Morecambe Offshore Windfarm: Generation Assets

Environmental Statement

Volume 5

Chapter 9 Benthic Ecology (Tracked)

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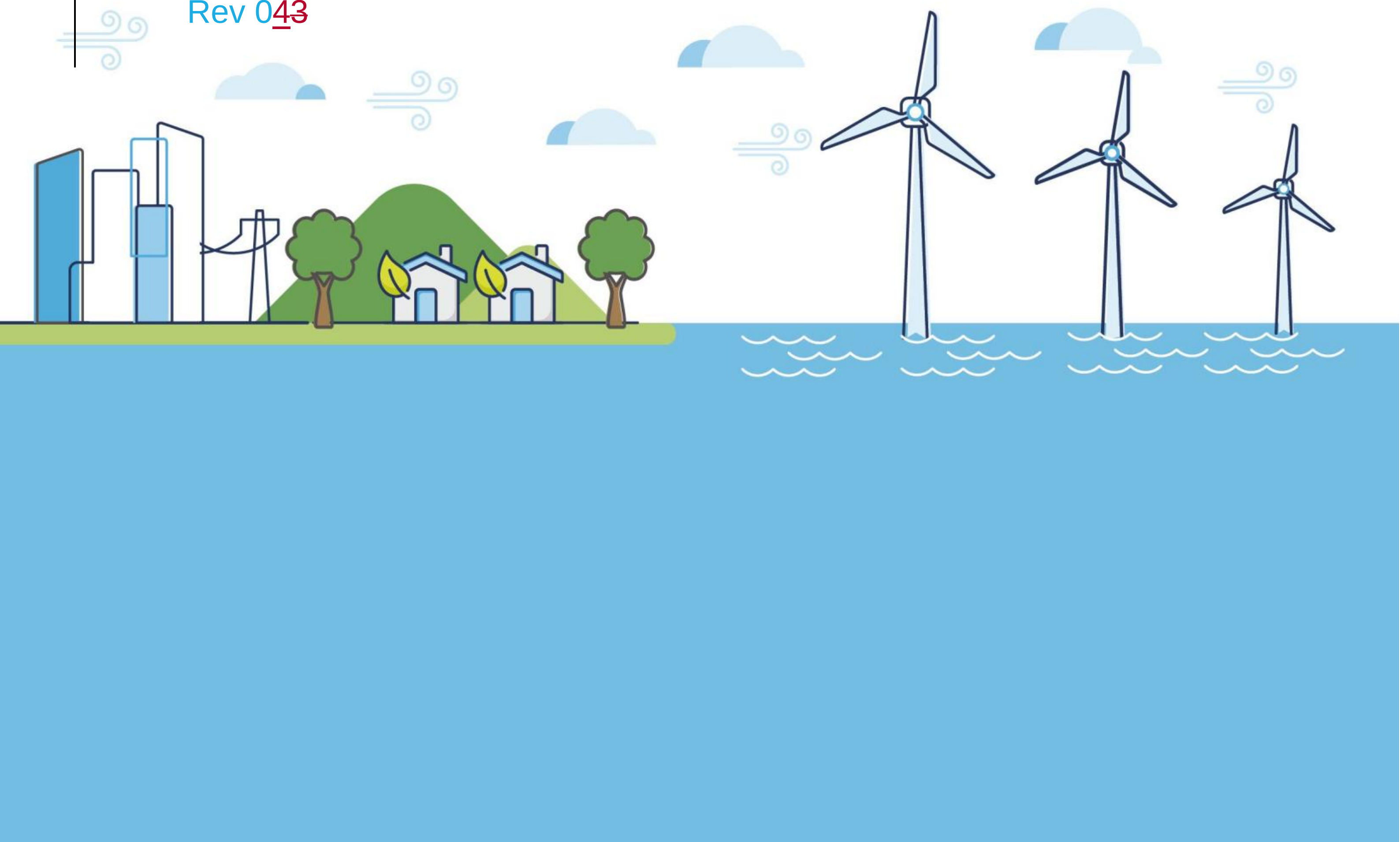

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Glossary of Acronyms

AL	Action Level
AoO	Advice on Operations
As	Arsenic
AyM	Awel y Môr (Offshore Windfarm)
BAP	Biodiversity Action Plan
BAS	Burial Assessment Study
BEIS	Department of Business, Energy and Industrial Strategy[1]
BGS	British Geological Survey
CBRA	Cable Burial Risk Assessment
Cd	Cadmium
CEA	Cumulative Effects Assessment
Cefas	Centre for Environment, Fisheries and Aquaculture
CIEEM	Chartered Institute of Ecology and Environmental Management
Cr	Chromium
cSAC	Candidate Special Area of Conservation
Cu	Copper
DBT	Dibutyltin
DCO	Development Consent Order
DDC	Drop-down Camera
DESNZ	Department for Energy Security and Net Zero
EA	Environment Agency
EIA	Environmental Impact Assessment
EMF	Electromagnetic Field
EPP	Evidence Plan Process
ERL	Effects Range – Low
ES	Environmental Statement
ETG	Expert Topic Groups
EUNIS	European Nature Information System
FOCI	Feature of Conservation Interest
GBS	Gravity Based Structures

[1] As of February 2023, BEIS is known as the Department for Energy Security and Net Zero (DESNZ)

Hg	Mercury
HPI	Habitat of Principal Importance
HRA	Habitat Regulation Assessment
IFCA	Inshore Fisheries and Conservation Authority
INNS	Invasive Non-Native Species
IPMP	In-Principle Monitoring Plan
JNCC	Joint Nature Conservation Committee
LSE	Likely Significant Effect
MarESA	Marine Evidence-based Sensitivity Assessment
MarLIN	Marine Life Information Network
MCAA	Marine Coastal Access Act 2009
MCZ	Marine Conservation Zone
MEAS	Merseyside Environmental Advisory Service
MMO	Marine Management Organisation
MPA	Marine Protected Area
NBN	National Biodiversity Network
NERC	Natural Environment and Rural Communities Act 2006
Ni	Nickel
NMBAQC	National Marine Biological Control Scheme
NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project
NWIFCA	North Western Inshore Fisheries and Conservation Authority
OEL	Ocean Ecology Limited
OSP	Offshore substation platform
OSPAR	Oslo-Paris Convention
OWF	Offshore Wind Farm
PAH	Polycyclic Aromatic Hydrocarbon
Pb	Lead
PCB	Polychlorinated Biphenyls
PDE	Project Design Envelope
PEIR	Preliminary Environmental Information Report
PEMP	Project Environmental Management Plan
PINS	Planning Inspectorate
PSD	Particle Size Distribution
RIAA	Report to Inform the Appropriate Assessment
RSMP	Regional Seabed Monitoring Plan

SAC	Special Area of Conservation
SCI	Sites of Community Importance
SPA	Special Protection Area
SPL	Sound Pressure Level
S-P-R	Source Pathway Receptor
SSC	Suspended Sediment Concentration
TBT	Tributyltin
THC	Total Hydrocarbon Content
TOC	Total Organic Carbon
TOM	Total Organic Matter
TSHD	Trailing Suction Hopper Dredger
UXO	Unexploded Ordnance
WoDS	West of Duddon Sands Offshore Windfarm
WTG	Wind turbine generator
Zn	Zinc
ZoI	Zone of Influence

Glossary of Unit Terms

km	Kilometre
kV	Kilovolt
m	Metre
mm	Millimetre
MW	Megawatts
µm	Micrometre

Glossary of Terminology

Advice on Operations (AoO)	Provides information on the activities capable of affecting site integrity and therefore achievement of the site's conservation objectives.
Applicant	Morecambe Offshore Windfarm Ltd
Application	This refers to the Applicant's application for a Development Consent Order (DCO). An application consists of a series of documents and plans which are published on the Planning Inspectorate's (PINS) website.
Agreement for Lease (AfL)	Agreements under which seabed rights are awarded following the completion of The Crown Estate tender process.
European sites	Designated nature conservation sites which include the National Site Network (designated within the UK) and Natura 2000 sites (designated in any European Union country). This includes candidate Special Areas of Conservation (cSAC), Sites of Community Importance (SCI), Special Areas of Conservation (SAC) and Special Protection Areas (SPA).
Evidence Plan Process (EPP)	A voluntary consultation process with specialist stakeholders to agree the approach, and information to support, the Environmental Impact Assessment (EIA) and Habitats Regulations Assessment (HRA) for certain topics. The EPP provides a mechanism to agree the information required to be submitted to PINS as part of the DCO Application. This function of the EPP helps Applicants to provide sufficient information in their application, so that the Examining Authority can recommend to the Secretary of State whether or not to accept the application for examination and whether an appropriate assessment is required.
Expert Topic Group (ETG)	A forum for targeted engagement with regulators and interested stakeholders through the EPP.
Far-field	The wider area that might also be affected indirectly by the Project.
Generation Assets (the Project)	Generation assets associated with the Morecambe Offshore Windfarm. This is infrastructure in connection with electricity production, namely the fixed foundation wind turbine generators (WTGs), inter-array cables, offshore substation platform(s) (OSP(s)) and possible platform link cables to connect OSP(s).
Inter-array cables	Cables which link the WTGs to each other and the OSP(s).
In-row	The distance separating WTGs in the main rows.
Inter-row	The distance between the main rows.
Landfall	Where the offshore export cables would come ashore.
Likely Significant Effect (LSE)	Meaning that there may be (as opposed to is likely to be) a significant effect of a proposal on the integrity of the site and its conservation objectives.

Morgan and Morecambe Offshore Wind Farms: Transmission Assets	The transmission assets for the Morgan Offshore Wind Project and the Morecambe Offshore Windfarm. This includes the OSP(s)[2], interconnector cables, Morgan offshore booster station, offshore export cables, landfall site, onshore export cables, onshore substations, 400kV cables and associated grid connection infrastructure such as circuit breaker infrastructure. Also referred to in this chapter as the Transmission Assets, for ease of reading.
Nacelle	The part of the turbine that houses all of the generating components
Near-field	The area within the immediate vicinity (tens or hundreds of metres) from the point of disturbance
Offshore export cables	The cables which would bring electricity from the OSP(s) to the landfall.
Offshore substation platform(s)	A fixed structure located within the windfarm site, containing electrical equipment to aggregate the power from the WTGs and convert it into a more suitable form for export to shore.
Onshore export cables	The cables which would bring electricity from landfall to the onshore project substation and from the onshore project substation to a National Grid substation.
Onshore substation	Part of an electrical transmission and distribution system. Substations transform voltage from high to low, or the reverse by means of electrical transformers.
Platform link cable	An electrical cable which links one or more OSP(s).
Safety Zones	An area around a structure or vessel which should be avoided, as set out in Section 95 of the Energy Act 2004 and the Electricity (Offshore Generating Stations) (Safety Zones) (Application Procedures and Control of Access) Regulations 2007.
Scour protection	Protective materials to avoid sediment being eroded away from the base of the foundations due to the flow of water.

[2] At the time of writing the Environmental Statement (ES), a decision had been taken that the offshore substation platforms (OSP(s)) would remain solely within the Generation Assets application and would not be included within the Development Consent Order application for the Transmission Assets. This decision post-dated the Preliminary Environmental Information Report (PEIR) that was prepared for the Transmission Assets. The OSP(s) are still included in the description of the Transmission Assets for the purposes of this ES as the cumulative effects assessment carried out in respect of the Generation/Transmission Assets is based on the information available from the Transmission Assets PEIR.

Study area	This is an area which is defined for each Environmental Impact Assessment (EIA) topic which includes the windfarm site as well as potential spatial and temporal considerations of the impacts on relevant receptors. The study area for each EIA topic is intended to cover the area within which an effect can be reasonably expected. For the purpose of the benthic ecology assessment, this is an area which includes the windfarm site and the Zone of Influence (ZoI), as well as wider areas within the Eastern Irish Sea from which contextual benthic data can be reported.
Technical stakeholders	Technical consultees are considered to be organisations with detailed knowledge or experience of the area within which the Project is located and/or receptors which are considered in the EIA and Habitats Regulations Assessment (HRA). Examples of technical stakeholders include Marine Management Organisation (MMO), local authorities, Natural England and Royal Society for the Protection of Birds (RSPB).
Tidal excursion ellipse	The path followed by a water particle in one complete tidal cycle.
Windfarm site	The area within which the WTGs, inter-array cables, OSP(s) and platform link cables will be present.
Wind Turbine Generator (WTG)	A fixed structure located within the windfarm site that converts the kinetic energy of wind into electrical energy.
Zone of Influence (ZoI)	The maximum anticipated spatial extent of a given potential impact.

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9 Benthic Ecology

9.1 Introduction

9.1 This chapter of the Environmental Statement (ES) considers the potential effects of the proposed Morecambe Offshore Windfarm Generation Assets (the Project) on benthic ecology. This chapter provides an overview of the existing environment, followed by an assessment of the potential effects and associated mitigation, where identified, for the construction, operation and maintenance and decommissioning phases.

9.2 The Project includes the Generation Assets to be located within the windfarm site (wind turbine generators (WTGs), inter-array cables, offshore substation platform(s) (OSP(s)) and possible platform link cables to connect OSP(s). The Environmental Impact Assessment (EIA) of the transmission assets, including offshore export cables to landfall and onshore infrastructure, is part of a separate Development Consent Order (DCO) application as outlined in **Chapter 1 Introduction** (Document Reference 5.1.1).

9.3 This assessment has been undertaken with specific reference to the relevant legislation and guidance, of which the primary sources are the National Policy Statements (NPS). Details of these and the methodology used for the Environmental Impact Assessment (EIA) and Cumulative Effects Assessment (CEA) are presented in **Chapter 6 EIA Methodology** (Document Reference 5.1.6) and **Section 9.4** of this chapter.

9.4 The assessment should be read in conjunction with the following linked ES chapters and supporting documentation:

- **Chapter 7 Marine Geology, Oceanography and Physical Processes** (assessments inform this chapter) (Document Reference 5.1.7)
- **Chapter 8 Marine Sediment and Water Quality** (assessments inform this chapter) (Document Reference 5.1.8)
- **Chapter 10 Fish and Shellfish Ecology** (informed by this chapter e.g. effects to prey species) (Document Reference 5.1.10)
- **Chapter 11 Marine Mammals** (informed by this chapter e.g. effects to prey species) (Document Reference 5.1.11)
- **Chapter 12 Offshore Ornithology** (informed by this chapter e.g. effects to prey species) (Document Reference 5.1.12)

9.5 Inter-relationships with these chapters are further described in **Section 9.8**.

9.6 Additional information to support the benthic ecology assessment includes:

- Interpretation of survey data specifically collected for the Project (**Appendix 9.1 Benthic Characterisation Survey** (Document Reference 5.2.9.1))
- Methods for assigning receptor sensitivity (**Appendix 9.2 Marine Evidence-based Sensitivity Assessment (MarESA)** (Document Reference 5.2.9.2))

9.2 Consultation

9.7 Consultation regarding benthic ecology has been undertaken in line with the general process described in **Chapter 6 EIA Methodology**. The key elements undertaken to inform this ES have included Scoping (Scoping Opinion from the Planning Inspectorate (PINS) received on 2nd August 2022), comments received on the Preliminary Environmental Information Report (PEIR) published for statutory consultation in April 2023, and the Evidence Plan Process (EPP) via the Marine Ecology Expert Topic Group (ETG) meetings.

9.8 As part of the EPP, a Marine Ecology Method Statement was submitted to the Marine Ecology ETG in May 2022. This consultation was used to inform the data requirements and the methodology for the assessment of potential Project effects set out in the EIA Scoping Report submitted to PINS in June 2022 (Morecambe Offshore Windfarm Ltd, 2022).

9.9 ETG meetings were held in June 2022, September 2022, November 2022, June 2023, October 2023 and January 2024, with attendees at some, or all meetings including the following organisations:

- Natural England
- Marine Management Organisation (MMO)
- Centre for Environment, Fisheries and Aquaculture Science (Cefas)
- The Wildlife Trusts
- North Western Inshore Fisheries and Conservation Authority (NWIFCA)
- Environment Agency
- Isle of Man Government
- Merseyside Environmental Advisory Service (MEAS)

9.10 The feedback received throughout the EPP, the Scoping Opinion published by PINS, and stakeholder comments on the PEIR, have been considered in preparing this ES. The key comments pertinent to this chapter are shown in **Table 9.1**~~**Table 9.1**~~, alongside details of how the Project team has had regard to the comments received and how these have been addressed within this chapter.

9.11 The MMO and Natural England also provided comments regarding the methodology proposed for a site-specific benthic characterisation survey undertaken in May/June 2022. Those comments, and detail of how they were addressed, are provided in the accompanying Morecambe Benthic Characterisation Survey Report (**Appendix 9.1**).

9.12 The consultation process is described further in **Chapter 6 EIA Methodology.** Full details on the consultation undertaken throughout the EIA process is presented in the Consultation Report (Document Reference 4.1) which is submitted as part of the DCO Application.

Table 9.1 Consultation responses received in relation to benthic ecology and how these have been addressed in the ES

Consultee	Date	Comment	Response/where addressed in the ES
Scoping Opinion responses			
PINS (ref. 3.3.8)	2nd August 2022	Baseline data sources: The intention to agree the baseline data with relevant stakeholders is noted. The Applicant is advised to check if there are any other relevant datasets available, for instance through the Marine Data Exchange, and to confirm the adequacy of the desk-based assessments with relevant stakeholders. The Applicant's attention is drawn to the comments from NE on this point.	Publicly available datasets/reports have been obtained through online resources including Marine Data Exchange. Data repository portals, namely National Biodiversity Network (NBN) Atlas, Regional Seabed Monitoring Plan, Cefas OneBenthic have been interrogated to identify useable data sources. A full list of the data sources used in this assessment is provided in **Section 9.4.2.2** which has been presented in ETG meetings and within the PEIR (no additional sources were identified by stakeholders).
Natural England	21st July 2022	Baseline data sources: Data from existing windfarms is relevant as context but will not be relevant to the Morecambe footprint. More detailed regional data sets such as NBN network, Marine Recorder, Regional Seabed monitoring plan baseline assessment should be included. Data relating to benthic species of conservation importance is not covered. Include these within the PEIR.	As above.
Natural England	21st July 2022	Baseline data sources: Description of the benthic habitats is very limited. Include a map with UKSeaMap/EUSeaMap data in the PEIR and ES.	Habitat data from EUSeaMap 2021 (EMODNet Seabed Habitats Consortium, 2022) is presented in **Section 9.5.4.2**.

Consultee	Date	Comment	Response/where addressed in the ES
MMO	21st July 2022	Baseline data sources: The existing datasets used to inform the benthic ecology assessment are provided in Table 8.8 of the draft scoping report. This list of datasets contains relevant and useful information from nearby developments and studies. The MMO recommend the list is checked against the datasets available in the Cefas OneBenthic data extraction tool to ensure other relevant datasets are not excluded.	Publicly available datasets/reports have been obtained through online resources. A full list of the data sources used in this assessment is provided in **Section 9.4.2.2** including the OneBenthic resource.
PINS (ref. 3.3.9)	2nd August 2022	Baseline Survey: The Scoping Report states that the benthic surveys were carried out in accordance with the guidance listed and that a detailed method statement was presented to stakeholders as part of the EPP. In the absence of information on the precise methods used, and the rationale behind the approach to sampling and the areas covered by the survey, it is difficult for the Inspectorate to understand if the baseline data is likely to be adequate. The ES should either demonstrate that the adequacy of the baseline data has been agreed through the EPP (with supporting information e.g. meeting minutes) or present a detailed justification as to why it is considered adequate.	The 2022 benthic survey methodology is outlined in **Section 9.4.2.1**, with full detail provided in the accompanying Morecambe Benthic Characterisation Survey Report (**Appendix 9.1**) which includes comments received by stakeholders and how these have been addressed. **Section 9.5** details the existing environment which, given the range of publicly available data and site-specific surveys, is considered adequate in terms of spatial and temporal coverage. No comments in relation to the baseline data were raised in Section 42 statutory consultation responses on the PEIR.
Natural England	21st July 2022	Baseline Survey: Natural England has provided discretionary advice to the Applicant on the benthic survey plan.	Noted. Comments provided by Natural England are highlighted (and responded to) within **Appendix 9.1**.
Natural England	21st July 2022	Baseline Survey: No detail has been given on data analysis for the benthic survey. Consult NE and the relevant ETG on the analysis of these data.	Data analysis methodology has been discussed as part of the EPP ETG, with full detail provided in the accompanying

Consultee	Date	Comment	Response/where addressed in the ES
			Morecambe Benthic Characterisation Survey Report (**Appendix 9.1**).
MMO (ref. 3.2.2)	21st July 2022	Baseline Survey: In addition to the existing datasets a series of geophysical, grab and video sampling surveys will also be conducted to identify benthic habitats and features. This approach is suitable and like that expected of other developments of this nature.	Noted within **Appendix 9.1**.
MMO (ref. 3.2.7)	21st July 2022	Baseline Survey: The MMO notes that the relevant datasets have been identified and acoustic and benthic (sediment sampling and imagery) surveys have been conducted with the Morecambe Offshore Wind Farm (OWF) area to address data gaps and to better characterise the benthic assemblage.	Noted within **Appendix 9.1**.
PINS (ref. 3.3.10)	2nd August 2022	Assessment methodology: The Scoping Report states that where information is unavailable relating to key species, proxy species with similar ecological features may be used in the assessment. The ES should explain (with supporting evidence) to what extent this approach has been agreed with the marine expert working group of the EPP.	Sensitive macrofauna (i.e. features of conservation interest or other ecological/conservation priority) were not identified during the 2022 benthic surveys of the site, nor from other studies that overlap with the study area. Assessments were based on biotopes recorded, as the sensitivity of characterising taxa of such biotopes would be captured by this assessment. MarESA assessment detail was available for all biotopes identified, hence proxies were not required.
PINS (ref. 3.3.11)	2nd August 2022	Assessment methodology: Where the duration of impacts is being determined with reference to the time for recovery for various receptors, the ES should explain what evidence is being relied on to reach conclusions about the likely recovery time for recovery from impacts.	In general, MarESA sensitivity assessments are based on resistance and resilience (i.e., capability of recovering) of a receptor. Full detail on this is provided for each biotope in

Consultee	Date	Comment	Response/where addressed in the ES
			Appendix 9.2. Where supplementary information (e.g. from post-construction monitoring at other offshore windfarms (OWFs)) is used in the assessment, it is referenced in the relevant section.
Natural England	21st July 2022	Assessment methodology: The study area only covers the areas of the OWF. Scoping in a wider area may be useful in consideration of indirect habitats. Consider data from a wider area within the PEIR and ES.	The Zone of Influence (ZoI) used for this assessment extends 15km from the windfarm site boundary in all directions, encompassing the tidal ellipse. The study area, for which existing data sources have been used to define the baseline goes beyond the ZoI to encompass the wider region. Further detail is provided in **Section 9.3.1**.
MMO (ref. 3.2.9)	21st July 2022	Assessment methodology: The MMO notes that an updated version (1.1) of the guidance document referenced in line 263 of the Scoping Report is available and recommend the Applicant confirms the most recent version is used for the assessment and referenced accordingly.	The most recent version of the Chartered Institute of Ecology and Environmental Management (CIEEM) guidance is referred to in this assessment (i.e., version 1.2, April 2022).
Natural England	21st July 2022	Physical disturbance and habitat loss: It is hard to ascertain the relative footprint when details of construction and cabling are not yet known. Will also depend on specific habitat in the location, and how this compares to habitat extent in the wider area. To note and refine in the ES when the parameters of the project and affected habitats are better understood.	Worst-case parameters (in terms of e.g., project footprint) are presented in **Section 9.3.2**.
PINS (ref 3.3.1)	2nd August 2022	Physical presence of infrastructure (change in habitat type): As described in the Scoping Report, this effect is expected only to arise in the operational phase when the sub-sea structures such as the foundations and cable/scour	The approach taken in this assessment is to scope out the presence of infrastructure in the decommissioning phase and cover off this eventuality by

Consultee	Date	Comment	Response/where addressed in the ES
		protection are in place. The Inspectorate agrees that this matter can be scoped out of further assessment for the construction phase. However, in the absence of detailed information on the extent to which sub-sea structures would be left in place after decommissioning, the Inspectorate is not in a position to agree to scope this matter out of further assessment. Accordingly, the ES should include an assessment of these matters or information demonstrating agreement with the relevant consultation bodies and the absence of Likely Significant Effects (LSE).	treating physical presence during the operation and maintenance phase as a permanent impact. The decommissioning phase impact instead looks at the potential impact of a further change in habitat type in the event of infrastructure removal.
PINS (ref. 3.3.12)	2nd August 2022	Physical presence of infrastructure (change in habitat type): The Scoping Report states that as part of the assessment of the presence of sub-sea structures [during the operation phase], potential indirect effects from localised changes in hydrodynamic/sedimentary processes would also be taken into account. However, the Scoping Report does not explain how this would be done. The Inspectorate is concerned that combining two different effects (colonisation of sub-sea structures and habitat loss/disturbance as a result of hydrodynamic/sedimentation changes) will be confusing. The ES should clearly distinguish between the two different impacts and their effects on benthic ecology.	Direct effects arising from the presence of structures and indirect effects from localised hydrodynamic/sedimentary changes are assessed separately, in **Sections 9.6.4.1** and **9.6.4.2**, respectively.
Natural England	21st July 2022	Physical presence of infrastructure (change in habitat type): The surface area introduced by the turbine foundations is substantially greater than that lost under the footprint of the turbine. This will vary depending on foundation type, but it is not an insignificant change. Lindeboom *et al.*, 2011, is dated and there are still gaps in our knowledge with work still ongoing to understand how OWF construction and operation affects benthic habitats and communities. Further consideration of the total area of habitat introduced should	The assessments set out in this report are based on realistic worst-case parameters relating to the footprint of the project (a Rochdale envelope approach that takes into account a variety of foundation types), see **Section 9.3.2**.

Consultee	Date	Comment	Response/where addressed in the ES
		be made in the ES when the parameters of the project are better understood.	
PINS (ref. 3.3.2)	2nd August 2022	Remobilisation of contaminated sediments: The Scoping Report notes that if the benthic sampling demonstrates low levels of contamination, then this matter would be scoped out of further assessment through the EPP. The Inspectorate agrees that if this approach is agreed through the EPP then this matter can be scoped out of further assessment. However, the specific contamination levels recorded through benthic sampling should still be provided as an annex to the ES.	Benthic sampling across the OWF site has indicated low levels of contaminants, all below environmental thresholds (Cefas Action level 1 and the US Environmental Protection Agency ERLs). Further detail, including recorded contamination levels, is provided in **Chapter 8 Marine Sediment and Water Quality** and **Appendix 9.1**. This impact is scoped out, as justified in **Section 9.6.3.2**, which has been agreed by Natural England (ref DAS/UDS-A001761/364191).
PINS (ref. 3.3.3)	2nd August 2022	Introduction and colonisation of invasive non-native species (INNS): The Scoping Report identifies this matter as something that will be assessed but Table 8.10 scopes it out for construction and decommissioning. For the avoidance of doubt, the risk of introducing INNS during construction and decommissioning should be assessed in the ES.	The risk of INNS introduction in the construction and decommissioning phases are considered in **Sections 9.6.3.4** and **9.6.5.5**.
MMO (ref. 3.2.4)	21st July 2022	Introduction and colonisation of INNS: While most of the relevant impacts have been scoped in, the MMO requires clarification regarding the scoping out of the impact of INNS from the construction phase of the development. Line 278 of the Scoping Report acknowledges that INNS are relevant at the construction phase, but the summary table (Table 8.10) excludes the impact from INNS from the construction stage (but includes the impact from INNS in the operation and maintenance phase). The increased presence of vessels in the area (particularly those used during construction that may operate globally) may lead to the introduction of INNS	As above.

Consultee	Date	Comment	Response/where addressed in the ES
		during construction and therefore appropriate mitigations and further evidence would be needed to scope this impact out.	
PINS (ref. 3.3.4)	2nd August 2022	Effects on water quality due to spillages and leakages: The Scoping Report proposes to scope out accidental pollution resulting from the construction and operation of the Proposed Development. The Inspectorate agrees that such effects are capable of mitigation through standard management practices and can be scoped out of the assessment. The ES should provide details of the proposed mitigation measures to be included in the Project Environment Management Plan and Marine Pollution Contingency Plan.	Details of the measures in place to prevent accidental pollution arising from construction/operational and maintenance activities are provided in **Chapter 8 Marine Sediment and Water Quality**. To summarise, all vessels involved would be required to comply with international legislation for pollution prevention and a Marine Pollution Contingency Plan (developed in consultation with stakeholders) would be in place. An outline Project Environmental Management Plan (PEMP) (Document Reference 6.2) is provided as part of the DCO Application.
PINS (ref. 3.3.5)	2nd August 2022	Effects from Electro Magnetic Fields (EMF) during operation: The Scoping Report cites various studies which show that various benthic species do not respond to EMF. However, it does not explain whether the cable burial depth in these studies is similar to the cable burial depth for the Proposed Development. In the absence of information such as evidence demonstrating clear agreement with relevant statutory bodies, the Inspectorate is not in a position to agree to scope these matters from the assessment. Accordingly, the ES should include an assessment of these matters or the information referred to demonstrating agreement with the relevant consultation bodies and the absence of LSE. The Applicant's attention is also drawn to comments from NE on this point.	An assessment of the potential effects of EMF during operation is provided in **Section 9.6.4.3**.

Consultee	Date	Comment	Response/where addressed in the ES
Natural England	21st July 2022	Effects from EMF during operation: We do not agree that impacts to benthic invertebrates due to EMF should be scoped out at this stage. We note this issue is covered in a draft revised energy NPS that was consulted on in late 2021.	As above.
MMO (ref. 3.2.3)	21st July 2022	Effects from EMF during operation: The Scoping Report includes relevant literature and the MMO agree with the scoping decision made regarding the interaction of the benthos with EMF. However, the MMO recommend the applicant refers to Scott *et al.*, 2021, which contains additional evidence for scoping out the impacts of EMF. The MMO recommend that the Applicant provides further evidence to support the decision to scope out the effects of EMF from the EIA.	As above.
PINS (ref. 3.3.6)	2nd August 2022	Underwater noise during operation: The Scoping Report seeks to scope this matter out on the grounds that monitoring studies from several operational OWFs demonstrate that levels of noise and vibration during operation are only marginally above ambient noise levels. However, the Inspectorate notes that NE do not consider the available evidence to be conclusive. In addition, the size of turbines likely to be installed may be considerable larger than those assessed in the monitoring studies. In the absence of information such as evidence demonstrating clear agreement with relevant statutory bodies, the Inspectorate is not in a position to agree to scope these matters from the assessment. Accordingly, the ES should include an assessment of these matters or the information referred to demonstrating agreement with the relevant consultation bodies and the absence of LSE.	The assessment of effects of underwater noise and vibration during the operation and maintenance phase is provided in **Section 9.6.4.7**.

Consultee	Date	Comment	Response/where addressed in the ES
Natural England	21st July 2022	Underwater noise during operation: Evidence for the effects of underwater noise on benthic fauna is inconclusive. Underwater noise should not be scoped out at this stage and should be considered in the ES.	As above.
MMO (ref. 3.2.5)	21st July 2022	Underwater noise during operation: The MMO notes that the latest literature will be included in the ES regarding the impact of noise and vibration and the Scoping Report refers to recent and appropriate literature (Stöber and Thomsen, 2021).	As above.
PINS (ref. 3.3.13)	2nd August 2022	Increased sedimentation deposition from maintenance during operation: It is not clear from the wording of the Scoping Report if the intention is to assess this impact or scope it out of further consideration. For the avoidance of doubt, this impact should either be assessed in the ES or a justification should be provided as to why significant environmental effects are unlikely.	The effects of sediment disturbance and subsequent settlement is assessed in **Section 9.6.4.5**
PINS (ref. 3.3.14)	2nd August 2022	Temperature changes from the presence and operation of cables have not been discussed in the Scoping Report and it is unclear whether this would have an impact on benthic communities. The ES should determine if there would be any temperature changes as a result of cable presence and assess any impacts on benthic communities where they are likely to occur.	The effects of increased temperature at subsea cables during the operation and maintenance phase is provided in **Section 9.6.4.4**.
Natural England	21st July 2022	Potential for localised benthic temperature changes has not been considered. Include in PEIR.	As above.
Natural England	21st July 2022	In conjunction with the information to be gathered on the proposed offshore array through survey work, the ES should include details on the following technical aspects relating to the construction and operation of the Morecambe OWF:	A summary of the worst-case design parameters (in terms of effects on benthic ecology) is provided in **Section 9.3.2**. Full details of the Project are provided in **Chapter 5 Project**

Consultee	Date	Comment	Response/where addressed in the ES
		- Footprint of area affected by inter-array electrical cables - Footprint of area affected by inter-array cable protection - Estimation of EMF potentially arising from cables both at exterior or cables and at surface of seabed above buried cables - Footprint of area affected by installation of WTG foundations - Footprint of area affected by installation vessels - Duration and rate of cable-laying - Number and types of vessels to be used in cable-laying operations - Routes of vessels for cable works	**Description**. This includes information on footprints and vessels.
PINS (3.3.7)	2nd August 2022	Transboundary effects: The Scoping Report seeks to scope this matter out on the grounds that the effects of the Proposed Development would not occur beyond English waters. The Inspectorate agrees that effects on EEA States are unlikely to occur and this matter can be scoped out of further assessment.	Transboundary effects are scoped out of the assessment.
MMO (ref. 3.2.5)	21st July 2022	The Scoping Report proposed that potential impacts on the benthic assemblage at the decommissioning phase are considered at a high level and that the Applicant will carry out a more detailed assessment subsequently to better understand the change to the benthic assemblage at the time of decommissioning. The MMO agree that this approach is appropriate and reasonable.	High level decommissioning effects are assessed in **Section 9.6.5**.

Consultee	Date	Comment	Response/where addressed in the ES
Statutory consultation feedback on the PEIR			
MMO	30th May 2023	N/A	No comments were received, and it was confirmed at the ETG meeting in June 2023 that the MMO and Cefas had reviewed the chapter and had no comments to make.
Natural England	2nd June 2023	Recommend continued use of recent evidence on the effect of noise on benthic communities that may not yet be reflected in NE's Advice on Operations	The latest publicly-available evidence has been used to inform the assessments set out in **Section 9.6.3.3**, **Section 9.6.4.7** and **Section 9.6.5.4**.
Natural England	2nd June 2023	Whilst content that the potential for spread of INNS due to introduction of new infrastructure is recognised, NE note that there is no evidence presented to confirm that the increase of additional infrastructure does not increase the risk. Recommend that monitoring for INNS is implemented following construction to gauge the effect of the new infrastructure.	Mitigation set out in **Section 9.6.4.8** includes the potential for INNS monitoring, which would be taken into consideration when developing post-construction inspection surveys of hard substrate.
Natural England (ref. B3)	2nd June 2023	Number, and spacing of survey stations was adequate, as indicated by the existing evidence, which suggested a fairly homogenous sedimentary environment. However, the distribution of bedforms (as identified in the geophysical survey) and boulders, did not appear to be factored into the selection of survey stations. For example, the video transects were very limited in number, and appeared to be concentrated on the east of the study area. Transects across megaripples, or grab stations positioned on cress and troughs would have given a better indication of possible local variation in the benthic communities present. Recommendation: Natural England advises that when the ground truthing	It is noted that there is no Project overlap with designated sites and that following the reduction of the windfarm site boundary since PEIR, no identified sandwaves are present within the windfarm site and the prevalence of megaripples has reduced. The video transects are all contained within the windfarm site, noting that the western area of survey area (PEIR boundary) is no longer part of the windfarm site. Given the ground conditions within the windfarm site, it is not considered that

Consultee	Date	Comment	Response/where addressed in the ES
		surveys are considered alongside the geophysical surveys there is likely to be sufficient confidence to characterise the seabed and the associated communities. However, preconstruction survey design will need to modified to provide an adequate baseline, particularly where the study area overlaps with designated sites. We advise that any sampling strategy should include representation of potential local variation caused by morphological features such as megaripples, or other bedforms. This will need to be captured in the In Principle Monitoring Plan at the time of submission.	any further ground truthing surveys are required. However, further geophysical surveys would be undertaken pre-construction (as outlined in the In Principle Monitoring Plan (IPMP)).
Manx National Heritage	2nd June 2023	Note the need for protection of the seabed with particular reference to areas of high conservation or carbon sequestration value as highlighted in the Manx Marine Nature Reserves. Also note the need for protection of the seabed from scour and silt.	The 15km ZoI of the Project would not extend into Manx territorial waters or Marine Nature Reserves. See **Sections 9.6.3.2** and **9.6.4.2** for further detail. The assessment presented in **Section 9.6** focuses on habitats of conservation value within the ZoI. Embedded mitigation measures built into the design to reduce the risk of scour and siltation are presented in **Table 9.3~~Table 9.3~~**.
North West Wildlife Trusts	22nd May 2023	Recommend that cables and array areas avoid benthic MPAs [marine protected areas]. Management of cable corridors can serve to mitigate the need for benthic compensation, for example, by excluding damaging activities such as fishing and anchoring.	There is no overlap between the Project and any benthic MPAs. This comment is noted; however, exclusion zones around cable corridors are not being proposed.
North West Wildlife Trusts (ref. A2.3)	22nd May 2023	Concerned to note that the worst-case cumulative area of seabed disturbance (3.5km^2) is underplayed as a 'small' area within the PEIR, and thus of small magnitude for impact assessment.	Note that since the PEIR was issued, the maximum area of disturbance has been refined to approximately 2.4km^2 (see **Table 9.2~~Table 9.2~~** for details). Regardless, 'small' in the sense used in the PEIR (and this ES) is relative; in this

Consultee	Date	Comment	Response/where addressed in the ES
			instance, the affected habitat types are ubiquitous across the wider study area (demonstrated in **Section 9.5.4**), in which context, 2.4km² is a limited area of habitat for the purpose of defining magnitude of impact. If it represented 2.4km² of a scarcer/more vulnerable habitat type, then the magnitude of impact would be greater.
North West Wildlife Trusts (Ref. A2.5)	22nd May 2023	Several strategies could be used to mitigate the effects from EMF, and these should be considered in the design phase of projects. For example, shielding, burial and bundling are recommended.	Wherever practicable, cables would be buried to a target depth of 1.5m. Where ground conditions do not allow burial, cable armour would be laid. Further detail on embedded measures to reduce the risk of EMF are presented in **Table 9.3~~Table 9.3~~**.
North West Wildlife Trusts (Ref. A2.6)	22nd May 2023	Concerned that the baseline conditions already represent a degraded state from its potential, given the 'shifting baseline syndrome'. Biodiversity net gain is essential to achieve through development.	Net gain requirements would be reviewed as legislation linked to the marine environment is progressed. An Environmental Benefit and Net Gain Statement is provided (Document Reference 4.4) as part of the DCO Application. It is considered outside the scope of this ES to consider changes from pre-industrial baseline for impact assessment.
North West Wildlife Trusts (Ref. A2.7 and 9)	22nd May 2023	Fishing should not be considered as part of the baseline and should be included in the Cumulative Effect Assessment. Fishing is a licensable activity that has the potential to have an adverse impact on the marine environment.	As no evidence exists to support a position on what the future trends in fishing activity will look like across the wider region, the current assumption is that fishing would continue at a comparable intensity/rate and inclusion

Consultee	Date	Comment	Response/where addressed in the ES
			in the baseline is considered appropriate. This approach is in line with recent DCO precedent, including Awel y Môr and Hornsea Four OWFs. Should fishing practices materially change at a future date, it would be the responsibility of the competent authority (e.g. MMO, IFCA) to review this in fishing licensing plans.

9.3 Scope

9.3.1 Study area

9.13 The windfarm site (encompassing all Project infrastructure) is located in the Eastern Irish Sea and encompasses a seabed area of 87km^2. It is located approximately 30km from the nearest point on the coast of Lancashire.

9.14 The study area for benthic ecology encompasses the extent of potential effects on benthic receptors (the ZoI), plus the wider subtidal Eastern Irish Sea region (included for context) shown in **Figure 9.1**.

9.15 Direct effects are likely to occur within the offshore footprint of the Generation Assets and construction, operation and maintenance, and decommissioning activity. Such effects would be confined entirely within the windfarm site (i.e the ZoI for these impacts is restricted to the windfarm site). Indirect effects may extend beyond the site boundary, determined by the extent of potential changes to marine physical processes and sediment redeposition, as described in **Chapter 7 Marine Geology, Oceanography and Physical Processes** and **Chapter 8 Marine Sediment and Water Quality**. For indirect effects, a precautionary ZoI incorporating 15km from the windfarm site boundary has been used in this assessment, as this sufficiently encompasses the extent of one excursion of the spring tidal ellipse (10km) (hence the maximum distance to which changes in physical processes and sedimentation could realistically occur).

9.3.2 Realistic worst-case scenario

9.16 The final design of the Project would be confirmed through detailed engineering design studies that would be undertaken post-consent to enable the commencement of construction. To provide a precautionary but robust impact assessment at this stage of the development process, realistic worst-case scenarios have been defined. The realistic worst-case scenario (having the most impact) for each individual impact is derived from the Project Design Envelope (PDE) to ensure that all other design scenarios would have less or the same impact. Further details are provided in **Chapter 6 EIA Methodology**. This approach is common practice for developments of this nature, as set out in PINS Advice Note Nine: Rochdale Envelope (PINS, 2018).

9.17 The realistic worst-case scenarios for the benthic ecology assessment are summarised in **Table 9.2**~~**Table 9.2**~~. These are based on the project parameters described in **Chapter 5 Project Description**, which also provides details regarding specific activities and their durations. The envelope presented has been refined as much as possible between PEIR and ES, presenting a project description with design flexibility only where it is needed.

9.18 A separate marine licence application would be made for the UXO clearance once the scale of UXO clearance required is further understood through detailed surveys and upon refinement of the layout. A high-level assessment is provided in **Section 9.6.3.1** based on the assessment presented in Chapter 7 Marine Geology, Oceanography and Physical Processes which incorporated information from UXO clearance campaigns undertaken at other offshore windfarms.

Table 9.2 Realistic worst-case scenarios for benthic ecology

Impact	Worst-case scenario	Notes and rationale
Construction phase		
Impact 1: Physical disturbance and loss of benthic habitat	**WTG & offshore substation platform (OSP) foundations:** ▪ 35 x WTGs with Gravity Base Structure (GBS) foundations (including jack-up vessel footprint) = 303,625m^2 ▪ Two x OSPs with GBS foundations (including jack-up vessel footprint) = 17,350m^2 ▪ Anchoring for 35 WTGs and two OSPs = 26,640m^2 Total = **347,615m^2**	Given the seabed preparation is the same per foundation for smaller and larger WTGs, the worst-case assumes 35 x smaller WTGs with GBS foundations. GBS foundations are assumed to have a diameter of 65m + 10m disturbance either side. The worst-case scenario is for two jack-up visits per WTG/OSP foundation in different positions over the construction period (each jack-up with 6 legs, each with a 250m^2 footprint). This equates to a total footprint of 1,500m^2 per jack-up vessel visit and 3,000m^2 over the construction period per WTG/OSP foundation. The worst-case scenario is for two anchor positions per foundation (including resetting), with up to 12 anchors per location. Each anchor width is estimated to be 6m, with an approximate seabed footprint of 30m^2 per anchor. It is noted that the area upon which scour protection would be placed is assessed as operation and maintenance Impact 1.
	Inter-array and platform link cables: ▪ Inter-array cables = 1,750,000m^2 ▪ Platform link cables = 250,000m^2 Total = **2,000,000m^2**	The worst-case scenario for physical disturbance for cables is based on a maximum length of 70km of inter-array cables and 10km of platform link cables, with a 25m wide installation corridor in which cable preparation activities may take place (this encompasses pre-lay activities (e.g. boulder removal and deposition), trenching and spoil width).
	Cumulative area of seabed disturbance: 2,347,615m^2 (approximately 2.4km^2)	

Impact	Worst-case scenario	Notes and rationale
Impact 2: Increased SSCs and subsequent deposition	**Sediment displaced during seabed preparation for WTGs and OSPs foundations:** - 35 WTGs with Gravity Based Structures (GBS) foundations = 455,438m^3 - Two OSPs with GBS foundations = 26,025m^3 Total = **481,463m^3**	The seabed preparation area parameters are outlined in Impact 1 above. The seabed preparation area would be dredged to a depth of up to 1.5m. Seabed preparation (e.g. excavation using a trailing suction hopper dredger (TSHD) or other specialist bed leveller/trencher such as mass flow excavation) may be required. This is a volume of sediment that is disturbed prior to installation of WTG/OSP foundation and involves the removal of sediment from the seabed. The worst-case scenario assumes that sediment would be removed and returned to the water column at the sea surface (e.g. during disposal from a dredger vessel[3]) for WTGs and OSPs. Drill arisings from drive-drill-drive installation methodology would result in a lower volume of sediment being disturbed (55,865m^3 – based on monopile foundations), however, are assessed in **Section 9.6.3.2** in relation to area of seabed covered by mounds.
	Sediment displaced during sandwave clearance/levelling for cables: - Inter-array cables = 70,000m^3 - Platform link cables = 10,000m^3	The worst-case length of inter-array cables is 70km and platform link cables is 10km. The worst-case assumes that 10% of the length of inter-array and platform link cables would require sandwave clearance/levelling. A clearance width of 10m and height of 1m is used. The worst case

[3] It is possible that seabed preparation would be undertaken by plough and sediment would therefore not be released at the surface, however disposal at the surface has been retained for the worst-case scenario.

Impact	Worst-case scenario	Notes and rationale
	Total = **80,000m³** **Sediment displaced during cable installation:** ▪ Inter-array cables = 472,500m³ ▪ Platform link cables = 67,500m³ Total = **540,000m³**	assumes sediment would be released at the water surface. The worst-case for cable installation assumes that 50% of inter-array and platform link cables are buried at 3m and 50% length is buried at 1.5m by jetting in a box-shaped trench, with a 3m trench width.
	Cumulative volume of sediment disturbed: 1,101,463m³ (approximately 1.1km³)	
Impact 3: Underwater noise and vibration	**Largest hammer energy** ▪ Diameter of monopiles: 12.0m ▪ Maximum monopile penetration depth: 56m ▪ Maximum hammer driving energy: 6,600 kJ ▪ Number of piled foundations: 37 **Longest duration** ▪ Number of pin pile foundations: 148 (each WTG/OSP foundation has 4 pin piles) ▪ Diameter of pin piles: 3.0m ▪ Maximum hammer driving energy: 2,500 kJ ▪ Duration: 1 pin pile = 4 hours 30 minutes duration. 4 pin piles = 18 hours duration (per foundation). Total duration is 666 hours for all WTGs & OSPs	Larger WTGs require a greater pile diameter than smaller WTGs and therefore would generate more noise for a given hammer driving energy. This assessment assumes the largest pile diameter (12m) for WTGs and OSPs and is therefore precautionary. Pin piles are the worst-case scenario in terms of the length of time likely to be taken for installation.
Impact 4: Introduction and colonisation of INNS	Maximum number of return trips for vessels per year: **2,583** Maximum number of vessels on site at any time: **37**	The risk of introducing INNS during construction primarily relates to vessel activities, should vessels come from other marine bioregions. The worst-case represents the maximum number of vessels, and it is noted that not all vessels would come

Impact	Worst-case scenario	Notes and rationale
		from other bioregions and once on site would remain for a period of time.
Operation and maintenance phase		
	Seabed footprint of WTG/OSP foundations: ▪ 35 x GBS WTGs with scour protection = 248,080m² ▪ Two GBS OSPs with scour protection = 14,176m² Total = **262,256m²**	The worst-case scenario assumes 35 x WTGs and two x OSPs (each with a 65m diameter conical GBS foundation, plus scour protection extending 15m from foundations in all directions).
Impact 1: Change in habitat type due to presence of Project subsurface infrastructure	**Seabed footprint of cable protection:** ▪ Inter-array cables = 91,000m² ▪ Platform link cables = 13,000m² ▪ Entry to WTGs and OSPs = 45,500m² Total = **149,500m²**	The worst-case is based on 70km of inter-array cables and 10km of platform link cables. Assumes 10% of cable length is unburied due to ground conditions with a 13m cable protection width at the base and 2m height. The worst-case for cable protection for the entry to WTGs and OSPs assumes 70 points of entry, each with a length of cable protection of 50m, width at the base of 13m. The seabed footprint of cable protection per entry point is 650m².
	Footprint of cable/pipeline crossings: ▪ Inter-array cable/pipeline crossings (9) = 40,050m² ▪ Platform link cable/pipeline crossings (6) = 26,700m² Total = **66,750m²**	The worst-case for cable/pipeline crossings is based on nine cable/pipeline crossings across inter-array cables and six cable/pipeline crossings across platform link cables. Assumes each crossing footprint is 4,450m² (17.8m width at the base, 250m length and 2.8m in height).

Impact	Worst-case scenario	Notes and rationale
	Replacement scour protection and cable protection material: ▪ Scour protection = 13,950m^2 ▪ Cable protection including crossings and entries to WTGs/OSPs) = 21,625m^2 Total = **35,575m^2**	It is assumed that up to 10% of the total scour protection and cable protection material installed during construction would be required to be replaced or replenished during the operation and maintenance phase. It is assumed that all replacement scour protection and cable protection material would be placed within the same footprint as outlined above.
	Total subsurface infrastructure footprint: 514,081^2 (approximately 0.51km^2)	
Impact 2: Change in hydrodynamic conditions due to presence of Project subsurface infrastructure	As per operation Impact 1.	
Impact 3: EMF from subsea cables	**Inter-array & platform link cables** ▪ Target burial depth of 1.5m (burial range 0.5-3.0m) ▪ 70km of inter-array and 10km of platform link ▪ 66kV or 132kV (inter-array cables) and up to 275kV (platform link cables)	The maximum length of cables would result in the greatest potential for EMF-related effects. It should be noted that where cables are unable to be buried, they would instead be protected which would afford a degree of attenuation of EMF.
Impact 4: Increase in seabed temperature from subsea cables	As per operation Impact 3.	
Impact 5: Temporary physical disturbance of the seabed during operational and maintenance activities.	**Jack-up vessel deployments:** ▪ Jack-up vessel footprint every other year = 1,500m^2	The worst-case scenario for jack-up deployments assumes the use of one jack-up vessel with a seabed footprint of 1,500m^2 (up to six legs, each with a footprint of up to 250m^2) every other year. The worst-case is based on an average of 200m of cable repaired/replaced every year and an average of

Impact	Worst-case scenario	Notes and rationale
	Cable repair/replacement and reburial: - Average cable repair/replacement footprint per year = 2,000m² - Average cable reburial footprint per year = 1,000m² **Anchoring:** - Average temporary anchor footprint per year = 720m² Total per year (noting jack-ups are only assumed every other year) = **5,220m²** Total over operational period = **155,700m²**	100m of cable reburied every year, with a 10m disturbance width. The worst-case for anchoring is anticipated to be on average one anchoring event per year. It is noted that the total disturbance over the 35-year operational period is based on yearly averages and thus assesses for example that there may be no cable repair in one year and then longer lengths of cable repair/replacement and/or reburial in other years.
Impact 6: Temporary increases in SSCs /sedimentation during operational and maintenance activities	See operation and maintenance Impact 5: Temporary habitat loss/disturbance. **Sediment displaced during cable repair/replacement and reburial every year:** - Average cable repair or replacement sediment volume = 6,000m³ - Average cable reburial sediment volume = 3,000m³ Total disturbed per year (on average) = **9,000m³** Total over operational period = **315,000m³**	Temporary increases in SSCs would result from periodic jack-up vessel deployment, and cable repair, replacement and reburial activities. The worst case assumes on average 200m of cables would be repaired/replaced every year, with a 10m disturbance width and 3m maximum depth for a box-shaped trench. The worst case assumes up to 100m of cable would be reburied every year, with a 10m disturbance width and 3m maximum depth for a box-shaped trench. It is noted that the total volume over the 35-year operational period is based on yearly averages and thus assesses for example that there may be no cable repair in one year and then longer lengths of cable repair/replacement and/or reburial in other years. The volume of sediment that could be suspended due to the presence of jack-up vessels has not been calculated but would be a much smaller proportion

Impact	Worst-case scenario	Notes and rationale
		compared to the quantity generated by construction and decommissioning activities.
Impact 7: Underwater noise and vibration	30 x larger WTGs in operation.	Underwater noise in operation and maintenance phase would principally arise from mechanical forces within the nacelle of WTGs. Such forces are generally greater in larger turbines (Tougaard *et al.*, 2020), hence the worst-case scenario is based on the operation of 30 x largest WTGs.
Impact 8: Colonisation of infrastructure by INNS	Area of new substrate: As per operation and maintenance Impact 1. Maximum number of operation vessels on site at any one time: **3 vessels** during a standard year, or **10 vessels** during a heavy maintenance year. Maximum number of vessels return trips from windfarm site to port per year: **384 vessel return trips** during a standard year, or **832 vessel return trips** during a heavy maintenance year.	The risk of introducing INNS during operation and maintenance is primarily related to vessel activities, should vessels come from other marine bioregions. The presence of introduced hard substrate has the potential to encourage colonisation of invasive epifaunal species.
Decommissioning phase		
Impact 1: Removal of introduced hard substratum	**Footprint of hard structures/substrate that would be removed:** ▪ 35 x WTGs plus two x OSPs with GBS foundations (including scour protection) = 262,256m^2 ▪ Cable protection (including inter-array cable protection, platform link cable protection and entry to WTG/OSPs) = 149,500m^2 ▪ Cable/pipeline crossings = 66,750m^2 ▪ Replacement of scour protection and cable protection material = 35,575m^2	The decommissioning policy for the offshore project infrastructure is not yet defined. While it is likely that some elements would be left *in situ*, particularly scour protection and cable protection, for the purpose of the assessment of decommissioning Impact 1 it is assumed that all introduced above seabed hard structure/substrate would be removed. Worst case assumptions are outlined in operation and maintenance Impact 1.

Impact	Worst-case scenario	Notes and rationale
	Total = **514,081m^2 (approximately 0.51km^2)**	
Impact 2: Physical disturbance to seabed habitats	As per construction Impact 1.	For the purposes of the worst-case scenario, it is anticipated that the impacts would be comparable to those identified for the construction phase.
Impact 3: Increases in SSCs and subsequent deposition	As per construction Impact 2.	

9.3.3 Summary of mitigation embedded in the design

9.19 This section outlines the embedded mitigation relevant to the benthic ecology assessment, which has been incorporated into the design of the Project (Table 9.3~~Table 9.3~~). Where additional mitigation measures are proposed, these are detailed in the impact assessment (**Section 9.6** and **Section 9.7**).

Table 9.3 Embedded mitigation measures

Parameter	Mitigation measures embedded into the design of the Project
WTG spacing	A minimum separation distance of up to 1,060m has been defined between adjacent WTGs within the same row and 1,410m between each row, minimising the potential for interaction between adjacent WTGs with respect to marine physical process and consequent effects on benthic communities.
Seabed preparation	Micro-siting would be used (for foundations and cable installation) where possible to minimise the requirements for seabed preparation prior to foundation and cable installation.
Scour protection	Scour protection is built into the design for each foundation type in consideration and, where installed after the foundation, it would be installed as early as practicable (typically within the same season) after the foundation installation.
Cables	Cables would be buried where possible. The cable burial range would be between 0.5m and 3.0m below the seabed (with a target depth of 1.5m where ground conditions allow (recognised industry good practice which would reduce effects of electromagnetic fields (EMF))). A CBRA would also be required to confirm the extent to which cable burial can be achieved. Where it is not reasonably practicable to achieve cable burial, additional cable protection may be required. Following industry best-practice the Applicant would seek to minimise the use of cable protection. Cables would be specified to reduce EMF and thermal emissions as per industry standards and best practice, such as the relevant IEC (International Electrotechnical Commission) specifications. To minimise the extent of any unnecessary habitat disturbance, material displaced as a result of cable burial activities would be back-filled, where practicable, in order to promote recovery.
Foundations	The selection of appropriate foundation designs and sizes at each WTG and OSP location would be made following pre-construction surveys within the windfarm site.
	For piled foundation types, such as monopiles and jackets with pin piles, pile-driving would be used in preference to drilling, where it is practicable to do so (i.e. where ground conditions allow). This would minimise the quantity of sub-surface sediment released into the water column from the installation process.
Construction hours	During construction, overnight working practices would be employed offshore so that construction activities could continue 24/7, thereby reducing the overall programme for offshore works and the period in which potential construction related impacts may occur.

Parameter	Mitigation measures embedded into the design of the Project
Biosecurity	Implementation of biosecurity measures in line with international and national regulations and guidance, namely: ▪ International Convention for the Prevention of Pollution from Ships (MARPOL), which sets out the requirements for appropriate vessel maintenance ▪ The Environmental Damage (Prevention and Remediation) (England) Regulations 2015, which set out a 'polluter pays' principle whereby operators who cause a risk of significant damage to water and biodiversity receptors are responsible for i) preventing damage from occurring; and ii) bearing the costs for full reinstation of the environment (to original condition) in the event of damage occurring ▪ The International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention), which provides an international framework for the control of transfer of potentially invasive species from ballast water These would be listed within the PEMP, an Outline of which is provided as part of the DCO Application (Document Reference 6.2).
Decommissioning	An Offshore Decommissioning Programme would be developed post-consent and implemented at the time of decommissioning.

9.4 Impact assessment methodology

9.4.1 Policy, legislation and guidance

9.4.1.1 National Policy Statements

9.20 The assessment of potential effects on benthic ecology has been made with specific reference to the relevant NPS. These are the principal decision-making documents for Nationally Significant Infrastructure Projects (NSIPs). Those relevant to the Project are:

- Overarching NPS for Energy (EN-1) (Department for Energy Security and Net Zero (DESNZ), 2023a)
- NPS for Renewable Energy Infrastructure (EN-3) (DESNZ, 2023b)

9.21 The specific assessment requirements for benthic ecology, as detailed in the NPS, are summarised in **Table 9.4**~~**Table 9.4**~~, together with an indication of the section of the ES chapter where each is addressed.

Table 9.4 NPS assessment requirements for benthic ecology

NPS requirement	NPS reference	ES reference
NPS for Renewable Energy Infrastructure (EN-3)		
Applicants must undertake a detailed assessment of the offshore ecological, biodiversity and physical impacts of their proposed development, for all phases of the lifespan of that development, in accordance with the appropriate policy for offshore wind farm EIAs, HRAs and MCZ assessments.	Paragraph 2.8.101	An assessment of effects on benthic ecology for the construction, operation/maintenance and decommissioning phases is presented in **Section 9.6** and **Section 9.7**.
Applicants need to consider environmental and biodiversity net gain as set out in Section 4.6 of EN-1 and the Environment Act 2021. Applicants should assess the potential of their proposed development to have net positive effects on marine ecology and biodiversity, as well as negative effects.	Paragraph 2.8.102 – 2.8.103	An Environmental Benefit and Net Gain Statement (Document Reference 4.4) has been submitted as part of the DCO Application.
Applicants should consult at an early stage of pre-application with relevant statutory consultees and energy not-for profit organisations/non governmental organisations as appropriate, on the assessment methodologies, baseline data collection, and potential avoidance, mitigation and compensation options which should be undertaken.	Paragraph 2.8.104	The MMO and Cefas have been consulted with throughout the DCO pre-application process, including via the EPP and consultation on the PEIR (**Section 9.2**).
Applicant assessment of the effects on the subtidal environment should include: ▪ loss of habitat due to foundation type including associated seabed preparation, predicted scour, scour protection and altered sedimentary processes, e.g. sandwave/boulder/UXO clearance ▪ environmental appraisal of inter-array and other offshore transmission and installation/maintenance methods, including predicted loss of habitat due to	Paragraph 2.8.126	An assessment of effects on the subtidal environment is set out in **Section 9.6** and **Section 9.7**.

NPS requirement	NPS reference	ES reference
predicted scour and scour/cable protection and sandwave/boulder/UXO clearance ▪ habitat disturbance from construction and maintenance/repair vessels' extendable legs and anchors ▪ increased suspended sediment loads during construction and from maintenance/repairs ▪ predicted rates at which the subtidal zone might recover from temporary effects ▪ potential impacts from EMF on benthic fauna ▪ potential impacts upon natural ecosystem functioning ▪ protected sites; and ▪ potential for invasive/non-native species introduction.		
Applicants should design construction, maintenance and decommissioning methods appropriately to minimise effects on subtidal habitats, taking into account other constraints. Mitigation measures which applicants are expected to have considered include: ▪ surveying and micrositing of the turbines, designing array layout, or re-routing of the export and inter-array cables to avoid adverse effects on sensitive/protected habitats, biogenic reefs or protected species; ▪ Reducing as much as possible the amount of infrastructure that will cause habitat loss in sensitive/protected habitats; ▪ burying cables at a sufficient depth, taking into account other constraints, to allow the seabed to recover to its natural state; and ▪ the use of anti-fouling paint could be minimised on subtidal surfaces in certain environments, to encourage	Paragraph 2.8.233 – 2.8.234	Embedded mitigation measures are set out in **Section 9.3.3**. Where applicable, other mitigation measures required to reduce the risk of significant adverse effects on benthos are detailed in the corresponding subsections in **Section 9.6** and **Section 9.7**.

NPS requirement	NPS reference	ES reference
species' colonisation on the structures, unless this is within a soft sediment MPA and thus would allow colonisation by species that would not normally be present.		
NPS for Energy (EN-1)		
Where the development is subject to EIA, the applicant should ensure that the ES clearly sets out any effects on internationally, nationally, and locally designated sites of ecological or geological conservation importance (including those outside England), on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity, including irreplaceable habitats.	Paragraph 5.4.17	An assessment of effects on benthic features of marine designated sites and other benthic habitats/species of principal importance is presented in **Section 9.6** and **Section 9.7**.
The applicant should show how the project has taken advantage of opportunities to conserve and enhance biodiversity and geological conservation interests.	Paragraph 5.4.19	An Environmental Benefit and Net Gain Statement (Document Reference 4.4) has been submitted as part of the DCO Application.
The design process should embed opportunities for nature inclusive design. Energy infrastructure projects have the potential to deliver significant benefits and enhancements beyond Biodiversity Net Gain, which result in wider environmental gains (see Section 4.6 on Environmental and Biodiversity Net Gain). The scope of potential gains will be dependent on the type, scale, and location of each project.	Paragraph 5.4.21	
Applicants should include appropriate avoidance, mitigation, compensation and enhancement measures as an integral part of the proposed development. In particular, the applicant should demonstrate that: ▪ during construction, they will seek to ensure that activities will be confined to the minimum areas required for the works	Paragraph 5.4.35	Embedded mitigation measures are set out in **Section 9.3.3**. Where applicable, other mitigation measures required to reduce the risk of significant adverse effects on benthos are detailed in the corresponding subsections in **Section 9.6** and **Section 9.7**.

NPS requirement	NPS reference	ES reference
▪ the timing of construction has been planned to avoid or limit disturbance ▪ during construction and operation best practice will be followed to ensure that risk of disturbance or damage to species or habitats is minimised, including as a consequence of transport access arrangements ▪ habitats will, where practicable, be restored after construction works have finished ▪ opportunities will be taken to enhance existing habitats rather than replace them, and where practicable, create new habitats of value within the site landscaping proposals. Where habitat creation is required as mitigation, compensation, or enhancement, the location and quality will be of key importance. In this regard habitat creation should be focused on areas where the most ecological and ecosystems benefits can be realised. ▪ mitigations required as a result of legal protection of habitats or species will be complied with.		An Environmental Benefit and Net Gain Statement (Document Reference 4.4) has also been submitted as part of the DCO Application.
The applicant should be particularly careful to identify any effects of physical changes on the integrity and special features of Marine Protected Areas (MPAs). These could include MCZs, habitat sites including Special Areas of Conservation and Special Protection Areas with marine features, Ramsar Sites, Sites of Community Importance, and SSSIs with marine features.	Paragraph 5.6.13	The designated sites assessed in this chapter are outlined in **Section 9.6.1**, followed by an assessment of effects in **Sections 9.6.3 - 9.7.**

9.4.1.2 Nature conservation legislation

9.22 UK legislation concerning marine habitats and species includes the following:

- The Conservation of Habitats and Species Regulations 2017 (as amended)[4]
- The Conservation of Offshore Marine Habitats and Species Regulations 2017
- The Marine and Coastal Access Act 2009 (MCAA)
- Marine Annex I habitats (i.e. marine habitats that are listed under Annex I of the Habitats Directive as natural habitats types of community interest)
- Annex II species (i.e. marine species that are listed under Annex II of the Habitats Directive as animal and plant species of community interest)

9.23 For benthic ecology relevant European sites are Special Areas of Conservations (SAC). Habitats Regulations Assessment (HRA) is a necessary component of any marine development wherein there may be adverse effects on the status of qualifying features that consequently jeopardise achievement of SAC conservation objectives.

9.24 Under the MCAA, Marine Conservation Zones (MCZs) have been designated in English and Welsh marine areas. MCZs are intended to conserve functioning marine ecosystems by affording protection to broadscale habitats and features of conservation interest (FOCI). MCZ assessment is a necessary component of marine development wherein there may be adverse effects on the status of qualifying features that consequently jeopardise MCZ conservation objectives.

9.25 In line with the above, this chapter is supplemented by a Report to Inform the Appropriate Assessment (RIAA) and a MCZ Assessment Report.

[4] As amended by the Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019

9.4.1.3 Marine policy: North West Inshore and North West Offshore Marine Plan

9.26 The North West Marine Plan[5] has built on the Marine Policy Statement to provide marine development policies specific to the North West inshore and offshore areas. Full detail is provided in **Chapter 3 Policy and Legislation** (Document Reference 5.1.3). Policies relevant to the topic of benthic ecology are listed below:

- NW-MPA-1: Proposals that may have adverse impacts on the objectives of marine protected areas must demonstrate that they will, in order of preference, (a) avoid; (b) minimise; (c) mitgate adverse impacts, with due regard given to statutory advice on an ecologically coherent network.
- NW-BIO-1: Proposals that may have significant adverse impacts on the distribution of priority habitats and priority species must demonstrate that they will, in order of preference, (a) avoid; (b) minimise; (c) mitigate adverse impacts so that they are no longer significant; and (d) compensate for significant adverse impacts that cannot be mitigated.
- NW-BIO-2: Proposals that may cause significant adverse impacts on native species or habitat adaptation or connectivity, or native species migration, must demonstrate that they will, in order of preference, (a) avoid; (b) minimise; (c) mitigate adverse impacts so that they are no longer significant; and (d) compensate for significant adverse impacts that cannot be mitigated.
- NW-INNS-1: Proposals must put in place appropriate measures to avoid or minimise significant adverse impacts that would arise through the introduction and transport of INNS, particularly when (1) moving equipment, boats or livestock from one water body to another; (2) introducing structures suitable for settlement of INNS, or the spread of INNS known to exist in the area.

9.27 The assessment of effects presented in **Sections 9.6** and **9.7** provides the information required to demonstrate that the Project is compliant with the above policies.

[5] https://www.gov.uk/government/publications/the-north-west-marine-plans-documents

9.4.2 Data and information sources

9.4.2.1 Site-specific benthic characterisation survey

9.28 In order to provide site-specific and up-to-date baseline information on which to base the impact assessment, a benthic characterisation survey was undertaken by Ocean Ecology Limited (OEL) in May/June 2022. The full survey report produced by OEL is provided as **Appendix 9.1**.

9.29 The survey included a total of 50 sampling stations distributed across the 125km^2 survey area (the windfarm site assessed in PEIR). With a subsequent reduction in the windfarm site boundary since PEIR (as described in **Chapter 4 Site Selection and Assessment of Alternatives**), this now represents 36 stations within the reduced (87km^2) windfarm site and a further 14 stations within 5km of the western boundary. At each station, a sediment sample was collected by 0.1m^2 benthic Day Grab for the purpose of analysing macrofaunal abundance/biomass and particle size distribution (PSD). At 20 of the 50 sampling stations (including 14 of the 36 stations within the reduced windfarm site), an additional sample was taken in order to test for a suite of contaminants. In advance of the grab samples being collected, drop-down camera (DDC) methodology was employed for the purpose of i) assessing the suitability of the station for collection of the grab sample; and ii) assessing the epifauna and habitat types present at each.

9.30 In addition to the grab sample and DDC imagery (video and stills) from each station, DDC imagery was obtained from four transects within the windfarm site in order to ground-truth geophysical (side-scan sonar and multibeam bathymetry) data from a survey undertaken in November 2021.

9.31 Locations of the 50 grab sample/DDC stations and the four DDC transects are presented in **Figure 9.2**.

9.32 All elutriation, extraction, identification and enumeration of macrobenthos in the grab samples was undertaken in line with the National Marine Biological Control Scheme (NMBAQC) Processing Requirement Protocol (Worsfold and Hall, 2010). Biomass data was presented per major taxonomic group (Annelida, Crustacea, Mollusca, Echinodermata and Miscellaneous taxa) as ash-free dry weight, following conversion from blotted wet weight, using standard conversion factors (Eleftheriou and Basford, 1989).

9.33 European Nature Information System (EUNIS) habitat and biotope classifications were assigned, based on the distribution of distinct macrobenthic assemblage groupings identified from multivariate analysis of the macrofaunal abundance data, alongside supporting evidence from PSD analysis and DDC imagery.

9.34 DDC imagery analysis was undertaken in line with Joint Nature Conservation Committee (JNCC) epibiota remote monitoring interpretation guidelines (Turner *et al.*, 2016), with consideration of the latest NMBAQC/JNCC Epibiota Quality Assurance Framework guidance and identification protocols (NMBAQC, 2022). An Annex I habitat assessment was undertaken on the DDC imagery to determine whether any habitats present met the criteria for definition as Annex I geogenic or biogenic reef.

9.4.2.2 Other available data sources

9.35 To provide further information on the benthic environment within the 15km ZoI, as well as providing context with regard to benthic habitats in the wider Eastern Irish Sea marine study area, the data sources listed in **Table 9.5**~~**Table 9.5**~~ were interrogated. Note, there is a lower level of confidence with older data sources, however these are still presented to supplement the more recent surveys in **Section 9.5**.

9.36 Given the interconnected nature of the Project and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets, the benthic subtidal baseline survey for the Transmission Assets PEIR has also been used to inform this chapter (Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023a).

Table 9.5 Existing data sources used in this chapter

Data source	Date	Data contents
EUSeaMap 2021 (EMODNet Seabed Habitats Consortium, 2022)	2021	This is the fifth iteration of the EUSeaMap. All versions have been produced as part of the EMODNet Seabed Habitats project, which provides regional baseline mapping derived from data from consortium members (in this instance JNCC).
NBN Atlas	2022	NBN Atlas provides a depository for species recordings across the UK. All data available from the study area is taken from a 2015 benthic characterisation survey undertaken by Natural England and the EA at Fylde MCZ (considered separately below).
Regional Seabed Monitoring Plan (RSMP)	2022	A search of The Crown Estate’s Marine Data Exchange Portal plus datasets from the RSMP and Cefas’ OneBenthic portal was undertaken to find relevant benthic studies in the Irish Sea. Individual studies are described separately in this table.
Cefas OneBenthic		
Marine Data Exchange		

Data source	Date	Data contents
Fylde MCZ Benthic Survey (Miller and Green, 2017)	2015	This benthic grab survey provides macrobenthic community and habitat/biotope information from stations in and around Fylde MCZ, including stations within the 15km ZoI, and was used to improve the evidence base for the MCZ and provide a baseline dataset for future monitoring.
Shell Flat and Lune Deep SAC and Fylde MCZ Interpretation and Mapping (Envision Mapping Ltd., 2014)	2014	This is a habitat mapping study which used historic benthic data sources within Shell Flat and Lune Deep SAC and Fylde MCZ to identify – to biotope level – habitats within the designations, including locations where they overlap with the 15km ZoI.
Walney OWF Post-construction Monitoring Surveys (CMACS, 2014)	2012 – 2014	Benthic baseline datasets and/or reporting from baseline, pre- and post-construction surveys at other OWFs in the Eastern Irish Sea.
Rhiannon benthic baseline surveys (Celtic Array Ltd., 2014)	2010 – 2012	
West of Duddon Sands OWF Pre-construction Benthic Baseline Survey (CMACS, 2012)	2012	
Gwynt y Môr Pre-construction Benthic Baseline Survey (CMACS, 2011)	2010 – 2011	
Awel y Môr (AyM) Offshore Wind Farm Pre-construction Benthic Baseline Survey (Fugro, 2021)	2020	
Burbo Bank Extension Benthic Characterisation Study (CMACS, 2013)	2011 – 2012	
Mona and Morgan Offshore Wind Projects baseline survey (Mona Offshore Wind Limited, 2023 and Morgan Offshore Wind Limited, 2023)	2021	
Marine Life Network (MarLIN) Marine Evidence-based Sensitivity Assessment (MarESA)	2018	The MarLIN 'evidence base' remains the largest review yet undertaken on the effects of human activities and natural events on marine species and

Data source	Date	Data contents
		habitats and includes evidence-based sensitivity assessments that have been used in the impact assessment. Full details of the MarESA are provided in **Section 9.4.3.1**.
Morgan and Morecambe Offshore Wind Farms: Transmission Assets PEIR and technical appendices (Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023a)	2023	Benthic baseline datasets and/or reporting from baseline, pre- and post-construction surveys at other OWFs in the Eastern Irish Sea.

9.4.3 Impact assessment methodology

9.37 **Chapter 6 EIA Methodology** provides a summary of the general impact assessment methodology applied to the Project. The assessment of effects on benthic ecology is based on the Source-Pathway-Receptor (S-P-R) conceptual model, as described further in **Chapter 7 Marine Geology, Oceanography and Physical Processes**.

9.38 The following key terms have been used in this assessment:

- **Impact** – used to describe a change via the Project (i.e., increased SSCs etc.)
- **Receptor** – used to define the environment being exposed to the Impact (e.g., subtidal sand habitat and associated benthic fauna))
- **Effect** – the consequence of an Impact combining with a Receptor, defined in terms of Significance (exact significance dependant on magnitude of impact and the sensitivity of the receptor)
- **Adverse effect** – an alteration of the existing environment with negative implications for the affected receptor
- **Beneficial effect** – an alteration of the existing environment with positive implications for the affected receptor

9.39 The following sections provide tailored information regarding the specific methodology used to assess the potential impacts on benthic ecology.

9.40 The data and information sources summarised in **Section 9.4.2** have been used to characterise the existing benthic environment within the study area. A description of the baseline is presented in **Section 9.5**, which includes information on the following:

- Seabed sediment characterisation and chemistry

- Macrofaunal communities within the sediment at the windfarm site
- Seabed habitats and biotopes within the study area (including those of particular conservation interest or importance)
- A summary of marine protected areas with benthic features

9.41 A number of impacts which may affect benthic ecology receptors (which have been identified using evidence-based judgement and discussed through the scoping process and EPP) have been assessed in terms of their 'significance' using the methods described below. The outcome of the assessment is presented in **Section 9.6** and **Section 9.7**.

9.42 Assessment of impacts on benthic ecology have followed the guidelines set out in the CIEEM guidance *Guidelines for Ecological Impact Assessment in the UK and Ireland v1.2: Terrestrial, Freshwater, Coastal and Marine* (CIEEM, 2022).

9.4.3.1 Definitions of sensitivity, value and magnitude

Sensitivity

9.43 The approach to defining sensitivity for a given benthic ecology receptor/receptor group differs slightly from the general approach outlined in **Chapter 6 EIA Methodology**. The definitions of sensitivity are based on the MarLIN's MarESA (Tyler-Walters *et al.*, 2018), which determines sensitivity based on resistance (tolerance) and resilience (recoverability). This approach has been agreed through the EPP. Resistance and resilience, in the MarESA assessments, are defined as:

- Resistance: the likelihood of damage (termed intolerance or resistance) due to a pressure
- Resilience: the rate of (or time taken for) recovery (termed recoverability, or resilience) once the pressure has abated or been removed

9.44 The MarESA assessments allot a rating 'level' for both resistance and resilience. Definition of each level is described in Table 9.6~~Table 9.6~~.

Table 9.6 Definitions of resistance and resilience levels used in MarESA

Level	Definition (Tyler-Walters *et al.*, 2018)
Resistance (tolerance)	
None	Key functional, structural, characterizing species severely decline and/or physicochemical parameters are also affected e.g. removal of habitats causing a change in habitat type. A severe decline/reduction relates to the loss of 75% of the extent, density or abundance of the selected species or habitat component (where this can be sensibly applied).
Low	Significant mortality of key and characterizing species with some effects on the physicochemical character of habitat. A significant

Level	Definition (Tyler-Walters *et al.*, 2018)
	decline/reduction relates to the loss of 25-75% of the extent, density, or abundance of the selected species or habitat component.
Medium	Some mortality of species (can be significant where these are not keystone structural/functional and characterizing species) without change to habitats relates to the loss of less than 25% of the species or habitat component.
High	No significant effects on the physicochemical character of habitat and no effect on population viability of key/characterizing species but may affect feeding, respiration and reproduction rates.
Resilience (recovery)	
Very low	Negligible or prolonged recovery possible; at least 25 years to recover structure and function.
Low	Full recovery within 10-25 years.
Medium	Full recovery within 2-10 years.
High	Full recovery within 2 years.

9.45 A matrix-based approach is utilised by the MarESA assessments to determine sensitivity. The sensitivity matrix used in the sensitivity assessments is presented in Table 9.7~~Table 9.7~~.

Table 9.7 MarESA sensitivity matrix

		Resistance			
		None	**Low**	**Medium**	**High**
Resilience	**Very low**	High	High	Medium	Low
	Low	High	High	Medium	Low
	Medium	Medium	Medium	Medium	Low
	High	Medium	Low	Low	Not sensitive

9.46 The MarESA assessment of sensitivity was guided by the presence of key structural or functional species/assemblages and/or those that characterise the biotope assessed. Physical and chemical characteristics are also considered where they structure the community.

9.47 MarESA has been used in order to determine sensitivity of EUNIS[6] level 5 biotopes recorded during the site-specific benthic characterisation surveys, as well as those understood to be present (or potentially present) in the 15km

[6] EUNIS is a widely recognised habitat and biotope classification system developed by the European Environment Agency

ZoI. The sensitivity ratings are presented in the assessment set out in **Section 9.6** and **Section 9.7**. **Appendix 9.2** provides rationale behind the MarESA sensitivity assessment biotopes considered in the assessment.

9.48 The assessment also considers the sensitivity of EUNIS level 3 (habitat and biotope classification system) broadscale habitats, given that these can be attributed to the study area with more confidence than specific biotopes. MarESA sensitivities are not available at EUNIS level 3, hence sensitivity of a given broadscale habitat reflects that of its most sensitive constituent biotope.

9.49 MarESA sensitivities, while useful, do not take into account local evidence regarding habitat resilience and resistance. Where such information is available from post-construction benthic monitoring elsewhere within the general area (i.e. at other offshore windfarms in the Eastern Irish Sea), sensitivities may be modified accordingly.

Value

9.50 The conservation or ecological 'value' of a given receptor forms an important element within the assessment. 'High' value and 'high' sensitivity are not necessarily correlational, as a receptor could be of high value (e.g. a species of significant conservation interest) but have a low physical/ecological sensitivity to an impact or, inversely, a receptor could be of relatively low value but have a high degree of sensitivity. This is judged on a receptor-by-receptor basis. The value of a receptor has been considered, where relevant, as a modifier for the sensitivity level, based on evidence-based judgement. Definitions of 'value' are presented in **Table 9.8~~Table 9.8~~**.

Table 9.8 Definitions of value for benthic ecology receptors

Value	Definition
High	Habitats (and species) protected under international law (e.g. Annex I habitats within a SAC boundary).
Medium	Habitats protected under national law (e.g. Annex I habitats within an MCZ boundary; UK Biodiversity Action Plan (BAP)[7] priority habitats and species). Species/habitat that may be rare or threatened in the UK. Habitats or species that provide prey items for other species of conservation value.
Low	Regional UK Biodiversity Action Plan (BAP) priority habitats.

[7] The UK BAP has been superseded by the UK Post-2010 Biodiversity Framework, though the BAP species and habitats lists have been used to draw up statutory lists of priority species and habitats under Section 41 of the Natural Environment and Rural Communities Act 2006 (England) and Section 7 of the Environment Act (Wales). For brevity, the term 'BAP' habitats and species has been used herein to denote priority habitats and species from statutory lists.

Value	Definition
Negligible	Habitats and species which are not protected under conservation legislation and are not considered to be particularly important or rare.

Magnitude of impact

9.51 Definitions of magnitude used for the purpose of the benthic ecology assessment are in line with those presented in **Chapter 6 EIA Methodology**. The specific definitions used in the assessment herein are outlined in Table 9.9~~Table 9.9~~.

9.52 A key consideration in the definition of 'magnitude' is the spatial scale of an effect (i.e. the extent over which a given receptor is affected). In general, effects on benthic habitats and species are considered in terms of their extent/distribution across the wider Eastern Irish Sea. However, for benthic features of marine designations such as MCZs and SACs, effects are considered in terms of the extent of such features within designated area boundaries.

Table 9.9 Definition of impact magnitude for the benthic ecology assessment

Magnitude	Definition
High	Fundamental, permanent/irreversible changes, affecting the whole receptor extent/ area of distribution, and/or fundamental alteration to key characteristics or features of the receptor's character or distinctiveness.
Medium	Considerable, permanent/irreversible changes, over the majority of the receptor extent/area of distribution, and/or discernible alteration to key characteristics or features of the receptor's character or distinctiveness.
Low	Discernible, temporary* change, over a minority of the receptor extent/area of distribution, and/or limited but discernible alteration to key characteristics or features of the receptor's character or distinctiveness.
Negligible	Discernible, temporary* change, or barely discernible change for any length of time, over a small area of the receptor extent/area of distribution, and/or slight alteration to key characteristics or features of the receptor's character or distinctiveness.

**The duration of time is dependent on the impact to the receptor and durations have been quantified in each impact*

9.4.3.2 Effect significance

9.53 The potential significance of effect for a given impact, is a function of the sensitivity and value of the receptor and the magnitude of the impact (see **Chapter 6 EIA Methodology** for further details). A matrix is used (Table 9.10~~Table 9.10~~) as a framework to determine the significance of an effect. Definitions of each level of significance are provided in Table 9.11~~Table 9.11~~. Impacts and effects may be deemed as being either positive (beneficial) or negative (adverse). Note that, where MarESA assessment has determined a receptor as ‘not sensitive’ to an impact, the corresponding sensitivity was read as ‘negligible’ in the table.

9.54 It is important that the matrix (and indeed the definitions of sensitivity and magnitude) is seen as a framework to aid understanding of how a judgement has been reached from the narrative of each effect assessment and it is not a prescriptive formulaic method.

9.55 Potential effects are described followed by a statement of whether the effect is significant in terms of the EIA Regulations. Potential effects identified within the assessment as major or moderate are regarded as significant in terms of the EIA Regulations. Whilst minor effects (or below) are not significant in EIA terms in their own right, it is important to distinguish these as they may contribute to significant effects cumulatively or through interactions.

9.56 Following initial assessment, if the effect does not require additional mitigation (or none is possible), the residual effect would remain the same. If, however, additional mitigation is proposed, an assessment of the post-mitigation residual effect is provided.

Table 9.10 Effect significance matrix

		Adverse Magnitude				Beneficial Magnitude			
		High	Medium	Low	Negligible	Negligible	Low	Medium	High
Sensitivity	High	*Major*	*Major*	*Moderate*	*Minor*	*Minor*	*Moderate*	*Major*	*Major*
	Medium	*Major*	*Moderate*	*Minor*	*Minor*	*Minor*	*Minor*	*Moderate*	*Major*
	Low	*Moderate*	*Minor*	*Minor*	*Negligible*	*Negligible*	*Minor*	*Minor*	*Moderate*
	Negligible	*Minor*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Minor*

Table 9.11 Definition of effect significance

Significance	Definition
Major	Very large or large change in receptor condition, both adverse or beneficial, which are likely to be important considerations at a regional or district level because they contribute to achieving national, regional or local objectives, or could result in exceedance of statutory objectives and/or breaches of legislation.
Moderate	Intermediate change in receptor condition, which are likely to be important considerations at a local level.
Minor	Small change in receptor condition, which may be raised as local issues.
Negligible	No discernible change in receptor condition.
No change	No impact hence no pathway for change in receptor condition.

9.4.4 Cumulative effect assessment methodology

9.57 The CEA considers other plans, projects and activities that may impact cumulatively with the Project. As part of this process, the assessment considers which of the residual impacts assessed for the Project on its own have the potential to contribute to a cumulative effect. **Chapter 6 EIA Methodology** provides further details of the general framework and approach to the CEA.

9.58 For benthic ecology, the potential cumulative activities include inter alia other OWFs (including maintenance of existing OWFs and construction of planned OWFs), installation of subsea cables and pipelines and oil and gas exploration and operations. As a general rule, other activities are only screened into the CEA where there is a spatial and/or temporal overlap in impacts such that a cumulative effect could be possible, or where impacts may be additive and affect a defined receptor group (such as within the boundaries of a designated site).

9.59 As described in **Chapter 1 Introduction,** the transmission assets associated with the Project are undergoing a separate consent process as part of the Morgan and Morecambe Offshore Wind Farms: Transmission Assets project. To enable impacts from the Project and the Transmission Assets to be considered together, a 'combined' assessment is made within the cumulative assessment to identify any key interactions and additive effects (**Section 9.7.3.1**).

9.4.5 Transboundary effects

9.60 **Chapter 6 EIA Methodology** provides details of the general framework and approach to the assessment of transboundary effects.

9.61 Given the limited range to which benthic features may be affected, transboundary impacts are unlikely to occur and have been scoped out of the EIA. This is on the basis that the area of influence highlighted in the physical processes chapter, and the ecological receptors present (as highlighted in the baseline description) only include benthic habitats in England. With regard to the potential for wider spread of invasive species, necessary mitigation and biosecurity measures would be in place to prevent and manage the spread of invasive species.

9.62 In its Scoping Opinion, PINS agreed that transboundary effects are unlikely to occur and that the matter could indeed by scoped out of further assessment (Table 9.1~~Table 9.1~~; PINS, 2022).

9.4.6 Assumptions and limitations

9.63 A large amount of benthic faunal and sedimentary data has been collected within the windfarm site by the site-specific survey undertaken in 2022. While the survey coverage was limited outside the windfarm site itself, there is an abundance of benthic data available from other studies (as described in **Table 9.5**~~**Table 9.5**~~) to provide context of benthos within the wider Eastern Irish Sea subtidal marine area. As a result, the benthic ecology of the Project site itself has been thoroughly characterised and there is a high degree of confidence in contextual data from the wider area for the purpose of informing the impact assessment.

9.64 With regard to habitat and biotope mapping presented in this chapter, confidence in the assignment of broadscale habitats is generally higher than confidence in assignment of more detailed biotope complexes and biotopes. This is generally due to the added complexity of differentiating between key characterising taxa leading to the potential for 'confusion' between biotopes and biotope complexes which occupy similar habitats (for example, sublittoral sands and component biotopes mapped instead as infralittoral sands and vice-versa). This is an inherent limitation of the benthic habitat mapping process. However, it is not considered to materially affect the overall confidence in the conclusions of the assessment, since the sensitivity ratings considered in the assessment also take into account broadscale habitats (for example, 'subtidal sands') which can be attributed to the study area with a greater degree of confidence (**Section 9.4.3.1**).

9.5 Existing environment

9.65 The environmental baseline, including descriptions of sediment type, macrofaunal communities and biotopes, is presented in this section for the study area. A description of protected areas and important species in the vicinity of the windfarm site is also provided. The information in this section is supplemented by in-depth analysis of benthic datasets for the windfarm site presented in **Appendix 9.1.**

9.5.1 Sediment characterisation

9.66 PSD analysis was completed for all 36 stations within the Project windfarm site and 14 stations to the west of the windfarm site where benthic grab samples were taken. Stations were described by their size class based on the Wentworth classification system (Wentworth, 1922) and statistics such as bulk sediment classes (i.e. proportions of gravel, sand and silt) were derived in accordance with the Folk (1954) classification.

9.67 Sand (grain size > 63µm < 2mm) was the dominant fraction of the sediment at almost all stations, ranging from 44.4% (ST45) to 100% (ST10 and ST37) with a mean of 81.01% (± 2.03%). Only at one station (ST45) was mud (grain size <63µm) the dominant fraction (55.6%), with the mud content at other stations ranging from 0.0% (at 5 stations) to 49.9% (ST38). Mean mud content across all stations was 18.46% (± 2.03%). Gravel (grain size >2mm) content ranged from 0.00% (at 27 stations) to 20.6% (ST01), though at all stations apart from ST01 gravel content was ≤0.05%. Mean gravel content was 0.51% (± 0.41%). Plate 9.1~~Plate 9.1~~ illustrates the sediment fractions for every station.

9.68 Based on the proportions of gravel, sand and mud, six sediment types have been identified across the windfarm site based on the Folk (1954) classification. By far the most common sediment type is muddy sand 'mS' (27 stations, including 24 within the windfarm site), followed by slightly gravelly sand '(g)S' (eight stations; three within the windfarm site), sand 'S' (seven stations; three within the windfarm site), slightly gravelly muddy sand '(g)mS' (six stations; three within the windfarm site), gravelly muddy sand 'gmS' (one station, within the windfarm site) and sandy mud 'sM' (one station, within the windfarm site). **Figure 9.3** maps the distribution of these sediment types. Stations within the southwest part of the windfarm site, and those outside the western boundary, tended to be comprised of slightly coarser sediments (i.e. higher gravel content) than those located across the rest of the windfarm site. This is evident when comparing the mean grain size across the site (see **Figure 9.4**).

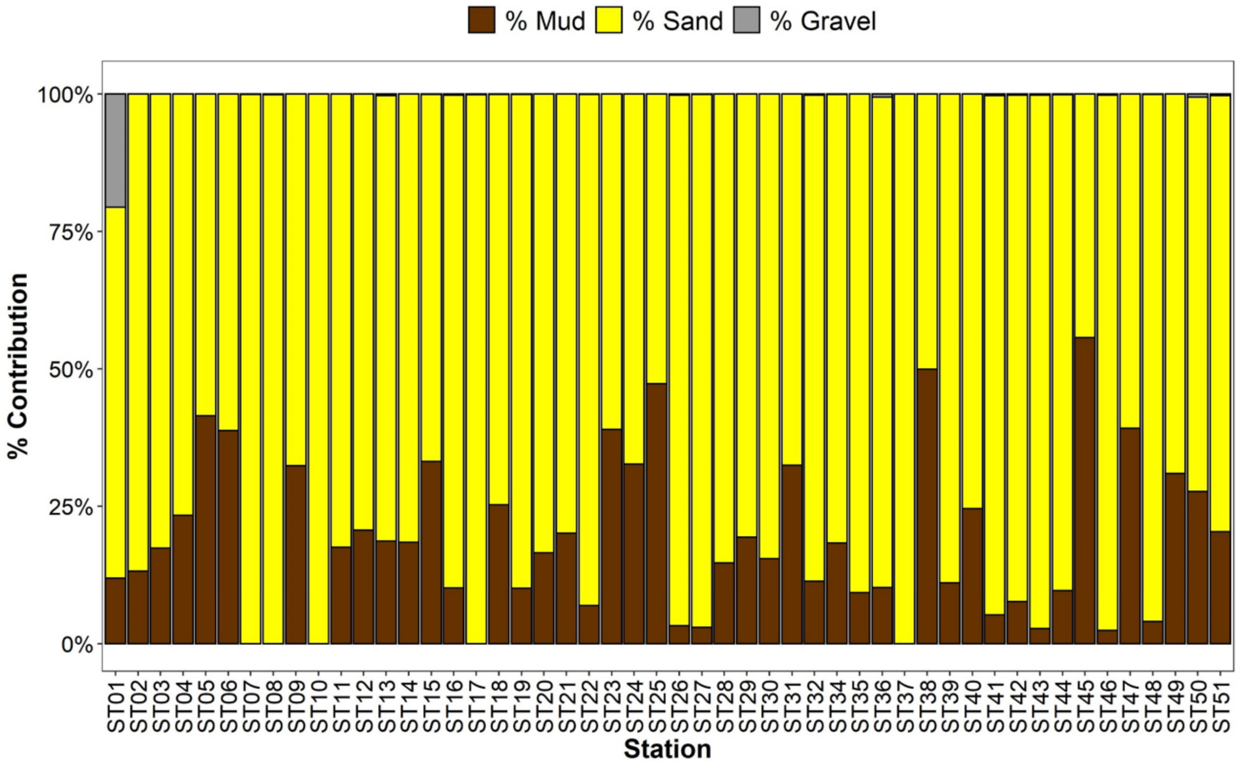

Plate 9.1 Principal sediment components (gravel, sand, mud) as determined from PSD analysis of stations sampled across Morecambe windfarm survey area (taken from ***Appendix 9.1****)*

9.69 Distribution of seabed sediment types across the entire UK marine area (as per the Folk (1954) classification) is available from the British Geological Survey (BGS) in its GeoIndex Offshore mapping portal (UKRI, 2022), at a scale of 1:250,000. Information on sediment types present in the wider Irish Sea area is presented in **Figure 9.5**. The transition from slightly finer material to slightly coarser material (east to west) in the windfarm site is a reflection of the general trend shown in the lower-resolution BGS data whereby finer sediment (e.g. muddy sand) along coastal areas on the North West coast of England (particularly around Morecambe Bay) transition towards coarser sediments further offshore.

9.5.2 Sediment chemistry

9.70 To inform the baseline for sediment quality, 20 grab samples were taken for chemical analysis during benthic surveys of the Morecambe windfarm survey area (see **Appendix 9.1** for details). Sample locations are shown in **Figure 9.2,** noting 14 are within the windfarm site.

9.71 Analysis was undertaken for the following contaminants:

- Total Organic Carbon (TOC)
- Total Organic Matter (TOM)
- Heavy and trace metals (arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni) and zinc (Zn))
- Polycyclic Aromatic Hydrocarbons (PAHs) and Total Hydrocarbon Content (THC)
- Organotins (Dibutyltin (DBT) and Tributyltin (TBT))
- Polychlorinated Biphenyls (PCBs)

9.72 The context of contaminant concentrations within the sediment samples is established through comparison with recognised guidelines and action levels, notably Cefas Action Levels (ALs) and US Environmental Protection Agency's Effects Range – Low (ERL). Cefas ALs are widely used for assessing contamination risk in UK marine development and are available for a range of contaminants. ERLs are quality guidelines used by Oslo-Paris Convention (OSPAR) and are defined as the lower tenth percentile of the dataset of concentrations in sediments which were associated with biological effects. If concentrations within the sampled sediment generally do not exceed the lower threshold values (i.e. AL 1 and ERL), then contamination levels are not considered to be of significant concern and are low risk in terms of potential impacts on marine benthic communities.

9.73 A comparison of the sediment chemistry data against guideline action levels has been undertaken within **Chapter 8 Marine Sediment and Water Quality**, Section 8.5.2.2 and is not repeated here. To summarise, however, the comparison demonstrated that no samples exceeded either Cefas AL 1 or ERLs, hence sediment contamination levels are low and the risk of adverse effect on the benthic community arising from disturbance of contaminated sediment is consequently low.

9.5.3 Macrofaunal communities

9.74 The Project benthic characterisation survey was used to identify the presence and distribution of macrobenthic fauna across the windfarm site, comprising infauna (i.e. living within the sediment) and epifauna (i.e. living on the surface of the seabed). Epifauna comprised sessile solitary species such as sea urchins and brittlestars; colonial organisms such as bryozoans were largely absent, given the lack of hard substrate for colonisation. Full detail on the macrofaunal communities recorded during the benthic characterisation surveys is provided in **Appendix 9.1**.

9.75 The macrobenthic assemblage identified from the 50 benthic samples collected was comprised of a total of 8,127 individuals from 154 different taxa (all individuals were identified to the lowest taxonomic level practicable), with a mean of 24 (±1) taxa per station, a mean abundance of 162 (±19) individuals per station and a mean biomass of 0.9504g (±0.1573g) (ash-free dry weight) per station.

9.76 Of the 154 taxa identified, Annelida was the most diverse phylum present, representing approximately 40% of the taxa recorded. This was followed by Crustacea, Mollusca, miscellaneous other phyla (namely bryozoans, cnidarians, entoprocta and tunicates) and Echinodermata. No INNS or commercial species were recorded.

9.77 By contrast, Mollusca taxa contributed most to the overall abundance recorded in the survey, accounting for approximately 40% of all individuals recorded, followed by Echinodermata (33%). Echinodermata represented 67% of the total biomass across the Morecambe windfarm survey area.

9.78 The two-toothed Montagu shell *Kurtiella bidentata* was the most abundant and frequently occurring taxon recorded from the survey, with 2,706 individuals (accounting for 33.0% of all individuals recorded) and present in 44 samples (i.e. 88% of stations). Other abundant and/or frequently-occurring taxa included the brittlestar *Amphiura filiformis* (accounting for 29.2% of all individuals and present in 78% of samples) and the polychaete *Sthenelais* *limicola* (accounting for only 2.0% of all individuals but present in 78% of samples).

9.79 Multivariate analysis was undertaken on the macrobenthic abundance data to identify spatial distribution patterns in assemblages across the survey area. Four broad macrobenthic groups (Groups A, B, C and D)[8] were identified, with one outlier (ST46). The four groups were differentiated by having different dominant taxa and/or an absence of taxa present in other groups. Spatial distribution of the macrobenthic groups is presented in **Figure 9.6**. Variations between the assemblages were primarily driven by the different sediment types and composition at each.

9.80 Group A was the largest group recorded and was particularly dominant within the windfarm site (comprising 31 of the 36 stations sampled therein), where there was generally slightly finer sediment. Defining taxa were the bivalves *K. bidentata* and *Nucula nitidosa* and the brittle star *A. filiformis.* Together, these species accounted for around 50% of the total abundance within this group.

9.81 Group B comprised four samples (ST07, ST08, ST17 and ST43) in areas of slightly coarser sediment. One of these samples is within the westernmost extent of the windfarm site and three outside the western boundary. Characterising taxa included the ribbon worms Nemertea and the polychaete *Spiophanes bombyx*, together accounting for 54% of the total abundance within this group.

9.82 Group C comprised just two samples (ST10 within the windfarm site, and ST27 to the west of the site), both of which were locations with very high (>97%) sand content and virtually no gravel content. Defining taxa for this group included the polychaetes *S. limicola* and *Nephtys cirrosa* and the amphipod *Bathyporeia gracilis*, together accounting for 53% of the total abundance within this group.

9.83 Group D comprised five samples (ST26, ST37, ST41, ST42 and ST48) at stations with sand or slightly higher gravel content. Two of these samples are in the southwestern part of the windfarm site and three outside the western boundary. Defining taxa included the polychaetes *Scalibregma inflatum*, *S. limicola*, *N. cirrosa* and *Scolopolos armiger*, which together accounted for 54% of the total abundance within this group.

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[8] Macrobenthic groups are assigned based on statistically similar characteristics and do not necessarily align directly with a single biotope classification.

9.5.4 Seabed habitats and biotopes

9.5.4.1 Project (2022) benthic characterisation survey

9.84 Seabed video footage at 47 stations and 4 transects across the surveyed area, plus associated still imagery (a total of 404 still images), were used in conjunction with the particle size data and macrofaunal data, to classify stations in terms of broadscale/main habitats and biotopes in line with the EUNIS habitat classification. Further information on the classification of seabed habitats and biotopes is available in **Appendix 9.1**.

9.85 Four EUNIS level 4 habitat types were encountered during review of the imagery from the benthic surveys, summarised in **Table 9.12~~Table 9.12~~**. A5.26 'circalittoral muddy sand' was the most frequently encountered, having been assigned to 69% of the images analysed from the site. A5.25 'circalittoral fine sand' was encountered in 16% of the images, A5.44 'circalittoral mixed sediments' were encountered in 12% of the images and A5.35 'circalittoral sandy mud' was encountered in 3% of the images.

Table 9.12 EUNIS habitat type classifications identified during benthic surveys at the windfarm survey area

Level 3 Broadscale habitat (EUNIS 2012)	Level 4 habitat type (EUNIS 2012)	EUNIS 2022 equivalent
A5.2 Sublittoral sand	A5.25 Circalittoral fine sand	MC52 Atlantic circalittoral sand
	A5.26 Circalittoral muddy sand	
A5.3 Sublittoral mud	A5.35 Circalittoral sandy mud	MC62 Atlantic circalittoral mud
A5.4 Sublittoral mixed sediment	A5.44 Circalittoral mixed sediments	MC42 Atlantic circalittoral mixed sediment

9.86 Spatial distribution of the Level 4 EUNIS habitat types recorded across the surveyed area during the DDC survey are presented in **Figure 9.7**. The windfarm site itself was dominated by A5.26 circalittoral muddy sand, whilst areas surveyed outside the western boundary were dominated by A5.25 circalittoral fine sands. Circalittoral mixed sediments were generally only recorded at the southern edge of the windfarm site. Example imagery of the four EUNIS level 4 habitat types is presented in Plate 9.2~~Plate 9.2~~.

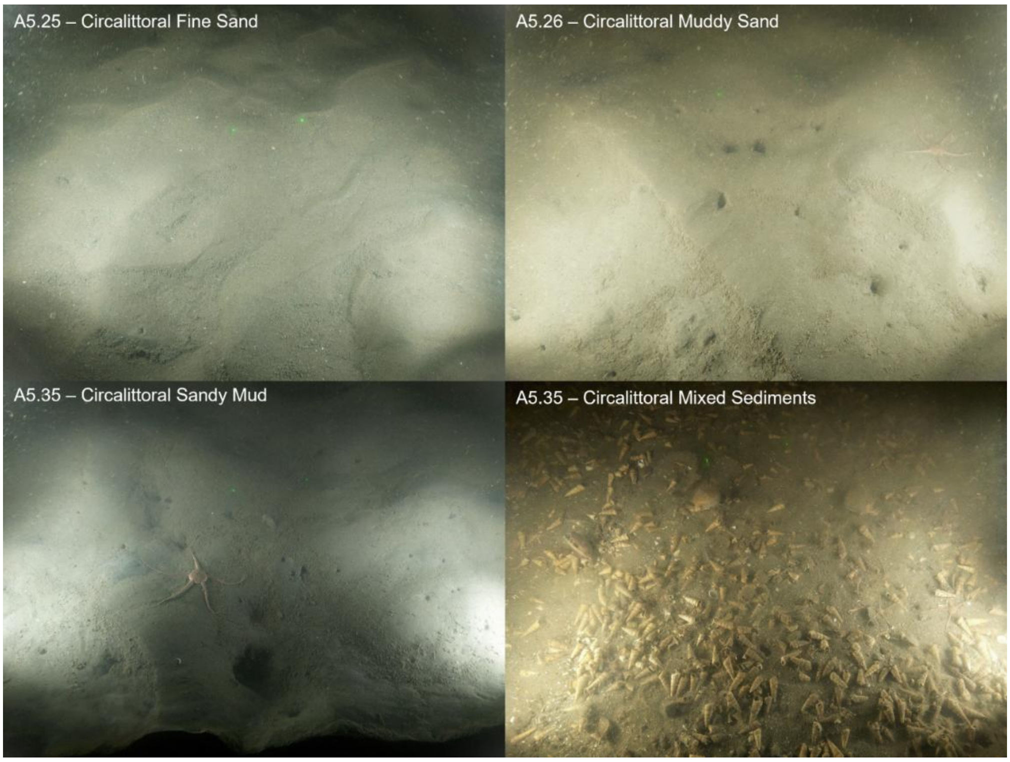

Plate 9.2 Example imagery of EUNIS classifications identified within the Morecambe windfarm survey area (source: OEL)

9.87 Benthic biotope mapping has been undertaken using geophysical data sets along with the benthic sample PSD and macrofaunal data to interpret the distribution of habitats and biotopes across the windfarm site. The biotope mapping process is described in **Appendix 9.1**.

9.88 For each of the four macrobenthic groups described in **Section 9.5.3**, biotopes were assigned according to the JNCC classification tool (JNCC, 2015) based upon their faunal and sedimentary characteristics. In total, two biotopes were described, the spatial distribution of which is presented in **Figure 9.8**.

9.89 The biotope most closely aligned with the community observed in macrobenthic group A is EUNIS (2012 classification) biotope A5.351 '*Amphiura filiformis, Mysella bidentata* and *Abra nitida* in circalittoral sandy mud'. The equivalent EUNIS biotope under the 2022 classification is MC6211 '*Amphiura filiformis, Mysella bidentata* and *Abra nitida* in Atlantic circalittoral sandy mud'. This biotope is consistent with the presence of fines in the sediment composition at the associated stations and is dominant across most of the windfarm site.

9.90 The biotope most closely aligned with the communities observed in macrobenthic groups B, C and D is EUNIS biotope A5.252/MC5212 '*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand'. This biotope is consistent with sediments at the associated stations being sandier, with marginally higher gravel content, and is prevalent in the south western part of the windfarm site and areas outside the western boundary.

9.5.4.2 EUSeaMap 2021

9.91 The EUSeaMap 2021 (EMODnet Seabed Habitats Consortium, 2022) seabed habitat mapping indicates that the windfarm site is dominated by the EUNIS broadscale habitats listed in **Table 9.13Table 9.13**. Distribution of the broadscale habitats as per EUSeaMap is presented in **Figure 9.9**.

9.92 The outcome of the sediment PSD analysis (described in **Section 9.5.1**) and the seabed video and stills imagery during the 2022 benthic survey gives confidence that the distribution of habitats presented in EUSeaMap 2021 is generally representative of actual conditions at the windfarm site and surrounding area, as there is good alignment in terms of the habitats present.

Table 9.13 EUSeaMap (2021) broadscale habitats within the windfarm site

EUNIS 2012 classification	EUNIS 2022 broadscale habitat equivalent	JNCC classification equivalent
A5.35 Circalittoral sandy mud	MC62 Atlantic circalittoral mud	*SS.SMu.CsaMu* Circalittoral sandy mud
A5.37 Deep circalittoral mud	MD62 Atlantic offshore circalittoral mud	*SS.Smu.Omu* Offshore circalittoral mud
A5.27 Deep circalittoral sand	MD52 Atlantic offshore circalittoral sand	*SS.Ssa.Osa* Offshore circalittoral sand
A5.25 Circalittoral fine sand; or A5.26 Circalittoral muddy sand	MC52 Atlantic circalittoral sand	*SS.Ssa.CfiSa* Offshore circalittoral fine sand, or; *SS.Ssa.CmuSa* Offshore circalittoral muddy sand

9.93 To the north and the east of the windfarm site, within the 15km ZoI around the site boundary, the broadscale habitats present are similar to those within the site itself (i.e. those listed in **Table 9.13Table 9.13**). To the south and west of the windfarm site, broadscale habitats generally transition to those that are coarser in nature, categorised as A5.27 ‘deep circalittoral sand’, A5.15 ‘deep circalittoral coarse sediment’ and A5.45 ‘deep circalittoral mixed sediment’. It is evident from the broadscale habitat mapping presented in the EUSeaMap 2021 project that the habitats present in (and within 15km of) the windfarm site are widely distributed across the wider Eastern Irish Sea.

9.5.4.3 Habitats and biotopes recorded from other studies overlapping with the 15km ZoI

Transmission Assets benthic subtidal baseline survey (2022)

9.94 A grab sample and DDV survey of 77 stations within the Transmission Assets area was undertaken in summer 2022 and presented in the corresponding

PEIR (Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023a). The survey area extended along proposed export cable corridors from the windfarm sites of both the Morgan Offshore Wind Project Generation Assets and the Project. A total of 45 stations were within the 15km ZoI of the Project, located north and east of the windfarm site (**Figure 9.10**).

9.95 Sediment types followed the trend expected from the Project survey and the EUSeaMap, in that those stations closer inshore (i.e. east and north of the Project windfarm site) were generally comprised of finer sediments (sands and sandy muds) than those extending towards the Morgan Offshore Wind Project Generation Assets (i.e. to the northwest of the Project windfarm site) which had a higher gravel composition.

9.96 Stations within the 15km Project ZoI to the north and east of the windfarm site were predominantly classified the biotope A5.351 '*Amphiura filiformis, Mysella bidentata* and *Abra nitida* in Atlantic circalittoral sandy mud', the dominant biotope within the windfarm site itself, with smaller areas of A.5.355 '*Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud' and A5.261 '*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment'.

9.97 Stations within the 15km Project ZoI to the northwest of the windfarm site were principally classified as a mix of A.5.355 '*Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud' and A5.443 '*Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment', with smaller areas of A5.251 '*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand'.

Mona Offshore Wind Project and Morgan Offshore Wind Project Generation Assets baseline survey (2021)

9.98 A grab sample and DDV survey of 95 stations across the Mona and Morgan OWF array areas, located northwest, west and southwest of the Project windfarm site, was undertaken in summer 2021 and presented in the PEIR for the two windfarms (Mona Offshore Wind Limited, 2023 and Morgan Offshore Wind Limited, 2023). A total of nine stations were within the 15km ZoI of the Project, all in the proposed Mona array area (see **Figure 9.10**).

9.99 Sediment types were generally coarser than those in the Project area, comprising sands, gravelly sands and gravelly muddy sands, with gravel content increasing with distance south and west. This aligns with the distribution of broadscale habitat types presented in the EUSeaMap 2021.

9.100 No features of interest were recorded at the Mona and Morgan stations, with no evidence of FOCI such as 'sea pens and burrowing megafauna communities' or geogenic/biogenic reef habitats.

9.101 Biotopes classified within the Project ZoI included A5.14 'circalittoral coarse sediment', A5.44 'circalittoral mixed sediments', A5.443 '*Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment' and A5.451 '*polychaete-rich deep Venus community in offshore mixed sediments*'.

Fylde MCZ benthic survey/Shell Flat and Lune Deep SAC and Fylde MCZ interpretation and mapping (2015)

9.102 A grab sample survey of Fylde MCZ was undertaken in 2015 (Miller and Green, 2017), constituting 82 stations within and outside the MCZ boundary. Two stations were within the footprint of the windfarm site and a further 39 were within the 15km ZoI (see **Figure 9.11**). This was supplemented by an interpretation and mapping study of the MCZ and adjacent Shell Flat and Lune Deep SAC (Envision Mapping Ltd., 2014).

9.103 Stations in the centre and south of the MCZ were principally subtidal sand. Stations in the north and northwest of the MCZ and stations to the west of the MCZ (i.e. those within the ZoI) were principally subtidal mud.

9.104 Biotopes classified within the ZoI are listed in **Table 9.14~~Table 9.14~~**. The majority of stations, including the two stations within the windfarm site, were assigned the biotope A5.351 '*Amphiura filiformis, Mysella bidentata* and *Abra nitida* in circalittoral sandy mud', the same biotope that dominated the windfarm site in the Project 2022 benthic survey. The biotopes identified in the MCZ survey generally align with those from the 2022 Transmission Assets survey (as presented in **Figure 9.10**) where they overlap, providing further confidence in the baseline characterisation.

Table 9.14 Biotopes classified within Project ZoI during benthic studies of Fylde MCZ (Miller and Green, 2017; Envision Mapping Ltd., 2014)

EUNIS 2012 level 3 classification	EUNIS 2012 level 5 biotope
A5.1 Sublittoral coarse sediment	A5.133 *Moerella* spp. with venerid bivalves in infralittoral gravelly sand
	A5.135 *Glycera lapidum* in impoverished infralittoral mobile gravel and sand
	A5.145 *Branchiostoma lanceolatum* in circalittoral coarse sand with shell gravel
A5.2 Sublittoral sand	A5.241 *Echinocardium cordatum* and *Ensis* spp. in lower shore and shallow sublittoral slightly muddy fine sand
	A5.242 *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand
	A5.261 *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment

EUNIS 2012 level 3 classification	EUNIS 2012 level 5 biotope
A5.3 Sublittoral mud	A5.351 *Amphiura filiformis*, *Mysella bidentata* and *Abra nitida* in circalittoral sandy mud
A5.4 Sublittoral mixed sediments	A5.443 *M. bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment

Walney OWF post-construction monitoring surveys and West of Duddon Sands OWF pre-construction baseline survey (2012 – 2014)

9.105 A three-year monitoring programme was undertaken at Walney OWF (CMACS, 2014) and a baseline survey was undertaken at the neighbouring West of Duddon Sands (WoDS) OWF (CMACS, 2012). Two stations from the Walney OWF monitoring and 12 stations from the WoDS survey were located within the 15km Project ZoI (**Figure 9.12**).

9.106 The most recent monitoring at Walney OWF (2014) classified offshore stations as A5.351 '*A. filiformis*, *M.bidentata* and *A. nitida* in circalittoral sandy mud', or simply as biotope complex A5.35 'circalittoral sandy mud'. Both stations within the Project ZoI were classified as biotope A5.351 during the final year of monitoring.

9.107 At WoDS OWF, the majority of stations were also classified as biotope A5.351. Other biotopes recorded within the Project ZoI were A.5.355 '*Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud'/A5.261 '*A. alba* and *N. nitidosa* in circalittoral muddy sand' and A.5.361 'Sea pens and burrowing megafauna in circalittoral fine mud'. The latter is an OSPAR and UK FOCI.

9.108 A small number of different biotopes were classified at locations further inshore (for example, along export cable routes). These related to infralittoral habitats within or adjacent to the shallow estuarine environment at Morecambe Bay, significantly beyond the Project ZoI.

9.5.4.4 Habitats and biotopes recorded from studies elsewhere in the Eastern Irish Sea

Gwynt y Môr OWF (2010/11), Awel y Môr (2020) and Burbo Bank Extension (2011/12) pre-construction benthic baseline surveys

9.109 Although relatively distant (approximately 30km) from the Project windfarm site and outside the 15km Project ZoI, baseline surveys at Gwynt y Môr (CMACS, 2011), AyM (Fugro, 2021) and Burbo Bank Extension (CMACS, 2013) OWFs provide contextual information on habitats/biotopes present to the south of the Project, from the mouth of the Mersey west towards Anglesey.

9.110 The dominant habitats/biotopes recorded in the surveys are indicative of fine sand/muddy sand infralittoral sediment near to the Mersey Estuary, transitioning to coarser sediments to the west (as demonstrated by the 2021 EUSeaMap). Dominant biotopes from the surveys are listed in Table 9.15Table 9.15.

Table 9.15 Dominant biotopes recorded during benthic surveys at Gwynt y Môr, AyM and Burbo Bank Extension OWFs (CMACS, 2011; Fugro, 2020; CMACS, 2013)

EUNIS 2012 level 3 classification	EUNIS 2012 level 5 biotope
A5.1 Sublittoral coarse sediment	A5.133 *Moerella* spp. with venerid bivalves in infralittoral gravelly sand
	A5.142 *Mediomastus fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel
	A5.145 *Branchiostoma lanceolatum* in circalittoral coarse sand with shell gravel
A5.2 Sublittoral sand	A5.233 *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand
	A5.242 *'Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand'
A5.3 Sublittoral mud	A5.351 'Amphiura filiformis, *Mysella bidentata* and *Abra nitida* in circalittoral sandy mud'

Celtic Array 'Rhiannon' benthic baseline surveys (2010 and 2012)

9.111 The Rhiannon OWF baseline surveys (Celtic Array Ltd., 2014) provide evidence of the presence of coarser sediments to the west and south of the Project. Within the Rhiannon survey area, two dominant biotope complexes/biotopes were recorded, both of which are characteristic of sublittoral coarse or mixed sediment habitats:

- A5.14 'Circalittoral coarse sediment'
- A mosaic of A5.44 'Circalittoral mixed sediments' and A5.445 *'Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment'

9.112 The biotope complexes A5.62 'Sublittoral mussel beds on sediment' and A4.21 'Echinoderms and crustose communities on circalittoral rock' classified within the extensive survey area are indicative of potential Annex I biogenic/geogenic reef. The extent of Annex I reef in this area (i.e. to the North of Anglesey) does not overlap with the Project ZoI.

9.5.5 Habitats/species of conservation interest

9.113 Based on the baseline data presented in this assessment, there is potential for a number of sensitive habitats to be present within the 15km Project ZoI, including habitats listed in the OSPAR list of threatened and/or declining habitats, habitats listed in Annex I of the Habitats Directive as 'habitat types of community interest' and habitats of 'principal importance' as listed in accordance with Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006.

9.114 No species listed in the OSPAR list of threatened and/or declining species and no species of principal importance/BAP species were recorded during the 2022 benthic characterisation survey of the windfarm site, nor were any reported from other studies within 15km of the windfarm site.

9.115 Table 9.16~~Table 9.16~~ lists the habitats of conservation interest likely to be present within the ZoI.

Table 9.16 Summary of habitats of conservation interest potentially present within the 15km Project ZoI

Feature	Designation/status	Relevant EUNIS habitats
Subtidal sands and gravels	UK Habitat of Principal Importance (HPI)	A5.1 Sublittoral coarse sediment A5.2 Sublittoral sand (MCZ FOCI)
Mud habitats in deep water	UK HPI	A5.3 Sublittoral mud (MCZ FOCI)
Sea-pen and burrowing megafauna communities	UK HPI; OSPAR list of threatened and/or declining habitats; MCZ FOCI	
Sandbanks which are slightly covered by sea water all the time	Annex I	A5.1 Sublittoral coarse sediment A5.2 Sublittoral sand (MCZ FOCI)

9.5.5.1 Annex I habitats

9.116 No Annex I subtidal marine habitats (i.e., sandbanks which are slightly covered by sea water all the time, reefs, submarine structures made by leaking gases) were identified from geophysical or DDC surveys within the windfarm site (see **Appendix 9.1**).

9.117 JNCC and Natural England have mapped the presence of Annex I habitats within the Eastern Irish Sea, covering the study area, as presented in **Figure 9.13**. There is an extensive area of Annex I sandbank habitat located approximately 8km east of the windfarm site, which encompasses Fylde MCZ and Shell Flat and Lune Deep SAC and is a designation feature of the latter. This Annex I habitat extends into Morecambe Bay as well as to the south and west of Walney Island and the Cumbrian coast.

9.118 The benthic communities of the Annex I sandbank at Shell Flat are characterised by A5.242 *'Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand' and A5.261 *'Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment' biotopes, the former predominantly in fine shallower sediments of the banks and the latter predominantly in the muddier sediments on the slopes and in deeper areas (Envision Mapping Ltd., 2014).

9.119 The closest mapped Annex I reef is a small, isolated area located approximately 13.5km to the southeast of the windfarm site. An extensive area of recorded Annex I reef is located at and adjacent to Lune Deep and along the Fylde coastline, where geogenic reef is characterised by mixed faunal turf communities. Such areas are outside the Project ZoI. More distant still is an extensive area of Annex I reef off the north coast of Anglesey.

9.5.5.2 Subtidal sands and gravels

9.120 A5.2 'sublittoral sand' was the dominant broadscale habitat present across the entire extent of the windfarm site, namely the EUNIS Level 4 habitats A5.25 'circalittoral fine sand' and A5.26 'circalittoral muddy sand'. Habitat mapping of the wider study area in the EUSeaMap 2021 (EMODnet Seabed Habitats Consortium, 2022) indicates that the Level 4 habitats A5.27 'deep circalittoral sand' and A5.15 'deep circalittoral coarse sediment' are widely distributed to the south and west of the windfarm site.

9.121 These broadscale habitats, and their component biotope complexes, are categorised within the broad definition of subtidal sand and gravels (BRIG, 2011), a UK BAP habitat listed under Section 41 of the NERC Act 2006. Although subtidal sands and gravels are identified as a UK HPI, and therefore considered to be of conservation importance, this habitat is widespread within the Eastern Irish Sea and further afield in UK waters.

9.5.5.3 Mud habitats in deep water

9.122 A5.2 'sublittoral mud' was recorded at a small number of locations western part of the windfarm site, namely the EUNIS level 4 habitat A5.25 'circalittoral sandy mud'. EUSeaMap 2021 (EMODnet Seabed Habitats Consortium, 2022) and the benthic studies in the Eastern Irish Sea outlined in **Section 9.5.4** indicate that this habitat is prevalent across the North and East of the study area and beyond. A5.37 'deep circalittoral mud' and A5.36 'circalittoral fine mud' have also been recorded in the study area. These habitats are defined within the broad definition of mud habitats in deep water (BRIG, 2011), a UK BAP and Section 41 broadscale habitat. Again, however, this broadscale habitat is widespread within the Eastern Irish Sea and further afield.

9.5.5.4 Sea pens and burrowing megafauna communities

9.123 From the seabed imagery gathered during the benthic survey at the Project windfarm site, areas of burrowed mud were identified across the site. Where megafaunal burrows were present, based on burrow size and density, they fit the criteria classified as the OSPAR/UK FOCI habitat 'sea pens and burrowing megafauna communities' (Robson, 2014). Average density of burrows across the surveyed area was between 8 and 43m^{-2}; average density of burrows 3cm or more in size was between 1 and 8m^{-2}. No clear trend in the spatial distribution of burrow density was identified, with areas of higher and lower density interspersed throughout the surveyed area.

9.124 Formal definition of 'sea pens and burrowing megafauna communities' FOCI is provided by OSPAR:

"*Plains of fine mud, at water depths ranging from 15-200m or more, which are heavily bioturbated by burrowing megafauna with burrows and mounds typically forming a prominent feature of the sediment surface. The habitat may include conspicuous populations of sea pens, typically Virgularia mirabilis and Pennatula phosphorea. The burrowing crustaceans present may include Nephrops norvegicus, Calorcaris macandreae or Callianassa subterranean. The burrowing activity of megafauna creates a complex habitat, providing deep oxygen penetration. This habitat occurs extensively in sheltered basins of fjords, sea lochs, voes and in deeper waters such as the North Sea and Irish Sea basins*."

9.125 No sea pens were recorded from the DDC imagery; hence the evidence indicates that sea pens are absent from the Project windfarm site, or present only at very low density. However, the presence of sea pens is not required to meet this habitat classification (Robson, 2014: *"burrowing megafauna is an essential element of the habitat but sea pens may, and by extension may not, be present"*). Two individuals of the burrowing crab *Corystes cassivelaunas* were identified from seabed imagery, one each at ST02 and ST30.

9.126 Evidence from other studies, including post-construction monitoring surveys at West of Walney and WoDS OWFs (CMACS, 2012 and 2014) indicate the presence of burrowed mud habitat – at a density considered suitable for classification as a UK HPI – within the wider area. Indeed, the West of Walney MCZ is in part designated for this FOCI.

9.5.6 Designated sites

9.127 The following section provides a brief summary of the marine protected areas with benthic features of interest with the potential to be affected by the Project due to a potential pathway being identified. Specific assessment of European Sites is provided in the accompanying RIAA (Document Reference 4.9) (issued in accordance with the Habitats Regulations). Specific assessment of MCZs is provided in the Marine Conservation Zone Assessment (MCZA) Report (Document Reference 4.13) (in accordance with the MCAA).

9.128 Benthic features of marine protected areas in Isle of Man territorial waters are outside the 15km ZoI of the Project and would not be affected.

9.5.6.1 Fylde MCZ

9.129 Fylde MCZ is located approximately 8km east of the windfarm site, at the nearest point, as shown in **Figure 9.14**.

9.130 The MCZ is designated for its extensive areas of subtidal sediment habitat and associated flora/fauna. Specifically, the MCZ is designated for the following broadscale marine habitats:

- Subtidal sand (principally in the centre and south of the MCZ)
- Subtidal mud (principally in the north and northwest of the site)

9.131 Within the 15km Project ZoI, both of the above features have been recorded, as outlined in **Section 9.5.4.3**.

9.5.6.2 West of Walney MCZ

9.132 West of Walney MCZ is located approximately 13km north of the windfarm site, at the nearest point, as shown in **Figure 9.14**.

9.133 The MCZ is designated for its extensive areas of subtidal sediment habitat and associated flora/fauna. The MCZ is designated for the following broadscale marine habitats:

- Subtidal sand (principally in a small area in the northeast of the MCZ)
- Subtidal mud (the dominant habitat type present across the site)

9.134 In addition, the MCZ is designated for the following FOCI:

- Sea-pen and burrowing megafauna communities (present across the MCZ)

9.135 Within the 15km Project ZoI both broadscale habitats are present, including areas with the FOCI ‘sea-pen and burrowing megafauna communities’.

9.5.6.3 Shell Flat and Lune Deep SAC

9.136 Shell Flat and Lune Deep SAC is located approximately 9.5km east of the windfarm, at the nearest point, as shown in **Figure 9.14**.

9.137 The site is designated for the following Annex I habitats:

- Sandbanks which are slightly covered by seawater all the time (Shell Flat)
- Reefs (Lune Deep)

9.138 The eastern part of Shell Flat overlaps with the Project 15km ZoI. There is no overlap between Lune Deep (and associated Annex I reef habitats) and the ZoI.

9.5.6.4 Liverpool Bay SPA

9.139 Liverpool Bay Special Protection Area (SPA) abuts the eastern boundary of the windfarm site, as shown in **Figure 9.14**. This site is principally designed for the protection of marine/coastal ornithological features (further information on which is provided in **Chapter 12 Offshore Ornithology**).

9.140 The supporting features of Liverpool Bay SPA include marine habitats which overlap with the 15km Project ZoI, namely:

- A5.2 subtidal sand
- A5.3 subtidal mud

9.5.7 Climate change and future trends

9.141 The baseline conditions for benthic ecology are considered to be relatively stable within the study area, with multiple data sets covering several years exhibiting similar patterns.

9.142 Anthropogenic pressures that currently exist across the study area, such as commercial fishing, have the potential to influence future change in the existing benthic environment. Fisheries management measures have the potential to reduce fishing effort, therefore reducing fishing related pressures on benthic ecology; but may also displace fishing effort and potentially increase impacts in other areas. Displacement effects, including fisheries management measures, are assessed in **Chapter 13 Commercial Fisheries**.

9.143 Climate changes in local community structures within UK waters have and will continue to evolve in response to climate change (and associated events such as eutrophication (Frid *et al.*, 2009; Shojaei *et al.*, 2016). Changes in the distribution of benthic indicator species have been projected, including decreases in distribution area (Weinert *et al.*, 2021). Additionally, as the mean bottom temperature is projected to increase, so biological processes and functioning within benthic communities are likely to change. For example, bioturbation potential is projected to decrease in response to increasing seabed temperatures (Weinert *et al.*, 2022; Moore and Smale, 2020).

9.6 Assessment of effects

9.6.1 Impact receptors

9.144 The principal receptor groups with respect to benthic ecology are outlined in **Sections 9.6.1.1 – 9.6.1.3**.

9.6.1.1 Subtidal sands and gravels

9.145 Receptors included in this group are those broadscale habitats and biotopes present (or potentially present) within the 15km Project ZoI that are components of the UK BAP/FOCI habitat 'subtidal sands and gravels', as per the 2022 benthic survey of the Project windfarm site (see **Section 9.5.4.1**) and other studies that overlap with the ZoI (see **Section 9.5.4.2** to **Section 9.5.4.4**).

9.6.1.2 Subtidal mud/mud habitats in deep water

9.146 Receptors included in this group are those broadscale habitats and biotopes present (or potentially present) within the 15km Project ZoI that are components of the MCZ broadscale habitat 'subtidal mud' and the FOCI 'mud habitats in deep water'.

9.147 The density of burrows across the windfarm site met the criteria to be classed as the deep-water mud-associated FOCI 'sea-pen and burrowing megafauna communities' (see **Section 9.5.5.4**). Although the characterising taxa, particle size distribution and habitats observed at stations in the windfarm site do not classify as component biotopes of this FOCI, the biotope A5.361 'Sea pens and burrowing megafauna in circalittoral fine mud' was recorded from other studies in the wider area (e.g. at Walney OWF, CMACS (2014)). To assess the potential sensitivity of the FOCI within the windfarm site, this biotope has been assigned.

9.6.1.3 Designated sites

9.148 Receptors included in the assessment are those MCZs, SPAs and SACs with benthic features that overlap with the 15km Project ZoI (described in **Section 9.5.6**).

9.6.1.4 Receptor summary

9.149 The specific features defined within the above receptor groups as requiring further assessment are listed in **Table 9.17**~~**Table 9.17**~~. It is noted that the table does not include the Annex I feature 'reef'. While Annex I reef forms a feature of the Shell Flat and Lune Deep SAC, distribution of this feature within the

SAC is beyond the 15km Project ZoI and, hence, would be unaffected by the Project.

Table 9.17 Benthic ecology receptors relevant to the Project

Receptor group	Receptor	Status
Subtidal sands and gravels	A5.1 Sublittoral coarse sediment	Potential presence within 15km ZoI
	A5.133 *Moerella* spp. With venerid bivalves in infralittoral gravelly sand	Potential presence within 15km ZoI
	A5.135 *Glycera lapidum* in impoverished infralittoral mobile gravel and sand	Potential presence within 15km ZoI
	A5.145 *Branchiostoma lanceolatum* in circalittoral coarse sand with shell gravel	Potential presence within 15km ZoI
	A5.2 Sublittoral sand	Recorded within the windfarm site
	A5.242 *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand	Potential presence within 15km ZoI
	A5.251 *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	Potential presence within 15km ZoI
	A5.252 *Abra prismatica, Bathyporeia elegans* and polychaetes in circalittoral fine sand	Recorded within windfarm site
	A5.261 *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	Potential presence within 15km ZoI
Subtidal mud / mud habitats in deep water	A5.3 Sublittoral mud	Recorded within windfarm site
	A5.351 *Amphiura filiformis, Mysella bidentata* and *Abra nitida* in circalittoral sandy mud.	Recorded within windfarm site
	A5.355 *Lagis koreni* and *Phaxus pellucidus* in circalittoral sandy mud	Potential presence within 15km ZoI
	A5.361 Sea pens and burrowing megafauna in circalittoral fine mud	Potential presence within 15km ZoI; considered representative of burrowing megafauna communities that

Receptor group	Receptor	Status
		have been recorded in the windfarm site
Designated sites with benthic features	Fylde MCZ (subtidal sand and subtidal mud)	8km from the windfarm site
	Shell Flat and Lune Deep SAC (Annex I sandbank)	9.7km from the windfarm site
	West of Walney MCZ (subtidal mud and seapen and burrowing megafauna communities)	13km from the windfarm site

9.150 It should be noted that, while the assessment that follows includes consideration of impacts on the benthic features of the designated sites, these are also assessed fully in the accompanying RIAA (Document Reference 4.9) and MCZA (Document Reference 4.13).

9.151 Impacts on the supporting features of the Liverpool Bay SPA, which is located immediately adjacent to the eastern boundary of the windfarm site, are not assessed explicitly in this chapter. Instead, the benthic ecology assessment (focussed on the impact on subtidal sands and gravels and subtidal mud) provides context to the assessments presented in **Chapter 12 Offshore Ornithology** and the accompanying RIAA (Document Reference 4.9).

9.6.2 Sensitivity ratings

9.152 As described in **Section 9.4.3.1**, the sensitivity of benthic receptors is based on the MarESA method, which describes the sensitivity of biotopes in relation to different anthropogenic pressures. These sensitivities are modified, where appropriate, by local evidence, for example from post-construction benthic monitoring surveys at other OWFs within the Eastern Irish Sea, or if habitats or biotopes are of conservation value.

9.153 The MarESA assessments used herein to determine receptor sensitivity are listed in

~~9.153~~ **Table** 9.18

9.154 ~~**Table** 9.18~~.

Table 9.18 MarESA assessments used in this chapter

Biotope	MarESA reference
A5.133 *Moerella* spp. With venerid bivalves in infralittoral gravelly sand	Tillin (2016a)

Biotope	MarESA reference
A5.135 *Glycera lapidum* in impoverished infralittoral mobile gravel and sand	Tillin (2016b)
A5.145 *Branchiostoma lanceolatum* in circalittoral coarse sand with shell gravel	Tillin (2016c)
A5.242 *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand	Tillin and Rayment (2016)
A5.251 *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	Tillin (2022)
A5.252 *Abra prismatica, Bathyporeia elegans* and polychaetes in circalittoral fine sand	Tillin (2016d)
A5.261 *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	Tillin and Budd (2016)
A5.351 *Amphiura filiformis, Mysella bidentata* and *Abra nitida* in circalittoral sandy mud	De-Bastos and Hill (2016)
A5.355 *Lagis koreni* and *Phaxus pellucidus* in circalittoral sandy mud	De-Bastos (2016)
A5.361 Sea pens and burrowing megafauna in circalittoral fine mud	Hill *et al.* (2020)

9.155 Direct impacts of the construction, operation and maintenance and decommissioning phases, namely physical disturbance, presence of infrastructure and temperature/EMF changes, would be confined to the footprint of the Project. Pressures associated with such impacts would only affect those biotopes recorded within the windfarm site. The sensitivity ratings to such pressures are presented in Table 9.19~~Table 9.19~~.

9.156 Indirect impacts, namely changes in suspended sediment levels (and subsequent deposition), underwater noise and vibration changes, potential spread of INNS and hydrodynamic/sedimentary process changes, have the potential to extend beyond the windfarm site boundary. Pressures associated with such impacts may affect other biotopes present within the 15km Project ZoI. The sensitivity ratings to such pressures are presented in Table 9.20~~Table 9.20~~.

9.157 Further information relating to the MarESA resistance and resilience assessments (which inform biotope sensitivity classifications) is presented in **Appendix 9.2**.

9.158 For marine designated sites in the UK, Natural England provides 'Advice on Operations' (AoO) for individual benthic features, which is an indicator of the sensitivity of a given feature to construction/operation/decommissioning related pressures from ‘Renewable energy sources – Offshore Wind’. In the case of habitat features, this Advice is drawn from the MarESA sensitivity ratings for the typical component biotopes of that habitat.

9.159 The sensitivity ratings of the features of the Fylde MCZ, West of Walney MCZ and Shell Flats and Lune Deep SAC to pressures associated with indirect impacts of the Project, as per the respective AoO (Natural England, 2022a, 2022b and 2022c), are also presented in **Table 9.20**~~Table 9.20~~.

Table 9.19 Biotope sensitivities to pressures associated with direct construction, operation and maintenance and decommissioning phase impacts

Biotope	MarESA sensitivity rating					
	Removal of substratum	Abrasion/ disturbance	Substratum penetration/ disturbance	Smothering and siltation rate changes (heavy)	Physical change (to another seabed type)	Temperature increase (local)
Subtidal sands and gravels (A5.2 sublittoral sand)						
A5.252 *Abra prismatica, Bathyporeia elegans* and polychaetes in circalittoral fine sand	Medium	Low	Low	Medium	High	Low
Subtidal mud / mud habitats in deep water (A5.3 sublittoral mud)						
A5.351 *Amphiura filiformis, Mysella bidentata* and *Abra nitida* in circalittoral sandy mud	Medium	Medium	Medium	Medium	High	Not sensitive
A5.361 Sea pens and burrowing megafauna in circalittoral fine mud	High	Medium	High	Not sensitive	High	Medium

Table 9.20 Biotope sensitivities to pressures associated with indirect construction, operation and maintenance and decommissioning phase impacts

Habitat/biotope	MarESA sensitivity rating					
	Smothering and siltation rate changes (light)	Changes in suspended solids (water clarity)	Underwater noise change	Introduction or spread of INNS	Water flow (tidal current) changes (local)	Wave exposure changes (local)
Subtidal sands and gravels (A5.1 sublittoral coarse sediment and A5.2 sublittoral sand)						
A5.133 *Moerella* spp. With venerid bivalves in infralittoral gravelly sand	Low	Low	Not relevant[1]	High	Not sensitive	Not sensitive
A5.135 *Glycera lapidum* in impoverished infralittoral mobile gravel and sand	Low	Not sensitive	Not relevant[1]	High	Not sensitive	Not sensitive
A5.145 *Branchiostoma lanceolatum* in circalittoral coarse sand with shell gravel	Low	Not sensitive	Not relevant[1]	No evidence	Not sensitive	Not sensitive
A5.242 *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand	Low	Low	Not relevant[1]	High	Not sensitive	Not sensitive
A5.251 *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	Low	Low	Not relevant[1]	High	Not sensitive	Not sensitive

Habitat/biotope	MarESA sensitivity rating					
	Smothering and siltation rate changes (light)	Changes in suspended solids (water clarity)	Underwater noise change	Introduction or spread of INNS	Water flow (tidal current) changes (local)	Wave exposure changes (local)
A5.252 *Abra prismatica, Bathyporeia elegans* and polychaetes in circalittoral fine sand	Low	Low	Not relevant[1]	High	Not sensitive	Not sensitive
A5.261 *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	Low	Low	Not relevant[1]	High	Not sensitive	Not sensitive
A5.443 *Mysella bidentata* and *Thyasira* spp. In circalittoral muddy mixed sediment	Not sensitive	Not sensitive	Not relevant[1]	High	Not sensitive	Not sensitive
A5.451 Polychaete-rich deep *Venus* community in offshore mixed sediments'	Low	Low	Not relevant[1]	High	Not sensitive	Not sensitive
Subtidal mud/mud habitats in deep water (A5.3 sublittoral mud)						
A5.351 *Amphiura filiformis, Mysella bidentata* and *Abra nitida* in circalittoral sandy mud	Not sensitive	Not sensitive	Not relevant[1]	No evidence	Not sensitive	Not sensitive
A5.355 *Lagis koreni* and *Phaxus pellucidus* in circalittoral sandy mud	Not sensitive	Not sensitive	Not sensitive	No evidence	Not sensitive	Not sensitive
A5.361 Sea pens and burrowing megafauna in circalittoral fine mud	Not sensitive	Not sensitive	Not relevant[1]	No evidence	High	Not sensitive

Habitat/biotope	MarESA sensitivity rating					
	Smothering and siltation rate changes (light)	Changes in suspended solids (water clarity)	Underwater noise change	Introduction or spread of INNS	Water flow (tidal current) changes (local)	Wave exposure changes (local)
MCZ and SAC designated features						
Subtidal sand (Fylde MCZ and West of Walney MCZ)	Low	Low	Not sensitive	High	Low	Not sensitive
Subtidal mud (Fylde MCZ and West of Walney MCZ)	Low	Low	Not relevant[1]	High	Medium	Not sensitive
Sea-pen and burrowing megafauna communities (West of Walney MCZ)	Not sensitive	Not sensitive	Not relevant[1]	No evidence	High	Not sensitive
Annex I sandbank – subtidal sand (Shell Flat and Lune Deep SAC)	Low	Low	Not sensitive	High	Low	Not sensitive
Annex I sandbank – subtidal mud	Low	Low	Not relevant[1]	High	Medium	Not sensitive

[1] 'Not relevant' is recorded in the MarESA assessments where the evidence suggests that there is no direct interaction between the pressure and the receptor and hence is classed in the assessment herein as 'not sensitive'

9.6.3 Potential effects during construction

9.6.3.1 Impact 1: Physical disturbance to seabed habitat

Description of impact

9.160 As a result of construction activities, there is potential for direct impact in the form of temporary (limited to the installation period for each activity over the 2.5 year construction period) physical disturbance to and/or removal of benthic habitats and species within the footprint of the windfarm site. The principal sources of seabed disturbance/habitat loss would include the preparation of the seabed at the WTG and OSP locations for foundation and scour protection installation (i.e. sandwave clearance, levelling and boulder removal), the burial of the inter-array and platform link cables that would link the WTGs and OSP(s). UXO clearance, if required, is also included within this impact for information. However, it is noted that a separate marine licence for UXO clearance would be made once more detail of any UXO clearance activities are known. Vessel activities, such as jacking up of installation vessels and anchoring (if required), would also result in temporary physical disturbance to the seabed.

9.161 The assessment in this section focuses on the short-term, temporary impacts associated with seabed preparation, cable laying and vessel use, from which habitats and species would be able to recover once construction is complete. Where disturbed sediments are subsequently covered with infrastructure (e.g. WTG/OSP foundations, scour protection, cable protection), habitat loss or change associated with the presence of such infrastructure would be long-term or permanent. While these long-term impacts would initially manifest during the construction phase, they would endure throughout the lifetime of the Project, hence are considered separately as an operation and maintenance impact to avoid duplication.

Effects on habitats and biotopes recorded within the windfarm site

Sensitivity

9.162 Given the direct nature of this impact, only habitats and biotopes present within the windfarm site itself would be affected. Habitats and biotopes outside the site are therefore not considered in the assessment of this impact.

9.163 Habitats present within the site (**Figure 9.7** and **Figure 9.8**) are almost exclusively comprised of A5.2 sublittoral sand and A5.3 sublittoral mud. Biotopes identified, albeit classified with a lesser degree of certainty than broadscale habitat, are A5.252 '*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand' and A5.351 '*Amphiura filiformis*, *Mysella bidentata* and *Abra nitida* in circalittoral sandy mud'. The FOCI 'sea-pens and burrowing megafauna communities' may be present at the site given the density of burrows, hence impact on A5.361 'sea-pens and burrowing megafauna in circalittoral fine mud' is also considered.

9.164 The sensitivity of these habitats/biotopes has been assessed in relation to MarESA pressures relevant to construction phase temporary habitat loss/physical disturbance. These are:

- Habitat structure changes – removal of substratum (extraction)
- Abrasion/disturbance of the surface of the substratum or seabed
- Penetration or disturbance of the substratum subsurface

9.165 The sensitivity of identified habitats and biotopes to temporary habitat loss/disturbance pressures are summarised in **Table 9.19~~Table 9.19~~** and range from low to high.

9.166 The dominant sublittoral mud habitat and associated biotope A5.351 is classified as having **medium** sensitivity to all pressures. The sublittoral sand habitat and associated biotope is classified as having **medium** sensitivity to the process of substrate removal, but **low** sensitivity to abrasion/disturbance of the seabed and substrate penetration.

9.167 The FOCI 'sea-pens and burrowing megafauna communities' and associated biotope A5.361 has **medium** sensitivity to sediment abrasion and disturbance but is **highly** sensitive to the removal and/or penetration of the substratum. However, the MarESA assessment attributes this sensitivity specifically to the sensitivity of sea-pen species to substrate removal and seabed penetration, which would result in the loss of these species. Given that sea-pens are understood to be absent from the site (see **Section 9.5.5.4** for detail), and whilst acknowledging that other burrowing megafauna would still be affected, it is considered that, in this instance, a sensitivity of **medium** would be appropriate.

9.168 Post-construction monitoring at the nearby Walney OWF (CMACS, 2014) indicated that, for muddy sand, the associated biotopes (particularly A5.351) were generally recorded at similar stations in the Year 1, Year 2 and Year 3 post-construction surveys as they were in the pre-construction baseline survey, with only a few exceptions where characteristic taxa of the A5.351 biotope decreased in abundance. This suggests that recovery of this biotope is possible within a relatively small timeframe (i.e. within two to three years), which supports the MarESA sensitivity assessment of resilience/recovery and **low** to **medium** sensitivity.

9.169 The post-construction monitoring at Walney OWF (CMACS, 2014) looked specifically at trends in burrow density before and after construction. Burrow numbers were seen to decrease following construction, particularly in windfarm and near-field locations, where the decrease was statistically significant. However, in this instance it was noted that this did reflect a wider scale reduction, which may have partly explained the trend.

9.170 As such, a worst-case sensitivity rating of **medium** has been assigned to the receptor groups (subtidal sands and gravels, subtidal mud, sea-pens and burrowing megafauna communities) present at the site.

170.1 As detailed in Section 7.6.2.9 in Chapter 7 Marine Geology, Oceanography and Physical Processes, studies on the potential size of depressions left behind after clearance of a 700kg UXO resulted in a crater with a diameter of 21.1m (Dogger Bank Wind Farm, 2018). While such a detonation would lead to a temporary loss of habitat, as described in Section 7.6.2.9 of Chapter 7 Marine Geology, Oceanography and Physical Processes, due to the dynamic nature of the underlying sediment and strong tidal currents within the windfarm site, craters would be expected to refill with sediment over the course of days to months, depending on sedimentary and hydrodynamic conditions at the site. In addition, the overall spatial extent of any craters resulting from UXO clearance will be negligible in the context of the habitat present in the windfarm site and wider Irish Sea and any direct effects would be remote from any benthic designated sites.

Magnitude

9.171 Disturbance would be temporary and intermittent over the construction period. The total footprint of seabed disturbance, as set out in **Table 9.2~~Table 9.2~~**, is approximately 2.4km^2, representing 2.8% of the windfarm site. The area of disturbance was considered to be small in the context of the extent of sublittoral mud and sand habitats/biotopes present in unaffected areas within the windfarm site itself and very small within the context of the wider Eastern Irish Sea marine area, as indicated by the EUSeaMap 2021 (EMODnet Seabed Habitat Consortium, 2022) and evidenced by other relevant studies outlined in **Section 9.5.4**.

9.172 A discernible yet temporary (i.e. part or all of the construction phase plus an ensuing period of recovery) change affecting a small proportion of the subtidal sand and mud habitats present across the wider Eastern Irish Sea is anticipated and, as such, the magnitude of this impact was assessed as **low**.

Significance of effect

9.173 Based on a **medium** sensitivity and a **low** magnitude of impact, physical disturbance and habitat removal during the construction phase would have a **minor adverse** effect on the biotopes and habitats that are present at the windfarm site, which is not significant in EIA terms.

Effects on designated sites

9.174 Given that there is no spatial overlap between the windfarm site and benthic nature conservation designations, there is no pathway for any direct effects. As such, there would be **no change** to benthic features of Fylde MCZ, West of Walney MCZ or Shell Flat and Lune Deep SAC as a result of physical disturbance and/or habitat removal within the windfarm site.

9.6.3.2 Impact 2: Increased SSCs and subsequent deposition

Description of impact

9.175 During construction activities there may be temporary (limited to the installation period for each activity over the 2.5 year construction period) increases in SSCs and subsequent deposition of disturbed sediment. Increases in SSCs have the potential to affect benthic ecology receptors by blocking feeding apparatus as well as by smothering sessile species upon redeposition.

9.176 A conceptual evidence-based assessment of the extent and magnitude of increases in SSCs and seabed level changes as a result of deposition is detailed in **Chapter 7 Marine Geology, Oceanography and Physical Processes**. The same chapter also describes how the outcomes of that conceptual assessment are supported by numerical modelling undertaken for the Mona Offshore Wind Project, Morgan Offshore Wind Project Generation Assets and AyM Offshore Wind Farm (which are considered to have comparable marine physical processes – see Section 7.4.3.3 of **Chapter 7 Marine Geology, Oceanography and Physical Processes**). This conceptual assessment approach was confirmed as '*largely appropriate'* by the MMO and '*presents an improvement to the previous conceptual approach and will result in a better supported ES'* by Natural England. The outcome of the assessment is summarised in the following paragraphs.

9.177 Excavation during seabed preparation to create a suitable base for WTG and OSP foundations, plus preparation (levelling) during the installation of inter-array and platform link cables, would result in a modest concentration plume advected along the tidal axis. Coarser (i.e. sand) components of the sediment would fall out of suspension rapidly, forming a mound (tens of centimetres in height) local only to the release point. Given the sediment in the Project windfarm site is principally composed of sand with low mud content, this would not represent a significant alteration in seabed composition. Deposition levels would decrease rapidly with distance from the release point, with deposition of finer material within the tidal ellipse (approximately 10km) resulting in very minor bed level changes (millimetres).

9.178 Arisings from potential drilling of piles at each foundation location would result in the disturbance of consolidated clasts from below the surficial sediment layer. These would fall out of suspension almost immediately and form mounds local to the release point. Fine unconsolidated sediments brought into suspension from drilling would result in increases in SSCs which, away from the immediate vicinity of the release location, would be within the range of natural variability.

9.179 Other relatively minor seabed disturbances, namely those from deployment of jack-up vessels and/or anchors, and placement of scour protection and cable protection onto the seabed, would not be expected to cause an increase in SSCs/deposition to the extent that there would be a discernible impact to benthic ecology receptors.

9.180 Consideration is also given to the remobilisation of contaminants with disturbed sediment. The context of contaminant concentrations within the sediment samples is established through comparison with recognised guidelines and action levels, notably Cefas ALs and US Environmental Protection Agency's ERL (refer to **Section 9.5.2**). Cefas ALs are widely used for assessing contamination risk in UK marine development and are available for a range of contaminants. ERLs are quality guidelines used by OSPAR and are defined as the lower tenth percentile of the dataset of concentrations in sediments which were associated with biological effects. If concentrations within the sampled sediment generally do not exceed the lower threshold values (i.e., AL 1 and ERL), then contamination levels are not considered to be of significant concern and are low risk in terms of potential impacts on marine benthic, fish and shellfish communities.

9.181 A comparison of the sediment chemistry data against guideline action levels has been undertaken within **Chapter 8 Marine Sediment and Water Quality** (Section 8.5.2.2). This included chemical analyses of sediment samples from the windfarm site undertaken in May/June 2022. No samples exceeded either Cefas AL 1 or ERLs.

9.182 With respect to metals, concentrations indicate very low levels of contamination. The only parameter exceeding sediment guideline values was mercury for OSPAR Background Assessment Concentrations (BAC) (five samples) and only one sample recorded levels at the Canadian (ERL) (i.e. sample concentration equalled the ERL).

9.183 With respect to PAHs, several samples exceeded the BAC. Where exceedances occurred, concentrations were only marginally above the BAC value. Concentrations of PAHs are therefore very low across the windfarm site.

9.184 All other parameters were below the limits of detection.

9.185 As sediment contamination levels are low, the risk of adverse effect on benthos arising from disturbance of the sediment is consequently **low**. As contaminant levels are not found to be present at levels whereby effects would arise, this impact (remobilisation of contaminated sediments) is therefore scoped out of the assessment for all phases. The scoping out of this impact was agreed by Natural England and the MMO (confirmed by email on 28th September 2023).

Effects on habitats and biotopes recorded within the 15km Project ZoI

Sensitivity

9.186 Given that potential effects on seabed habitats/biotopes from this impact may occur, to a varying extent, anywhere within the tidal ellipse (i.e. to the maximum spatial extent of any sediment plume), all habitats and biotopes listed in **Table 9.17**~~Table 9.17~~ are considered herein.

9.187 The sensitivity of these habitats/biotopes has been assessed in relation to MarESA pressures relevant to construction-phase increases in SSCs and deposition. These are:

- Smothering and siltation rate changes
- Changes in suspended solids (water clarity)

9.188 The assessment of potential changes in seabed level presented in **Chapter 7 Marine Geology, Oceanography and Physical Processes** indicates that, aside from the near-field localities of areas of disturbance (i.e. at a distance in the order of tens to hundreds of metres), where coarser or consolidated sediment fractions would quickly fall out of suspension, deposition of fines would be on the scale of millimetres. As such, the MarESA assessment for those habitats and biotopes not present within the windfarm site itself is based only on the pressure ‘smothering and siltation rate changes (light)’, which is defined as deposition of up to 5cm of fine material in a single discrete event.

9.189 The sensitivity of identified habitats and biotopes to increased SSCs and deposition pressures are summarised in **Table 9.19**~~Table 9.19~~ and **Table 9.20**~~Table 9.20~~ and range from ‘**not sensitive’** to ‘**medium**’.

9.190 Outside the windfarm site itself, where deposition would be considered ‘light’, sensitivity of all habitats/biotopes ranges from **‘not sensitive’** to **‘low’**. The subtidal mud and sand habitats present within the windfarm site, where deposition may exceed 5cm local to sources of sediment disturbance, are considered to have **‘medium’** sensitivity to ‘heavy’ deposition. The FOCI ‘sea pens and burrowing megafauna communities’ is considered to be **insensitive** (i.e. negligible sensitivity) even to ‘heavy’ deposition.

9.191 In all instances, there is **none** to **low** sensitivity to increased SSCs within the water column.

9.192 As was noted for construction Impact 1 (**Section 9.6.3.1**), the post-construction monitoring at Walney OWF (CMACS, 2014) indicated that, for muddy sand, the associated biotopes (particularly A5.351) were generally recorded at similar stations in the Year 1, Year 2 and Year 3 post-construction surveys as they were in the pre-construction baseline survey, with only a few exceptions where characteristic taxa of the A5.351 biotope decreased in abundance. This suggests that recovery of this biotope following periods of sedimentation is possible within a relatively small timeframe (i.e. within two to three years), which supports the MarESA sensitivity assessment of resilience/recovery. As such, there is a degree of confidence in assigning a worst-case sensitivity rating of **medium** to the subtidal sand/gravel and subtidal mud biotopes and broadscale habitats present within the ZoI.

Magnitude

9.193 The total volume of sediment that would be disturbed and may potentially be brought into suspension during construction, as set out in **Table 9.2**~~**Table 9.2**~~, is approximately 1.1 million m^3. However, disturbance would be temporary and intermittent over the construction period, and any increases in SSCs around each foundation/location along the cable routes would last a fraction of this time (a matter of hours to days).

9.194 The area over which 'heavy' deposition (i.e. more than 5cm of fine material, as defined by MarESA assessments) may occur, based on the assessment of changing bed levels set out in **Chapter 7 Marine Geology, Oceanography and Physical Processes**, would be restricted to the immediate vicinity of the point of release. Such an area would be very small in the context of the extent of sublittoral mud and sand habitats/biotopes present in unaffected areas within the windfarm site and the wider Eastern Irish Sea marine study area, as indicated by the EUSeaMap 2021 (EMODnet Seabed Habitat Consortium, 2022) and evidenced by other relevant studies outlined in **Section 9.5.4**.

9.195 The area over which 'light' material deposition (i.e. less than 5cm of fine material, as defined by MarESA assessments) may occur, again based on the assessment of changing bed levels set out in **Chapter 7 Marine Geology, Oceanography and Physical Processes**, although potentially anywhere within the tidal ellipse, is still considered to be small in the context of the extent of subtidal habitats within the wider Eastern Irish Sea study area. Across the tidal ellipse (beyond the immediate vicinity of disturbance activities) seabed deposition would be in the order of millimetres. It is likely that fine materials in areas of light deposition would be remobilised and redistributed within a short period of time. The conceptual evidence based-assessment presented in **Chapter 7 Marine Geology, Oceanography and Physical Processes** concludes that impacts (changes to seabed level) would be of negligible magnitude in the far-field and low magnitude in the near-field.

9.196 As such a discernible, yet temporary (i.e. part or all of the construction phase plus an ensuing period of recovery), change affecting only the windfarm site and surrounding habitats (which represent a small proportion of the subtidal sand and mud habitats present across the wider Eastern Irish Sea) is anticipated. Consequently, the magnitude of this impact was assessed as **low**.

Significance of effect

9.197 Based on a **negligible** (sea-pens and burrowing megafauna communities) and **medium** (subtidal sands/gravels, subtidal mud) sensitivity and a **low** magnitude of impact, increases in SSCs and subsequent deposition during the construction phase would have a **negligible** to **minor adverse** effect on the biotopes and habitats that are present within the Project ZoI, which is not significant in EIA terms.

Effects on designated sites

Sensitivity

9.198 The sensitivity of features from Fylde MCZ, West of Walney MCZ and Shell Flat and Lune Deep SAC, as set out in the respective AoO, is summarised in **Table 9.20**~~**Table 9.20**~~. Pressures considered are those categorised under marine activity ‘Electricity from renewable energy sources – Offshore wind (during construction)’ that are relevant to construction-phase increases in SSCs and deposition, namely:

- Smothering and siltation rate changes (light)
- Changes in suspended solids (water quality)

9.199 Given that the designated sites are located a considerable distance from the windfarm site, there is no need to consider sensitivity to heavier smothering and siltation rate changes.

9.200 In all instances, the component biotopes of the designated features (as considered in the AoO) have no or low sensitivity to the effects of increased SSCs or subsequent light siltation. Conservatively, therefore, the sensitivity of this receptor group was assessed as **low**.

Magnitude

9.201 The evidence-based assessment set out in **Chapter 7 Marine Geology, Oceanography and Physical Processes** concludes that the far-field (encompassing designated sites) magnitude of impact (changes to seabed level) is negligible.

9.202 At a distance of approximately 8km from the windfarm site (the shortest distance between the site and any of the above designations), the evidence-based assessment concluded that sediment disposal would be indistinguishable from background levels and well in line with the range of natural variability.

9.203 As such, it is likely that any impact within the designated sites would be indiscernible and hence the impact on benthic features was assessed as **negligible** magnitude.

Significance of effect

9.204 Based on a **low** sensitivity and a **negligible** magnitude of impact, increases in SSCs and subsequent deposition during the construction phase would have a **negligible** adverse effect on the benthic features of designated sites, which is not significant in EIA terms.

9.6.3.3 Impact 3: Underwater noise and vibration

Description of impact

9.205 Underwater noise and vibration from pile driving for the installation of WTG and OSP foundations have the potential to impact on benthic ecology receptors. UXO clearance campaigns would be subject to a separate licence (once the need for clearance is identified) and are not considered as part of this assessment. Note, the effects of UXO clearance on the benthic environment is covered in **Section 9.6.3.1**.

9.206 There have been some studies on the ability of aquatic invertebrates to respond to noise and vibration. For example, Horridge (1966) found the hair-fan organ of the common lobster *Homarus gammarus* to act as an underwater vibration receptor. Lovell *et al*. (2005) showed that the common prawn *Palaemon serratus* is capable of hearing sounds within a range of 100 to 3,000Hz, and the brown shrimp *Crangon crangon* has shown behavioural changes at frequencies around 170Hz (Heinisch and Weise, 1987). De Soto *et al*. (2013) suggested that underwater noise can cause body malformations and development delays in marine larvae. Laboratory studies by Wale *et al*. (2013) and Roberts *et al*. (2016) indicated that noise and vibration negatively affects foraging and antipredator behaviour in crustaceans such as the shore crab *Carcinus maenas* and the hermit crab *Pagurus bernhardus*. During seismic surveys, polychaetes have been observed to retreat into the bottom of their burrows or retract their palps, and bivalve species to withdraw their siphons (Richardson *et al*., 1995).

9.207 Whilst these studies demonstrate potential for noise to negatively impact benthic invertebrates, notably crustacea, the sensitivity of benthic species to noise and vibration in general is poorly understood. As such, it is not possible to make firm conclusions about individual receptor sensitivity, or determine threshold noise levels above which effects may begin to manifest. It is likely, however, that aquatic invertebrates are capable of detecting particle motion, including seabed vibration.

9.208 Noise and vibration sources from other activities, such as dredging during seabed preparation, ploughing for cable installation, scour protection/cable protection placement and vessel use, are unlikely to have a significant effect on benthic ecology, as the benthos in the ZoI is likely to be habituated to ambient noise such as that created by vessel traffic, aggregate dredging etc.

Effects on habitats and biotopes recorded within the 15km Project ZoI

Sensitivity

9.209 Given that potential effects on seabed habitats/biotopes from construction-phase noise and vibration may occur, to a varying extent, anywhere within the ZoI, all habitats and biotopes listed in **Table 9.17**~~**Table 9.17**~~ are considered herein.

9.210 Sensitivity of these habitats/biotopes has been assessed in relation to MarESA pressures relevant to construction-phase changes in ambient noise level, as summarised in **Table 9.20**~~**Table 9.20**~~. The MarESA sensitivity assessment for the habitats and biotopes present within the ZoI concludes that noise impacts are 'not relevant', hence suggesting that receptors are not sensitive to this impact. However, given the recent evidence that suggests that certain benthic species may actually perceive and react to noise, the sensitivity of benthic habitats and biotopes to underwater noise and vibration is precautionarily considered to be **low**.

Magnitude

9.211 Underwater noise and vibration from the worst-case sources (described in **Table 9.2**~~**Table 9.2**~~) would result in temporary (i.e. for part of the construction phase) change in noise and vibration level. Underwater noise and vibration from loud construction-phase activities, such as piling, would not be constant throughout the construction phase, as there would be downtime between piles/groups of piles, as well as downtime associated with adverse weather. Underwater noise and vibration from construction-phase activities would cease following completion of the construction phase. Maximum noise and vibration levels would likely arise from the piling installation of the largest monopile foundations using the largest hammer energy (6,600kJ). Installation of jacket foundations would likely result in a lower noise level (2,500kJ hammer used), but would take longer, given the number of pin piles required per jacket. Taking the modelled range for mortality in fish species reliant on particle-motion detection for hearing as a proxy (based on SPL_{peak} impact thresholds (Popper *et al*., 2014; presented in **Appendix 11.1 Underwater Noise Assessment**), particle motion-sensitive invertebrates may experience effects to a maximum distance of 320m from source for a single maximum energy hammer strike for a monopile, although it is likely to be considerably less given the low sensitivity of benthic fauna.

9.212 In the event that individual characteristic taxa of the biotopes listed in Table 9.17~~Table 9.17~~ are affected by noise levels and/or vibration increases within the vicinity of the source, the area affected is considered to be small in the context of the extent of sublittoral mud and sand habitats/biotopes present in unaffected areas within the ZoI and the wider Eastern Irish Sea marine study area, as indicated by the EUSeaMap 2021 (EMODnet Seabed Habitat Consortium, 2022) and evidenced by other relevant studies outlined in **Section 9.5.4**.

9.213 As such, a discernible, yet temporary, change in underwater noise and vibration affecting a small proportion of the subtidal sand and mud habitats present across the wider Eastern Irish Sea is anticipated. Consequently, the magnitude of this impact was assessed as **low**.

Significance of effect

9.214 Based on a **low** sensitivity and a **low** magnitude of impact, changes in underwater noise and vibration during the construction phase would have a **minor adverse** effect on the biotopes and habitats that are present within the ZoI, which is not significant in EIA terms.

Effects on designated sites

Sensitivity

9.215 The sensitivity of features from Fylde MCZ, West of Walney MCZ and Shell Flat and Lune Deep SAC, as set out in the respective AoO, is summarised in Table 9.20~~Table 9.20~~. Pressures considered are those categorised under marine activity ‘Electricity from renewable energy sources – Offshore wind (during construction)’ that are relevant to construction-phase sources of underwater noise, namely:

- Underwater noise changes

9.216 The MarESA sensitivity assessment concludes that, for the component biotopes of the designated features, noise impacts are either ‘not sensitive’ or ‘not relevant’ (suggesting that they are not sensitive). However, given the recent evidence that suggests certain benthic species perceive and react to noise, sensitivity of the features is precautionarily considered to be **low**.

Magnitude

9.217 Underwater noise and vibration changes would remain a temporary impact, affecting the designated sites on a non-constant basis and only during part of the construction phase. While underwater noise can propagate to a considerable distance, at a distance of at least approximately 8km from the windfarm site (the shortest distance between the Project and any of the above designations), noise levels are likely to be minimal (and well below the levels which may be injurious to benthic fauna). The impact on benthic habitats was assessed as **negligible** magnitude.

Significance of effect

9.218 Based on a **low** sensitivity and a **negligible** magnitude of impact, underwater noise and vibration changes arising during the construction phase would have a **negligible adverse** effect on the features of the designated sites, which is not significant in EIA terms.

9.6.3.4 Impact 4: Introduction and spread of INNS

Description of impact

9.219 Should INNS become established within a new habitat they can out-compete native species for space and resources, or may prey on native species, or introduce new pathogens (Roy *et al.*, 2012). As such, the introduction and/or spread of INNS during the construction phase could potentially lead to changes in the ecological functionality of the benthic communities in the 15km Project ZoI and wider study area.

9.220 As a growing consideration for offshore marine developments in the UK, the primary pathway for the potential introduction of INNS would be from the use of vessels and infrastructure that originated from outside the Irish Sea and Northeast Atlantic region, particularly from regions that are ecologically distinct from the Eastern Irish Sea. Ship ballast water appears to be the largest single vector for INNS, and bio-fouling communities on ships are also a contributor (Glasby *et al*. 2007). The pathway for introduction of INNS would be greatest during the construction phase (due to the regularity and volume of construction-related vessel movements). An estimated 2,583 annual return vessel trips are expected during the construction phase to deliver and install the main components to the windfarm site, to undertake cable installation and for support and crew vessels (note this is an estimate and may be lower in some years). There is potential for localised spread of INNS where vessels arrive from nearby locations, though this would be managed in much the same way as for vessels from other regions.

9.221 No INNS were recorded from benthic grab samples and DDC imagery undertaken during the 2022 benthic characterisation survey of the Project windfarm site. As such, the risk of spread of INNS from the windfarm site to other marine areas was assessed as minimal.

9.222 The impacts from colonisation and establishment of INNS on OWF infrastructure following introduction has been considered separately as an operation and maintenance impact (**Section 9.6.4.8**).

Effects on habitats and biotopes recorded within the 15km Project ZoI

Sensitivity

9.223 Given that the potential introduction of INNS from vessels operating at (or commuting to) the windfarm site may affect seabed habitats/biotopes beyond the windfarm site itself, all habitats and biotopes listed in **Table 9.17**~~Table 9.17~~ are considered herein.

9.224 The sensitivity of these habitats/biotopes has been assessed in relation to the MarESA-assessed pressure 'introduction or spread of INNS', as summarised in **Table 9.20**~~Table 9.20~~.

9.225 For most broadscale habitats and component biotopes in the receptor group 'subtidal sands and gravels', sensitivity to the introduction and spread of INNS is high. No evidence was available for MarESA assessments regarding sublittoral mud biotopes; from a precautionary perspective it is assumed that such biotopes would also have a high sensitivity.

9.226 As such, general sensitivity of all benthic receptors present (or potentially present) in the ZoI was assessed as **high**.

Magnitude

9.227 The risk of introducing INNS during the construction phase is reasonably high, and there would be potential for spread across an extensive area (particularly for INNS distributed within the water column). There are estimated to be up to 2,583 return vessel trips per annum during the construction phase. However, the risk of introducing or spreading INNS is controlled via mandatory control measures, i.e. the implementation of biosecurity measures in line with international and national regulations and guidance, set out in **Table 9.3**~~Table 9.3~~, namely:

- International Convention for the Prevention of Pollution from Ships (MARPOL), which sets out the requirements for appropriate vessel maintenance
- The Environmental Damage (Prevention and Remediation) (England) Regulations 2015, which set out a 'polluter pays' principle whereby operators who cause a risk of significant damage to water and biodiversity receptors are responsible for i) preventing damage from occurring; and ii) bearing the costs for full reinstatement of the environment (to original condition) in the event of damage occurring
- The International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention), which provides an international framework for the control of transfer of potentially invasive species from ballast water

9.228 Contractor commitments under the above (plus any other biosecurity commitments agreed in advance with stakeholders) would be implemented via a PEMP (as detailed in **Section 9.3.3**).

9.229 With the above controls in place, the risk of introduction of INNS would be as low as reasonably practicable. As such, there is no long-term or significant risk to benthos either within the ZoI or the wider study area, and the magnitude of impact was assessed as **negligible**.

Significance of effect

9.230 Based on a **high** receptor sensitivity, yet **negligible** magnitude of impact, potential INNS introduction and/or spread during the construction phase would have a **minor adverse** effect on benthic habitats and biotopes within the ZoI, which is not significant in EIA terms.

Effects on designated sites

Sensitivity

9.231 The sensitivity of features from Fylde MCZ, West of Walney MCZ and Shell Flat and Lune Deep SAC, as set out in the respective AoO, is summarised in **Table 9.20**~~**Table 9.20**~~. Pressures considered are those categorised under marine activity 'Electricity from renewable energy sources – Offshore wind (during construction)' that are relevant to the risk of INNS introduction/spread during the construction phase, namely:

- Introduction or spread of invasive non-indigenous species

9.232 The MarESA sensitivity assessment concludes that, for the component biotopes of the designated features, sensitivity ranges from 'not sensitive' to 'high'. For some component biotopes, there is insufficient evidence for the AoO to provide a sensitivity rating to this particular pressure. In such instances, this assessment conservatively considers sensitivity to be high. As such, the sensitivity of the features to introduction and/or spread of INNS was assessed as **high**.

Magnitude

9.233 With the INNS prevention measures set out in **Table 9.3**~~**Table 9.3**~~ in place, the risk of introduction of INNS would be reduced to as low as reasonably practicable. As such, there is no long-term or significant risk to benthic features of the designated sites considered in this assessment, and the magnitude of impact was assessed as **negligible**.

Significance of effect

9.234 Based on a **high** receptor sensitivity yet **negligible** magnitude of impact, potential INNS introduction and/or spread during the construction phase would have a **minor adverse** effect on benthic features of designated sites, which is not significant in EIA terms.

9.6.4 Potential effects during operation and maintenance

9.6.4.1 Impact 1: Change in habitat type due to presence of OWF subsurface infrastructure

Description of impact

9.235 Following loss of habitat during seabed preparation works and cable burial during the construction phase (**Section 9.6.3.1**), the presence of physical structures on the seabed (namely WTG/OSP foundations, scour protection and cable protection) throughout the lifetime of the Project would ultimately represent a long term or permanent change to habitat type, from the soft sediment habitats described in the baseline to an artificial hard substrate.

9.236 It is currently unknown whether structures would be removed at the point of decommissioning, hence at the current stage it is unknown if change in habitat type during the operation and maintenance phase would be considered long term (albeit temporary (lifetime of the Project)) or permanent. As a precautionary approach to this assessment, change in habitat type has been assumed to be a permanent impact, since there is the potential that some structures may be left *in situ* (such as external cable protection or scour protection).

9.237 As such, this would represent a permanent change in the biotopes present within the footprint of the physical structures/artificial substrate on the seabed. Characterising taxa that are currently present may be lost from the affected areas, with new taxa likely to fill any void by colonising new structures/substrate. There is potential for this to lead to a localised increase in biodiversity (e.g. Lindeboom *et al*., 2011; Raoux *et al*., 2017; Coolen *et al*., 2020), as the presence of the structures would provide habitat for mobile epibenthos or colonial epibenthos which require a hard substrate (currently absent from the site). This does, however, represent a change to the baseline ecology of the affected area(s), including potential changes to trophic functionality. There may be a very small area of soft-sediment habitat immediately adjacent to structures (i.e. within metres) wherein changes to community composition may result from, for example, detachment of fouling species from the structures, sediment enrichment and export of organic matter to the seabed by fouling organisms (Coolen *et al*., 2022).

9.238 One minor benefit that could result from the presence of physical structures is the displacement of bottom-towed fishing activity from the immediate surrounds, which may promote benthic recovery (Coolen *et al*., 2022).

However, it should be noted that on a wider scale this is offset by the likelihood that displaced activities would merely target seabed habitats elsewhere.

9.239 Indirect effects on surrounding areas of habitat that are not within the footprint of the structures, namely as a result of changes to the existing hydrodynamic and/or sediment transport regime, are considered separately in **Section 9.6.4.2**.

Effects on habitats and biotopes recorded within the windfarm site

Sensitivity

9.240 Given the direct nature of this impact (i.e. effects would be limited only to the direct footprint of the physical infrastructure), only those habitats and biotopes present within the windfarm site itself would be affected. Habitats and biotopes outside the site are therefore not considered in the assessment of this impact.

9.241 The sensitivity of habitats/biotopes within the windfarm site has been assessed in relation to MarESA pressures relevant to operation and maintenance phase permanent change in habitat type. These are:

- Physical change (to another seabed type)

9.242 The sensitivity of the habitats/biotopes within the site to permanent change in habitat type is summarised in **Table 9.19~~Table 9.19~~**.

9.243 By its very definition, all of the habitats/biotopes present within the windfarm site would have a **high** sensitivity to change in habitat type, given that this would represent a permanent loss within the affected area, with no chance of recovery given the presence of introduced hard substrate.

Magnitude

9.244 The worst-case footprint for permanent infrastructure includes the footprint of foundations and scour protection for up to 35 WTGs and two OSPs with GBS foundations, plus cable protection and cable crossing protection along the inter-array and platform link cable routes and at the entry to WTGs/OSPs. The maximum area of permanent habitat loss is approximately 0.51km^2 (see **Table 9.2~~Table 9.2~~** for a breakdown of the parameters). Permanent habitat loss represents around a 0.6% of the total seabed area within the windfarm site itself.

9.245 Given that the habitats/biotopes present are distributed across the windfarm area, and further afield, as demonstrated by other studies in the Eastern Irish Sea marine study area (see **Section 9.5.4**), the extent to which the affected habitats would be reduced would be negligible in the context of their wider distribution in the study area. This includes the FOCI ‘sea pens and burrowing megafauna communities’ since burrows were recorded (to varying extent) across the entirety of the windfarm site, and this feature has also been recorded from other locations in the Eastern Irish Sea study area (e.g. CMACS, 2014), as well as being a FOCI of the West of Walney MCZ.

9.246 Although permanent, the effect on overall availability of circalittoral sand and mud habitats/biotopes within the windfarm site (and further afield) would be barely discernible. As such, the magnitude of the impact was assessed as **negligible**.

Significance of effect

9.247 Based on a **high** receptor sensitivity yet **negligible** magnitude of impact, the direct impact of the physical presence of permanent infrastructure (i.e. in terms of changes to habitat type) would have a **minor adverse** effect on benthic habitats and biotopes, which is not significant in EIA terms.

Effects on designated sites

9.248 Given that there is no spatial overlap between the windfarm site and designated sites, there is no pathway for any direct effects. As such, there would be **no change** to the benthic features of Fylde MCZ, West of Walney MCZ or Shell Flat and Lune Deep SAC as a result of changes in habitat type within the footprint of OWF structures.

9.6.4.2 Impact 2: Change in hydrodynamic conditions due to presence of OWF subsurface infrastructure

Description of impact

9.249 The presence of the WTG and OSP foundation structures on the seabed/water column within the windfarm site has the potential to alter the baseline tidal and wave regime. Any change in the tidal regime has the potential to contribute to changes in seabed morphology (and hence availability of benthic habitat) due to alteration of sediment transport patterns.

9.250 A conceptual evidence-based assessment of the extent and magnitude of changes in tidal and wave conditions as result of the Project infrastructure is detailed in **Chapter 7 Marine Geology, Oceanography and Physical Processes**. The same chapter also describes how the outcomes of that conceptual assessment are supported by numerical modelling undertaken for the Mona Offshore Wind Project, Morgan Offshore Wind Project Generation Assets and AyM Offshore Wind Farm (which are considered to have comparable marine physical processes), as well as post-construction studies at other OWFs.

9.251 Each foundation would present an obstacle to the passage of currents locally, causing a small modification to the height and/or phase of the water levels and a localised wake in the current flow, with a ZoI that would extend no further than the excursion of one spring tidal ellipse. Current speeds return to baseline conditions with progression downstream of each foundation. Each foundation would also present an obstacle to the passage of waves locally, causing a small modification to the height and/or direction of waves as they pass, creating a small wave shadow effect, with baseline conditions restored downstream of each WTG and OSP. Current wakes and wave shadow effects generally would not interact with effects from adjacent foundations due to the separation distances. Consequent changes in the sediment transport regime would be largely confined to the footprint of the current wakes and wave shadow effects.

9.252 Overall, to date there is no evidence of significant changes of the seabed beyond the vicinity (i.e. within a matter of tens of metres) of the foundation structures due to the installation of windfarms (Lindeboom *et al*, 2011; Hutchison *et al*., 2020).

Effects on habitats and biotopes recorded within the 15km Project ZoI

Sensitivity

9.253 Given that potential effects on seabed habitats/biotopes from this impact may occur, to a varying extent, anywhere within excursion of one tidal ellipse, all habitats and biotopes listed in **Table 9.17**~~Table 9.17~~ are considered herein.

9.254 The sensitivity of these habitats/biotopes has been assessed in relation to MarESA hydrological pressures, relevant to the presence of subsurface physical infrastructure at the seabed and in the water column. These are:

- Water flow (tidal current) changes (local)
- Wave exposure changes (local)

9.255 The sensitivity of identified habitats and biotopes to the above pressures are summarised in **Table 9.20**~~Table 9.20~~.

9.256 For most habitats/biotopes present in the 15km Project ZoI, there is **negligible** sensitivity to localised changes in tidal flow and wave activity. The exception to this is the biotope A5.361, a component of the FOCI 'Sea-pens and burrowing megafauna communities', for which the MarESA assessment classifies sensitivity to hydrological pressures as **high**, given that it has low resilience and resistance to any changes in tidal current. The sensitivity of the A5.361 biotope specifically relates to the sensitivity of characterising sea-pen species (Hill *et al*., 2020), such as *Virgularia mirabilis* and *Funiculina quadrangularis*, which are typical of low energy environments and cease to filter nutrients effectively in higher energy environments (Hiscock, 1983; Greathead *et al*., 2015).

9.257 As described in **Section 9.5.5.4**, sea pens were not recorded in the windfarm site during the 2022 benthic surveys, and the potential presence of the FOCI is based on density of burrows recorded at the seabed, rather than sea pen abundance (Robson, 2014). As such, sensitivity was considered to be considerably less for the case of the FOCI in the ZoI and is instead classified as **medium**.

Magnitude

9.258 The conceptual evidence-based assessment set out in **Chapter 7 Marine Geology, Oceanography and Physical Processes** indicates that changes to hydrodynamic conditions in the near-field would be of low magnitude, and changes in the far-field would be of **negligible** magnitude, though detectable to the extent of the excursion of one tidal ellipse. Post-construction monitoring at Dudgeon OWF (North Sea) was referenced in the evidence-based assessment, as it demonstrated that changes to seabed sediment distribution due to the presence of turbines are minimal.

9.259 Based on the conceptual assessment, it can be concluded that effects may be discernible within the near-field and only barely discernible out to the extent of the excursion of one tidal ellipse (far-field). Given that the area of subtidal mud and sand habitat that would be affected would represent a small proportion of the habitat availability in the study area, the magnitude of the impact was assessed as **low**.

Significance of effect

9.260 Based on a **negligible** (most subtidal sand/gravel and mud biotopes) to **medium** (sea-pen and burrowing megafauna communities) receptor sensitivity and **low** magnitude of impact, the indirect impact of the physical presence of WTG and OSP structures (i.e. in terms of localised changes to the hydrodynamic regime) would have a **negligible** to **minor adverse** effect on benthic habitats and biotopes, which is not significant in EIA terms.

Effects on designated sites

Sensitivity

9.261 The sensitivity of features from Fylde MCZ, West of Walney MCZ and Shell Flat and Lune Deep SAC, as set out in the respective AoO, is summarised in **Table 9.20~~Table 9.20~~**. Pressures considered are those categorised under marine activity ‘Electricity from renewable energy sources – Offshore wind (operation and maintenance)’ that are relevant to operation and maintenance phase changes to hydrodynamic conditions, namely:

- Water flow (tidal current) changes, including sediment transport considerations
- Wave exposure changes

9.262 In all instances, the component biotopes of the designated features have no sensitivity to the effects of wave exposure changes, due to the presence of subsurface structures. Sensitivity to water flow (tidal current) changes range between **low** sensitivity (subtidal sand component biotopes) and **high** sensitivity (sea-pen and burrowing megafauna communities at the West of Walney MCZ). Conservatively, therefore, the sensitivity of this receptor group was assessed as **high**.

Magnitude

9.263 The evidence-based assessment set out in **Chapter 7 Marine Geology, Oceanography and Physical Processes** concluded that changes in hydrodynamic climate would extend no further than the excursion of one tidal ellipse (approximately 10km from each WTG/OSP). The assessment concludes that the far-field magnitude of impact is **negligible**, with a **low** magnitude of impact at near-field locations.

9.264 At a distance of approximately 8km from the windfarm site (the shortest distance between the site and any of the above designations) it is likely that any effect within the designated sites would be indiscernible and, hence, the impact on benthic features was assessed as **negligible** magnitude.

Significance of effect

9.265 Based on a **high** sensitivity, yet **negligible** magnitude, of impact, changes in the hydrodynamic regime due to the physical presence of WTG and OSP foundation structures would have a **minor adverse** effect on the benthic features of designated sites, which is not significant in EIA terms.

9.6.4.3 Impact 3: EMF from subsea cables

Description of impact

9.266 The Project would transmit generated energy along a network of inter-array and platform link cables, linking the individual WTGs and the OSP(s). The alternating current (AC) passing through the cables would induce electric fields in the surrounding environment, the magnitude of which would be proportionate to the amount of electricity transmitted.

9.267 Operational voltage would likely be 66kV or 132kV (though may be up to 275kV for platform link cables) and cables would have a diameter of up to 220mm. A maximum of 70km of inter-array cables and 10km of platform link cables would be installed, based on worst-case scenarios (Table 9.2~~Table 9.2~~). Cables typically transmit AC at 50-Hz or cycles per second, inducing a weak electric field in the surrounding ocean that is unrelated to the voltage of the cable, but is dependent on the current flow through the cable. Inter-array and platform link cables would have a burial depth of between 0.5 and 3.0m (with a target depth of 1.5m); burial substantially reduces the levels of EMF detectable in the surrounding area, by increasing the distance between receptors and the source of EMF. If there are areas where cable burial is not possible, e.g. due to ground conditions or at cable crossing locations, cable protection installed over the cable at such locations would also increase the distance between receptors and the EMF source (i.e. the cables).

9.268 The evidence base regarding the effect of EMF on seabed benthos is very limited (generally, studies focus on the effects of EMF on elasmobranchs and other sensitive fish). EMFs as a result of the presence of offshore cables may attract, or repel, electromagnetic-sensitive benthic fauna, such as crustaceans (e.g. Gill *et al.*, 2012; Woodruff *et al.*, 2012). Effects would be highly localised, as EMFs are strongly attenuated and decrease as an inverse square of the distance from the cable (Gill and Barlett, 2010).

Effects on habitats and biotopes recorded within the windfarm site

Sensitivity

9.269 Given that the ZoI of EMF change would be highly localised around the footprint of the buried/protected cable, there is only potential for habitats and biotopes present within the windfarm site itself to be affected.

9.270 The MarESA sensitivity assessments do not consider there to be sufficient evidence to support sensitivity classification of benthic receptors to electromagnetic changes, hence sensitivity assessment within this section is based on the (albeit limited) literature that is available on the topic.

9.271 Evidence of invertebrates, such as arthropods and molluscs, responding to natural magnetic fields has been described from a number of studies (e.g. Ugolini and Pezzani, 1995; Ugolini, 2006; Boles and Lohmann, 2003). Laboratory studies have shown that some crustaceans, such as edible crab *Cancer pagurus*, may elicit attraction behaviour towards sources of EMF (of a similar strength to that expected around OWF subsea cables), thereby affecting natural behaviour (Scott *et al*., 2021), although individuals did not present stress-related physiological signs. Conversely, a study by Taormina *et al*. (2020) found no statistically significant effect on the exploratory and sheltering behaviour of juvenile European lobster *H. gammarus* following exposure to AC B-field EMF. A study by Jacubowska *et al*. (2019) on polychaetes indicated that there were no particular physiological effects or attraction/avoidance behaviour towards EMF, but there was an increase in burrowing activity.

9.272 A study by Love *et al.* (2016) compared the differences in soft-sediment invertebrate communities alongside both energised and unenergised subsea cables and concluded that there were no functional differences between the two groups. The invertebrate assemblage around each was generally similar. A review of studies regarding the response of faunal communities to the presence of subsea cables (Gill and Desender, 2020) concluded that benthic communities growing along cable routes are generally similar to those in nearby areas, with some locations perhaps showing a difference in the abundance of a few species. It also was noted in this review that potential changes may also be a result of the physical presence of structures or other environmental factors, rather than EMF. Gill and Desender (2020) conclude that, whilst 'research, both field and laboratory studies, has shown measurable effects and responses to E- and/or B-fields on a small number of individual species', this was 'not at the EMF intensities associated with [renewable energy]'.

9.273 For an assessment of potential impact on the characterising fauna of the habitats/biotopes present at the windfarm site, it is difficult to apply the above studies (which are generally focused at the individual-level, or are species-specific). However, in general it appears that, based on the extremely localised nature to which EMF fields are detectable, changes in community composition and structure due to avoidance and/or attraction of characterising taxa would be minimal. As such, the resistance of the biotopes/habitats present would be relatively high and the overall sensitivity to the impact would be **low**.

Magnitude

9.274 Electromagnetic changes would be induced by the alternating current through the inter-array and platform link cables throughout the lifetime of the Project, and would only cease upon decommissioning, hence is considered a long-term impact.

9.275 Only a very small area within the immediate vicinity (a matter of metres) around the inter-array and platform link cables would potentially experience detectable changes in EMF. Based on a maximum total cable length of approximately 80km (70km of inter-array cables and 10km of platform link cables), and an affected area of 1-2m either side of the cable, an area of approximately 0.08 to 0.16km^2 would be affected, representing 0.2% of the total seabed area within the windfarm site itself. Note that the cables would be buried at a target depth of around 1.5m. At this depth, EMF changes would be barely detectable at the surface, hence the area affected is, in reality, likely to be substantially less. Where cable burial is not possible, cable protection would have a similar shielding effect to EMF to burial in the seabed.

9.276 Given that the habitats/biotopes present are distributed across the windfarm site and further afield, as demonstrated by other studies in the Eastern Irish Sea (**Section 9.5.4**), the extent to which the affected habitats would be reduced would be **negligible** in the context of their wider distribution in the study area. This includes the FOCI 'sea-pens and burrowing megafauna communities', since burrows were recorded (to varying extent) across the entirety of the windfarm site, and this feature has been recorded from other locations in the Eastern Irish Sea study area (e.g. CMACS, 2014), as well as being a FOCI of the West of Walney MCZ.

9.277 Although long term (yet temporary, i.e. over the operation and maintenance period), the effects on benthic communities associated with circalittoral sand and mud habitats/biotopes would be highly localised and barely discernible even on a local scale. As such, the magnitude of the impact was assessed as **negligible**.

Significance of effect

9.278 Based on a **low** receptor sensitivity, and **negligible** magnitude of impact, the impact of changes in EMF would have a **negligible adverse** effect on benthic habitats and biotopes, which is not significant in EIA terms.

9.279 Given the unknowns still associated with this topic, a number of research projects are ongoing, and the Applicant would maintain a watching brief on any developments.

Effects on designated sites

9.280 Given that there is no spatial overlap between the windfarm site and benthic nature conservation designations, there is no pathway for effect. As such, there would be **no change** to benthic features of Fylde MCZ, West of Walney MCZ or Shell Flat and Lune Deep SAC as a result of electromagnetic changes around the subsea inter-array and platform link cables.

9.6.4.4 Impact 4: Increases in seabed temperature from subsea cables

Description of impact

9.281 A certain amount of energy gets lost as heat when electricity is transmitted through subsea cables. This radiated heat has the potential to increase temperature at the cable surface and may cause localised warming of the surrounding sediments. This is only likely to affect buried cables, since unburied cables, or those covered by hard substrate for protection, would see heat energy dissipated by the water flow (Worzyk, 2009).

9.282 While there is a lack of field data on the effects of thermal radiation from OWF subsea cables on benthic habitats (NIRAS Consulting Ltd., 2015), studies suggest that the thermal effect would represent a small increase in temperature within a few centimetres of the cable (Boehlert and Gill, 2010), with only burrowing species likely to be affected (NSN Link Ltd., 2014).

Effects on habitats and biotopes recorded within the windfarm site

Sensitivity

9.283 Given that the ZoI of heat radiation would be highly localised around the footprint of the buried cable, there is only potential for habitats and biotopes present within the windfarm site itself to be affected. Habitats and biotopes outside the site are, therefore, not considered in the assessment of this impact.

9.284 The sensitivity of these habitats/biotopes has been assessed in relation to the MarESA pressure ‘Temperature increase (local)’. The pressure threshold used in the MarESA assessments is a short-term increase of 5°C, or a longer-term increase of 2°C, which is likely to be representative of changes within the surface sediments at the windfarm site.

9.285 The sensitivity of the habitats/biotopes within the site to localised temperature increase is summarised in **Table 9.19**~~**Table 9.19**~~.

9.286 Sublittoral sand habitats/biotopes and the predominant subtidal mud habitats/biotopes within the windfarm site have no to **low** sensitivity to localised temperature increase. The FOCI ‘sea-pens and burrowing megafauna communities’, and the representative biotope A5.361 used in the assessment, has a **medium** sensitivity. The higher sensitivity for this biotope is attributed to the fact that sea-pens are predominantly found in habitats and depths where wide and rapid variations in temperature are not common, and so may be less resistant of temperature increases at or above the 5ºC (short term) and 2ºC (long term) thresholds.

9.287 While sea-pens were not recorded at the windfarm site in the 2022 benthic survey (**Section 9.5.4.1**), the prevalence of burrowing fauna in the FOCI may, regardless, indicate a higher level of sensitivity, given that burrowing megafauna are more likely to be affected by increases in sediment temperature (NSN Link Ltd., 2014). As such, the sensitivity of the FOCI is conservatively assessed as **medium**.

Magnitude

9.288 Thermal increases in the surrounding sediment where cables are buried may arise throughout the lifetime of the Project, and would only cease upon decommissioning, hence is considered a long-term impact.

9.289 Only a very small area of sediment within the immediate vicinity (a matter of metres) around the inter-array and platform link cables would potentially experience detectable changes from ambient temperature. Based on a maximum total cable length of approximately 80km, and an affected area of 1-2m either side of the cable, an area of approximately 0.08 to 0.16km^2 would be affected, representing 0.2% of the total seabed area within the windfarm site itself. Note that, for most of the cable, the target burial depth would be around 1.5m below the surface of the sediment. At this depth, temperature changes would be barely detectable in surface sediments, where the majority of infauna reside (Borrmann, 2006), hence the area affected is, in reality, likely to be substantially less.

9.290 Given that the habitats/biotopes present are distributed across the windfarm area, and further afield, as demonstrated by other studies in the Eastern Irish Sea study area (**Section 9.5.4**), the extent to which habitats would be affected would be negligible in the context of their wider distribution. This includes the FOCI ‘sea-pens and burrowing megafauna communities’, since burrows were recorded (to varying extent) across the entirety of the windfarm site, and this feature has been recorded from other locations in the Eastern Irish Sea study area (e.g. CMACS, 2014), as well as being a FOCI of the West of Walney MCZ.

9.291 Although long term (yet temporary, i.e. over the operation and maintenance period), changes to benthic communities associated with circalittoral sand and mud habitats/biotopes would be highly localised and barely discernible even on a local scale. As such, the magnitude of the impact was assessed as **negligible**.

Significance of effect

9.292 Based on a **low** receptor sensitivity (subtidal sands/gravels and subtidal mud), or **medium** sensitivity (sea-pen and burrowing megafauna communities), and a **negligible** magnitude of impact, the impact of temperature increases in sediment within close proximity to subsea cables would have a **negligible** to **minor adverse** effect on benthic habitats and biotopes, which is not significant in EIA terms.

Effects on designated sites

9.293 Given that there is no spatial overlap between the windfarm site and benthic nature conservation designations, there is no pathway for effect. As such, there would be **no change** to benthic features of Fylde MCZ, West of Walney MCZ or Shell Flat and Lune Deep SAC as a result of localised increases in temperature around the subsea inter-array and platform link cables.

9.6.4.5 Impact 5: Temporary physical disturbance of the seabed during operation and maintenance activities

9.294 There is potential for ongoing temporary physical disturbance of the seabed from maintenance activity during the operations and maintenance phase, such as cable repair/reburial and WTG/OSP repairs (including replacement scour protection) using jack-up vessels. In general, the impacts from maintenance activities would be temporary (limited to intermittent maintenance activities during this phase), localised and smaller in scale than the seabed disturbances experienced during construction.

Effects on seabed habitats and biotopes in the windfarm site

Sensitivity

9.295 Given the direct nature of this impact (i.e. effects would be limited only to the direct footprint of the operation and maintenance activities), only those habitats and biotopes present within the windfarm site itself would be affected.

Habitats and biotopes outside the site are therefore not considered in the assessment of this impact.

9.296 The sensitivity of the habitats and biotopes present (or potentially present) in the windfarm site to sediment disturbance-related pressures are described in detail in **Section 9.6.3.1**, with MarESA assessment for the pressures presented in **Table 9.19~~Table 9.19~~**. An overall sensitivity rating of **medium** has been assigned for these MarESA pressures:

- Habitat structure changes – removal of substratum (extraction)
- Abrasion/disturbance of the surface of the substratum or seabed
- Penetration or disturbance of the substratum subsurface

Magnitude

9.297 The impact would be intermittent, highly localised and temporary, with disturbance ceasing upon completion of maintenance at a given location. The spatial extent of seabed disturbance during the operation and maintenance phase is considerably smaller than the extent of seabed disturbance during seabed preparation and cable installation works in the construction phase.

9.298 With this in mind, the area affected by seabed disturbance during maintenance activities (realistic worst-case scenarios as per **Table 9.2~~Table 9.2~~**) would represent a very small proportion of the subtidal sand and mud habitats/biotopes in the context of their distribution across the wider Irish Sea, and a fraction of the area affected during the construction phase. A discernible, temporary change, over a very small area of the receptor, is anticipated and, therefore, the magnitude of this effect was assessed as **negligible**.

Significance of effect

9.299 Based on a **medium** sensitivity, and a **negligible** magnitude of impact, increases in SSCs, and subsequent deposition, during operational and maintenance activities would have a **minor adverse** effect on the biotopes and habitats that are present within the survey area, which is not significant in EIA terms.

Effects on designated sites

9.300 Given that there is no spatial overlap between the windfarm site and benthic nature conservation designations, there is no pathway for any direct effects. As such, there would be **no change** to benthic features of Fylde MCZ, West of Walney MCZ or Shell Flat and Lune Deep SAC, as a direct result of disturbance to seabed habitats during operational and maintenance activities.

9.6.4.6 Impact 6: Temporary increases in SSCs/sedimentation during operational and maintenance activities

Description of impact

9.301 During the operation and maintenance phase, periodic maintenance activities may include repair to subsea cables and/or foundations, which require limited disturbance of the seabed in order to undertake. During such maintenance activities, small volumes of sediment could be re-suspended; though it should be noted that the volumes of sediment disturbed during maintenance works at any given time would be lower than those during construction phase seabed preparation and cable burial works.

9.302 Sediment disturbance, as a result of operation and maintenance phase activities, are expected to cause localised and short-term increases in SSCs at the point of discharge. Released sediment may then be transported by tidal currents in suspension in the water column, before being redeposited back on to the seabed.

Effects on habitats and biotopes recorded within the 15km Project ZoI

Sensitivity

9.303 The sensitivity of the habitats and biotopes present (or potentially present) in the 15km Project ZoI to increased SSCs, and subsequent sedimentation, are described in detail in **Section 9.6.3.2**, with MarESA assessment for the pressures 'smothering and siltation rate changes (heavy)', smothering and siltation rate changes (light)' and 'changes in suspended solids (water clarity)' presented in **Table 9.19~~Table 9.19~~** and **Table 9.20~~Table 9.20~~**.

9.304 A worst-case sensitivity rating of **medium** is assigned for subtidal sand/gravel and subtidal mud habitats, driven by the sensitivity of biotopes present within the windfarm site itself to heavier siltation rate changes within close proximity to the point of discharge. Sensitivity of the FOCI 'sea-pens and burrowing megafauna communities' is **negligible**.

Magnitude

9.305 Operational phase maintenance is likely to require periodic jack-up vessel deployments, anchoring events, and cable repair, replacement and reburial activities. Increased SSCs due to jack-up vessel deployments, anchoring events and replacement of scour/cable protection, are expected to be very small. Cable repair, replacement and reburial would mobilise larger volumes of sediment, but the impact would still be smaller in magnitude than that during initial cable installation during the construction phase, given that a smaller total volume of material would be disturbed during each maintenance activity (realistic worst-case scenarios as per **Table 9.2~~Table 9.2~~**).

9.306 As described in more detail in **Section 9.6.3.2**, sediment brought into suspension would be transported across the tidal ellipse, with the magnitude decreasing to within natural variations. Elevated SSCs would last for a period of hours to days. Given the localised nature of the impact, and the short duration of sediment plumes, it is highly unlikely that there would be any significant overlap between plumes from different maintenance works.

9.307 Seabed level changes outside the immediate vicinity of the operational maintenance activities would be in the order of millimetres, and materials that are redeposited onto the seabed would be remobilised and redistributed within a short period of time.

9.308 Given that effects may extend across the windfarm site and near-field habitats, a discernible yet temporary effect would be expected during each maintenance activity. The areas affected would represent a small proportion of the subtidal sand and mud habitats present in the ZoI and wider Eastern Irish Sea study area. Consequently, the magnitude of this impact was assessed as **negligible**.

Significance of effect

9.309 Based on a **negligible** (sea pens and burrowing megafauna communities) to **medium** (subtidal sands/gravels, subtidal mud) sensitivity, and a **negligible** magnitude of impact, increases in SSCs, and subsequent deposition, during operational and maintenance activities in this phase would have a **negligible** to **minor adverse** effect on the biotopes and habitats that are present within the survey area, which is not significant in EIA terms.

Effects on designated sites

Sensitivity

9.310 The sensitivity of features from Fylde MCZ, West of Walney MCZ and Shell Flat and Lune Deep SAC, as set out in the respective AoO, is summarised in **Section 9.6.3.2** and **Table 9.20~~Table 9.20~~**.

9.311 In all instances, the component biotopes of the designated features (as considered in the AoO) have **no** or **low** sensitivity to the effects of increased SSCs or subsequent light siltation, during operational and maintenance activities. Conservatively, therefore, the sensitivity of this receptor group was assessed as **low**.

Magnitude

9.312 As noted above, the magnitude of impact during the operation and maintenance phase would be lower than that assessed for the construction phase. At a distance of approximately 8km from the windfarm site (the shortest distance between the site and any of the above designations), an evidence-based assessment, as set out in **Chapter 7 Marine Geology, Oceanography**

and Physical Processes, concluded that increases in SSCs and subsequent disposal would be indistinguishable from background levels and well in line with the range of natural variability.

9.313 As such, it is likely that any effect within the designated sites would be indiscernible and, hence, the impact on benthic features was assessed as **negligible** magnitude.

Significance of effect

9.314 Based on a **low** sensitivity and a **negligible** magnitude of impact, increases in SSCs and subsequent deposition during operation and maintenance would have a **negligible adverse** effect on the benthic features of designated sites, which is not significant in EIA terms.

9.6.4.7 Impact 7: Underwater noise and vibration

Description of impact

9.315 Noise generated by the mechanical activity of WTGs, as well as a result of wind-induced vibration at high wind speeds, can be transmitted through the tower and foundations and radiate into the water column. Underwater noise is proportional to the size of the WTG; larger WTGs require greater mechanical forces and hence produce higher noise levels (Tougaard *et al*., 2020).

9.316 Underwater noise emissions from maintenance activities, such as repairs to foundations and cables (i.e. cable de-burial and re-burial) and replacement of scour protection, would be temporary (limited to infrequent operational and maintenance activities during this phase) and short-lived, and would not be expected to have any effect on benthic ecology, given that associated noises (e.g. vessel use, dredging activity) would be in line with ambient noise in the wider area.

Effects on habitats and biotopes recorded in the 15km Project ZoI

Sensitivity

9.317 The sensitivity of the habitats and biotopes present (or potentially present) in the ZoI to changes in ambient noise levels are described in detail in **Section 9.6.3.3**, with MarESA assessment for the pressure 'underwater noise change' presented in **Table 9.20~~Table 9.20~~**. The sensitivity of benthic habitats and biotopes to underwater noise and vibration was assessed as **low**.

Magnitude

9.318 The worst-case scenario, in terms of underwater noise during the operation and maintenance phase, would be related to the operation of the 30 larger WTGs, given that the larger turbines feature greater mechanical forces and hence produce higher noise levels (Tougaard *et al.*, 2020).

9.319 Monitoring studies of underwater noise from operational WTGs have shown the noise levels from North Hoyle, Scroby Sands, Kentish Flats and Barrow offshore windfarms (WTGs with 2MW to 3MW capacity) to be only marginally above ambient noise levels (Stober and Thomsen, 2021). A multi-turbine model (Tougaard *et al.*, 2020) indicated that elevated noise levels (analysis based on WTGs ranging from 0.2MW to 6.15MW capacity) could be detected up to a few kilometres from the WTGs under very low ambient noise conditions; however, in situations where ambient noise is affected by shipping, or high wind speeds, underwater noise from WTGs was below ambient levels, unless in close proximity to the WTGs.

9.320 While it is acknowledged that the WTGs present at the sites used in the above studies are lower capacity than those proposed for the Project (see **Table 9.2~~Table 9.2~~**), a study by Tougaard *et al.* (2020) on the cumulative contribution of OWFs to the underwater soundscape (and potential impact on marine ecosystems) determined that the most important factor explaining sound level is the physical distance from the WTGs, with WTG size (and wind speed) being a smaller, secondary factor. The reason why the size of the WTG is of a lesser influence on sound level may be explained by the fact that, for larger WTGs, the distance from the noise source in the nacelle to the water is correspondingly larger (Tougaard *et al.*, 2020). The study concluded that, findings from earlier studies (e.g. Madsen *et al*., 2006), i.e. that underwater noise radiated from individual WTGs is low, compared to ambient noise from e.g. ships, still applies, despite WTG capacity and size having increased over time. In areas with particular low ambient noise, this may still represent an impact to marine life; however, the Project is in a marine area with heavy traffic associated with ferry routes (e.g. Liverpool – Belfast and Heysham – Isle of Man), plus operational vessel traffic at Walney OWF and West of Duddon Sands OWF, and various oil and gas installations (based on 2019 and 2022 AIS data from MarineTraffic (2022)). The natural environment itself – for example, wind and wave action – is also a source of notable ambient noise.

9.321 Noise from the WTGs would be largely continuous throughout the lifetime of the Project (ceasing only during periods of weather downtime or equipment downtime). Exacerbation of noise caused by vibration in high wind speeds would be infrequent.

9.322 Given the above, it is predicted that underwater noise from WTGs would be barely discernible, or indiscernible, albeit on a long-term (i.e. over the operation and maintenance period) (and constant) basis, away from the immediate vicinity of the WTGs. The area likely to be affected would form a small proportion of the subtidal sand/gravel and subtidal mud habitats available in the ZoI and wider Eastern Irish Sea study area. As such, the magnitude of this impact was assessed as **negligible**.

Significance of effect

9.323 Based on a **low** sensitivity and a **negligible** magnitude of impact, underwater noise changes arising from the operation and maintenance phase of the Project would have a **negligible adverse** effect on the benthic habitats/biotopes within the ZoI, which is not significant in EIA terms.

Effects on designated sites

Sensitivity

9.324 The sensitivity of the features from Fylde MCZ, West of Walney MCZ and Shell Flat and Lune Deep SAC to changes in ambient noise levels are described in **Section 9.6.3.3**, with MarESA assessment for the pressure 'underwater noise change' presented in **Table 9.20~~Table 9.20~~**.

9.325 As described, the sensitivity of the benthic features to underwater noise and vibration changes is precautionarily considered to be **low**.

Magnitude

9.326 Underwater noise from operational and maintenance activities would be generally in line with ambient noises in the general area (i.e. vessel noises) and would be of **negligible** magnitude.

9.327 Underwater noises from the WTG structures themselves would persist throughout the lifetime of the Project. However, at a distance of at least 8km from the windfarm site (the shortest distance between the site and any of the above designations), underwater noise from WTGs would have attenuated sufficiently that noise changes would be barely discernible (or indiscernible). The impact on benthic habitats was assessed as **negligible** magnitude.

Significance of effect

9.328 Based on a **low** sensitivity and a **negligible** magnitude of impact, underwater noise changes arising from the operation and maintenance phase of the Project would have a **negligible adverse** effect on the features of the designated sites, which is not significant in EIA terms.

9.6.4.8 Impact 8: Colonisation of infrastructure by INNS

Description of impact

9.329 There is a risk that artificial hard substrates introduced in the form of Project infrastructure (including WTG/OSP foundations, scour protection and cable protection) could act as potential 'stepping stones' or vectors for INNS, thereby facilitating the spread of such species. In total, a seabed area of up to 0.51km^2 of new hard substrate may be introduced for the Project (realistic worst-case scenario as per **Table 9.2~~Table 9.2~~**).

9.330 As per the construction phase, the primary pathway for the potential introduction of INNS is from the use of vessels and infrastructure that have originated from outside the Irish Sea and Northeast Atlantic region. An anticipated 384 vessel return trips between the windfarm site and port during a standard year, or up to 832 vessel return trips during a 'heavy maintenance' year, would be undertaken during the operation and maintenance phase of the Project. The measures to control risk of INNS introduction and spread set out for the construction phase (**Section 9.6.3.4**) would apply also during the operation and maintenance phase. However, there is risk of spread by other vessels operating in the general area (for example, ferries and fishing vessels) that would not be controlled by Project-specific environmental control measures in the Outline PEMP.

9.331 The provision of new 'intertidal' habitat – this is, the new hard surface supplied by the foundation transition piece, that would be regularly covered and exposed by the tides - is not considered to present a significant risk of introduction of intertidal INNS to the offshore environment, since the distance to shore is too far for a natural transfer of INNS. There is no apparent existing data regarding subtidal INNS colonisation on OWF structures in the Irish Sea.

Effects on habitats and biotopes recorded within the 15km Project ZoI

Sensitivity

9.332 The sensitivity of the habitats and biotopes present (or potentially present) in the ZoI to the introduction and spread of INNS are described in detail in **Section 9.6.3.4**, with the relevant MarESA assessments for the pressure 'Introduction or spread of INNS' presented in **Table 9.20**~~**Table 9.20**~~.

9.333 Although there was insufficient supporting evidence related to the sensitivity of subtidal mud habitats, an overall worst-case sensitivity rating of **high** was assigned, based on the sensitivity of subtidal sand habitats/biotopes in the MarESA assessments.

Magnitude

9.334 As with the assessment for construction phase introduction/spread of INNS (**Section 9.6.3.4**), in the absence of suitable controls the risk of introducing INNS during the operation and maintenance phase would be reasonably high. There would be potential for spread across an extensive area, particularly for INNS distributed within the water column. During the operation and maintenance phase, colonisation and further spread of INNS introduced during the construction phase may also manifest, given the presence of suitable hard substrates.

9.335 The risk of introducing, or spreading, INNS during the operation and maintenance phase (and the risk of INNS establishment following introduction of hard substrate during the construction phase) through vessel activities would be mitigated via the embedded measures set out in Table 9.3Table 9.3. The measures would be applicable to both construction and operational and maintenance phase vessels.

9.336 Monitoring of INNS colonisation of the Morecambe structures would be taken into consideration when developing post-construction inspection surveys of the hard substrate. Data from monitoring would allow the effects of potential colonisation to be gauged and further control measures put in place, where necessary.

9.337 With such measures in place, the risk of introduction of INNS would be reduced to as **low** as reasonably practicable, and any early colonisation (i.e. within the first three years) of structures by subtidal INNS would be monitored and controlled. As such, there is no long-term, or significant risk to benthos, either within the ZoI or within the wider Eastern Irish Sea study area, and the magnitude of impact was assessed as **negligible**.

Significance of effect

9.338 Based on a **high** receptor sensitivity, yet **negligible** magnitude of impact, potential INNS introduction and/or spread during the construction phase would have a **minor adverse** effect on benthic habitats and biotopes within the ZoI, which is not significant in EIA terms.

Effects on designated sites

Sensitivity

9.339 **Section 9.6.3.4** describes the sensitivity of features from Fylde MCZ, West of Walney MCZ and Shell Flat and Lune Deep SAC to the introduction and/or spread of INNS. Based on the information set out in Natural England's AoO and the MarESA assessment, the sensitivity of the benthic features to introduction and/or spread of INNS in the operation and maintenance phase was assessed as **high**.

Magnitude

9.340 With the embedded measures set out in Table 9.3Table 9.3 in place, the risk of introduction of INNS would be reduced to as low as reasonably practicable. As such, there is no long-term, or significant risk, to benthic features of the designated sites considered in this assessment, and the magnitude of impact was assessed as **negligible**.

Significance of effect

9.341 Based on a **high** receptor sensitivity, yet **negligible** magnitude of impact, potential INNS introduction and/or spread during the operation and maintenance phase would have a **minor adverse** effect on benthic features of designated sites, which is not significant in EIA terms.

9.6.5 Potential effects during decommissioning

9.342 Decommissioning impacts are considered at this stage to be comparable to construction.

9.343 Given the lack of information regarding timing and methodology used for decommissioning, as well as the benthic ecology baseline that would be in place at the time of decommissioning, it is not possible to undertake a detailed assessment at this time. A further assessment would be undertaken at the time of decommissioning and, at this current stage, decommissioning impacts are only covered at a high level. This approach was agreed with regulators through the scoping exercise (Table 9.1~~Table 9.1~~).

9.6.5.1 Impact 1: Removal of introduced hard substratum

9.344 As detailed in **Section 9.6.4.1**, the change in habitat type within the footprint of permanent or long-term physical infrastructure (namely WTG foundations, scour protection and cable protection) would likely result in colonisation of those new hard substrates by epifauna. The subsequent removal of those structures during decommissioning, although not confirmed at this stage, would therefore result in loss of those communities present on the hard substrate. It would, however, result in a return to the soft sediment habitat and offer an opportunity for recolonisation by the baseline communities currently present at the windfarm site.

9.345 Note that, in the event of biogenic (Annex I) reef, or other FOCI, establishing on the hard substrate, an appropriate approach to decommissioning would be agreed with the relevant authority(s) at the time of decommissioning.

Effects on habitats and biotopes recorded within the windfarm site

Sensitivity

9.346 Regardless of the fact that, at this stage, there is little understanding of the communities that may establish on the hard substrates (if any), the sheer fact that removal of hard substrate would result in the total loss of such habitat within the area (given that the baseline environment is that of extensive areas of soft sediment) means that the colonising communities would have high sensitivity to such loss. However, while the removal of this substrate may represent a localised decrease in biodiversity, it would allow recolonisation by the original soft sediment benthos present at the site; as such, communities would instead return to their pre-construction state. As such, sensitivity of the general benthic community would be **low**.

9.347 As noted above, the establishment of Annex I features or similar, in the intervening period, would require further conversation with regulators and the sensitivity of the receptors present would be reassessed at the time of decommissioning.

Magnitude

9.348 The worst-case loss of habitat would be a total area of around 0.51km^2 (i.e. the maximum combined area of WTG/OSP foundations, scour protection and cable protection presented in Table 9.2~~Table 9.2~~). In the context of natural hard substrate habitats available in the Eastern Irish Sea (for example, Lune Deep, and in areas of coarse/mixed sediment to the east of the windfarm site), the area affected is localised and small. As such, the magnitude of impact would be **low**.

Significance of effect

9.349 Given the predicted **low** sensitivity of receptors (as per the current baseline), and the predicted **low** magnitude of impact, loss of artificial hard substrate during the decommissioning phase is predicted to have a **negligible adverse** effect on the general benthic community, which is not significant in EIA terms. This would be reassessed at the time of decommissioning.

Effects on designated sites

9.350 Impacts would be restricted to the footprint of the decommissioning activities, hence, there would be no pathway for effect for the existing designated sites (i.e. **no change**). This would be reassessed at the time of decommissioning, should new designations and/or changes to boundaries of existing designations occur in the intervening period.

9.6.5.2 Impact 2: Physical disturbance to seabed habitats

9.351 Temporary (limited to intermittent activities during the decommissioning phase) disturbance of the seabed and subsequent habitat loss may arise should jack-up vessels, or similar, be used for the purpose of removing infrastructure during decommissioning. This may also be the case in the event of de-burial of inter-array and platform link cables.

Effects on habitats and biotopes recorded within the windfarm site

Sensitivity

9.352 The sensitivity of seabed habitats and biotopes currently present within the site to the disturbance impacts (namely substrate removal, abrasion/disturbance of the seabed and penetration/disturbance of the seabed subsurface) is described in **Section 9.6.3.1** and Table 9.19~~Table 9.19~~. Overall sensitivity was assessed as **medium**.

Magnitude

9.353 The extent of seabed disturbance during the decommissioning phase cannot be quantified at this stage, although it is likely to be similar to, or less than, the area affected by seabed disturbance during the construction phase (if subsea cables are left *in situ*, it would be substantially less). As such, the magnitude of impact is estimated to be **low** (**Section 9.6.3.1**).

Significance of effect

9.354 Given the predicted **medium** sensitivity of receptors (as per the current baseline), and the predicted **low** magnitude of impact, temporary physical disturbance and/or habitat loss during the decommissioning phase is predicted to have a **minor adverse** effect, which is not significant in EIA terms. This would be reassessed at the time of decommissioning.

Effects on designated sites

9.355 As per the construction phase, impacts would be restricted to the footprint of the decommissioning activities, hence, there would be no pathway for effect for the existing designated sites (i.e. **no change**). This would be reassessed at the time of decommissioning, should new designations, and/or changes to boundaries of existing designations, occur in the intervening period.

9.6.5.3 Impact 3: Increases in SSCs and subsequent deposition

9.356 Increases in SSCs and sediment deposition from the decommissioning works may arise during the removal of subsea installations, namely the de-burial and removal of inter-array and platform link cables. In the event that cables are left *in situ*, increases in SSCs and deposition would relate to the disturbance of seabed from jack-up vessels and, hence, would be very minor.

Effects on seabed habitats and biotopes recorded in the 15km Project ZoI

Sensitivity

9.357 The sensitivity of seabed habitats and biotopes currently present within the ZoI to increases in SSCs and subsequent deposition (namely MarESA assessed pressures 'smothering and siltation rate changes' and 'changes in suspended solids') is described in **Section 9.6.3.2** and **Table 9.20**~~**Table 9.20**~~. Overall sensitivity was assessed as **negligible** to **medium**.

Magnitude

9.358 Increases in SSCs and subsequent deposition, during the decommissioning phase cannot be quantified at this stage, although they are likely to be similar to, or less than, that predicted for the construction phase (if subsea cables are left *in situ* they would be substantially less). As such, the magnitude of impact is estimated to be **low** (see **Section 9.6.3.2**).

Significance of effect

9.359 Given the predicted **negligible** to **medium** sensitivity of receptors (as per the current baseline), and the predicted low magnitude of impact, increased SSCs and deposition is predicted to have a **negligible** to **minor adverse** effect, which is not significant in EIA terms. This would be reassessed at the time of decommissioning.

Effects on designated sites

Sensitivity

9.360 The sensitivity of benthic features of Fylde MCZ, West of Walney MCZ and Shell Flat and Lune Deep SAC to increases in SSCs, and subsequent deposition, is described in **Section 9.6.3.2** and Table 9.20~~Table 9.20~~. Overall sensitivity was assessed as **low**.

Magnitude

9.361 As noted above, increases in SSCs and subsequent deposition, during the decommissioning phase cannot be quantified at this stage, although they are likely to be similar to, or less than, that predicted for the construction phase (if subsea cables are left *in situ* they would be substantially less). As such, the magnitude of impact is estimated to be **negligible**, given the distance between the windfarm site and the nearest designation (see **Section 9.6.3.2**).

Significance of effect

9.362 Given the predicted **low** sensitivity of benthic features (as per the current baseline), and the predicted **negligible** magnitude of impact, increased SSCs and deposition is predicted to have a **negligible adverse** effect, which is not significant in EIA terms. This would be reassessed at the time of decommissioning.

9.6.5.4 Impact 4: Underwater noise and vibration

9.363 Underwater noise would predominantly arise from the use of vessels and/or any cutting activity required for the removal of substructures. For the most part, decommissioning phase noise sources would be similar to those expected during the construction phase, though with the significant omission of piling activity.

Effects on seabed habitats and biotopes recorded in the 15km Project ZoI

Sensitivity

9.364 The sensitivity of seabed habitats and biotopes currently present within the ZoI to changes in underwater noise is described in **Section 9.6.3.3** and Table 9.20~~Table 9.20~~. Overall, sensitivity was assessed as **low**.

Magnitude

9.365 Sources of underwater noise during the decommissioning phase cannot be quantified at this stage, although they are likely to be significantly less than that predicted for the construction phase, given that there is no requirement for piling activity. As such, the magnitude of impact is estimated to be **negligible**.

Significance of effect

9.366 Given the predicted **low** sensitivity of receptors (as per the current baseline), and the predicted **negligible** magnitude of impact, underwater noise and vibration is predicted to have a **negligible adverse** effect, which is not significant in EIA terms. This would be reassessed at the time of decommissioning.

Effects on designated sites

Sensitivity

9.367 The sensitivity of benthic features of Fylde MCZ, West of Walney MCZ and Shell Flat and Lune Deep SAC to changes in underwater noise is described in **Section 9.6.3.3** and **Table 9.20~~Table 9.20~~**. Overall, sensitivity was precautionarily considered to be **low**.

Magnitude

9.368 As noted above, changes in underwater noise during the decommissioning phase cannot be quantified at this stage, although they are likely to be less than that predicted for the construction phase. As such, the magnitude of impact is estimated to be **negligible**, given the distance between the windfarm site and the nearest designation (**Section 9.6.3.3**).

Significance of effect

9.369 Given the predicted **low** sensitivity of benthic features (as per the current baseline), and the predicted **negligible** magnitude of impact, changes in underwater noise during the decommissioning phase is predicted to have a **negligible adverse** effect, which is not significant in EIA terms. This would be reassessed at the time of decommissioning.

9.6.5.5 Impact 5: Introduction and spread of INNS

9.370 As with the construction phase, the risk of introduction and/or spread of INNS during the decommissioning phase would primarily be attributed to the use of vessels that originate from outside the Irish Sea and Northeast Atlantic region, particularly from regions that are ecologically distinct from the Eastern Irish Sea.

9.371 Vessel use during the decommissioning phase is likely to be at a similar degree as that during the construction phase, with vessels likely to be required for activities including the removal of any topside and subsurface infrastructure not left *in situ* (the extent of removal would be set out in the Decommissioning Programme).

Effects on habitats and biotopes recorded within the 15km Project ZoI

Sensitivity

9.372 The sensitivity of seabed habitats and biotopes currently present within the ZoI to the introduction of INNS is described in **Section 9.6.3.4** and **Table 9.20~~Table 9.20~~**. Overall sensitivity of the habitats and biotopes that are potentially present in the ZoI (as per the existing baseline) was assessed as **high**.

Magnitude

9.373 Quantification of vessel movement during the decommissioning phase is not possible at this stage given that i) vessel capacity/capability may evolve during the lifetime of the Project; and ii) it is unclear at this stage exactly what assets would be left *in situ*. As a worst-case scenario, it would be assumed that all assets are to be removed, in which case vessel use is likely to be similar to that predicted for the construction phase. As with the construction phase, mandated and best-practice biosecurity measures would be implemented; these may be similar to those set out in **Section 9.6.3.4**, although the most up-to-date guidance/best-practice available at the time of decommissioning would be considered. With such measures in place, the magnitude of impact is estimated to be **negligible**.

Significance of effect

9.374 Given the predicted **high** sensitivity of receptors (as per the current baseline), and the predicted **negligible** magnitude of impact, ~~underwater noise and vibration~~the introduction and spread of INNS is predicted to have a **minor adverse** effect, which is not significant in EIA terms. This would be reassessed at the time of decommissioning.

Effects on designated sites

Sensitivity

9.375 The sensitivity of benthic features of Fylde MCZ, West of Walney MCZ and Shell Flat and Lune Deep SAC to the decommissioning phase risks of INNS introduction are akin to the construction phase risks set out in **Section 9.6.3.4** and **Table 9.20~~Table 9.20~~**. Overall, sensitivity was assessed as **high**.

Magnitude

9.376 As noted above, vessel usage during the decommissioning phase cannot be quantified at this stage, although it is likely to be similar to, or less than, that predicted for the construction phase. Mandated and best-practice measures, determined at the time of decommissioning, to ensure such measures are based on up-to-date information, would be implemented, to maintain the risk as low as reasonably practicable. As such, the magnitude of impact is estimated to be **negligible**, particularly given the distance between the windfarm site and the nearest designation.

Significance of effect

9.377 Given the predicted **high** sensitivity of benthic features (as per the current baseline), yet predicted **negligible** magnitude of impact, the risk of introducing/spreading INNS during the decommissioning phase is predicted to have a **minor adverse** effect, which is not significant in EIA terms. This would be reassessed at the time of decommissioning.

9.7 Cumulative effects

9.378 In order to undertake the CEA, and as per the PINS advice note (PINS, 2019), the potential for cumulative effects has been established considering each Project-alone effect (and the ZoI of each impact) alongside the list of other plans, projects and activities that could potentially interact. These stages are detailed below.

9.7.1 Identification of potential cumulative effects

9.379 Part of the cumulative assessment process was the identification of which individual impacts assessed for the Project have the potential for a cumulative effect on receptors (impact screening). This information is set out in **Table 9.21**~~**Table 9.21**~~. Screening considered the ZoI of the impacts and the plans and projects identified in **Table 9.22**~~**Table 9.22**~~ (presented in **Figure 7.10**). Impacts for which the significance of effect was assessed in the Project-alone assessment as ‘negligible’, or above, were considered in the CEA screening (i.e. only those assessed as ‘no change’ were not taken forward as there is no potential for them to contribute to a cumulative effect[9]).

[9] The following impacts concluded ‘No change’: Construction Impact 1 (effects on designated sites only); Operation and maintenance Impacts: 1 (effects on designated sites only); 3 (effects on designated sites only), 4 (effects on designated sites only) and 5 (effects on designated sites only); Decommissioning: Impacts 1 (effects on designated sites only) and 2 (effects on designated sites only).

Table 9.21 Potential cumulative impacts (impact screening)

Impact	'Project-alone' residual effect significance	Potential for cumulative effect	Rationale
Construction phase			
Impact 1: Physical disturbance to seabed habitat	Minor adverse	No	Across the study area there are common and widespread habitats. While the effect of disturbance from the Project and other plans and projects would be additive in nature, effects are spatially separate. Impacts occur at discrete locations, for a time-limited duration and are local in nature (compared to the wider availability of the same habitats), with a low impact magnitude. Areas disturbed during construction activities would be able to recover. In the exception of areas where hard substrate is placed, where recovery is not possible, cumulative effects of habitat loss in the operation and maintenance phase are assessed.
Impact 2: Increases in SSCs and subsequent deposition	Negligible to minor adverse	Yes	Increases in SSCs during the construction phase, although of low magnitude and temporary in nature, may have an interaction with sediment plumes from other activities and, hence, the significance of the impact may be affected.
Impact 3: Underwater noise and vibration	Negligible to minor adverse	No	The sensitivity of the receptors assessed to underwater noise changes is low, and the magnitude of this impact from the Project-alone is low-negligible. Impacts would be temporary and localised. Given the scale of Project-alone effect, there would be no interaction of effects, and additive effects across the study area would be negligible across projects.

Impact	'Project-alone' residual effect significance	Potential for cumulative effect	Rationale
Impact 4: Introduction and spread of INNS	Minor adverse	No	Biosecurity measures would be in place for all projects to prevent the introduction of INNS and the magnitude of impact is negligible. The risk of introduction of INNS to the Eastern Irish Sea is not considered to be significantly increased due to the construction of the Project. Although pre-construction monitoring is not proposed, the Applicant has identified monitoring of INNS in the windfarm site during the operation and maintenance phase is appropriate and would allow for additional control measures to be implemented as required.
Operation and maintenance phase			
Impact 1: Change in habitat type due to physical presence of infrastructure	Minor adverse	Yes	Due to the potential permanence of this impact, additive losses of affected habitat should be considered across the cumulative ZoI.
Impact 2: Change in hydrodynamic conditions due to physical presence of OWF infrastructure	Negligible to minor adverse	No	The potential cumulative effect on the hydrodynamic conditions is assessed in Section 7.7.3.2 of **Chapter 7 Marine Geology, Oceanography and Physical Processes**. Any additive effects from the presence of physical infrastructure associated with other offshore windfarms and the Project are localised and minor in comparison with the large-scale processes driving tidal currents, waves and sediment transport and therefore any cumulative effects are of no greater significance than assessed for the Project-alone. This impact is therefore not assessed in this chapter.

Impact	'Project-alone' residual effect significance	Potential for cumulative effect	Rationale
Impact 3: EMF from subsea cables	Negligible	No	The effects of EMF during the Project lifetime would be highly localised within the immediate vicinity (in the order of metres, at worst) of the subsea cables. Given the scale of Project-alone effect there would be no interaction of effects, additive effects across the study area would be negligible across projects.
Impact 4: Increases in seabed temperature from subsea cables	Negligible to minor adverse	No	The effects of temperature change during the Project lifetime would be highly localised within the immediate vicinity (in the order of metres, at worst) of the subsea cables. Given the scale of Project-alone effect, there would be no interaction of effects and negligible additive effects across the study area.
Impact 5: Temporary physical disturbance to seabed habitat during operational and maintenance activities	Minor adverse	No	Impacts would occur only at discrete locations within the windfarm site and for a time-limited duration. Given the scale/frequency of Project-alone effect, there would be no interaction of effects and negligible additive effects across the study area.
Impact 6: Temporary increases in SSCs and subsequent deposition during operational and maintenance activities	Negligible to minor adverse	Yes	Increases in SSCs during the operation and maintenance phase, although of low magnitude and temporary in nature, may have an interaction with sediment plumes from other activities and, hence, the significance of the impact may be affected.
Impact 7: Underwater noise and vibration	Negligible adverse	No	The sensitivity of the receptors assessed to underwater noise changes is low, and the magnitude of this impact from the Project-alone is negligible. Given the scale of Project-alone effect, there would be no interaction of effects and negligible additive effects across the study area.

Impact	'Project-alone' residual effect significance	Potential for cumulative effect	Rationale
Impact 8: Colonisation of infrastructure by INNS	Minor adverse	No	Artificial hard substrates on the seabed such as foundations, scour protection and cable protection, have the potential to act as 'stepping stones', enabling the spread of INNS. However, prior to the construction of the Project, there is already connectivity between similar such structures. Benthic invertebrate larvae can disperse over distances of tens to over a hundred kilometres (Álvarez-Noriega, 2020) and, within this range, are a number of other OWFs (including Walney, West of Duddon Sands, Ormonde, Barrow, Burbo Bank and Gwynt y Mor) as well as oil and gas infrastructure, hence, the addition of artificial hard substrates at the windfarm site would not materially increase the stepping stone potential of INNS. Any cumulative impact would be negligible, however the Applicant has identified monitoring of INNS in the windfarm site is appropriate, and would allow for additional control measures to be implemented as required.
Decommissioning phase			
Impact 1: Removal of introduced hard substratum	Negligible	No	Impacts would only occur within the footprint of the windfarm infrastructure. While this would represent a permanent loss, it would result in potential for colonization by soft sediment communities, and a reversion to the pre-construction baseline.
Impact 2: Physical disturbance to seabed habitats	Minor adverse	No	Impacts occur at discrete locations, for a time-limited duration and are local in nature, with a low impact magnitude. Given the scale and frequency of Project-

Impact	'Project-alone' residual effect significance	Potential for cumulative effect	Rationale
			alone effect, there would be no interaction of effects and negligible additive effects across the study area.
Impact 3: Increased SSCs and subsequent deposition	Negligible to minor adverse	Yes	Increases in SSCs during the decommissioning phase, although of low magnitude and temporary in nature, may have an interaction with sediment plumes from other activities and, hence, the significance of the impact may be affected.
Impact 4: Underwater noise and vibration	Negligible adverse	No	The sensitivity of the receptors assessed to underwater noise changes is negligible, and the magnitude of this impact from the Project-alone is also negligible. Impacts would be temporary and localised. Given the scale of Project-alone effect, there would be no interaction of effects and negligible additive effects across the study area.
Impact 5: Introduction and spread of INNS	Minor adverse	No	Biosecurity measures would be in place to prevent the introduction of INNS and the magnitude of impact is negligible. The risk of introduction of INNS to the Eastern Irish Sea is not considered to be significantly increased due to the decommissioning of the Project. Consideration of potential INNS colonisation would be taken into account when designing the Decommissioning Programme.

9.7.2 Identification of other plans, projects and activities

9.380 The identification and review of other plans, projects and activities that may result in cumulative effects (described as 'project screening') is undertaken alongside an understanding of Project-alone effects. For this chapter, a 30km distance is used to identify possible projects for inclusion in the CEA, as this distance encompasses the ZoI for all relevant impacts, as well as incremental changes over the wider area. This project screening information is set out in **Table 9.22**~~**Table 9.22**~~. This includes consideration of the relevant details of each project, including current status (e.g. under construction), planned construction period, distance to the Project, status of available data and rationale for including or excluding from the CEA.

9.381 All projects considered for CEA across all topics have been identified within **Appendix 6.1 CEA Project Long List** (Document Reference 5.2.6.1), which forms an exhaustive list of plans, projects and activities relevant to the Project.

9.382 While Unexploded Ordnance (UXO) clearance for the Project[10] and for other projects in the region can cause habitat disturbance and increased SSCs, effects would be highly localised, temporary and recoverable and as such UXO clearance activities are not considered to cause cumulative effects.

[10] UXO clearance activities for the Project would be considered as part of a separate licence application.

Table 9.22 Summary of projects considered for the CEA in relation to benthic ecology

Project	Status (at the time of assessment)	Construction period	Closest distance to the Project (km)	Screened into CEA (Y/N)	Rationale
Morgan and Morecambe Offshore Wind Farms: Transmission Assets	Pre-application stage. PEIR published in October 2023	2026 – 2029	0 (adjacent)	Y	Small potential for temporal overlap and some interaction between the dredging plumes from the export cable installation or other activities such as booster station installation. Potential for cumulative effects also considering habitat loss across the region.
Vodafone Lanis 1 telecom cable	Operational	N/A	0 (bisects the windfarm site)	Y	There is potential for some interaction between the sediment plumes arising from maintenance activities and plumes from cable operation and maintenance activities. Existing cables and pipelines outside of the windfarm site are not considered, given the small scale and low frequency of any maintenance activities.
EXA Atlantic (formerly GTT Hibernia Atlantic) telecom cable	Operational	N/A	0 (along the southern boundary of the windfarm site)		
Carbon Capture Storage Area (EIS Area 1)	Licences awarded in 2023 (see Morecambe Net Zero Cluster Project below)	Unknown	0	Y	Licence area noted and awarded to Spirit Energy (the project considers repurposing the North and South Morecambe natural gas fields to create a carbon storage cluster). Exploration surveys are being undertaken (2024), however, project timescales are unknown and there are no specific details of associated offshore works. It is possible existing infrastructure would be used.
Morecambe Net Zero Cluster Project (carbon storage cluster)	Early planning				

Project	Status (at the time of assessment)	Construction period	Closest distance to the Project (km)	Screened into CEA (Y/N)	Rationale
South Morecambe DP3 (gas platform)	Decommissioned	N/A	0	N	Gas platform and jacket decommissioning activities completed in 2023 with no above ground infrastructure remaining.
Calder CA1 platform (and associated cables and pipelines)	Operational	N/A	0 (the associated cables and pipelines bisect the windfarm site, whilst the platform itself is located 0.9km to the west of the windfarm site)	Y	Limited activities at the platform anticipated to interact with marine physical processes. Possible interaction with maintenance activities. Other existing oil and gas infrastructure located at a greater distance from the Project windfarm site is not considered cumulatively given the small scale and low frequency of any maintenance activities and uncertainty around potential decommissioning timeframes.
South Morecambe CPP1 (and surrounding South Morecambe platforms)	Operational	N/A	1.6		
Gateway Gas Storage Project	On hold	N/A	4.1	Y	Project noted, however, there is insufficient information available as the project has been on hold since 2010.
Isle of Man Interconnector	Operational	N/A	4.6	Y	Licence for maintenance works to repair/replace cable protection. Programme unknown.
South Morecambe DP4 (gas platform)	Decommissioned	N/A	5.1	N	As per South Morecambe DP3.

Project	Status (at the time of assessment)	Construction period	Closest distance to the Project (km)	Screened into CEA (Y/N)	Rationale
Carbon Capture Storage Licence (CS004)	Licensed in 2020	Unknown	7.5	Y	Licence area linked to the HyNet North West project. Applications for the HyNet Carbon Dioxide pipeline and HyNet North West Hydrogen Pipeline projects encompass onshore works only and there are no specific details of associated offshore works, however it is possible existing infrastructure would be used.
Liverpool Bay aggregate production area (Area 457)	Open	N/A	9.7	Y	There is potential for some interaction between the dredging plumes from the aggregate exploration and option areas and sediment plumes from cable/foundation installation /decommissioning and operation and maintenance activities from the Project.
Mona Offshore Wind Project	Pre-application stage. PEIR submitted 2023.	2026 - 2029	10.0	Y	Potential for temporal overlap and some interaction between the dredging plumes from the cable/foundation installation as well as additive effects from infrastructure.
West of Duddon Sands Offshore Windfarm	Operational	N/A	12.9	Y	Fully commissioned, operational OWFs would only be subject to small scale operational and maintenance activities; however, there may potentially result in interaction of suspended sediment plumes. Potential cumulative effect on wave and tidal regime, and from ongoing maintenance activities as well as additive effects from infrastructure.

Project	Status (at the time of assessment)	Construction period	Closest distance to the Project (km)	Screened into CEA (Y/N)	Rationale
Morgan Offshore Wind Project Generation Assets	Pre-application stage. PEIR published 2023.	2026 - 2029	16.7	Y	As per Mona Offshore Wind Project.
Site Y Disposal Area	Open	N/A	16.8	Y	There is potential for some interaction between the sediment disposal plumes and sediment plumes from cable/foundation installation/decommissioning and operation and maintenance activities from the Project.
Walney Extensions Offshore Windfarms	Operational	N/A	18.8	Y	As per West of Duddon Sands Offshore Windfarm.
Walney 1 Offshore Windfarm	Operational	N/A	20.3		
Barrow Offshore Windfarm	Operational	N/A	21.0		
Walney 2 Offshore Windfarm	Operational	N/A	22.7		
IS205 Barrow D Disposal Area	Open	N/A	22.7	Y	As per Site Y Disposal Area.
Site Z Disposal Area	Open	N/A	23.9		
Liverpool Bay aggregate exploration and	Open	N/A	25.7	Y	As per Liverpool Bay aggregate production area (Area 457)

Project	Status (at the time of assessment)	Construction period	Closest distance to the Project (km)	Screened into CEA (Y/N)	Rationale
option area (Area 1808)					
Ormonde Offshore Windfarm	Operational	N/A	27.0	Y	As per West of Duddon Sands Offshore Windfarm.
AyM Offshore Wind Farm	Consent granted 2023.	2027 - 2030	28.9	Y	As per Mona Offshore Wind Project.
Gwynt y Môr Offshore Windfarm	Operational	N/A	28.9	Y	As per West of Duddon Sands Offshore Windfarm.
Hibre Swash aggregate production area	Open	N/A	29.0	Y	As per Liverpool Bay aggregate production area (Area 457).
Burbo Bank Extension Offshore Windfarm	Operational	N/A	29.1	Y	As per West of Duddon Sands Offshore Windfarm
Morecambe Bay: Lune Deep Disposal Area	Open	N/A	30.1	Y	As per Site Y Disposal Area.

9.7.3 Assessment of cumulative effects

9.383 Having established the residual effects from the Project with the potential for a cumulative effect, along with the other relevant plans, projects and activities, the following sections provide an assessment of the level of cumulative effect that may arise. These are detailed per impact where the potential for cumulative effects have been identified (in line with **Table 9.21**~~**Table 9.21**~~).

9.384 Given the interconnected nature of the Project and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets, a separate ‘combined’ assessment of these has been provided within the CEA (**Section 9.7.3.1**). Thereafter, the cumulative assessment considered all plans, projects and activities screened into the CEA (**Section 9.7.3.2**).

9.7.3.1 Cumulative assessment – the Project and Transmission Assets (combined assessment)

9.385 While the Transmission Assets[11] are being considered in a separate ES as part of a separate DCO application (combined with the Morgan Offshore Wind Project transmission assets), given the functional link, a ‘combined’ assessment has made considering both the Project and the Transmission Assets for the purposes of cumulative assessment. This provides an assessment including impact interactions and additive effects and thus any change in the significance of effects as assessed separately.

9.386 The Transmission Assets PEIR (Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023a) informed the assessment. The assessment was also undertaken in reference to the baseline presented in **Section 9.5,** which includes benthic characterisation across the Project and Transmission Assets boundaries.

9.387 Only the marine elements of the Transmission Assets would interact with the Project in relation to benthic ecology, including:

- Export cables adjoining the Morgan Offshore Wind Project Generation Assets and the Project and making landfall south of Blackpool
- Booster station required for the Morgan Offshore Wind Project Generation Assets
- OSP(s) (for the Project and Morgan Offshore Wind Project)

[11] As the Transmission Assets includes infrastructure associated with both the Project and the Morgan Offshore Wind Project Generation Assets, it should be noted that the combined assessment considers the transmission infrastructure for both the Project and the Morgan Offshore Wind Project Generation Assets.

9.388 The following (project-alone) impacts were concluded in the Transmission Assets PEIR (Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023a):

- Temporary habitat loss/disturbance (all phases) – **minor/negligible adverse** effect (not significant in EIA terms)
- Increased SSC and associated deposition (all phases) – **minor/negligible adverse** effect (not significant in EIA terms)
- Disturbance/remobilisation of sediment-bound contaminants (all phases) – **minor/negligible adverse** effect (not significant in EIA terms)
- Long term habitat loss (all phases) – **minor adverse** effect (not significant in EIA terms)
- Introduction of artificial structures (construction and operation and maintenance phases) - **minor adverse** effect (not significant in EIA terms)
- Increased risk of introduction and spread of INNS (all phases) – **minor adverse** effect (not significant in EIA terms)
- Removal of hard substrates (construction phase) – **minor adverse** effect (not significant in EIA terms)
- Changes in physical processes (operation and maintenance phase) – **minor adverse** effect (not significant in EIA terms)
- Impacts to benthic invertebrates due to EMF (operation and maintenance phase) – **negligible adverse** effect (not significant in EIA terms)
- Heat from subsea electrical cables (operation and maintenance phase) – **negligible adverse** effect (not significant in EIA terms)

9.389 These impacts align with those assessed for the Project (with small differences in wording). While all effects are additive between the Project and the Transmission Assets, due to the localised and spatially separate effects, there is no material change in the significance of effects when considering the majority of impacts together (as described in **Table 9.21**~~**Table 9.21**~~).

9.390 There is however the potential for interaction relating to suspended sediments and deposition (potential for plumes to coalesce). Additionally, following habitat disturbance/loss during construction, there is potential for additive long-term regional habitat change (including effects on the same designated sites) due to the physical presence of infrastructure during the operation and maintenance phase. These impacts are therefore assessed in further detail below.

Cumulative Impact 1: Increased SSCs and subsequent deposition

9.391 The predicted cumulative volume of material likely to be disturbed during the construction phase of the Project and the Transmission Assets (when the maximum amount of sediment disturbance is anticipated) would be in the region of 13.4 million m^3 (**Table 9.23**~~Table 9.23~~). This includes approximately 1.1 million m^3 associated with the Project (see **Table 9.2**~~Table 9.2~~) plus approximately 12.3 million m^3 associated with the Transmission Assets (Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023a).

Table 9.23 Summary of sediment volume disturbed for the Project and Transmission Assets

Activity	Sediment volume (m^3)	
	Transmission Assets[12]	The Project
Sandwave clearance for export & interconnector cables	8,163,200	N/A
Sandwave clearance for inter-array cables	N/A	70,000
Sandwave clearance for platform link cables	N/A	10,000
Seabed preparation/sandwave clearance for WTG/OSPs	N/A	481,463
Export & interconnector cable installation	3,015,000	N/A
Inter-array cable installation	N/A	472,500
Platform link cable installation	N/A	67,500
Sandwave clearance for OSPs & booster station	1,148,965	N/A
Total	**13,428,628**	

9.392 As described in **Section 9.6.3.2**, 'heavy' deposition would only occur within a very short distance of the source of disturbance, and at more than 1km distance increases in SSCs and deposition levels would be low. As such, areas of interaction between plumes from the Project and Transmission Assets would largely see 'light' deposition (in the order of millimetres).

9.393 The sensitivity of subtidal receptors that would be affected (i.e. biotopes associated with UK BAP/FOCI broadscale habitats and benthic features of the Fylde MCZ, West of Walney MCZ and Shell Flat and Lune Deep SAC) by 'light' deposition, ranges from 'not sensitive' to 'medium' (**Section 9.6.3.1**).

[12] Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023a

While the Transmission Assets pass through the Fylde MCZ, given the distance of the Project to this MCZ or any other benthic designated sites, there would be a negligible contribution to effects assessed for the Transmission Assets.

9.394 Given the relationship of the Project and the Transmission Assets, site preparation and installation of infrastructure would be phased, and SSC increases are unlikely to occur concurrently. However, should multiple operations be undertaken concurrently, plumes would be advected on the tide (not towards one another) and these activities would be of limited spatial extent and frequency, with plume interactions likely of a low magnitude and short duration. For both the Project and the Transmission Assets the majority of sedimentation would occur within close proximity (i.e. within 1km) to each installation activity, however, given the active sediment transport regime, deposited material would be redistributed across the vicinity.

9.395 As any interaction of sediment plumes and deposition would be localised (i.e. of small spatial extent) and temporary, the magnitude of the impact was assessed as low.

9.396 Based on a medium sensitivity and low magnitude of impact, increased SSCs and subsequent deposition would have a **minor adverse** effect on the biotopes and habitats that are present within the ZoI of the Project and the Transmission Assets, which is not significant in EIA terms.

Cumulative Impact 2: Change in habitat type due to the installation and physical presence of infrastructure

Temporary habitat loss/disturbance during the construction and operation and maintenance phase

9.397 The cumulative temporary habitat loss/disturbance from the Project and the Transmission Assets during the construction phase (when temporary loss would be greatest) would equate to approximately 46.87km^2 (**Table 9.24~~Table 9.24~~**). This includes the approximate 2.33km^2 associated with the Project (**Table 9.2~~Table 9.2~~**), plus approximately 44.54km^2 associated with the Transmission Assets (Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023a).

9.398 The cumulative temporary habitat loss/disturbance footprint from the Project and the Transmission Assets during the operation and maintenance phase would equate to approximately 11.06km^2 (**Table 9.24~~Table 9.24~~**). This includes the approximate 0.16km^2 associated with the Project (**Table 9.2~~Table 9.2~~**) plus 10.9km^2 associated with the Transmission Assets (Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023a).

Table 9.24 Summary of temporary habitat loss/disturbance for the Project and Transmission Assets during the construction and operation and maintenance phases

Activity	Footprint (km²)	
	Transmission Assets[13]	The Project
Construction phase		
Sandwave clearance for export & interconnector cables	38.4	N/A
Sandwave clearance for inter-array cables	N/A	1.8
Sandwave clearance for platform link cables	N/A	0.3
Sandwave clearance for WTG/OSPs	N/A	0.2
Jack-up installation vessels	0.03	N/A[14]
Anchoring events	0.01	0.03
Pre-lay preparation (boulder and debris clearance) for export and interconnector cables	6.0	N/A
Sandwave clearance for OSPs & booster station	0.1	N/A
Total	**46.8**	
Operation and maintenance phase		
Jack-up vessel footprint	0.1	0.03
Cable repair/replacement and/or reburial	10.8	0.1
Anchoring events	N/A	0.03
Total	**11.06**	

9.399 The sensitivity of affected receptors (i.e. biotopes associated with UK BAP/FOCI broadscale habitats and benthic features of the Fylde MCZ, West of Walney MCZ and Shell Flat and Lune Deep SAC) to temporary habitat loss/disturbance is 'medium' (see **Section 9.6.3.1**). While the Transmission Assets pass through the Fylde MCZ, given the distance of the Project to this MCZ, or any other benthic designated sites, there would be no contribution to physical disturbance effects assessed for the Transmission Assets.

9.400 In the context of the wider Eastern Irish Sea study area, the habitats that would be affected by the Project and the Transmission Assets are abundant. The

[13] Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023a

[14] Encompassed within the sandwave clearance footprint for WTGs/OSP(s)

localised and short to medium-term nature of the disturbances would affect only a small proportion of the habitats present in the study area. As such, the magnitude of this cumulative impact was assessed as **low**.

9.401 Based on a medium sensitivity and low magnitude of impact, temporary habitat loss/disturbance during construction and operation and maintenance would have a **minor adverse** cumulative effect on the biotopes and habitats that are present within the ZoI of the Project and Transmission Assets, which is not significant in EIA terms.

Long term/permanent habitat loss/disturbance during the operation and maintenance phase

9.402 The cumulative long term/permanent presence of physical infrastructure from the Project and the Transmission Assets during the operation and maintenance phase (leading to a change in habitat type and loss of soft sediment) would equate to approximately 2.01km^2 (**Table 9.25**~~**Table 9.25**~~). This includes approximately 0.51km^2 associated with the Project (**Table 9.2**~~**Table 9.2**~~), plus approximately 1.5km^2 associated with the Transmission Assets (Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023a).

Table 9.25 Summary of long term/permanent presence of physical infrastructure for the Project and Transmission Assets during the operation and maintenance phase

Instructure	Footprint (km^2) Transmission Assets[15]	The Project
Foundations (WTGs/OSPs/booster station) and scour protection	0.1	0.25
Cable protection	1.2	0.15
Cable/pipeline crossings	0.2	0.07
Replacement scour protection and cable protection material	N/A	0.04
Total	**2.01**	

9.403 The sensitivity of affected receptors (i.e. biotopes associated with UK BAP/FOCI broadscale habitats and benthic features of the Fylde MCZ and

[15] Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023a

Shell Flat and Lune Deep SAC) to a permanent change in habitat type due to the presence of physical structures is 'high' (see **Section 9.6.4.1**).

9.404 In the context of the wider Eastern Irish Sea study area, the habitats that would be affected by the Project and the Transmission Assets are abundant. The extremely localised nature of the permanent infrastructure would affect only a very small proportion of the designated and protected habitat present in the study area (noting there is no overlap of the Project with any designated site or habitat). The cable protection (causing habitat change) that may be required within the Fylde MCZ is 0.16km^2 (0.06% of the total MCZ area[16], as estimated in the Transmission Assets MCZ Assessment (Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023b)) and was considered to be of a small scale in relation to the overall scale of the MCZ. As such, the magnitude of this cumulative impact was assessed as **negligible**.

9.405 Based on a high sensitivity and negligible magnitude of impact, long term/permanent changes to habitat type would have a **minor adverse** cumulative effect on the biotopes and habitats that are present within the ZoI of both the Project and the Transmission Assets, which is not significant in EIA terms.

Summary

9.406 Key interactions and additive effects between the Project and the Transmission Assets have been considered with no identification of effects that would result in impacts of greater significance than assessed for either the Project or the Transmission Assets (**negligible** to **minor adverse**). A summary is provided in **Table 9.26**~~**Table 9.26**~~ considering all residual impacts from the Project and the Transmission Assets.

Table 9.26 Summary of impacts from the Project and Transmission Assets alone and combined (note: wording of impacts has been summarised to encompass both projects)

Impact	Transmission Assets significance of effect	Project- alone significance of effect	Combined assessment
Construction/decommissioning phases			
Temporary habitat loss/disturbance	Minor/negligible adverse	Minor adverse	Given the limited interactions,

[16] Note that this is based on 20% of the 63.2km of Morgan export cables and 15% of the 31.6km of Morecambe export cables requiring cable protection (Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023b).

Impact	Transmission Assets significance of effect	Project- alone significance of effect	Combined assessment
Increased SSC and associated deposition	Minor/negligible adverse	Minor/ negligible adverse	localised nature and small scale of effects in the context of the abundance of benthic habitats in the wider study area, the cumulative significance of these impacts is not considered to be elevated beyond those individually assessed.
Underwater noise and vibration	N/A	Negligible/minor adverse	
Disturbance/remobilisation of sediment-bound contaminants	Minor/negligible adverse	Scoped out	
Removal of artificial hard substrate	Minor adverse	No change /negligible adverse	
Increased risk of introduction and spread of INNS	Minor adverse	No change	
Operation and maintenance phase			
Temporary habitat loss/disturbance	Minor/ negligible adverse	Minor adverse	Effect interactions are limited. While additive in nature across the study area, the significance of these impacts is not considered to be elevated beyond those individually assessed in terms of EIA significance.
Increased SSC and associated deposition	Minor/ negligible adverse	Minor adverse	
Disturbance/remobilisation of sediment-bound contaminants	Minor/ negligible adverse	Scoped out	
Long term habitat loss/change	Minor adverse	Minor adverse	
Underwater noise and vibration	N/A	Negligible adverse	
Increased risk of introduction and spread of INNS	Minor adverse	Minor adverse	
Changes in physical processes	Negligible adverse	Minor/ negligible adverse	
EMF and heat	Negligible adverse	Negligible adverse	

9.7.3.2 Cumulative assessment – All plans and projects

9.407 Based on both the impacts (Table 9.21Table 9.21) and other plans and projects (Table 9.22Table 9.22) identified, where required, a detailed cumulative assessment has been undertaken considering all relevant information from the Project and other plans and projects (including the Transmission Assets).

Cumulative Impact 1: Increased SSCs and subsequent deposition

9.408 There is potential for construction, operation and maintenance (and decommissioning) activities at other developments/projects to result in sediment disturbance, leading to advection of sediment plumes, in addition to those that may arise during the Project's construction, operation and maintenance and decommissioning phases. Where sediment plumes interact, there is likely to be a corresponding increase in SSCs (and subsequent sedimentation) at that location over and above what would be expected should the developments be undertaken in isolation.

9.409 Marine habitats/biotopes present within the extent of one excursion of the tidal ellipse around the Project windfarm site have 'no' to 'low' sensitivity to changes in SSCs, hence, would be unaffected by the cumulative effects on suspended sediment. However, there is 'low' to 'medium sensitivity to smothering caused by subsequent sedimentation, as set out in **Section 9.6.3.2**.

9.410 As discussed in **Sections 9.6.3.2** (construction), **9.6.4.6** (operation and maintenance) and **9.6.5.3** (decommissioning), and based on a conceptual evidence-based assessment supported by modelling undertaken for Morgan and Mona Offshore Wind Projects and AyM Offshore Wind Farm as set out in **Chapter 7 Marine Geology, Oceanography and Physical Processes**, increases in seabed level at any stage of the Project would be temporary (i.e. deposited fines would be redistributed within a short period of time by hydrodynamic forces) and very localised. Beyond around 1km from the point of release deposition impacts would be of negligible magnitude (in the order of millimetres). As such, impacts could only realistically interact in the instance that sediment-disturbing activities are taking place at the Project and other developments simultaneously, and sediment plumes from other developments encroach into the near-field area of the Project's activities.

9.411 Morgan is located approximately 16.7km to the north-west of the Project and AyM is located approximately 28.9km to the south. Given the spring tidal ellipses of approximately 10km in an east-west orientation, any suspended sediment plumes arising from construction phase activities for the Project are not anticipated to coalesce with the suspended sediment plumes arising from Morgan or AyM and therefore they have not been assessed further[17].

9.412 The worst-case scenario in terms of cumulative effects would arise should the construction periods of the Transmission Assets (overlapping and adjacent to the Project) and Mona Offshore Wind Project (10km west of the Project) coincide with the Project.

9.413 Numerical modelling undertaken for Mona and a conceptual assessment for the Transmission Assets (supported by numerical modelling undertaken for Morgan Offshore Wind Project Generation Assets (Morgan Offshore Wind Limited, 2023)) identify that magnitude of impacts outside the near-field area would be low. Regardless, it is likely that plumes from both the Transmission Assets and Mona and the Project would move within a tidal ellipse excursion, in the direction of the currents at the time of disturbance, and, hence, would be limited overlap. Even if there is some overlap, the area affected would be small in terms of the unaffected subtidal sand and mud habitats/biotopes present within the ZoI and the wider Eastern Irish Sea study area. Therefore, while impacts are additive across the study area, due to the limited magnitude of effects identified for all projects, cumulative effects are not anticipated to be greater than those identified for the Project-alone (**negligible** to **minor adverse** and not significant in EIA terms).

9.414 Increases in SSCs caused by maintenance activities for operational OWFs, as well as maintenance activities for existing cables and oil and gas infrastructure, in the Eastern Irish Sea, would be considerably lower than those during construction of OWFs or other infrastructure. The majority of suspended sediment arising from each maintenance activity would fall rapidly to the seabed after the start of construction and would not travel further than one spring tidal excursion. Given the distance of other OWFs to the Project, and the alignment of the tidal axis, no cumulative impact is anticipated with other existing windfarms in the Irish Sea.

9.415 Liverpool Bay aggregate production area is approximately 9.7km away from the Project, and Hilbre Swash 29.0km. An assessment of cumulative sedimentation impacts with the aggregate dredging site is described in **Chapter 7 Marine Geology, Oceanography and Coastal Processes**, which concludes, based on conceptual assessment of the Project and plume modelling at analogous aggregate sites, that sediment plumes from the Project construction activities are unlikely to coalesce with those elicited

[17] The offshore export cables for the Morgan Offshore Wind Project Generation Assets are assessed under the Transmission Assets Project.

during aggregate dredging activities. As such, no cumulative impact on marine habitats/biotopes is predicted.

9.416 Site Y, Site Z and Barrow D disposal areas are all located more than 15km from the Project. The CEA presented in **Chapter 7 Marine Geology, Oceanography and Coastal Processes** concludes that sediment plumes would not coalesce, and would not be discernible over the ZoI (and wider study area), hence, there would be no cumulative impact.

9.417 Given the above, there would be no significant cumulative effect or elevation beyond the Project-alone assessment (**minor adverse** and not significant in EIA terms).

9.418 Given that no significant cumulative impacts are anticipated during the construction phase, the same would apply during the operation and maintenance phase, given that operational and maintenance activities during the operation and maintenance phase would be small, discrete, works to specific parts of the site, rather than a site-wide impact (see also **Section 9.6.4.6**).

9.419 During the decommissioning phase of the Project, it is predicted that the magnitude and extent of increases in SSCs would be similar to, or less than, those during the construction phase, hence, there would similarly be no cumulative impact. However, the cumulative assessment would be revisited at the time of decommissioning, when a decommissioning plan is in place, and updated baseline information is available.

Cumulative Impact 2: Change in habitat type due to installation and physical presence of infrastructure

9.420 Given the direct nature of this impact, only habitats and biotopes present within the Project windfarm site itself would be affected. Therefore, given the distance of the Project to any benthic designated sites, there would be no contribution to cumulative physical disturbance effects with other plans or projects.

Temporary habitat loss/disturbance during the construction and operation and maintenance phase

9.421 The sensitivity of affected receptors (i.e. biotopes associated with UK BAP/FOCI broadscale habitats) to temporary habitat loss/disturbance is 'medium' (**Section 9.6.3.1**). In the context of the wider Eastern Irish Sea study area, the habitats that would be affected by the Project and other plans and projects are abundant. The localised and short to medium-term nature of the disturbances would affect only a small proportion of the habitats present in the study area. As such, the magnitude of this cumulative impact was assessed as **low**.

9.422 Similar effects have been identified from the infrastructure installation activities (such as seabed preparation) for AyM, Mona and Morgan. Considering estimates of seabed disturbance footprints at these projects and the effects identified at each, the cumulative magnitude of impact on benthos would remain negligible given that a very small proportion of the subtidal sand/gravel and mud habitats available in the wider Eastern Irish Sea would be affected.

9.423 Based on a medium sensitivity and low magnitude of impact, temporary habitat loss/disturbance in the construction and operation and maintenance would have a **minor adverse** cumulative effect on the biotopes and habitats that are present within the ZoI, which is not significant in EIA terms.

Long term/permanent habitat loss/disturbance during the operation and maintenance phase

9.424 Given that change in habitat type (from soft sediment to hard substrate) within the footprint of the Project substructures (including scour protection and cable protection) would represent a potentially permanent change of that habitat to benthic communities, the additive effect with other potential substructures should be considered as part of the CEA. Note that there may be localised benefits for colonising epifauna (which require a hard substrate on which to settle), and other benthic fauna, and an increase in diversity; however, this still represents a change in the baseline ecosystem. In total, a footprint of 0.51km^2 of soft sediment habitat would be replaced by hard substrate from the Project.

9.425 Similar effects have been identified from the placement of cable protection over unburied sections of the Transmission Assets (and associated booster station foundations), plus construction of AyM, Mona and Morgan (foundations and scour and cable protection). Considering estimates of cable protection at these projects and the effects identified at each, the cumulative magnitude of impact on benthos would remain negligible given that a very small proportion of the subtidal sand/gravel and mud habitats available in the wider Eastern Irish Sea would be affected.

9.426 Considering the localised habitat change (and loss of soft sediment) across the region for projects listed in **Table 9.22**~~**Table 9.22**~~ across the wider available habitat, no cumulative effects are identified.

9.427 Given the above, there would be no significant cumulative effect or elevation beyond the Project-alone assessment (**minor adverse** and not significant in EIA terms).

Summary

9.428 Given the spatial distribution of other plans and projects, and the temporary and transient nature of increased SSCs and minimal sedimentation depths, no cumulative effects from increased SSCs and sedimentation beyond Project-alone are identified. Similarly, given the limited interactions, localised nature and small scale of effects from changes in habitat type due to installation and physical presence of infrastructure in the context of the abundance of benthic habitats in the wider study area, no cumulative effect beyond Project-alone is identified.

9.8 Inter-relationships

9.429 There are clear inter-relationships between the benthic ecology topic, and several other topics, that have been considered within this ES. Table 9.27~~Table 9.27~~ provides a summary of the principal inter-relationships and sign-posts to where those issues have been addressed in the relevant chapters.

Table 9.27 Benthic ecology inter-relationships

Topic and description	Related chapter	Where addressed in this chapter	Rationale
Construction phase			
Increases in SSCs and subsequent deposition	**Chapter 7 Marine Geology, Oceanography and Physical Processes** **Chapter 8 Marine Sediment and Water Quality**	Effects on marine benthos as a result of increased SSCs during the construction phase are addressed in **Section 9.6.3.2** (as well as cumulatively in **Section 9.7**). The chapter is also informed by the risk of contaminants as presented in **Chapter 8 Marine Sediment and Water Quality**.	A conceptual evidence-based assessment of increases in SSCs, and seabed level changes, are presented in **Chapter 7 Marine Geology, Oceanography and Physical Processes**. Changes in SSCs, and smothering during deposition, could potentially affect benthic communities within the 15km Project ZoI.
Fish and Shellfish, prey resources, nursery and spawning grounds	**Chapter 10 Fish and Shellfish Ecology***	N/A – this chapter informs the assessment in **Chapter 10 Fish and Shellfish Ecology.**	Potential impacts on shellfish species are not assessed within this chapter, rather these are assessed within **Chapter 10 Fish and Shellfish Ecology**. Many of the benthic species identified in this chapter are prey for shellfish species identified

Topic and description	Related chapter	Where addressed in this chapter	Rationale
			in **Chapter 10 Fish and Shellfish Ecology**.
Operation and maintenance phase			
Increases in SSCs and subsequent deposition	**Chapter 7 Marine Geology, Oceanography and Physical Processes**	Effects on marine benthos, as a result of increased SSCs during the operation and maintenance phase, are addressed in **Section 9.6.4.6** (as well as cumulatively in **Section 9.7**).	A conceptual evidence-based assessment of increases in SSCs, and seabed level changes, is presented in **Chapter 7 Marine Geology, Oceanography and Physical Processes**. Changes in SSCs, and smothering during deposition, could potentially affect benthic communities within the 15km Project ZoI.
Indirect changes to habitat as a result of changes in hydrodynamic conditions	**Chapter 7 Marine Geology, Oceanography and Physical Processes**	Effects on marine benthos as a result of localised changes in hydrodynamics are addressed in **Section 9.6.4.2**.	A conceptual evidence-based assessment of changes to the hydrodynamic regime (and consequent effect on sediment transport), due to the presence of physical OWF structures, is presented in **Chapter 7 Marine Geology, Oceanography and Physical Processes**. Such changes have the potential to adversely affect local benthic communities.
Fish and Shellfish, prey resources, nursery and spawning grounds	**Chapter 10 Fish and Shellfish Ecology***	N/A – this chapter informs the assessment in **Chapter 10 Fish and Shellfish Ecology.**	Potential impacts on shellfish species are not assessed within this chapter, rather, these are assessed within **Chapter 10 Fish and Shellfish Ecology**. Many of the benthic species identified in this chapter are prey for shellfish species identified in **Chapter 10 Fish and Shellfish Ecology**.
Decommissioning phase			

Topic and description	Related chapter	Where addressed in this chapter	Rationale
Increases in SSCs and subsequent deposition	**Chapter 7 Marine Geology, Oceanography and Physical Processes**	Effects on marine benthos, as a result of increased SSCs, during the decommissioning phase are addressed in **Section 9.6.5.3**.	A conceptual evidence-based assessment of increases in SSCs, and seabed level changes, are presented in **Chapter 7 Marine Geology, Oceanography and Physical Processes**. Changes in SSCs, and smothering during deposition, could potentially affect benthic communities within the 15km Project ZoI.
Fish and Shellfish, prey resources, nursery and spawning grounds	**Chapter 10 Fish and Shellfish Ecology***	N/A – this chapter informs the assessment in **Chapter 10 Fish and Shellfish Ecology**	Potential impacts on shellfish species are not assessed within this chapter, rather, these are assessed within **Chapter 10 Fish and Shellfish Ecology**. Many of the benthic species identified in this chapter are prey for shellfish species identified in **Chapter 10 Fish and Shellfish Ecology**.

** Further indirect effects to prey species are also assessed in **Chapter 11 Marine Mammals** and **Chapter 12 Offshore Ornithology.***

9.9 Interactions

9.430 The impacts identified and assessed in this chapter have the potential to interact with each other. The areas of potential interaction between impacts are presented in Table 9.28~~Table 9.28~~, Table 9.29~~Table 9.29~~ and Table 9.30~~Table 9.30~~. This provides a screening tool for which impacts have the potential to interact. The impacts have been assessed relative to each development phase (i.e. construction, operation and maintenance or decommissioning) to see if (for example) multiple construction impacts affecting the same receptor could increase the level of impact upon that receptor.

9.431 Following this, a lifetime assessment has been undertaken, which considers the impact interactions identified, as well as effects on receptors across all development phases (Table 9.31~~Table 9.31~~).

Table 9.28 Interaction between impacts - screening (construction phase)

	Potential interaction between construction phase impacts			
	Impact 1: Physical disturbance to seabed habitat	Impact 2: Increased SSCs and subsequent deposition	Impact 3: Underwater noise and vibration	Impact 4: Introduction and spread of INNS
Impact 1: Physical disturbance to seabed habitat		Yes	No	Yes
Impact 2: Increased SSCs and subsequent deposition	Yes		No	No
Impact 3: Underwater noise and vibration	No	No		No
Impact 4: Introduction and spread of INNS	Yes	No	No	

Table 9.29 Interaction[18] between impacts – screening (operation and maintenance phase)

	Potential interaction between operation and maintenance phase impacts							
	Impact 1: Change in habitat type due to presence of OWF subsurface infrastructure	Impact 2: Change in hydrodynamic conditions due to presence of OWF subsurface infrastructure	Impact 3: EMF from subsea cables	Impact 4: Increases in seabed temperature from subsea cables	Impact 5: Temporary physical disturbance of the seabed during operational and maintenance activities	Impact 6: Temporary increases in SSCs/ sedimentation during operational and maintenance activities	Impact 7: Underwater noise and vibration	Impact 8: Colonisation of infrastructure by INNS
Impact 1: Change in habitat type due to presence of OWF subsurface infrastructure		Yes	No	No	Yes	Yes	No	Yes
Impact 2: Change in hydrodynamic conditions due to presence of OWF subsurface infrastructure	Yes		No	No	Yes	Yes	No	Yes
Impact 3: EMF from subsea cables	No	No		No	No	No	No	No

[18] Effects with no interaction are due to the highly localised level of change and/or the receptor is not sensitive to the impact.

	Potential interaction between operation and maintenance phase impacts							
	Impact 1: Change in habitat type due to presence of OWF subsurface infrastructure	Impact 2: Change in hydrodynamic conditions due to presence of OWF subsurface infrastructure	Impact 3: EMF from subsea cables	Impact 4: Increases in seabed temperature from subsea cables	Impact 5: Temporary physical disturbance of the seabed during operational and maintenance activities	Impact 6: Temporary increases in SSCs/ sedimentation during operational and maintenance activities	Impact 7: Underwater noise and vibration	Impact 8: Colonisation of infrastructure by INNS
Impact 4: Increases in seabed temperature from subsea cables	No	No	No		No	No	No	No
Impact 5: Temporary physical disturbance of the seabed during operational and maintenance activities	Yes	Yes	No	No		Yes	No	Yes
Impact 6: Temporary increases in SSCs /sedimentation during operational and maintenance activities	Yes	Yes	No	No	Yes		No	No

	Potential interaction between operation and maintenance phase impacts							
	Impact 1: Change in habitat type due to presence of OWF subsurface infrastructure	Impact 2: Change in hydrodynamic conditions due to presence of OWF subsurface infrastructure	Impact 3: EMF from subsea cables	Impact 4: Increases in seabed temperature from subsea cables	Impact 5: Temporary physical disturbance of the seabed during operational and maintenance activities	Impact 6: Temporary increases in SSCs/ sedimentation during operational and maintenance activities	Impact 7: Underwater noise and vibration	Impact 8: Colonisation of infrastructure by INNS
Impact 7: Underwater noise and vibration	No	No	No	No	No	No		No
Impact 8: Colonisation of infrastructure by INNS	Yes	Yes	No	No	Yes	No	No	

Table 9.30 Interaction between impacts – screening (decommissioning phase)

	Potential interaction between decommissioning phase impacts			
	Impact 1: Removal of introduced hard substrate	Impact 2: Physical disturbance to seabed habitats	Impact 3: Increased SSCs and subsequent deposition	Impact 4: Underwater noise and vibration
Impact 1: Removal of introduced hard substrate		Yes	Yes	No
Impact 2: Physical disturbance to seabed habitats	Yes		Yes	No
Impact 3: Increased SSCs and subsequent deposition	Yes	Yes		No
Impact 4: Underwater noise and vibration	No	No	No	

Table 9.31 Interaction between impacts – phase and lifetime assessment

Receptor	Highest significance of effect level				
	Construction phase	**Operation and maintenance phase**	**Decommissioning phase**	**Phase assessment**	**Lifetime assessment**
Habitats/ biotopes present within the 15km Project ZoI	Minor adverse	Minor adverse	Minor adverse	**No greater than individually assessed impacts for each phase.** **Construction:** Physical disturbance of the seabed may increase susceptibility to changes in SSCs/sedimentation rate and the introduction of INNS. However, all impacts were of minor adverse significance, or less, and the effects of physical disturbance are confined to the direct footprint of construction activities, which represents a very small proportion of the receptor of subtidal sand/gravel and mud habitats/biotopes (including the FOCI 'sea-pens and burrowing megafauna communities') present in the ZoI. **Operation**: Short-term habitat loss, due to physical disturbance of the seabed during operational and maintenance, combined with	**No greater than individually assessed impacts for each phase.** As with the phase assessment, all potential impacts are non-significant and localised in nature, limiting the potential for different impacts to interact across the different phases. Impacts from construction and decommissioning are temporary in nature, limiting their potential to result in a synergistic or greater impact with those considered in other phases.

Receptor	Highest significance of effect level				
	Construction phase	Operation and maintenance phase	Decommissioning phase	Phase assessment	Lifetime assessment
				potentially permanent loss of soft sediment habitat within the footprint of the physical infrastructure, may increase susceptibility to changes in SSCs/sedimentation rate, changes in hydrodynamic conditions and/or colonisation of INNS. However, habitat loss/change would be restricted to the physical footprint of the OWF and associated operational and maintenance works, hence, would represent a very small proportion of the receptor habitats in the ZoI and wider study area. **Decommissioning:** As with the construction phase, removal of hard substrates (i.e. reversal to soft sediment habitat) and temporary disturbance may increase susceptibility to increases in SSCs. Effects of physical disturbance would be confined to the direct footprint of decommissioning activities, which represents a very small	

Receptor	Highest significance of effect level				
	Construction phase	Operation and maintenance phase	Decommissioning phase	Phase assessment	Lifetime assessment
				proportion of the receptor habitats/biotopes present in the ZoI and wider study area. As a result, none of the potential interactions identified, with respect to benthic ecology, are expected to result in a synergistic or greater impact than those already assessed.	
Designated sites	Minor adverse	Minor adverse	Minor adverse	**No greater than individually assessed impacts for each phase.** Given that there is no overlap between the Fylde MCZ, West of Walney MCZ and Shell Flat and Lune Deep SAC and the windfarm site, there is no risk of direct impact within any of these designations during any phase of the Project. The distance between the designated sites and the Project means there is no risk of increasing sensitivity or susceptibility to the minor/negligible changes in SSCs and sedimentation rate that may occur.	

9.10 Potential monitoring requirements

9.432 Monitoring requirements are described in the IPMP (Document Reference 6.4) included alongside the DCO Application and would be further developed and agreed with stakeholders prior to construction, based on the IPMP and taking account of the final detailed design of the Project.

9.433 A large amount of geophysical and benthic ecology monitoring information is available from the Project site-specific survey, as described in this chapter, and other accompanying chapters, within this ES. There are no Annex I biogenic or geogenic reef features within or near to the windfarm site, and those habitats/biotopes that are present within the windfarm site would not be significantly affected by the Project. Consequently, pre- and post-construction benthic monitoring is not proposed (although consideration of potential INNS colonisation would be taken into account when designing post-construction hard-substrate inspections, as described in the IPMP).

9.11 Assessment summary

9.434 This chapter has provided a characterisation of the existing environment for benthic ecology, based on both existing data and extensive site-specific survey data.

9.435 Seabed sediments across the windfarm site are dominated by subtidal sandy muds and fine sands, with the corresponding communities primarily recorded as the biotopes A5.351 '*Amphiura filiformis*, *Mysella bidentata* and *Abra nitida* in circalittoral sandy mud' (which dominates the windfarm site) and A5.252 '*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand' (which is found within the southwest of the windfarm site).

9.436 Benthic habitat maps, such as the EUSeaMap 2021 (EMODNet Seabed Habitats Consortium, 2022) and data from studies within the wider Eastern Irish Sea area, indicate that the EUNIS Level 3 sublittoral habitats present at the windfarm site are representative of the 15km Project ZoI and wider study area, particularly to the north and east, with slightly coarser sediment to the south and west of the windfarm site. No Annex I reef (biogenic or geogenic) was identified within the windfarm site. Annex I sandbank habitat is present within the 15km Project ZoI at Shell Flat and Lune Deep SAC. Within the windfarm site itself, there is evidence of the presence of the FOCI 'sea-pens and burrowing megafauna communities', although sea pens were not recorded from DDC imagery of the windfarm site.

9.437 The assessment has established that there would be some minor adverse residual effects during the construction, operation and maintenance and decommissioning phases of Project. Impacts are generally localised in nature, being restricted to the Project boundaries and immediate surrounding area.

9.438 A summary of the impact assessment for benthic ecology is provided in Table 9.32~~Table 9.32~~.

Table 9.32 Summary of potential effects on benthic ecology

Potential impact	Receptor group	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect	Cumulative residual effect
Construction phase							
Impact 1: Physical disturbance to seabed habitat	Subtidal sands and gravels	Medium	Low	Not Significant (Minor adverse)	None (above embedded or mandatory measures)	Not Significant (Minor adverse)	As per Project-alone impact-
	Subtidal mud	Medium	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
	Sea-pens and burrowing megafauna communities	Medium	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
Impact 2: Increased SSCs and subsequent deposition	Subtidal sands and gravels	Medium	Low	Not Significant (Minor adverse)	None (above embedded or mandatory measures)	Not Significant (Minor adverse)	As per Project-alone impact-
	Subtidal mud	Medium	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
	Sea-pens and burrowing	Negligible	Low	Not Significant		Not Significant	

Potential impact	Receptor group	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect	Cumulative residual effect
	megafauna communities			(Negligible adverse)		(Negligible adverse)	
	Designated sites with benthic features	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)	
Impact 3: Underwater noise and vibration	Subtidal sands and gravels	Low	Low	Not Significant (Minor adverse)	None (above embedded or mandatory measures)	Not Significant (Minor adverse)	As per Project-alone impact
	Subtidal mud	Low	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
	Sea-pens and burrowing megafauna communities	Low	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
	Designated sites with benthic features	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)	

Potential impact	Receptor group	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect	Cumulative residual effect
Impact 4: Introduction and spread of INNS	Subtidal sands and gravels	High	Negligible	Not Significant (Minor adverse)	None (above embedded or mandatory measures)	Not Significant (Minor adverse)	As per Project-alone impact
	Subtidal mud	High	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
	Sea-pens and burrowing megafauna communities	High	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
	Designated sites with benthic features	High	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
Operation and maintenance phase							
Impact 1: Change in habitat type due to presence of OWF subsurface infrastructure	Subtidal sands and gravels	High	Negligible	Not Significant (Minor adverse)	None (above embedded or mandatory measures)	Not Significant (Minor adverse)	As per Project-alone impact
	Subtidal mud	High	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)	

Potential impact	Receptor group	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect	Cumulative residual effect
	Sea-pens and burrowing megafauna communities	High	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
Impact 2: Change in hydrodynamic conditions due to presence of OWF subsurface infrastructure	Subtidal sands and gravels	Negligible	Low	Not Significant (Negligible adverse)	None (above embedded or mandatory measures)	Not Significant (Negligible adverse)	As per Project-alone impact
	Subtidal mud	Negligible	Low	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)	
	Sea-pens and burrowing megafauna communities	Medium	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
	Designated sites with benthic features	High	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
Impact 3: EMF from subsea cables	Subtidal sands and gravels	Low	Negligible	Not Significant (Negligible adverse)	None (above embedded or mandatory measures)	Not Significant (Negligible adverse)	As per Project-alone impact

Potential impact	Receptor group	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect	Cumulative residual effect
	Subtidal mud	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)	
	Sea pens and burrowing megafauna communities	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)	
Impact 4: Increases in seabed temperature from subsea cables	Subtidal sands and gravels	Low	Negligible	Not Significant (Negligible adverse)	None (above embedded or mandatory measures)	Not Significant (Negligible adverse)	As per Project-alone impact
	Subtidal mud	Negligible	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)	
	Sea-pens and burrowing megafauna communities	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
Impact 5: Temporary physical disturbance of	Subtidal sands and gravels	Medium	Negligible	Not Significant (Minor adverse)	None (above embedded or mandatory measures)	Not Significant (Minor adverse)	As per Project-alone impact-

Potential impact	Receptor group	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect	Cumulative residual effect
seabed during operational and maintenance activities	Subtidal mud	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
	Sea-pens and burrowing megafauna communities	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
Impact 6: Temporary increases in SSCs/ sedimentation during operational and maintenance activities	Subtidal sands and gravels	Medium	Negligible	Not Significant (Minor adverse)	None (above embedded or mandatory measures)	Not Significant (Minor adverse)	As per Project-alone impact-
	Subtidal mud	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
	Sea-pens and burrowing megafauna communities	Negligible	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)	
	Designated sites with benthic features	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)	

Potential impact	Receptor group	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect	Cumulative residual effect
Impact 7: Underwater noise and vibration	Subtidal sands and gravels	Low	Negligible	Not Significant (Negligible adverse)	None (above embedded or mandatory measures)	Not Significant (Negligible adverse)	As per Project-alone impact
	Subtidal mud	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)	
	Sea-pens and burrowing megafauna communities	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)	
	Designated sites with benthic features	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)	
Impact 8: Colonisation of infrastructure by INNS	Subtidal sands and gravels	High	Negligible	Not Significant (Minor adverse)	None (above embedded or mandatory measures)	Not Significant (Minor adverse)	As per Project-alone impact
	Subtidal mud	High	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)	

Potential impact	Receptor group	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect	Cumulative residual effect
	Sea-pens and burrowing megafauna communities	High	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
	Designated sites with benthic features	High	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
Decommissioning phase							
Impact 1: Removal of introduced hard substratum	General benthos	Low	Low	Not Significant (Negligible adverse)	None (above embedded or mandatory measures)	Not Significant (Negligible adverse)	As per Project-alone impact
Impact 2: Physical disturbance to seabed habitats	Subtidal sands and gravels	Medium	Low	Not Significant (Minor adverse)	None (above embedded or mandatory measures)	Not Significant (Minor adverse)	As per Project-alone impact-
	Subtidal mud	Medium	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
	Sea-pens and burrowing	Medium	Low	Not Significant		Not Significant	

Potential impact	Receptor group	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect	Cumulative residual effect
	megafauna communities			(Minor adverse)		(Minor adverse)	
Impact 3: Increased SSCs and subsequent deposition	Subtidal sands and gravels	Medium	Low	Not Significant (Minor adverse)	None (above embedded or mandatory measures)	Not Significant (Minor adverse)	Not Significant (Minor adverse)
	Subtidal mud	Medium	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
	Sea-pens and burrowing megafauna communities	Negligible	Low	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)	
	Designated sites with benthic features	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)	
Impact 4: Underwater noise and vibration	Subtidal sands and gravels	Low	Negligible	Not Significant (Negligible adverse)	None (above embedded or mandatory measures)	Not Significant (Negligible adverse)	As per Project-alone impact
	Subtidal mud	Low	Negligible	Not Significant		Not Significant	

Potential impact	Receptor group	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect	Cumulative residual effect
				(Negligible adverse)		(Negligible adverse)	
	Sea-pens and burrowing megafauna communities	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)	
	Designated sites with benthic features	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)	
Impact 5: Introduction and spread of INNS	Subtidal sands and gravels	High	Negligible	Not Significant (Minor adverse)	None (above embedded or mandatory measures)	Not Significant (Minor adverse)	As per Project-alone impact
	Subtidal mud	High	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
	Sea-pens and burrowing megafauna communities	High	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)	
	Designated sites	High	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)	

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