	Stoney and Bedrock Reef habitats				
	Ocean quahog				
	Kelp beds				

Predicted Effect	Receptor	Assessment Consequence	Significance	Mitigation Identified	Significance of Residual Effect
Colonisation of subsea infrastructure, scour protection, and support structures	Benthic Receptors	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in Table 9.12 as it was concluded that the effect was not significant.	Not Significant
Colonisation of cutting mounds	Benthic Receptors	Negligible Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in Table 9.12 as it was concluded that the effect was not significant.	Not Significant
Impact to benthic communities from any EMFs or thermal load arising from the cable during operation.	Benthic Receptors	Minor Effects	Not Significant	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in Table 9.12 as it was concluded that the effect was not significant.	Not Significant
Cumulative – Decommissioning					
Cumulative decommissioning effects on Benthic Ecology receptors are not expected to exceed those assessed for the construction phase.					

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