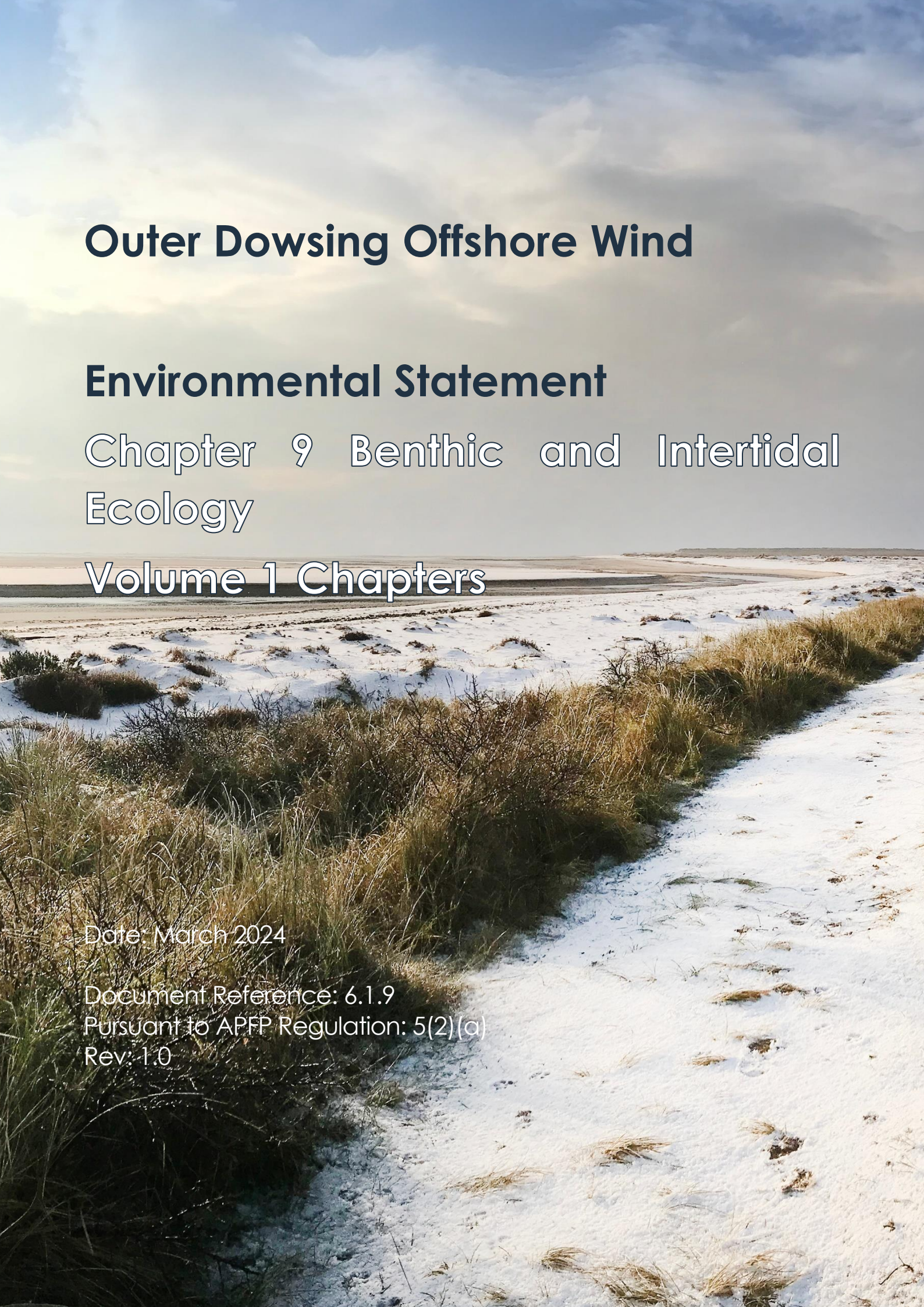

Outer Dowsing Offshore Wind

Environmental Statement

Chapter 9 Benthic and Intertidal Ecology

Volume 1 Chapters

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Table of Contents

Table of Tables

Acronyms & Definitions

Abbreviations / Acronyms

Abbreviation / Acronym	Description
AC	Alternating Current
BAP	Biodiversity Action Plan
CBRA	Cable Burial Risk Assessment
CBS	Cost Breakdown Structure
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CFE	Controlled Flow Excavator
CIA	Cumulative Impact Assessment
CIEEM	Chartered Institute of Ecology and Environmental Management
CSIP	Cable Specification and Installation Plan
DBT	Dibutyltin
DC	Direct Current
DCO	Development Consent Order
DECC	Department for Energy and Climate Change
Defra	Department of Environment, Food and Rural Affairs
DEP	Dudgeon Extension Project
DESNZ	Department for Energy Security and Net Zero, formerly Department of Business, Energy and Industrial Strategy (BEIS), which was previously Department of Energy & Climate Change (DECC)
DDV	Drop Down Video
DP	Decommissioning Programme
ECC	Export Cable Corridor
EDMS	Electronic Document Management System
eDNA	Environmental DNA
EEA	European Environment Agency
EIA	Environmental Impact Assessment
EMF	Electromagnetic Fields
EPP	Evidence Plan Process
ERL	Effects Range Low
ERM	Effect Range Median
ES	Environmental Statement
ETG	Expert Topic Group
EUNIS	European Nature Information System
FOCI	Features of Conservation Interest
GBS	Gravity Base Structure
GES	Good Environmental Status
GIG	Green Investment Group
GT R4 Limited	GT R4 or GT R4 Limited, the incorporated joint venture development Co.
HADA	Humber Aggregate Dredging Association
HDD	Horizontal Directional Drilling
HRA	Habitats Regulation Assessment
HW	High Water
IDC	Inter-Disciplinary Check
IFI	Issued for Information
IFC	Issued for Construction

Abbreviation / Acronym	Description
INNS	Invasive Non-Native Species
IVB	Independent Verification Body
JNCC	Joint Nature Conservation Committee
JUV	Jack-Up Vessel
LAT	Lowest Astronomical Tide
LW	Low Water
MarESA	Marine Evidence based Sensitivity Assessment
MarLIN	Marine Life Information Network
MBES	Multibeam Echosounder
MBT	Monobutyltin
MCAA	Marine and Coastal Access Act
MCCIP	Marine Climate Change Impacts Partnership
MCZ	Marine Conservation Zone
MDR	Master Document Register
MDS	Maximum Design Scenario
MFE	Mass Flow Excavation
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MMO	Marine Management Organisation
MNCR	Marine Nature Conservation Review
MPCP	Marine Pollution Contingency Plan
MPS	Marine Policy Statement
MSFD	Marine Strategy Framework Directive
MW	Middle Water
NERC	Natural Environment and Rural Communities
NPS	National Policy Statement
NSIPS	Nationally Significant Infrastructure Projects
ODOW	Outer Dowsing Offshore Wind, trading name of GT R4 Limited
OESEA	Offshore Energy Strategic Environmental Assessment
OFTO	Offshore Transmission Owner
O&M	Operation and Maintenance
ONS	Onshore Substation
OSP	Offshore Substation Platform
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
OSS	Offshore Substation
OWF	Offshore Wind Farm
PAH	Polycyclic Aromatic Hydrocarbon
PCM	Project Controls Manager
PD	Project Director
PE	Project Engineer
PEL	Probable Effects Level
PEMP	Project Environmental Management Plan
PLE	Project Planning Engineer
PMS	Project Management System
PMT	Project Management Team
PSA	Particle Size Analysis
PSD	Particle Size Distribution

Abbreviation / Acronym	Description
POSEIDON	Planning Offshore Wind Strategic Environmental Impact Decisions
REC	Regional Environmental Characterisation
RIAA	Report to Inform Appropriate Assessment
RPSS	Route Planning and Site Selection
SAC	Special Area of Conservation
SBES	Single-Beam Echo Sounder
SBP	Sub-Bottom Profiler
SEP	Sheringham Extension Project
SoS	Secretary of State
SSC	Suspended Sediment Concentrations
SSS	Side Scan Sonar
SSSI	Site of Special Scientific Interest
SPA	Special Protection Area
SPM	Suspended Particulate Matter
SPMP	Scour Protection Management Plan
TBT	Tributyltin
TEL	Threshold Effect Levels
TCE	The Crown Estate
TOC	Total Organic Carbon
TSHD	Trailer Suction Hopper Dredger
UHRS	Ultra-high Resolution Seismic
US EPA	United States Environmental Protection Agency
VER	Valued Ecological Receptor
WBS	Work Breakdown Structure
WTG	Wind Turbine Generators
ZoI	Zone of Influence

Terminology

Term	Definition
Array area	The area offshore within which the generating stations (including wind turbine generators (WTG) and inter array cables), offshore accommodation platforms, offshore transformer substations and associated cabling are positioned.
Baseline	The status of the environment at the time of assessment without the development in place.
Benthic subtidal and intertidal ecology study area	The benthic subtidal ecology study area is defined by a buffer of approximately 10km at landfall to 15km from the offshore ECC and 12km from the array, to represent the tidal ellipse distance in order to incorporate the maximum distance sediments may travel in one tidal cycle. The benthic intertidal ecology study area is defined by the intertidal habitats up to the MHWS mark within the 10 km buffer at landfall.
Cumulative effects	The combined effect of the Project acting cumulatively with the effects of a number of different projects, on the same single receptor/resource.
Cumulative impact	Impacts that result from changes caused by other past, present or reasonably foreseeable actions together with the Project.

Term	Definition
deemed Marine Licence (dML)	A licence administered under the Marine and Coastal Access Act 2009. The licence set out within a Schedule within the Development Consent Order (DCO).
Design Envelope	A description of the range of possible elements that make up the Project's design options under consideration, as set out in detail in the project description. This envelope is used to define the Project for Environmental Impact Assessment (EIA) purposes when the exact engineering parameters are not yet known. This is also often referred to as the "Rochdale Envelope" approach.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for a Nationally Significant Infrastructure Project (NSIP) from the Secretary of State (SoS) for Department for Energy Security and Net Zero (DESNZ).
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of an impact with the sensitivity of a receptor, in accordance with defined significance criteria.
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Directive and EIA Regulations, including the publication of an Environmental Statement (ES).
EIA Directive	European Union 2011/92/EU of 13 December 2011 (as amended in 2014 by Directive 2014/52/EU).
EIA Regulations	Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 and the Marine Works (Environmental Impact Assessment) (Amendment) Regulations 2017.
Environmental Statement (ES)	The suite of documents that detail the processes and results of the Environmental Impact Assessment (EIA).
Evidence Plan	A voluntary process of stakeholder consultation with appropriate Expert Topic Groups (ETGs) that discusses and where possible agrees the detailed approach to the Environmental Impact Assessment (EIA) and information to support Habitats Regulations Assessment (HRA) for those relevant topics included in the process, undertaken during the pre-application period.
Haplotype	Haplotypes comprise a distinct combination of alleles inherited together from a single parent, which are shared within a family group/lineage.
Impact	An impact to the receiving environment is defined as any change to its baseline condition, either adverse or beneficial.
Inter-array cable	Cable which connects the wind turbines to each other and to the offshore substation(s).
Intertidal	Area where the ocean meets the land between high and low tides.
Landfall	The location at the land-sea interface where the offshore export cable will come ashore.
Maximum Design Scenario	The maximum design parameters of the combined project assets that result in the greatest potential for change in relation to each impact assessed.
Mitigation	Mitigation measures, or commitments, are commitments made by the Project to reduce and/or eliminate the potential for significant effects to arise as a result of the Project. Mitigation measures can be embedded (part of the project design) or secondarily added to reduce impacts in the case of potentially significant effects.

Term	Definition
National Policy Statement (NPS)	A document setting out national policy against which proposals for Nationally Significant Infrastructure Projects (NSIPs) will be assessed and decided upon.
Outer Dowsing Offshore Wind	The Project.
Offshore Export Cable Corridor (ECC)	The Offshore Export Cable Corridor (Offshore ECC) is the area within the Order Limits within which the export cables running from the array to landfall will be situated.
Receptor	A distinct part of the environment on which effects could occur and can be the subject of specific assessments. Examples of receptors include species (or groups) of animals or plants, people (often categorised further such as 'residential' or those using areas for amenity or recreation), watercourses *etc*.
Rochdale Envelope	Provides flexibility in design options where details of the whole project are not available when the application is submitted, while ensuring the impacts of the final development are fully assessed during the Environmental Impact Assessment (EIA).
Statutory consultee	Organisations that are required to be consulted by the Applicant, the Local Planning Authorities and/or The Inspectorate during the pre-application and/or examination phases, and who also have a statutory responsibility in some form that may be relevant to the Project and the DCO application. This includes those bodies and interests prescribed under Section 42 of the Planning Act 2008.
The Planning Inspectorate	The agency responsible for operating the planning process for Nationally Significant Infrastructure Projects (NSIPs).
The Project	Outer Dowsing Offshore Wind including proposed onshore and offshore infrastructure.
Transboundary impacts	Transboundary effects arise when impacts from the development within one European Economic Area (EEA) state affects the environment of another EEA state(s).
Transition Joint Bays (TJBs)	The offshore and onshore cable circuits are jointed on the landward side of the sea defences/beach in Transition Joint Bays (TJBs). The TJBs are underground chambers constructed of reinforced concrete which provide a secure and stable environment for the cable. The TJBs have the potential to extend 1.5m above ground level.
Trenchless technique	Trenchless technology is an underground construction method of installing, repairing and renewing underground pipes, ducts and cables using techniques which minimise or eliminate the need for excavation. Trenchless technologies involve methods of new pipe installation with minimum surface and environmental disruptions. These techniques may include Horizontal Directional Drilling (HDD), thrust boring, auger boring, and pipe ramming, which allow ducts to be installed under an obstruction without digging a trench.
Trenched technique	Trenching is a construction excavation technique that involves digging a narrow trench in the ground for the installation, maintenance, or inspection of pipelines, conduits, or cables.
Wind Turbine Generator (WTG)	All the components of a wind turbine, including the tower, nacelle, and rotor.

9 Benthic Subtidal and Intertidal Ecology

9.2 Introduction

1. This chapter of the Environmental Statement presents the results of the Environmental Impact Assessment (EIA) for the potential impacts of Outer Dowsing Offshore Wind (the Project) on benthic subtidal and intertidal ecology. Specifically, this chapter considers the potential impact of the Project, seaward of Mean High Water Springs (MHWS), during the construction, operation and maintenance, and decommissioning phases.
2. GTR4 Limited (trading as Outer Dowsing Offshore Wind) hereafter referred to as the 'Applicant', is proposing to develop the Project. The Project will include both offshore and onshore infrastructure including an offshore generating station (windfarm) approximately 54km offshore of the Lincolnshire coast, export cables to landfall, Offshore Reactive Compensation Platforms (ORCPs), onshore cables, connection to the electricity transmission network, ancillary and associated development and areas for the delivery of up to two Artificial Nesting Structures (ANS) and the creation and recreation of a biogenic reef (if these compensation measures are deemed to be required by the Secretary of State) (see Volume 1, Chapter 3: Project Description (Document Reference 6.1.3).
3. This chapter should be read alongside the following chapters and appendices:
   - Volume 1, Chapter 3: Project Description (Document Reference: 6.1.3);
   - Volume 1, Chapter 7: Marine Processes (Document Reference: 6.1.7) ;
   - Volume 1, Chapter 8: Marine Water Quality (Document Reference: 6.1.8);
   - Volume 1, Chapter 10: Fish and Shellfish Ecology (Document Reference: 6.1.10);
   - Volume 1, Chapter 18: Infrastructure and Other Marine Users (Document Reference 6.1.18);
   - Volume 3, Appendix 7.2: Physical Processes Modelling Report (Document Reference 6.3.7.2);
   - Volume 3, Appendix 9.1: Benthic Ecology Technical Report (Array) (Document Reference 6.3.9.1);
   - Volume 3, Appendix 9.2: Benthic Ecology Technical Report (ECC) (Document Reference 6.3.9.2); and
   - Volume 3, Appendix 9.3: Intertidal Technical Report (Document Reference 6.3.9.3).

9.3 Statutory and Policy Context

4. This section highlights relevant legislation as well as national and local policy that is relevant to benthic subtidal and intertidal ecology. The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 ('the EIA Regulations'), and the Environment Act 2021 are considered along with the legislation relevant to benthic subtidal and intertidal ecology.
5. In undertaking the assessment, the following legislation has been considered:
   - The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017;

- The Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention; 1979);
- The Conservation of Habitats and Species Regulations 2017;
- The Conservation of Offshore Marine Habitats and Species Regulations 2017;
- Marine Strategy Regulations 20100;
- Marine and Coastal Access Act 2009; and
- The Wildlife and Countryside Act 1981 .

6. Guidance on the issues to be assessed for offshore renewable energy developments has been obtained through reference to:
   - The Overarching National Policy Statement (NPS) for Energy (NPS EN-1; Department for Energy Security and Net Zero (DESNZ) 2023a);
   - The National Policy Statement for Renewable Energy Infrastructure (NPS EN-3; DESNZ, 2023b;
   - The National Policy Statement for Electricity Networks Infrastructure (NPS EN-5; DESNZ, 2023c)
   - The United Kingdom (UK) Marine Policy Statement (MPS; HM Government, 2011); and
   - The United Kingdom (UK) Marine Strategy Part One (2019).

9.3.1 UK Marine Strategy

7. The UK Marine Strategy, as required by the Marine Strategy Regulations 2010, has also been considered in the Project assessment for benthic and intertidal ecology. The overarching goal of the Strategy is to achieve 'Good Environmental Status' (GES) by 2020 across the UK's marine environment. To this end, the regulations identify 11 high level qualitative descriptors for determining GES. In the interests of avoiding repetition these are not repeated, and instead those descriptors that are considered to be relevant to the benthic and intertidal ecology assessment for the Project are listed in Table 9.1, including a brief description of how and where these policies have been addressed in the Project assessment.

9.3.2 East Inshore and East Offshore Coast Marine Plans

8. The East Inshore and East Offshore Coast Marine Plans (MMO, 2014) are also relevant to benthic subtidal and intertidal ecology. The relevant provisions of these policies are summarised in Table 9.1, along with details as to how these have been considered within the Project assessment.
9. The relevant legislation and planning policy for offshore renewable energy Nationally Significant Infrastructure Projects (NSIPs), specifically in relation to benthic subtidal and intertidal ecology, are outlined in Table 9.1 below:

Table 9.1: Legislation and policy context

Legislation/Policy	Key Provisions	Section where comment addressed
The Overarching National Policy Statement (NPS) EN-1) (Department for Energy Security and Net Zero (DESNZ), 2023a)	Paragraph 5.4.17 states: "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 5.4.18 states: "The applicant should provide environmental information proportionate to the infrastructure where EIA is not required to help the Secretary of State consider thoroughly the potential effects of a proposed project."	The potential effects of the Project have been assessed in regard to international, national, and local sites designated for ecological or geological features of conservation importance (see section 9.5, 9.6 and 9.8).
	Paragraph 5.4.51 states: "The SoS is bound by the duties in relation to Marine Conservation Zones (MCZs) imposed by sections 125 and 126 of the Marine and Coastal Access Act (MCAA) 2009".	An MCZ assessment is presented within Part 6, Volume 2, Appendix 9.4: Marine Conservation Zone Assessment, with a summary of the relevant habitats presented within this chapter for completeness.
	Paragraph 5.4.8 states: "Development on land within or outside a [Site of Special Scientific Interest] SSSI, and which is likely to have an adverse effect on it (either individually or in-combination with other developments), should not normally be permitted. The only exception is where the benefits (including need) of the development in the location proposed clearly outweigh both its likely impact on the features of the site that make it of special	Designated sites within the region have been identified in section 9.5 as appropriate, and any potential impacts to features of the sites have been assessed in section 9.8.

Legislation/Policy	Key Provisions	Section where comment addressed
	scientific interest, and any broader impacts on the national network of SSSIs.	
The NPS for Renewable Energy Infrastructure (NPS EN-3) (DESNZ, 2023b)	Paragraph 2.11.36 states: "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 (See Sections 4.2 and 5.4 of EN-1).".	Consideration of the construction, operation and decommissioning phases of the scheme are set out in section 9.8.
	Paragraph 2.8.104 states: "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".	Consultation has been undertaken through the scoping process and is ongoing through the EIA Evidence Plan process as set out in section 0.
	Paragraph 2.8.106 states: "Any relevant data that has been collected as part of post-construction ecological monitoring from existing, operational OWFs should be referred to where appropriate".	Relevant data collected as part of post-construction monitoring from other OWFs has informed the assessment of section 9.9. The Marine Management Organisation (MMO) has produced a review (MMO, 2014) on post-construction monitoring that has been undertaken for OWFs within which it is noted that there have been limited effects arising on benthic communities from certain impacts.

Legislation/Policy	Key Provisions	Section where comment addressed
	Paragraph 2.8.103 states: "Applicants should assess the potential of their proposed development to have net positive effects on marine ecology and biodiversity as well as negative effects".	An assessment of both the positive and negative effects of the Project is provided in section 9.8.
	Paragraph 2.8.119 states: "Applicant assessment of the effects of installing offshore transmission infrastructure across the intertidal/coastal zone should demonstrate compliance with mitigation measures in any relevant plan-level HRA including those prepared by The Crown Estate as part of its leasing round, and include information, where relevant, about": ▪ any alternative landfall sites that have been considered by the applicant during the design phase and an explanation for the final choice; ▪ any alternative cable installation methods that have been considered by the applicant during the design phase and an explanation for the final choice; ▪ potential loss of habitat; ▪ disturbance during cable installation, maintenance/repairs and removal (decommissioning); ▪ increased suspended sediment loads in the intertidal zone during installation and maintenance/repairs; ▪ potential risk from invasive and non-native species;	An assessment of the effects of benthic and intertidal disturbances throughout the whole of the development can be found in section 9.8, with specific reference to construction vessels and anchors and habitat disturbance within the intertidal zone found in Table 9.10: Maximum design scenario for benthic subtidal and intertidal ecology for the Project alone. Potential impacts of habitat loss have been assessed under impact 1 of section 9.8. An assessment of the effects of benthic and intertidal disturbance throughout the whole of the development can be found in section 9.8. Consideration of the specific effects of increased suspended sediment load and the associated sediment deposition on benthic and intertidal ecology is set out in section 9.8.

Legislation/Policy	Key Provisions	Section where comment addressed
	▪ predicted rates at which the intertidal zone might recover from temporary effects, based on existing monitoring data; and ▪ protected sites	Consideration of the potential for effects associated with marine invasive non-native species on benthic species and habitats that may be attributable to the Project are set out in section 9.8. The likely rates of recovery of benthic and intertidal habitats/species have been presented for each impact assessed and are based on the Marine Evidence Based Sensitivity Assessment (MarESA) which has been used to inform the assessment as set out in section 9.8. Designated sites within the region have been identified in section 9.5. as appropriate, and any potential impacts to features of the sites have been assessed in section 9.8.
	Paragraph 2.8.123 states: “The applicant should demonstrate compliance with mitigation measures identified by The Crown Estate in any plan-level HRA produced as part of its leasing round.”	The likely rates of recovery of benthic and intertidal habitats/species have been presented for each impact assessed and are based on the Marine Evidence Based Sensitivity Assessment (MarESA) which has been used to inform the assessment as set out in section 9.8.
	Paragraph 2.8.126 states: “Applicant assessment of the effects on the subtidal environment should include":	Potential impacts of habitat loss have been assessed in impact 1 of section 9.8.

Legislation/Policy	Key Provisions	Section where comment addressed
	▪ 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 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.	Consideration of the specific effects of increased suspended sediment load and the associated sediment deposition on benthic and intertidal ecology is set out in section 9.8. Consideration of the indirect disturbance of Electromagnetic Fields (EMF) generated by inter-array and export cables and effects on protected species is set out in section 9.7. Consideration of protected sites and the potential effects on the relevant habitats associated with the construction, operation and decommissioning is set out in section 9.8. Reference to protected sites and their features is also made in the Part 7, Document 7,1: Report to Inform Appropriate Assessment (RIAA).
	Paragraph 2.8.234 states: "Mitigation measures which applicants are expected to have considered include:	Where considered appropriate, and where effects associated with the project may be considered significant in the absence of mitigation, mitigation has been considered during the assessment, in section 9.8.

Legislation/Policy	Key Provisions	Section where comment addressed
	▪ 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 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."	
	Paragraph 2.8.302 states: "The Secretary of State should consider the effects of a proposed development on marine ecology and biodiversity, considering all relevant information made available by the applicant".	Where relevant to benthic and intertidal ecology, effects on marine ecology and biodiversity have been described and considered within the assessment for the Project in section 9.8.
	Paragraph 2.11.57 states: "The designation of an area as a protected site (including SACs, SPAs, and Ramsar sites, MCZs and SSSIs) does not necessarily restrict the construction or operation of tidal stream arrays in, near, or through that area (see also Sections 5.4 of EN-1). Where adverse effects on site integrity/conservation objectives are likely the Secretary of State should consider the extent to	National Site Network sites (including HRA sites, MCZs and SSSIs) have been considered during the Project assessment with potential effects on the relevant habitats described in section 9.5.

Legislation/Policy	Key Provisions	Section where comment addressed
	which the effects are temporary or reversible, the timescales for recovery and the need for mitigation or if necessary, compensation.”.	
	Paragraph 2.8.218 states: “Mitigation will be possible in the form of careful design of the development itself and the construction techniques employed”.	Consideration of mitigation during the assessment, where considered appropriate and where effects associated with the project may be considered significant in the absence of mitigation, are set out in section 9.8.
	Paragraph 2.8.221 states: Applicants must develop an ecological monitoring programme to monitor impacts during the pre-construction, construction and operational phases to identify the actual impacts caused by the project and compare them to what was predicted in the EIA/HRA.	An In-Principal Monitoring Plan (document reference 8.3) has been submitted alongside the application which provides details of the proposed monitoring for the Project.
	Paragraph 2.8.222 states: “Should impacts be greater than those predicted, an adaptive management process may need to be implemented and additional mitigation required, to ensure that so far as possible the effects are brought back within the range of those predicted.”	An In-Principal Monitoring Plan (document reference 8.3) has been submitted alongside the application which provides details of the proposed monitoring for the Project.
	Paragraph 2.8.223 states: “Monitoring should be of sufficient standard to inform future decision-making. Increasing the understanding of the efficacy of alternatives and mitigation will deliver greater certainty on applicant requirements.”	An In-Principal Monitoring Plan (document reference 8.3) has been submitted alongside the application which provides details of the proposed monitoring for the Project.
	Paragraph 2.8.311 states:	Volume 1, Chapter 3 provides details of the Project Description, and Table 9.11 outlines

Legislation/Policy	Key Provisions	Section where comment addressed
	"The Secretary of State should be satisfied that cable installation and decommissioning has been designed sensitively, considering intertidal/coastal habitats".	the mitigations for the Project of relevance to Benthic and Intertidal Ecology, including commitments to avoiding impacts to the intertidal from cable installation through the use of Horizontal Directional Drilling techniques, with a subtidal punch out.
	Paragraph 2.8.317 states: "The Secretary of State should be satisfied that activities have been designed considering sensitive subtidal environmental aspects and discussions with the relevant conservation bodies have taken place".	Details of the consultations undertaken with regard to site selection and consideration of alternatives, including cable routing, etc. are presented within Volume 1, Chapter 4: Site Selection and Alternatives (document reference 6.1.4).
	Paragraph 2.8.352 states: "Where adverse effects are anticipated either during the construction or operational phases, in coming to a judgement, the Secretary of State should consider the extent to which the effects are temporary or reversible".	Section 9.9 of this chapter includes the duration and reversibility of effects in the assessment of effects.
	Paragraph 2.8.310 states: "The use of external cable protection has been suggested as a mitigation for EMF (by increasing the distance between fish species and individual cables). However, the Secretary of State should also consider any negative impacts from external cable protection on benthic habitats, and a balance between protection of various receptors must be made, with all mitigation and alternatives reviewed."	Offshore cables are proposed to be buried for the project. However, the potential need for cable protection (either for crossings and/or where burial is not achievable) has been considered within the assessments in relation to the potential effects on the receiving benthic environment. An assessment of the nature, potential burial depth, and installation of export cables is provided in section 9.8, in accordance with the cable design and specification as

Legislation/Policy	Key Provisions	Section where comment addressed
		presented in Chapter 7: Marine Processes (Document Reference 6.1.7).
UK Marine Strategy Part 1 (2019)	Descriptor 1 – Biological diversity: "Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions."	Consideration of the effects on biological diversity for the Project alone and cumulatively are set out in sections 9.8 and 9.9 of this chapter.
	Descriptor 2 – Non-indigenous species: "Non-indigenous species introduced by human activity are at levels that do not adversely alter the ecosystems."	Consideration of the potential for effects associated with marine invasive non-native species on benthic species and habitats that may be attributable to the Project are set out in section 9.8.
	Descriptor 4 –Marine food webs: "All elements of marine food webs, to the extent they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity."	Consideration of the effects on benthic and intertidal ecology, inclusive of the interlinkages with interdependent ecological receptors described in other chapters and wider ES with inter relations are set out in section 9.10.
	Descriptor 6 – Sea floor integrity: "Seafloor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected."	Consideration of the effects on benthic and intertidal ecology, inclusive of any risk to ecological integrity, for the Project alone and cumulatively are set out in sections 9.9 and 9.10.
	Descriptor 7 – Hydrographical conditions: "Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems."	Consideration of the potential for permanent alterations to hydrographical conditions that may be attributable to the Project to adversely affect marine ecosystems is set out in section 9.8.

Legislation/Policy	Key Provisions	Section where comment addressed
	Descriptor 8 – Contaminants: "Concentrations of contaminants are at levels not giving rise to pollution effects."	Consideration of the effects of contaminants on benthic and intertidal habitats and species are set out in section 9.8.
	Descriptor 10 – Marine litter: "Properties and quantities of marine litter do not cause harm to the coastal and marine environment."	A Project Environmental Management Plan (PEMP) will be produced post-consent and followed to cover the construction and O&M phase of the Project. The PEMP will include planning for accidental spills, address all potential contaminant releases and include key emergency contact details. A Decommissioning Programme will be developed post-consent to cover the decommissioning phase (Table 9.11).
East Inshore and East Offshore Marine Plans – ECO1	"Cumulative impacts affecting the ecosystem of the East marine plans and adjacent areas (marine, terrestrial) should be addressed in decision-making and plan implementation."	Cumulative effects are considered within section 9.9.
East Inshore and East Offshore Marine Plans - SOC3	"Proposals that may affect the terrestrial and marine character of an area should demonstrate, in order of preference: ▪ that they will not adversely impact the terrestrial and marine character of an area ▪ how, if there are adverse impacts on the terrestrial and marine character of an area, they will minimise them ▪ how, where these adverse impacts on the terrestrial and marine character of an area cannot be minimised, they will be mitigated against ▪ the case for proceeding with the proposal if it is not possible to minimise or mitigate the adverse impacts."	The current marine character regarding benthic subtidal and intertidal ecology aspects of the site has been detailed in Volume 3, Appendix 9.1: Benthic Ecology Technical Report (Array) and Volume 3, Appendix 9.2: Benthic Ecology Technical Report (ECC). Due regard has also been given to the Seascape Character Assessment (MMO, 2012) of the marine plan areas. Potential impacts to benthic subtidal and intertidal ecology marine character of the Marine Plan areas have been assessed in

Legislation/Policy	Key Provisions	Section where comment addressed
		section 9.5. Details of embedded mitigation is presented in Table 9.11.
East Inshore and East Offshore Marine Plans - BIO2	"Where appropriate, proposals for development should incorporate features that enhance biodiversity and geological interests."	Consideration will be given to the use of ecoengineering or methods to enhance biodiversity and geological interests where technologies exist which are sufficient to ensure the integrity of the infrastructure.
East Inshore and East Offshore Marine Plans – MPA1	"Any impacts on the overall Marine Protected Area network must be taken account of in strategic level measures and assessments, with due regard given to any current agreed advice on an ecologically coherent network."	Designated nature conservation sites within the Project benthic and intertidal ecology study area have been described in section 9.5 and assessed in section 9.8.

9.4 Consultation

10. Consultation is a key part of the Development Consent Order (DCO) application process. Consultation regarding benthic and intertidal ecology has been conducted through the Evidence Plan Process (EPP) Expert Topic Group (ETG) meetings and the EIA scoping process (Outer Dowsing Offshore Wind, 2022). An overview of the Project consultation process is presented within Chapter 6: Consultation Process (Document Reference 5.1).
11. A summary of the key issues raised during consultation to date, specific to benthic subtidal and intertidal ecology, is outlined in Table 9.2 below, together with how these issues have been considered in the production of this Environmental Statement.

Table 9.2: Summary of consultation relating to Benthic and Intertidal Ecology

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
Scoping Opinion (the Planning Inspectorate, 9 September 2022) Comment ID: 3.3.1	The ES should provide details of the proposed mitigation measures to be included in the PEMP and Marine Pollution Contingency Plan (MPCP) and identify how these plans are to be secured.	Table 9.11 details the embedded mitigation in relation to pollution prevention. These commitments have been secured through conditions within the deemed Marine Licence (dML).
Scoping Opinion (the Planning Inspectorate, 9 September 2022) Comment ID: 3.3.2	The ES should include an assessment of the increased risk of introduction and spread of marine Invasive Non-Native Species (INNS) during operation on benthic ecology receptors, where likely significant effects could occur. This should include consideration of the potential for cumulative effects.	An assessment of the impacts of marine INNS is provided within section 9.8. Embedded mitigation and control of invasive species measures in line with IMO (2019) have been incorporated and secured within the Outline PEMP (document reference 8.4) to ensure that no significant effects will arise from INNS (Table 9.11).
Scoping Opinion (the Planning Inspectorate, 9 September 2022) Comment ID: 3.3.3	The ES should include an assessment of changes in physical processes, where likely significant effects could occur.	An assessment of changes in physical processes resulting from the presence of the OWF subsea infrastructure on benthic species during O&M is provided in section 9.8.
Scoping Opinion (the Planning Inspectorate, 9 September 2022) Comment ID: 3.3.4	The Applicant should make effort to agree the approach to the assessment with relevant consultation bodies, including NE. The ES should assess effects on sensitive benthic ecology receptors from EMF, where likely significant effects could occur.	An assessment of EMF effects generated by inter-array and export cables on benthic species during O&M is provided in section 9.8, with the approach to assessments having been discussed within the ETGs.
Scoping Opinion (the Planning Inspectorate, 9 September 2022) Comment ID: 3.3.7	The ES should provide details of the proposed mitigation measures to be included in the Scour Protection Management Plan (SPMP) and explain how such measures will be secured.	An Outline Scour Protection and Cable Protection Management Plan (SPCPMP) (document reference 8.21) has been submitted as part of the DCO application. Specific mitigation measures for effects arising from the use of scour and cable protection are detailed within Table 9.11 and

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
		secured within the Outline SPCPMP (document reference 8.21).
Scoping Opinion (the Planning Inspectorate, 9 September 2022) Comment ID: 3.3.5 and 3.3.8	The ES must assess all cumulative effects where significant effects are likely to occur and any likely significant effects on benthic subtidal and intertidal receptors occurring as a result of interactions with other plans and projects.	Consideration of likely significant effects on benthic subtidal and intertidal receptors for the Project alone and cumulatively are set out in section 9.9.
Scoping Opinion (MMO, 26 August 2022) Comment ID: 3.2.1	The MMO considers it necessary that geophysical data be collected anywhere that the seabed would be physically disturbed by the Project, and for these data to be used to inform the micrositing where appropriate and practicable.	Within the Order Limits, geophysical survey data have been collected as set out in section 9.5. Geophysical data informed the location of ground-truth site specific characterisation. The In-Principle Monitoring Plan (document reference 8.3) sets out that additional pre-construction geophysical data will be collected. As noted within the Outline Biogenic Reef Mitigation Plan (document reference 8.22), pre-construction survey data will be used to help inform any micro-siting that might be required.
Scoping Opinion (MMO, 26 August 2022) Comment ID: 3.2.4	The baseline should be characterised using data that are less than ten years old, unless a strong justification can be provided for using older data.	The baseline has been informed by site-specific survey data collected across the Array area and offshore ECC, collected in 2021 and 2022. However, to understand the wider study area, where indirect impacts to benthic receptors are anticipated to be low risk, the Project has also utilised historic data and broadscale habitat data of variable sources to build a comprehensive characterisation. Data older than ten years is not relied on but provides useful temporal contextualisation.
Scoping Opinion (MMO, 26 August 2022)	The MMO requires changes in physical processes (e.g., scour, current regimes) and the spread of INNS	Both these impacts have been scoped into this assessment. An assessment of changes in physical processes resulting from the presence of the OWF subsea infrastructure on

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
Comment ID: 3.2.5	associated with the installation of OWF subsea infrastructure to be scoped in and assessed.	benthic species as well as the spread of INNS during O&M is provided in section 9.9.
Scoping Opinion (MMO, 26 August 2022) Comment ID: 3.2.6	The MMO advises that the ECC is routed to avoid designated sites that protect benthic features. If this is not feasible, then impacts on the protected benthic features within these sites should be minimised.	The development boundary selection was made following a series of constraints analyses, with the array area and offshore ECC route selected to ensure the impacts on sensitive environmental receptors are minimised. However, the offshore ECC must pass through the Inner Dowsing, Race Bank and North Ridge (IDRBNR) SAC. Additional mitigation measures for Annex I habitat within the SAC are detailed within Table 9.12. This includes having removable cable protection on sandbank features within the IDRBNR SAC, and that windfarm infrastructure will be micro-sited around Annex I habitat (*S. spinulosa* reef) as far as practicable (Table 9.12) as detailed within the Outline Biogenic Reef Mitigation Plan (document reference 8.22).
Scoping Opinion (Natural England, 30 August 2022) Comment ID: 54.	Natural England notes that the ECC includes several designated sites in the marine and coastal environment and depending on installation methodology impact pathways to sites features can't be excluded. Thorough assessment is required and continuation of progress on identifying mitigation and where required compensation measures.	A thorough assessment of the impacts to designated site features has been included in section 9.9. Where considered appropriate, and where effects associated with the project may be considered significant in the absence of mitigation, additional mitigation (Table 9.12) has been considered during the assessment, as shown in section 9.9.
Scoping Opinion (Natural England, 30 August 2022) Comment ID: 57.	Natural England advises that there are other pre and post consent data for the OWFs and interlinks that could be considered, though the limitations from the age and proximity of existing data should be taken account of.	Pre- and post-construction reports from other OWFs, including Triton Knoll, Hornsea One, Gunfleet sands, Lincs, Thanet, Lynn and Inner Dowsing as well as Viking Link Interconnector have informed the wider study area and impacts of OWF construction activities, as detailed in section 9.5.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
Scoping Opinion (Natural England, 30 August 2022) Comment ID: 58.	Natural England advises that landfall should avoid designated coastal sites and where that is not possible extensive mitigation measures will be required.	The final site selection was made following a series of constraints analyses, with the array area and offshore ECC route selected to ensure the impacts on sensitive environmental receptors are minimised. Furthermore, only HDD will be utilised for the landfall, which allow ducts to be installed under an obstruction without breaking open the ground and digging a trench. The exit pits for the HDD will be designed to a target of 500m below MLWS as such, there will be no impact to designated coastal sites.
Scoping Opinion (Natural England, 30 August 2022) Comment ID: 59.	Natural England advises that cable installation in this region within mix and coarse sediment has proved challenging for adjacent projects and therefore a cable burial risk assessment (CBRA), informed by geotechnical investigations as part of the application is required to determine the likelihood of cable protection being required and potential impacts to priority/Annex I reef habitats associated with mixed sediment.	A localised CBRA was undertaken on the offshore ECC through the IDRBNR SAC, which has informed the project design in this region. A full CBRA will be undertaken as part of the engineering design process, covering the whole of the route prior to construction. Cable burial is the preferred option for cable protection, and this will minimise any impacts associated with habitat loss (section 9.8).
Scoping Opinion (Natural England, 30 August 2022) Comment ID: 60 and 61.	Natural England advises that outline plans including any mitigation measures should be provided at the time of Application. Information is still to be provided including assurances that appropriate measures will be adopted to ensure environmental risks will be appropriately managed for marine pollution and INNS. Natural England advises that outline documents and/or assessment will need to be included in the Application to ensure that all impacts have been considered and appropriately managed.	Mitigation measures that have been adopted as part of the evolution of the project design are detailed within Table 9.11. This includes the development of a MPCP to manage marine pollution, and best practice guidelines will be followed and implemented through the development of a PEMP, which may also contain a Biosecurity Plan to minimise marine INNS introduction/spread in the event that gravity base structure (GBS) foundations are used. An Outline PEMP (document reference 8.4) has been submitted alongside the DCO application.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
Evidence Plan meeting ETG 11 January 2022	Natural England raised concerns surrounding the ability to detect natural change from development and queried if there are enough sample stations.	Site-specific survey data were collected across the Array area and offshore ECC at representative habitats and with a high density of sampling. The survey strategy was consulted on with Natural England, MMO and other stakeholders prior to the commencement of the surveys. The survey plan was designed following the Natural England advice for baseline characterisation (Phase I Best Practice Advice for Baseline Characterisation Surveys, Version 1.1, July 2022; Natural England, 2022). The wealth of historic data has also been reviewed to understand natural change.
Evidence Plan meeting ETG 11 January 2022	Natural England suggested the Project use other developer's pre-construction surveys and most recent information.	As stated above, available pre- and post-construction reports from other OWFs, including Triton Knoll, Hornsea One, Gunfleet Sands, Lincs, Thanet, Lynn and Inner Dowsing as well as Viking Link Interconnector have informed the wider study area and impacts of OWF construction activities, as detailed in section 9.5.2.10 (Existing Environment) and section 9.8 (Impact Assessment).
Evidence Plan meeting ETG 11 January 2022	Post meeting note: Centre for Environment, Fisheries and Aquaculture Science (Cefas) confirmed that the data used to inform the benthic ecology baseline should ideally be no more than ten years old. If there is an intention to use older data, then justification should be provided.	To understand the wider study area, where indirect impacts to benthic receptors are anticipated to be low risk, the Project has relied on historic data and broadscale habitat data from various sources to build a comprehensive baseline characterisation. Where data are older than 10 years they have been included to provide additional contextualisation for the wider region.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
Evidence Plan Meeting ETG 11 July 2022	Cefas recommended that JNCC, Natural England and MMO data layers are all used to produce baseline characterisation maps.	JNCC data were used to identify conservation features and designated sites (Volume 2, Figure 9.6) and the Cefas OneBenthic Tool was used to identify ecology and substrates across the benthic ecology study area (Volume 2, Figure 9.2). EMODnet (2022) data provided the best regional mapping data, presenting EUNIS Level 4 data across the area of interest (Volume 2, Figure 9.2).
Evidence Plan Meeting ETG 11 July 2022	Cefas queried whether INNS and EMF should be scoped out, as there are studies to show that both elements have presented themselves with similar projects and subsea cables. Cefas advised that despite INNS already being present, additional species could still be introduced.	An assessment of the impacts of marine INNS and EMF effects is provided within section **Error! Reference source not found.**
Evidence Plan Meeting ETG 12 October 2022	Cefas accepted the measures in place to prevent the introduction of marine INNS. However, Cefas confirmed the installation of infrastructure would create hard habitats and requested the Project consider the potential for infrastructure to be colonised by INNS and consider connection between structures.	An assessment of the impacts of marine INNS is provided within section**Error! Reference source not found.** Embedded mitigation and control of invasive species measures in line with IMO (2019) have been incorporated and will be included in the PEMP to ensure that no significant effects will arise from INNS (Table 9.11), as set out in the Outline PEMP (document reference 8.4).
Evidence Plan Meeting ETG 12 October 2022	Natural England stated that the Cefas OneBenthic data should be incorporated into the environmental baseline.	OneBenthic data has been included to provide secondary habitat data across the benthic and intertidal ecology study area (section 9.5).
Evidence Plan Meeting ETG 12 October 2022	Post meeting note from Natural England received on 02 November 2022: Natural England confirmed all post-construction monitoring reports are missing. Natural England advises that further information and	The Project's site-specific data have been the primary data used to inform the characterisation. To understand the wider study area, where impacts are anticipated to be low risk, the Project has relied on historic data and broadscale habitat data of variable sources and dates to build a comprehensive

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	assessment is required before we can provide comment of the sufficiency of the surveys.	picture and assist in the temporal understanding of the region although it has not been relied on as the primary source of information for characterisation of the site. Post-construction reports from other OWFs including Triton Knoll, Hornsea One, Gunfleet Sands, Lincs, Thanet, Lynn and Inner Dowsing as well as Viking Link Interconnector have been included to inform the wider study area or general impacts from OWFs.
Environment Agency S42 response July 2023	EA stated that they had have reviewed this chapter in so far as it relates to their marine ecology perspective and provided the applicant can agree to appropriate mitigation measures to protect sensitive habitats including chalk reef, we are satisfied that the risk assessments undertaken to date are appropriate.	No chalk reef has been identified within the offshore ECC from the characterisation surveys (section 9.1). Mitigation measures for other relevant sensitive habitats have been provided for and are described in Table 9.11.
Lincolnshire Wildlife Trust S42 response July 2023	Given the unfavourable condition of Annex 1 features according to Natural England's 2019 condition assessment and the outcomes from the 2023 Advice on Operations assessment matrix (Fig. 1), LWT argues that it is logical to conclude that the Annex 1 features within the IDRBNR SAC could be considered 'red risk features' and should therefore be avoided.	The justification for the site selection and the alternative routing options considered for the Project is detailed in Chapter 4: Site Selection and Assessment of Alternatives (Document Reference 6.1.4). It was not considered possible to avoid the SAC and the features of the site. In cognisance of the sensitivity of these features, extensive mitigation measures have been proposed for the cable routing through the SAC, as outlined within Chapter 3: Project Description (Document Reference 6.1.3) and this chapter (para 9.5.6 et seq.).
Lincolnshire Wildlife Trust S42 response July 2023	LWT does not agree with the Applicant's assessments of vulnerability and sensitivity, given the evidence provided from both Natural England and the JNCC. LWT would like to refer to the above evidence provided by Natural England's condition assessment from 2019,	The Applicant has reviewed the assessment in light of SNCB comments, including an appraisal of the most recent condition assessment for the IDRBNR SAC. The conclusions have been amended accordingly where appropriate.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	which outlines unfavourable conditions and no signs of recovery for all Annex 1 habitat assessed within this protected area. Unfortunately, the Applicant's claims are in direct conflict with both the current evidence base and conservation guidance.	Additionally, further engineering work has been undertaken to refine the worst-case scenarios for impacts to sandbanks within the SAC and the whole project combined, including a commitment to the use of only removeable cable protection in the event that any is required over the sandbank features of the SAC, as secured within the Outline SPCPMP (document reference 8.21).
Lincolnshire Wildlife Trust S42 response July 2023	The Secretary of State's decision letter in response to the Hornsea Project Three sets a precedence regarding the long-term impact of cable protection on Annex 1 sandbank features: 'In respect of the North Norfolk Sandbanks and Saturn Reef SAC and the Wash and North Norfolk Coast SAC, the Secretary of State considers that habitats which are subjected to cable protection, will experience the effects of habitat loss, habitat modification and changes in epifauna communities. As the cable protection will be in place for 35 years, this is considered a long-term effect. Furthermore, cable protection measures are likely to impede the restoration of the Annex 1 habitats for the duration that they are in place. These habitats are currently in unfavourable condition, and delays to their restoration would be contrary to the Conservation Objectives for the SACs.' We believe that this ruling directly applies to the impacts of the ECC of this Project. With regards to the impacts of the ECC on the IDRBNR SAC, we have outlined that:	The Applicant has reviewed the assessment in light of SNCB comments, including an appraisal of the most recent condition assessment for the IDRBNR SAC. The conclusions have been amended accordingly where appropriate. Additionally, further engineering work has been undertaken to refine the worst-case scenarios for impacts to sandbanks within the SAC and the whole project combined, including a commitment through additional mitigation to the use of only removeable cable protection in the event that any is required over the sandbank features of the SAC (Table 9.12), as secured within the Outline SPCPMP (document reference 8.21).

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	1. The features of IDRBNR SAC (H1170 Reefs and H1110 Sandbanks) are in unfavourable condition with no signs of recovery, according to Natural England's 2019 condition assessment. 2. IDBRNR Annex 1 habitats are sensitive to ECC activities, which pose medium high risk to these features, as demonstrated by the Advice on Operations matrix (Fig. 1) 3. The Crown Estate has clearly outlined that avoidance to be applied in the event of high-risk activities to at-risk features (evidence to support the assumption of high risk given by items 1 and 2) 4. There is a gross underestimation of the length of impact on protected features within the PEIR, and this claim is supported by a precedent set by Secretary of State's decision to Hornsea Project Three.	
Marine Management Organisation Letter S42 response July 2023	The MMO agrees with the benthic receptors that have been scoped into the assessment. It appears that the only relevant benthic feature that has been scoped out of the assessment is Annex I stony reef, and this is because the stations that potentially qualified as this habitat based on the presence of cobbles within the Array Area and ECC did not meet the required physical and / or ecological criteria (Sections 9.4.102 and 9.4.105 and Section 4.8.2 (Appendix 9.1), and Section 4.9.2 Appendix 9.2). The MMO defers to Natural England on this matter but would highlight that it may be	The Applicant acknowledges the concerns raised by MMO in relation to stony reef. However, it should be pointed out the only two features designated within the SAC are 'biogenic reefs' and 'sandbanks'. 'Stony reef' is a separate Annex I habitat which is not a feature of the SAC. The Applicant has undertaken pre-construction surveys of the proposed development in order to determine the location, extent and composition of any Annex I reef and have committed to micro-siting infrastructure where practicable.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	appropriate to be more precautionary when identifying potential Annex 1 stony reef along the ECC within the IDRBNR Special Area of Conservation (SAC), within which 'Reefs' is a protected feature.	Discussion in relation to *S. spinulosa* recorded during site specific surveys and associated reef features is provided in para 116 below.
Marine Management Organisation Letter S42 response July 2023	Regarding the impact of temporary habitat disturbance during the construction phase, it is stated that pre-construction surveys of *S. spinulosa* reef (an Annex I habitat within the IDRBNR SAC) will be conducted, and that if this feature is present then a mitigation plan will be created in consultation with the MMO and Natural England (see sections 9.7.14 and 9.7.32 of the document cited in Volume 1, Chapter 9: Benthic and Intertidal Ecology (Document Reference 6.1.9) Rev V1.0. June 2023). As the data collected during the most recent geophysical surveys of the Array Area and ECC did not reveal a unique signature associated with *S.spinulosa* aggregations observed in the ground-truthing data (see section 9.4.107 of Volume 1, Chapter 9: Benthic and Intertidal Ecology (Document Reference 6.1.9). Rev V1.0. June 2023), it seems possible that potential *S. spinulosa* reef could go undetected in future geophysical surveys. The MMO advises that ODOW indicate how they will ensure that the pre-construction surveys will be able to identify any areas of potential *S. spinulosa* reef so that they can be avoided by micro-siting / routeing.	The Applicant acknowledges the concerns raised by MMO in relation to the detection of *S. spinulosa* reef. However, it is typical for well established 'reef' to be evident as irregular ridges and low-grade reef within mixed sediment is increasingly difficult to delineate. The Applicant undertook a high sampling strategy for the baseline characterisation ground-truth campaign. The evidence from that survey did reveal that *S. spinulosa* found was low-grade and patchy in nature, supporting the geophysical results. Furthermore, a reanalysis of the geophysical and benthic characterisation data along the offshore ECC has been undertaken by Envision Ltd (document reference6.3.9.3), with the results of this work used to inform this assessment. The Applicant has committed to pre-construction surveys to identify the quality and extent of *S. spinulosa* reef and enable robust micrositing of infrastructure to occur.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
Marine Management Organisation Letter S42 response July 2023	Regarding the impact of permanent habitat loss / alteration during the operation & maintenance phase, the total area that may be affected is large (5.5 km^2). The MMO recommends that this area is reduced by design if practicable. The possible loss of habitat within the IDRBNR SAC due to any required cable protection is also a particular concern. However, it is noted that a cable burial risk assessment (CBRA) will be undertaken to help avoid significant impacts to Annex I sandbanks, though it is unclear whether impacts on Annex I reef can be avoided at this stage.	Further engineering work has been undertaken to refine the worst-case scenarios for impacts to sandbanks within the SAC and the whole project combined. Further evidence, inclusive of updated project parameters, has been used to inform the assessment, and the figure regarding the area of permanent/long-term habitat loss/alteration during the operation & maintenance phase has been revised to 4.4km^2 as indicated in Table 9.10. Additional mitigation (Table 9.12) is committed to Annex I sandbanks and Annex I reef. As detailed within the Table 9.12 additional mitigation will be applied to cable protection within the IDRBNR SAC (if required), this aims to reduce pressures on the sandbank features within this site. This mitigation plan has been developed in line with Natural England's mitigation hierarchy for designated sites (see section 9.8). As detailed within the Outline Biogenic Reef Mitigation Plan (document reference 8.22) windfarm infrastructure will be micro-sited around Annex I reef as far as practicable, to avoid where possible direct impacts to these sensitive habitats. As detailed within the In Principle Monitoring Plan (Document Reference 8.3) a pre-construction Annex I habitat survey will be undertaken and will subsequently be used to inform any micro-siting of windfarm infrastructure.
Marine Management Organisation Letter S42 response	The MMO stated that in relation to the impact of colonisation of the Wind Turbine Generators (WTGs) and scour / cable protection during the operation & maintenance phase, it is stated that this would affect an	Further engineering work has been undertaken to refine the worst-case scenarios for impacts with further evidence, inclusive of updated project parameters having been used to inform the assessment, and the figure regarding the impact

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
July 2023	area of 0.8 km^2 (see section 9.7.97 of Volume 1, Chapter 9: Benthic and Intertidal Ecology (Document Reference 6.1.9). Rev V1.0. June 2023). However, based on the information presented in Table 9.10 of the same document, it appears than an area of 8 km^2 would be affected. The MMO requests clarity on what the affected area will be and, if it's the larger area – as appears to be the case – then ODOW should indicate whether this affects their conclusion.	of colonisation of the Wind Turbine Generators (WTGs) and scour/cable protection during the operation & maintenance phase has been revised to 2.4 km^2 as indicated in Table 9.10.
Marine Management Organisation Letter S42 response July 2023	Regarding the potential spread of invasive non-native species (INNS) due to the presence of infrastructure during the operation & maintenance phase, it is acknowledged that there is uncertainty regarding whether this impact will occur, and which species will be involved if it does. Given this uncertainty, the MMO queries whether it would be suitably precautionary to increase the impact magnitude above 'negligible'? When considering the risk of this impact, it would be useful to consider the proximity of the infrastructure to other artificial or natural hard habitats in the area in the Cumulative Effects Assessment (CEA). This would indicate the potential for the installed infrastructure to act as stepping stones for the spread of Invasive Non-Native Species (INNS) in the region. Given the high level of uncertainty regarding the potential spread of INNS, the MMO considers it would be appropriate to monitor selected infrastructure for colonisation by INNS, followed by discussions with MMO	The Applicant has reviewed the assessment of INNS in light of MMO comments. Details of mitigation included in the PEMP are outlined in para 264 *et seq*. which the Applicant considers adequate to ensure that the magnitude of any potential impact associated with INNS remains negligible. The Applicant has committed to INNS monitoring in the event that GBS are used.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	regarding the possible application of adaptive management measures if INNS are recorded and action is deemed appropriate.	
Natural England S42 response July 2023	Natural England advise that the existing pressures on the interest features of IDRBNR SAC are likely to be hindering the conservation objectives for the site resulting in an Adverse Effect on Integrity (AEoI) arising. Every effort must therefore be made to mitigate project impacts to not only reduce the Project's alone effects but also ensure that it doesn't materially contribute to existing pressures/cumulative impacts. Otherwise, the site is likely to be taken further away from meeting those conservation objectives, and compensation measures are likely to be required to address the adverse effects. Whilst it is stated that the Outer Dowsing Offshore Wind (ODOW) project's export cable corridor (ECC) would overlap with 0.55% of the site, we draw the Project's attention to the many anthropogenic pressures already occurring within IDRBNR SAC and highlight that more than the extent conservation target will need to be considered within any Report to Inform Appropriate Assessment. We advise that these pressures should be fully considered in the cumulative impacts assessment. Please see Annex A to this document for our advice on small scale losses.	Project mitigation has been developed with measures in relation to benthic habitats detailed in section 9.6.3 and 9.6.4. The Applicant notes that the comment raised here by Natural England appears to be focused on the RIAA, rather than the EIA, and considers that the reference to "cumulative impacts assessment" should be to the "in-combination assessment". Notwithstanding, and in line with the assessment at PEIR, cumulative impacts arising from the Project to the benthic features of the SAC (and other benthic receptors) have been considered as part of the cumulative impact assessment and are presented in section 9.9 below.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
Natural England S42 response July 2023	Natural England has concerns with the available baseline data used to assess the presence and extent of Annex I Biogenic reef within the IDRBNR SAC. We also have concerns with the use of the data sets and the reliance upon additional Annex I pre-construction surveys and as yet undiscussed potential mitigation measures to draw conclusions on the impacts of this project on Annex I reef. We would further note that there is a need have due regard to S. spinulosa reef outside of the designated site under Section 41 of the NERC Act 2006. We advise that the assumptions made by the Applicant to draw the conclusion of No AEoI on Annex I reef features within IDRBNR and negligible impacts in EIA terms are not scientifically robust and require revisiting.	Well established *S. spinulosa* 'reef' is often evident as irregular ridges within geophysical data, whilst low grade *S. spinulosa* within mixed sediment is increasingly difficult to delineate in geophysical data. The Project undertook a high sampling strategy for the baseline characterisation ground-truth campaign. *S. spinulosa* that was found during surveys was low-grade and patchy in nature, supporting the geophysical results. Furthermore, a reanalysis of the geophysical and benthic characterisation data along the offshore ECC has been undertaken by Envision Ltd (document reference 6.9.3.5), with the results of this reanalysis used to inform the assessment. The Project has committed to pre-construction surveys to identify the quality and extent of any *S. spinulosa* reef and enable robust micrositing of infrastructure to occur. Due regard has also been given to *S. spinulosa* reef outside the SAC within the description of baseline environment section 9.5 and within the assessment as relevant, section 9.8.
Natural England S42 response July 2023	In relation to temporary impacts to Annex I sandbanks, Natural England advises that at the time of Application further evidence and commitments to mitigation measures will need to be included to demonstrate that impacts from cable installation have been minimised as much as possible and are temporary i.e., full recovery of the Structure and function of the sandbank feature will occur within appropriate time frames.	A CBRA has been undertaken and used to inform the Outline Cable Specification and Installation Plan (CSIP) (document reference 8.5) submitted alongside the Application. It is noted that there are no expected cable crossings within the SAC. Temporary impacts are discussed in full in section 9.8 Impact Assessment (below). Data from a sediment mobility study (document reference X.X.X), incorporating the geophysical and geotechnical data

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	As with Norfolk Boreas OWF, we advise that a sandwave levelling assessment and more thorough cable burial risk assessment is provided at the time of Application in order to provide the necessary confidence that impacts are temporary, and that recovery will occur in the short term.	collected along the offshore ECC have been used to detail expected sediment movement rates and inform predicted recovery rates for the sandbanks, and are presented within document reference 6.1.7.1.
Natural England S42 response July 2023	Natural England welcomes the inclusion of embedded mitigation but advises that further detail is provided on other mitigation measures that the project will seek to deploy. Examples of mitigation measures applied to offshore wind farm developments to date are presented in Annex B of this document. The project should consider each of the benthic mitigation measures to reduce impacts on MPAs (included in Annex B of this response), which have been applied to offshore wind developments to date.	The Applicant welcomes the advice from Natural England. Project mitigation has been developed with measures in relation to benthic habitats detailed in section 9.6.3 and 9.6.4.
Natural England S42 response July 2023	We welcome the proposal to microsite around potential Annex I habitat, however current proposals do not present enough evidence as to whether this would be achievable. Furthermore, the statement includes caveats of where practicable and where possible which causes concern. Given that the project has considered extension of the IDRBNR SAC in its without prejudice compensation document, the project should give greater consideration to the impacts it may have on suitable features located outside the IDRBNR SAC.	The Applicant has committed to avoid all known *S. spinulosa* reef within the IDRBNR SAC, with this firm commitment possible due to the extensive site investigations and analyses undertaken to inform the DCO application, combined with a consideration of the formation of *S. spinulosa* reef within the SAC from previous surveys. The Project undertook a high sampling strategy for the baseline characterisation ground-truth campaign. *S. spinulosa* that was found during surveys was low-grade and patchy in nature, supporting the geophysical results. Furthermore, a reanalysis of the geophysical and benthic characterisation data along the offshore ECC has been

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	We advise that a stronger commitment to avoid impacting these features where they exist outside of designated sites is required.	undertaken by Envision Ltd (document reference 6.9.3.5), with the results of this reanalysis used to inform the assessment. A pre-construction Annex I habitat survey will be undertaken and will subsequently be used to help inform any micro-siting of windfarm infrastructure as detailed within the In Principle Monitoring Plan (Document Reference 8.3) and Outline Biogenic Reef Mitigation Plan (document reference 8.22).
Natural England S42 response July 2023	We notice that the MMO fisheries closure byelaw areas within IDRBNR SAC have not been included as consideration for the project. These areas have been established to allow for feature recovery within the site and should be avoided. From the data presented it is unclear which of these byelaw areas might be impacted by this development. We advise that fisheries closure byelaw areas are included within the maps to clearly show how the project will avoid them and/or not hinder the habitat restoration purposes of the byelaws. Where the project cannot avoid them, they will need to show how they will mitigate the impact that operations may have on features contained within them or that have developed since the implementation of the closure.	The byelaw areas were considered in ES Chapter 4: Site Selection and Assessment of Alternatives (Document Reference 6.1.4). Whilst the ECC partially overlaps with an area to be managed as reef (as per the JNCC dataset), no construction works will be undertaken within this area (as detailed within the Outline Biogenic Reef Mitigation Plan (document reference 8.22)), thereby avoiding any impacts to the management of that area. Notwithstanding, it is notable that this area was surveyed during the characterisation surveys and no reef was identified.
Natural England S42 response July 2023	Natural England notes that gravity-based foundations have a comparably large seabed footprint to those of other foundations. And have not been used and/or considered necessary for any other English North Sea projects. We suggest that the foundation which would have the next largest footprint is used for the WCS and	The foundation type selected will ultimately be dependent on the final detailed site investigations, engineering design studies and the procurement process. A range of foundation types is being considered, based on the information the Applicant currently has about the prevailing site conditions and key design considerations, and is summarised in ES

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	that the use of GBS is excluded from consideration as an embedded mitigation measure.	Chapter 3: Project Design (document reference 6.1.3). The Project has committed to only 50% of WTG foundations being GBS but is unable to exclude this foundation type fully from the project design.
Natural England S42 response July 2023	The realistic worst-case scenario does not present a worst-case scenario for the scale of impacts that the development will have within the designated sites that it crosses. Natural England would expect further detailed commentary on expected installations operations and footprints of development specific to the designated sites that the ECC crosses in order to evaluate the impacts.	An assessment of direct impacts and indirect impacts (e.g., changes in SSC and sediment deposition) on designated sites, informed by the physical processes modelling presented in Volume 3, Appendix 7.2: Physical Processes Modelling Report (document reference 6.3.7.2), has been undertaken on relevant benthic subtidal and intertidal ecology features within sites that have the potential to be affected by the Project (see section 9.8). The area for cable protection within the SAC has been broken down to enable a full assessment of the impacts on the individual features.
Natural England S42 response July 2023	There is no clear justification of why WCS scenarios have been selected for temporary habitat disturbance both within the Array area and the ECC for construction impacts. Provide rationale as to why installation methods have been selected to represent the WCS.	An assessment of potential impacts associated with temporary habitat disturbance is provided in Para 9.8.1.9 *et seq.* Details of the extent of temporary habitat disturbance are provided in Table 9.10
Natural England S42 response July 2023	We note that whilst quantity of seabed disturbance is covered in Construction: Impact 2, this information alone cannot act as a proxy for contaminated sediment distributions where no information is provided on sediment contaminant concentrations. Natural England advises that data collected during the characterisation surveys of sediment contaminants for	Consideration of contaminants is provided in the assessment Impact 3 – para 164 *et seq*.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	different sediment types should be used to give an indication for the WCS as far as possible.	
Natural England S42 response July 2023	Limited justification for Impact 1 - Operation and Maintenance (O&M) Natural England advises that further clarification on the following points. - What type of Scour prevention and cable protection would represent the worst-case scenario and why. - Where scour protection has been accounted for in the footprint, does this take into account potential secondary scour and the need for further scour prevention? - Does footprint for offshore transformer stations include scour protection (we have previously advised against the use of GBS) - How was the assumption that 25% of all export and inter-array cabling will require cable protection has been calculated. - In a worst-case scenario, what percentage of this cable protection will be deployed within the designated sites and therefore would potentially impact on designated features?	Table 9.10 provides the breakdown of the MDS for the total footprint for permanent seabed impacts, including scour protection. Loose rock would lead to the greatest footprint for scour and cable protection. Scour protection would be designed to avoid further scouring. The cable protection requirements have been updated as part of the design refinement process incorporating the geotechnical data along the ECC and in the array area and the CBRA and sediment mobility studies undertaken. Details of the cable protection requirements within the SAC and particularly over the sandbank features are provided in Table 9.10 and document reference 6.1.3.
Natural England S42 response July 2023	Within the impact assessment and the Maximum Design Scenario (MDS) there is no indication that UXO detonation has been considered as a cause of temporary habitat disturbance during the construction phase. A UXO assessment and plan needs to be produced to establish how UXO impacts to the seabed will be	The Applicant is not looking to consent UXO detonation within the DCO. It is expected that a Marine Licence will be applied for in the post-consent phase. There is insufficient certainty at this stage to undertake a realistic assessment regarding total numbers and crater sizes. Based on data from Triton Knoll, the Project is expecting low density UXO and has

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	managed, both inside and outside of the designated sites.	committed to low order techniques as the primary method for detonation (where required). A qualitative assessment to benthic features has been undertaken within the ES. The Project, where practicable and safe, will detonate UXO outside of the SAC.
Natural England S42 response July 2023	Limited justification for O&M Impact 2 – Temporary Habitat Disturbance. Further explanation of how values of all seabed disturbance have been derived is required.	Further details are provided in Table 9.10.
Natural England S42 response July 2023	We welcome the consideration of measures included as mitigation for the proposed project. However, we do not believe it is sufficiently comprehensive. We advise that the proposed scour prevention management plan and cable specification and installation plan should be included at the time of submission as an outline plan and make specific reference to where the ECC crosses areas identified as designated features from characterisation surveys within MPAs. We also advise that all benthic mitigation measures listed in Annex B are considered in the ES.	An Outline SPCPMP (document reference 8.21) and Outline CSIP (document reference 8.5) have been provided alongside the ES.
Natural England S42 response July 2023	Natural England welcomes the inclusion of the embedded mitigation. However, we note that more specific detail on the sandwave levelling and deposition of dredged material to ensure that it is deposited in a way that doesn't impact on any existing habitat is required.	An Outline CSIP (document reference 8.5) has been provided alongside the ES. Data from a sediment mobility study (document reference X.X.X), incorporating the geophysical and geotechnical data collected along the ECC, has been used to detail expected sediment movement rates and inform predicted recovery rates for the sandbanks, and is presented within document reference 6.1.7.1.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	This should be considered in a Sandwave Levelling Assessment and an Outline Cable Specification and Installation Management plan for both inside and outside of designated site boundaries.	The Project is proposing to licence disposal within the full array area and ECC, however, final disposal locations will be approved by the MMO (in consultation with their advisors) and will be selected to ensure avoidance of impacts to *S. spinulosa* reef.
Natural England S42 response July 2023	Conclusion on the presence of Annex I stony reef within the Array area has used the correct assessment method for ground truthed data. However, whilst we agree with the conclusion that it's unlikely that additional areas of dense hard substrate identified from acoustic data are unlikely to be considered as Annex I reef, extrapolating this conclusion from a lack of representative species at the single site investigated is not appropriate. Natural England advise that be able to conclude that the sites with hard substrate do not constitute Annex I reef/NERC Priority Habitats further ground truthing investigation to confirm the absence of the characteristic species would be required. As this data is unlikely to be available until pre-construction, we query what commitments the Applicant can make now to minimise the impacts should Stony reef be found.	The Applicant is committed to micro-siting infrastructure around Annex I habitat as far as practicable, to avoid direct significant impacts on these sensitive habitats where possible (as detailed within the Outline Biogenic Reef Mitigation Plan (document reference 8.22) and Outline Cable Specification and Installation Plan (document reference 8.5)). A pre-construction Annex I habitat survey will be undertaken and will subsequently be used to help inform any micro-siting of Project infrastructure (see Section 9.6.4 Additional Mitigation), including for the ANS locations, which will be informed following completion of pre-construction surveys and microsited to avoid any potential Annex I habitats.
Natural England S42 response July 2023	EUNIS habitat codes provided in 2022 version only. To ease transition between 2012 and 2022 codes, Natural England requests that, where EUNIS 2022 codes are used, their 2012 equivalent, is also provided in brackets to aid review throughout the document.	The Applicant can confirm that EUNIS 2012 habitat codes have been provided alongside the 2022 codes to aid review.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
Natural England S42 response July 2023	The benthic characterisation surveys were unable to delineate Annex I biogenic reef features from the acquired acoustic data within the array area or within the export cable corridor. Natural England advises that the project needs to be able to draw conclusions on the impacts that it may have on this sensitive habitat and assess whether proposed mitigation measures would be feasible and effective. Information on extent and distribution of this habitat within the project red line boundary and, where applicable, the wider zone of impact is required to inform these assessments.	The Applicant undertook a high sampling strategy for the baseline characterisation ground-truth campaign. *S. spinulosa* that was found during these surveys was low-grade and patchy in nature, supporting the geophysical results. Furthermore, a reanalysis of the geophysical and benthic characterisation data along the offshore ECC has been undertaken by Envision (document reference 6.9.3.5), with the results of this reanalysis having been used to inform the assessment. The Project has committed to pre-construction surveys to identify the quality and extent of *S. spinulosa* and enable robust micrositing of infrastructure to occur. Discussion in relation to *S. spinulosa* recorded during site specific surveys and associated reef features are discussed in paragraph 116 below.
Natural England S42 response July 2023	Natural England is concerned with the proposed method of assessing Sabellaria reef by averaging height and patchiness scores recorded at every data point along each transect. Survey design for ground truthing reef with seabed imagery should target the full extent of identified potential reef including a run-in area where no reef would be observed. Patchiness and elevation values have been averaged across the length of the transect rather than the subsections of the transect where reef has been delineated. This gives the effect of downweighing potential reefiness scores. Reefiness values should be averaged over the segment along the transect where reef has been observed rather	The Applicant notes that *Sabellaria* was only found intermittently along a single camera transect. Single data points showing Low/Medium/High reef structure do not cover sufficient area ($25m^2$) (as per the guidance for defining reef, Gubbay, 2007) to be able to determine the presence of Annex I reef. Excluding these single reef structure data points, there were three sections of the transect where two or more adjacent data points showed Low/Medium/High reef structure. The three segments of Low/Medium/High reef structure were assessed as potentially separate reefs. For this assessment, the same reefiness assessment method has been used as in the technical report and so has not been repeated here. However, this assessment calculates average (mean)

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	than the entire length of the transect which is likely to underrepresent the reef quality. Further methodology on assessing patchiness of biogenic reef is presented in Jenkins et al. (2018) which was referenced by the technical report.	reefiness levels and the corresponding reef 'structure' for each segment, which is then assessed against the estimated area of the patch. It is not possible to accurately assess the areas of the reef from the available geophysical data, so the patch has been assumed to be circular with the diameter of the circle taken, on a precautionary basis, to be the straight-line distance between adjacent non-reef data points either side of the potential reef segment. This 'circular' patch assessment method has been used by Benthic Solutions Limited., for a number of *Sabellaria* and stony reef assessments over the past decade with no negative feedback from clients, regulators or SNCBs. The results of this analysis show that two of the patches would achieve overall reefiness levels (incorporating patchiness, elevation and area measures) of 'Not a Reef'. The third patch would be classified as 'Low Reef', for which strong justification would be needed for this to be considered Annex I reef. The Jenkins *et al*. (2018) paper includes some useful guidance for commercial pre-development surveys, specifically the combination of *Sabellaria* patchiness and tube elevation to calculate *Sabellaria* reef structure, which was taken from a method developed in 2010 by Benthic Solutions Limited., staff in conjunction with the JNCC. Splitting of footage into segments to provide more quantitative data is a good idea but, in reality, this method is still subjective as it requires the reviewer to assign a single reefiness level to a generally variable length of seabed; for this reason, Benthic Solutions Limited instead assess reefiness from still photographs or

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		video snapshots which can be classified in a non-subjective, quantitative manner. However, calculation of 'true patchiness' is complicated, particularly with regard to permutation and significance assessment of 'true patchiness' data. This measure, while interesting and of direct relevance to MPA condition monitoring (having been initially developed for this purpose), has no relevance to standard commercial habitat assessment surveys as it is not utilised in the assessment of 'reefiness'. Note: Benthic Solutions Limited discussed the above concerns with Joey O'Connor at the JNCC (co-author of the Jenkins paper) over email in 2020 and no disagreement to the above concerns were raised. A reanalysis of the geophysical and benthic characterisation data along the offshore ECC has also been undertaken by Envision Ltd (document reference 6.9.3.5), with the results of this reanalysis having been used to inform the assessment.
Natural England S42 response July 2023	Natural England are concerned with the statement the lack of unique SSS/MBES features associated with the *S. spinulosa* aggregations made it impossible to delineate the extent of the *Sabellaria* habitat within the ECC area. Ground truthing alone is not a sufficient method of understanding reef extent. To mitigate the risk to the Annex I biogenic reef from the project, particularly within the IDRBNR SAC, a thorough understanding of the extent of reef which may be impacted is required before any conclusions can be drawn and/or ensure mitigation measures such as	The Applicant found that the geophysical data have shown that well established 'reef' is often evident as irregular ridges within the data. It was found that low grade *S. spinulosa* within mixed sediment is increasingly difficult to delineate within this data. The Applicant undertook a high sampling strategy for the baseline characterisation ground-truth campaign. *S. spinulosa* that was found during these surveys was low-grade and patchy in nature, supporting the geophysical results. Furthermore, a reanalysis of the geophysical and benthic characterisation data along the offshore ECC has been undertaken by Envision Ltd (document reference 6.9.3.5),

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	micro-siting will be effective in avoiding impacts to Annex I reef.	with the results of this reanalysis used to inform the assessment. The Applicant is committed to micro-siting infrastructure around Annex I habitat as far as practicable, to avoid where possible direct significant impacts on these sensitive habitats. A pre-construction Annex I habitat survey will be undertaken and will subsequently be used to help inform any micro-siting of windfarm infrastructure (see Section 9.6.4 Additional Mitigation).
Natural England S42 response July 2023	No detail has been provided on how tube height for Annex I reef has been estimated. Given that seabed imagery was acquired with a top-down camera, understanding how tube height has been consistently estimated is vital to understanding the final reef classification scores. Provide details on how reef height was estimated.	The Applicant can confirm that the assessment of tube height is based on expert judgement. While the photographs are 'top-down', they are taken at an oblique camera angle, rather than plan view, which provide improved depth perception. The photographs are reviewed in conjunction with available SD and HD video footage, which further supports accurate assessment of tube heights on the stills. Assessment of scale is informed by a combination of the laser scale dots and reference to nearby visible fauna of a predictable size range (see Appendix 9.1: Benthic Ecology Technical Report (Array) (Document Reference 6.3.9.1); Appendix 9.2: Benthic Ecology Technical Report (ECC) (Document Reference 6.3.9.2).
Natural England S42 response July 2023	We have concerns about the impacts to herring spawning and favourable grounds for sand eel habitat primarily as a prey source for designated features of the Greater Wash SPA, Flamborough and Filey Coast SPA and the Southern North Sea SAC. However, we defer our response on impacts on fish populations and habitat to the technical expertise of CEFAS at this stage. We may	This is noted by the Project. Responses to comments received from Cefas via the MMO regarding fish and shellfish are provided in document reference 6.1.10.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	provide further response on this matter once we have reviewed the outcomes of the Section 42 consultation. No Action.	
Natural England S42 response July 2023	We notice that MMO fishery byelaws have not been presented as a consideration within the PEIR. Please note that these areas are closed to benthic trawling and therefore potentially present areas where a designated feature might be present. The project will need to demonstrate that, where ECC transects fisheries closure areas that habitat feature restoration will not be hindered by cable installation, noting that there is an expectation that the extent of Annex I reef will increase as a result of the byelaw.	Whilst the ECC partially overlaps with an area to be managed as reef (as per the JNCC dataset), no construction works will be undertaken within this area (as detailed within the Outline Biogenic Reef Mitigation Plan (document reference 8.22)), thereby avoiding any impacts to the management of that area. Notwithstanding, it is notable that this area was surveyed during the characterisation surveys and no reef was identified. A pre-construction Annex I habitat survey will be undertaken and will subsequently be used to help inform any micro-siting of windfarm infrastructure (see Section 9.6.4 Additional Mitigation).
Natural England S42 response July 2023	The use of the term sub tidal benthic ecology as an impact receptor to draw conclusions on for EIA assessment's is too broad. The Applicant should be clear the as to which specific habitat receptors are relevant to the conclusions it is making on the impacts of the project. (See Para. 9.7.31 for an example).	References to subtidal benthic ecology as an impact receptor have been updated to state the relevant habitat receptors.
Natural England S42 response July 2023	Operation and Maintenance Impact 2 – Permanent habitat loss/change We advise that this impact should be described as 'lasting' habitat loss/change (acknowledging the need to	This is noted by the Project and the terminology has been amended to 'permanent' where infrastructure may remain after decommissioning (subject to agreements at that stage) or 'long-term' where infrastructure will be removed at the end of the lifetime of the Project.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	remove infrastructure at decommissioning) as it has been referred to in Para 9.7.79.	
Natural England S42 response July 2023	Natural England notes that importance of the ecological feature is included as a factor for assessing sensitivity. However, it is not clear from Table 9.13 how ecological importance for each receptor is being considered within the matrix. Natural England advises that how receptor importance is defined and incorporated into assessing sensitivity is included within Table 9.13. Please also see more general point on value and evidence-based judgements for assessing impacts in the cover letter.	This is fully outlined in Table 9.13
Natural England S42 response July 2023	Natural England welcomes the provision to return material dredged from within the SAC back within the site. However, we would like to note that this will need to be done carefully to avoid impacting Annex I biogenic reef habitat. The deposition site should be located in an area of similar particle size and upstream of the original deposition site at a time with suitable hydrological conditions to ensure that deposited sediment falls at least 50m from Annex I biogenic reef features. This should be considered in an Outline Cable Specification and Installation Management plan for inside and outside of designated sites and a Sandwave Levelling Assessment.	This is noted by the Project and has been considered within the Outline CSIP (document reference 8.5). The final location will be determined in consultation with the MMO and Natural England post-consent and will be informed by further site specific surveys and studies, including the sediment mobility study and relevant updates to that document as further site specific data becomes available.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
Natural England S42 response July 2023	We note that the most recent assessment of condition for the designated features has not been incorporated into the assessment. As a minimum we advise that inclusion of latest feature condition (2019) for the designated features as well as that included in the updated Conservation Advice Package (May 2023)	Conditions assessment and the conservation advice package are referred to in para 126.
Natural England S42 response July 2023	It is unclear how the impacts of temporary disturbance associated with construction activity on Annex I sandbanks feature within the IDRBNR SAC and the Greater Wash SPA have been assessed. Is this included within the impacts on subtidal benthic ecology? If so, this approach is not appropriate and the impact of temporary habitat disturbance on this feature should be covered separately.	The features of the SPA and SAC are appraised for sensitivity and magnitude in relation to temporary habitat disturbance within section 9.8.
Natural England S42 response July 2023	Please see our general comment on the adoption of what the project is calling a precautionary approach. We advise that, in this instance, a precautionary approach is required due to not being able to delineate extent of reef within the PEIR boundary. To mitigate the risk to Biogenic reef from the project, particularly within the IDRBNR SAC, a thorough understanding of the extent of reef which may be impacted is required before any conclusions can be drawn and/or ensure mitigation measures such as micro-siting will be effective in avoiding impacts to Annex I reef.	The Project found that the geophysical data have shown that well established 'reef' is often evident as irregular ridges within the data. It was found that low grade *S. spinulosa* within mixed sediment is increasingly difficult to delineate within this data. The Project undertook a high sampling strategy for the baseline characterisation ground-truth campaign. *S. spinulosa* that was found during these surveys was low-grade and patchy in nature, supporting the geophysical results. Furthermore, a reanalysis of the geophysical and benthic characterisation data along the offshore ECC has been undertaken by Envision Ltd. (document reference 6.9.3.5),

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		with the results of this reanalysis used to inform the assessment. The Project confirm they have committed to pre-construction surveys to identify the quality and extent of *S. spinulosa* and enable robust micrositing of infrastructure to occur.
Natural England S42 response July 2023	Medium Sensitivity and Medium magnitude should be considered as Moderate Adverse and Significant in EIA terms rather than Minor. Given that the conclusion drawn that impact of smothering on the Annex I biogenic reef features is significant in EIA terms. We advise that further information is provided by the project on how the impact will be reduced. Please amend and clarify	This is noted by the Project and the impact assessment has been revised based on the refined project parameters.
Natural England S42 response July 2023	Natural England does not consider the potential shift in baseline conditions with the result of increasing biodiversity through the introduction of hard substrates to be a beneficial effect where species colonising hard substrates have different functions to the sediment dwelling species being displaced. Amend statement	This is noted and acknowledged within Section 9.7 when considering the impacts of colonisation of WTGs.
Natural England S42 response July 2023	The report details the % of the ECC that traverses the designated sites but this is not broken down into habitat/feature. Please update accordingly.	A breakdown of the overlap with different features of the site is provided in Section Table 9.9.
Natural England S42 response July 2023	As per the EIA assessment methodology, the designation (i.e., the importance of the habitat) should not change the magnitude of the impact but rather the sensitivity.	The Project has assessed sensitivity and magnitude in line with the criteria presented within Section 9.7.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	Natural England would also disagree with the assessment that the magnitude of the impact of permanent loss of habitat on the benthic features is low based on the EIA assessment criteria presented. We advise that this impact is reassessed with sensitivity/importance included after our comments on the EIA assessment methodology have also been addressed. We would further advise that the IDRBNR SAC is of high importance. We advise against the placement of external cable protection within the site. Any Rock protection within the SAC is likely to hinder the conservation objectives. We draw the applicants attention to the recent Hornsea Project 3, Norfolk Vanguard and Norfolk Boreas decisions and our generic position on cable protection submitted to the Norfolk Boreas Project. Appendix 2.5 of PINS – Natural England's Relevant Representations to the Norfolk Boreas Project.	In the 'Minor' magnitude category it also states 'and/or limited but discernible alteration to key characteristics or features of the particular receptors character or distinctiveness'. For example, whilst permanent habitat loss from cable protection is regarded long-term/permanent, in relation to the availability of broadscale habitats the impact magnitude is regarded as non-material or *de minimis* and therefore should not be classified as a major/moderate impact on account of the limited alteration. Sensitive features of the IDRBNR SAC have additional mitigation applied to reduce the magnitude of the impact (See Table 9.12 and Annex A). On this basis the Applicant does not propose to update the magnitudes presented within the ES.
Natural England S42 response July 2023	The project has assigned differing sensitivities to Annex I Sandbank features located outside and inside the IDRBNR SAC based purely on the conservation status of the features when located within the site. However, the project has also proposed, in its without prejudice benthic compensation document, that a suitable compensation measure would be to extend the IDRBNR SAC to cover areas of yet unprotected Annex I Sandbank habitat.	This is noted by the Project, however the project does not consider that these statements conflict as the assessment has taken into consideration currently designated site features. Were the sandbanks outside the SAC to be designated, they would be considered appropriately at that stage by other relevant projects; however, the decision to designate the sandbanks would in part consider the status of the sandbanks at the time of designation and if/how they will contribute to the National Site Network. It is also important to note that the possible extension areas identified within the 'Without

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	We advise that these two statements are in conflict. If there is any potential that the project is to utilise this method of compensation. Sandbanks outside of the SAC, which may be included in any future extension, should be treated in the same way as those currently inside it.	Prejudice Benthic Compensation Plan' (document reference 7.6) sit outside the Project order limits and therefore are not assessed or assigned a sensitivity within the assessment.
Natural England S42 response July 2023	Our comment above on the impact of cable protection in the IDRBNR SAC also applies to the impact of cable protection on the supporting habitats of the Greater Wash SAC. Please see comment above and address this paragraph appropriately.	The supporting habitats of the Greater Wash SPA have been assessed within the Section 9.8. Sandbanks of the IDRBNR SAC are the same as those protected within the Greater Wash SPA where they overlap with the offshore ECC and are therefore given additional consideration and mitigation as detailed within Table 9.12 and Annex A.
Natural England S42 response July 2023	We welcome the Project's commitment to ensuring no permanent habitat loss within the intertidal area of the offshore ECC. We would also welcome a commitment to extend this commitment in subtidal areas where long-shore sediment transport is known to occur Please undertake an assessment to support any additional commitments	The Project has committed to a sub-tidal punch out for the HDD at landfall, with the exit pits designed to a target of 500m below MLWS. Cable protection requirements close to shore will be designed to minimise changes to sediment transport pathways where practicable.
Natural England S42 response July 2023	We note that this paragraph states that a limited number of repair activities will occur within any one year. Natural England advises that anticipated numbers based upon current repair requirements for existing projects in similar environmental conditions should be added here, particularly with reference to activities occurring within designated sites along the ECC.	Information added to Table 9.10.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
Natural England S42 response July 2023	We note that whilst the project has included a rationale for why impacts have been ruled out for assessment as a cumulative impact, it is unclear which project impacts have been ruled out for which reasons. Include a justification of each impact pathway which has been screened out as per best practice guidance. There is also a requirement to review those impacts which have been screened out based for cumulative impacts based upon the advice presented to this consultation.	This has been noted by the Project and the cumulative assessment has been revisited, including the justifications for ruling out impacts from consideration in the cumulative assessment.
Evidence Plan Meeting ETG September 2023	Natural England raised that UXO detonation should be considered with the assessment. SEP and DEP provided an assessment of potential seabed disturbance impacts from UXO clearance within Cromer MCZ. We advise a similar document is also included within the ODOW application.	As detailed above, the Applicant is not looking to consent UXO detonation within the DCO. It is expected that a Marine Licence will be applied for in the post-consent phase. There is insufficient certainty at this stage to undertake a realistic assessment regarding total numbers and crater sizes. Based on data from Triton Knoll, the Project is expecting low density UXO and has committed to low order techniques as the primary method for detonation (where required). A qualitative assessment to benthic features has been undertaken within this chapter. The Project, where practicable and safe, will detonate UXO outside of the SAC.
Evidence Plan Meeting ETG September 2023	Natural England require the locations of reef extent to be able to ensure that the proposed micro siting mitigation measures are viable in the specific locations.	As detailed within Section 9.5.2.15 the geophysical and benthic characterisation data along the offshore ECC has been undertaken by Envision Ltd. (document reference 6.9.3.5), which concluded that no *S. spinulosa* reef was located within the Project Order Limits. However, due to the ephemeral nature of this species the Applicant has committed to pre-construction surveys to assess for Annex I biogenic reef, which if encountered at this stage would

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
		enable robust micrositing of infrastructure to occur, as detailed within the In Principle Monitoring Plan (Document Reference 8.3).
Evidence Plan Meeting ETG September 2023	Natural England raised the point on the summarisation of impacts where specific receptors are aggregated. Natural England advise that the project should check the summary of all impacts to ensure that it is clear which habitats they are stating the impact for when aggregating receptors	Where there is a benefit to the assessment relevant receptors have been split out, specifically with regard to the features of designated sites which overlap with the Project Order limits.

9.5 Baseline Environment

9.5.1 Benthic Subtidal and Intertidal Study Area

12. For the purposes of this report, the benthic subtidal and intertidal study areas (Volume 2, Figure 9.1) have been defined by the following:
    - The Order Limits are defined as the array area, along the offshore ECC to landfall at Wolla Bank on the Lincolnshire coast. The Order Limits also comprise the areas for the provision of the ANSs and for the creation of biogenic reef.
    - The benthic subtidal ecology study area is defined by a buffer of approximately 10km at landfall to 15km from the offshore ECC and 12km from the array, to represent the tidal ellipse distance, in order to incorporate the maximum distance sediments may travel in one tidal cycle (document reference 6.3.7.2). This study area is also referred to as the potential secondary Zone of Influence (ZoI) as this will be the area that will be potentially impacted by increases in SSC and deposition as a result of the development.
    - The benthic intertidal ecology study area is defined by the intertidal habitats up to the MHWS mark within the Order Limits.
13. Habitats landward of MLWS have been considered in the onshore ecology assessments (Chapter 21: Onshore Ecology (Document Reference 6.1.21) and Chapter 22 Onshore Ornithology (6.1.22).
14. The study area for the Cumulative Effects Assessment (CEA) is defined by the wider (up to) 15km buffer surrounding the Order Limits, to incorporate the maximum distance suspended sediments will travel in one tidal cycle and therefore the indirect impacts on benthic subtidal ecology arising from the Project that could interact cumulatively with impacts from other plans or projects.

9.5.2 Compensation Areas

15. Areas for potential compensation measures associated with the Project have been provided in section 9.5.2.14, with the baseline conditions in these areas detailed in this Section and the compensation areas assessed in Section 9.8 of this chapter.

9.5.2.9 Data Sources

16. Information on the benthic and intertidal communities within the Project benthic ecology study area was collected through a detailed desktop review of existing literature and data sources, and site-specific surveys. These have provided coverage across the Project benthic subtidal and intertidal ecology study area and wider region (Table 9.3 and Volume 2, Figure 9.2).
17. Site-specific surveys for the Project were undertaken to provide an up-to-date characterisation of the habitats and species occurring within the Order Limits. The subtidal surveys were conducted between 3 and 13 April 2022 (array area) and 17 and 26 July 2022 (ECC) by Benthic Solutions Limited (a marine environmental consultancy and survey company, who offer a range of capabilities in survey, analysis, interpretation and project management for the marine sector) and were conducted in accordance with the Joint Nature Conservation Committee (JNCC) marine monitoring handbook, relevant procedural guidelines and side scan sonar (SSS)/Multi-beam system (MBES) data review (Bullimore and Hiscock, 2001; Davies *et al.*, 2001; Hitchin *et al.*, 2015; Holt and Sanderson, 2001; Munro, 2001; OGUK, 2019) (Table 9.3). On 11 October 2022, APEM Limited carried out the intertidal survey that was primarily focused on Phase I intertidal biotope mapping while taking into account best practise recommendations (Davies *et al.*, 2001; Wyn *et al.*, 2006; JNCC, 2010; Saunders *et al.*, 2011; Noble-James *et al.*, 2018 and Natural Resources Wales, 2019) (Table 9.3).
18. A full description of the site-specific survey methodologies and sample analysis is presented within Volume 2, Appendix: 9.1: Benthic Ecology Technical Report (Array), Appendix 9.2: Benthic Ecology Technical Report (ECC) and Appendix 9.3: Intertidal Technical Report. Table 9.3 present details of the site-specific survey data collected.

Table 9.3: Key sources of information for benthic subtidal and intertidal ecology for the Project

Source	Summary	Spatial coverage of data in relation to the benthic and intertidal study area
Site-specific survey Data		
Project-specific geophysical, benthic and oceanographic survey data. Volume 52, Appendix 9.1: Benthic Ecology Technical Report (Array) based on Benthic Ecology OWF Area Results Report (Vol. 1) (GEOxyz, 2022a) Part 6, Volume 2, Appendix 9.2: Benthic Ecology Technical Report (ECC) based on Benthic Ecology ECC Area Results Report (Vol. 2) (GEOxyz, 2022b)	Geophysical survey using echo sounder MBES, SSS, sub-bottom profiler (SBP), magnetometry and ultra-high resolution seismic (UHRS). Benthic sediment grab samples were collected with 0.1m^2 Hamon grab at locations within the array (71 stations) areas and offshore ECC (59 stations). All benthic grab samples were subject to infaunal species analysis and Particle Size Analysis (PSA) as well as chemical contaminants analysis at 30 stations and video footage at 33 stations. Seven beam trawl transects underwent macroinvertebrate analysis.	Full coverage within the Array and Export Cable Corridor Order Limits. Partial coverage of biogenic reef creation areas.

Source	Summary	Spatial coverage of data in relation to the benthic and intertidal study area
Part 6, Volume 2, Appendix 9.3: Intertidal Technical Report based on Outer Dowsing Offshore Wind Project – Phase I Intertidal Survey (APEM, 2022).	Intertidal Phase I walkover survey carried out landward to mean low water springs (MLWS) to determine the intertidal biotope composition, distribution, extent of sub-features. Within each distinct soft sediment habitat, *in situ* sampling was carried out by digging a 20 x 20cm area to a depth of 10cm and sieving to look for characterising species and 1.0mm mesh sieve was used for subsequent sampling.	
Site-specific eDNA Survey. Benthic Ecology OWF & ECC Area eDNA Report (Vol. 7) (GEOxyz, 2022c)	A programme of water and sediment sampling was undertaken for environmental DNA analysis with the aim of ground-truthing the variation in seabed sediments and associated biota across the survey area. Benthic sediment grab samples were collected with a 0.1m^2 Shipek grab at locations within the offshore ECC (three stations) and array area (16 stations).	Representative coverage within the Array and Export Cable Corridor Order Limits. Partial coverage of biogenic reef creation areas.
S. spinulosa review (Envision, 2024; document reference 9.3.3)	*S. spinulosa* review with the principal objectives of identification and evaluation of *S. spinulosa* reefs within the offshore ECC, using project specific and third-party data sources (which included geophysical, benthic sample, and regional seabed monitoring data). The methodological framework integrates geophysical data with benthic sample data through geospatial statistical analyses. Seabed characteristics such as rugosity, backscatter variability, and bathymetry are used to predict the distribution of seabed habitats. The study also reviewed *S. spinulosa* distribution, abundance, and reef suitability, considering data from the JNCC and habitat suitability modelling.	Full coverage within the Export Cable Corridor Order Limits. Partial coverage of biogenic reef creation areas.
Existing Project Data		

Source	Summary	Spatial coverage of data in relation to the benthic and intertidal study area
Lynn and Inner Dowsing OWFs (Various datasets) including: Pre-construction characterisation surveys (AMEC, 2002); *S. spinulosa* mapping survey (Envision, 2004) Lynn and Inner Dowsing Geophysical and Biological Survey report (EGS (International Ltd, 2010) Post-construction monitoring survey reports (EGS, 2010; 2011; RPS, 2014)	Site-specific surveys carried out to characterise the benthic environment and inform EIA on OWF projects.	Coverage of representative habitats relevant to the inshore area of the offshore ECC and wider subtidal ecology study area.
Lincs OWF Benthic Baseline Survey Report (EMU. 2005) and Lincs OWF Post Construction Hydrographic, Geophysical and Benthic Survey (EGS International, 2015).	Baseline surveys carried out to characterise the benthic environment and inform EIA on OWF projects.	Coverage of representative habitats relevant to landfall and the inshore area of the subtidal ecology study area.
Triton Knoll Electrical Systems Benthic Ecology – Subtidal Ecology Technical Report (RWE, 2015), 2008 – 2011.	This report collates data from benthic site-specific grab, DDV and geophysical surveys.	Coverage of the offshore ECC and inshore area of the wider subtidal ecology study area. Partial coverage of biogenic reef creation areas.
Triton Knoll Offshore Wind Farm Project (Various datasets) including: Pre-Construction Benthic and Geophysical Baseline Report (Triton Knoll OWF Limited, 2019); and Post Cable Installation Monitoring Survey 2021 (Precision Marine Survey Ltd, 2021).	These reports collate data from benthic site-specific grab, DDV and geophysical surveys.	Coverage of the offshore ECC and inshore area of the wider subtidal ecology study area. Partial coverage of biogenic reef creation areas.
Race Bank Offshore Wind Farm, Environmental	Chapter 6 Biological environment collates information from the benthic grab, DDV and epifaunal beam trawling.	Coverage of the offshore ECC and wider subtidal ecology study area.

Source	Summary	Spatial coverage of data in relation to the benthic and intertidal study area
Statement (Centrica Energy, 2009)		Partial coverage of biogenic reef creation areas.
Humber Gateway datasets and studies including: Baseline study of marine ecology (ICES, 2005); Benthic monitoring programme (PMSL, 2010; 2012; 2013)	Survey data taken from subtidal and intertidal macrofaunal sampling and sediment analysis.	Provides data relevant to the inshore area of part of the wider subtidal ecology study area.
Hornsea Project One Array Survey (2010 – 2011)	DDV and grab sampling for the Hornsea One project. Epibenthic beam trawling was also carried out.	Coverage of the wider geographic region and the data will therefore be used to inform the wider regional baseline characterisation.
Hornsea Project One Offshore Wind Farm – Year 2 Post Construction Controlled Flow Excavation Monitoring Report (Orsted, 2020)	MBES and DDV transects along the Hornsea One export cable route.	Coverage of the wider geographic region and the data will therefore be used to inform the wider regional baseline characterisation.
Hornsea Project Two array Survey (2012)	DDV and grab sampling for the Hornsea Two project. Epibenthic beam trawling was also carried out in some zones.	Coverage of the wider geographic region and the data will therefore be used to inform the wider regional baseline characterisation.
Dogger Bank Creyke Beck A and B Environmental Statement (Forewind, 2013)	Benthic grab samples and DDV characterised Array area and cable route.	Provides data relevant to the inshore area of part of the offshore ECC.
Westermost Rough Pre-construction environmental monitoring survey reports (Westermost Rough Ltd, 2014)	Benthic grab samples and DDV characterised Array area, ECC and control sites around the Westermost Rough OWF.	Coverage of the wider subtidal ecology study area.
Hornsea Project Three OWF Benthic Ecology Technical Report (Orsted, 2018)	This technical report provides analysis of site-specific sampling data collected across the wider geographic region and has been drawn upon for this chapter.	Coverage of the wider geographic region and the data will therefore be used to inform the wider regional baseline characterisation.

Source	Summary	Spatial coverage of data in relation to the benthic and intertidal study area
Hornsea Project Four OWF Benthic Ecology Technical Report (Orsted, 2020).	This technical report details analysis of data collected throughout the wider geographic region and subtidal ecology study area.	Coverage of the wider geographic region and subtidal ecology study area.
Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects including: Dudgeon Extension Project (DEP) Benthic Characterisation Report (Fugro, 2020a); Sheringham Extension Project (SEP) Benthic Characterisation Report (Fugro, 2020b).	The technical reports provide analysis of site-specific DDV and grab sampling data collected throughout the wider geographic region.	Coverage of the wider geographic region and subtidal ecology study area.
Literature		
Humber Regional Environmental Characterisation (REC) (Tappin *et al*., 2012).	This study was a regional characterisation of the wider Humber area to support an aggregate dredging licensing process and included data from DDV, epifaunal beam trawls, and faunal and sediment grab samples.	Provides coverage of the offshore ECC and wider subtidal ecology study area, including the compensation areas.
Publicly Available Datasets		
EMODnet (2022) broad scale seabed habitat map for Europe.	EUNIS Level 4 model, detailing biological zone and substrate.	Complete modelled coverage for the array area, ECC and compensation areas up to MHWS.
Information on species of conservation interest (JNCC, 2007)	Species specific data, of native species of conservation interest	This data source provides species specific data of native species of conservation interest.
Cefas OneBenthic Baseline Tool (OneBenthic database, 2020)	OneBenthic brings together disparate benthic datasets from grab/core, trawl and imagery surveys in a cloud-based platform[1].	Provides partial coverage of the benthic subtidal and intertidal ecology study area, including the array area, ECC and compensation areas.
Planning Offshore Wind Strategic Environmental	Strategic environmental baseline data and spatial models for key benthic	Provides partial coverage of the benthic subtidal

[1] One Benthic - Cefas

Source	Summary	Spatial coverage of data in relation to the benthic and intertidal study area
Impact Decisions (POSEIDON) Project	species and the habitats most vulnerable to offshore wind impact. The project outputs will help guide future offshore wind development rounds and feed into wider marine planning and can be applied to the Project. Data from the POSIEDON Project have been acquired and added from the OneBenthic portal.	and intertidal ecology study area, including the array area, ECC and compensation areas.

9.5.2.10 Existing Environment

19. The following sections provide the broad regional characterisation of the benthic subtidal and intertidal ecology study area before focussing on the site-specific data within the offshore components of the development boundary. The Order Limits and wider subtidal ecology study area effectively characterise the predicted zone of potential primary (direct) and secondary (indirect) impacts of the development on benthic receptors respectively (see Volume 2, Figure 9.1). The regional characterisation presented within each section provides an adequate description of the ANS and biogenic reef creation areas for the purposes of informing the assessments here. Where further site specific data is available for these areas, they are discussed in the relevant sections below. Detailed baseline descriptions, univariate and multivariate analyses are presented within the technical appendices that accompany this Chapter, including spatial representations and figures. The following section provides a summary of the detail within those reports and therefore must be read in conjunction with the following:

    - Volume 3, Appendix 9.1: Benthic Ecology Technical Report (Array) (document reference 6.3.9.1);
    - Volume 3, Appendix 9.2: Benthic Ecology Technical Report (ECC) (document reference 6.3.9.2); and
    - Volume 3, Appendix 9.3: Intertidal Technical Report (document reference 6.3.9.3).

9.5.2.11 Bathymetry Seabed Features

Regional Context

20. Water depths within the wider southern North Sea (Humber region) are mainly shallow and, apart from the major deeps and sand banks, increase eastward from the coast across a gentle regional gradient. The seabed is gently undulating but superimposed upon the regional gradient, there is a prominent localised, relief formed by a number of large-scale features that include deeps and sediment banks. Most prominent are the major deeps of Sand Hole, Silver Pit, Sole Pit, Coal Pit, Well Hole and its southern extensions, and Markham's Hole. These deeps form elongate, linear and curvilinear submarine valleys, with the base of the Silver Pit up to 80m below the surrounding seabed (Tappin *et al*., 2012).
21. Sediment banks across the region are oriented in a generally northwest to southeast direction. In the southeast they form the northwest terminations of the Norfolk Banks with a relief of up to 20m. Banks also lie between the Silver and Sole pits, again showing a dominant northwest to southeast orientation. In the southwest of the area there are a series of sinuous, 'zigzag' shaped banks e.g., Race Bank, again orientated roughly northwest to southeast (Tappin *et al., 2012).*

22. Smaller-scale seabed features include sand waves of various sizes. These are mainly located to the east of the Silver Pit, with orientations orthogonal to the banks, generally between northeast to southwest and east-west. The seabed to the west of the Silver Pit is mainly planar and undulating with areas of low amplitude sediment waves up to one metre in height. Offshore, and south of Flamborough Head irregular, but generally linear, seabed prominences up to 5m high lie parallel to the coast (Tappin *et al*., 2012).

Array area

23. The array area is bound to the eastern edge by Sole Pit, and on the western boundary by the Outer Dowsing Channel. Water depths in the array area range from 6.1m to 45m, with over 90% between 15m and 25m (Lowest Astronomical Tide (LAT) (Volume 2, Figure 9.1). Several non-designated sandbanks are located in the north of the array, with heights from seabed of between 10 and 12m, as well as areas of northwest-facing sand waves with wave heights generally between 2 and 3m, although these reach up to 8m (Volume 2, Figure 9.1) (Enviros, 2022). In addition, two deeps known as the Dowsing Deeps are located in the centre of the array area, reaching a maximum depth of 45m (LAT) (Cathie, 2021).
24. Regional-scale assessments identify a net north-westerly direction of bedload transport for the Array area (Kenyon and Cooper, 2005). Suspended sediment in the region is mainly sourced from the eroding Holderness cliffs, which consist of 67% mud (Tappin *et al*., 2011). As a result of distance from these terrestrial sources, combined with a generally low fine seabed sediment signature, low surface concentrations of up to 5mg/l were recorded between the period 1998 to 2015 (Cefas, 2016) within the Array area. Higher values will occur during spring tides and storm conditions, with the greatest concentrations encountered close to the bed.

Offshore Export Cable Corridor

25. In the eastern part of the ECC, water depths range generally between 10 to 30m (LAT) (Volume 2, Figure 9.1), with the lowest depths corresponding to the Outer Dowsing Shoal, a shallow water bank with associated gravel and sand deposits (Museum of London Archaeology, 2010). The ECC then crosses through an area of relatively flat seabed with depth of 20 to 25m (LAT), before crossing the Triton Knoll and Dudgeon Shoal sandbanks, which at their highest point have water depths of around 10m (LAT). South of the Inner Silver Pit, water depths generally range between 10 and 30m (LAT) within the glacial outwash feature, described further in a subsequent section (Volume 2, Figure 9.1). From around 12km offshore, water depths typically shallow uniformly from around 14m towards the coast (EMODnet, 2022).
26. Bedload sediment transport in the most offshore part of the offshore ECC is directed towards the northwest. Localised changes to the broad scale sediment transport paths occur where the flow is diverted, such as around the Triton Knoll and Inner Dowsing sandbanks (TKOWFL, 2014). The ECC crosses a bedload parting approximately 35km offshore, with bedload transport directed to the south. Further inshore, there is a dominant southwards bedload sediment transport direction pathway, with an inshore direction into the Wash.

27. The Race Bank – North Ridge – Dudgeon Shoal and Inner Dowsing Annex I sandbank systems are located across the western half of the offshore ECC. Sediment transport modelling undertaken as part of the Race Bank OWF ES illustrated predominantly north-westerly sediment transport pathways across the majority of the site in question (Centrica, 2008). The Inner Dowsing sandbank is considered to be a relict feature, although it has experienced some changes in crest level, and is maintained by tidal currents (Centrica, 2007; JNCC, 2010).
28. Inner Silver Pit, located landward of the array area and on the northern boundary of the offshore ECC is an elongated, over-deepened and enclosed paleo-valley partly filled with unconsolidated sediments. This bathymetric depression is approximately 38km long, 2.5km wide and 100m deep, with changes in water depth in excess of 60m over 0.5km (Tappin *et al*., 2011). The depth of this feature enables tidal currents to erode sediments that are deposited within it, meaning there is little to no sediment accumulation (Proctor *et al*., 2001). This mechanism is enhanced by wave activity, particularly storm events, which can mobilise sediments throughout most of the deepest parts of the valley (TKOWFL, 2011).
29. Suspended Particulate Matter (SPM) levels within the nearshore zone of the offshore ECC are directly under the influence of terrestrial sources from the Humber Estuary and Holderness Cliffs, such that concentrations reach around 60mg/l, between the period 1998 to 2015 (Cefas, 2016). Maximum values coincide with the winter months when a greater frequency of storm events and fluvial inputs (including storm runoff) can be expected to occur.

Intertidal

30. The Lincolnshire coast is typically characterised by beaches with medium sands which grade into more varied sands, gravelly sands and mixed sediments further offshore. The intertidal area is varied with extensive beaches to the north of Mablethorpe. Between Mablethorpe and Chapel St Leonards beaches are typically narrower and often exhibit quite steeply shelving profiles (TKOWL, 2014). The coastal frontage at the proposed landfall site is characterised by the presence of a sandy beach backed by vegetated sand dunes (HADA, 2012).
31. Littoral transport diverges along the Lincolnshire coastline such that sediment is transported towards the mouth of the Wash and the Humber Estuary, with a southward transport direction at the landfall site.
32. Large parts of the Lincolnshire coast are subject to sediment recharge as part of flood defence schemes, including the area surrounding the proposed landfall location (Environment Agency, 2021).

9.5.2.12 Sediment Characteristics

Regional Context

33. The seabed sediments that characterise the benthic subtidal and intertidal ecology study area are typical of the southern North Sea, where large areas of similar well-sorted medium or fine sands were recorded offshore (Tappin *et al*., 2011; OneBenthic database, 2020). Nearshore reports of a heterogeneous distribution of sediments ranging from sand and mixed sediments to muddy sandy sediments are characteristic of the wider area (Defra, 2019; Forewind, 2013; Premier Oil, 2018).
34. Broadscale regional habitat mapping, detailing biological zone and substrate (EMODnet, 2022), indicates that the dominant habitats across the subtidal ecology study area and wider region are predominantly circalittoral coarse sediment with patches of circalittoral sand further offshore. The inshore area of the subtidal ecology study area becomes more variable with infralittoral coarse sediment, circalittoral mixed sediments, sublittoral biogenic reefs, sublittoral polychaete worm reefs on sediment and *S. spinulosa* on stable circalittoral mixed sediment and circalittoral fine sand or circalittoral muddy sand (Volume 2, Figure 9.2). The wider region also includes faunal communities on deep moderate energy circalittoral rock, deep circalittoral sand, deep circalittoral mud and deep circalittoral mixed sediments.
35. The spatial patterns evident in sediment composition are likely due to regional hydrodynamics, confirmed by the subtidal baseline surveys of the adjacent Triton Knoll OWF which identified predominantly sublittoral coarse sediment and sublittoral sand and sublittoral mixed sediment commonly present, with sediment including sandy gravel with scattered boulders in the northern area and sand and gravel with megaripples in the southern area (RWE, 2015).

Array area

36. Spatial distribution of EUNIS biotope complexes identified through single point grab sampling and interpretation of SSS data are presented in Volume 2, Figure 9.4. It can be seen from the collaboration of this data that the array is dominated by circalittoral coarse sand with patches of mixed sediment.
37. PSA of the sediments sampled across the array determined that sediment type varied spatially; sediments in the northern area contained high proportions of sand associated with shallow depths and sandbank features. While the proportion of gravel in the form of pebbles and gravel interspersed with sand was observed in deeper areas in the southern array area. When the graphical mean particle size of the samples was considered, this was classified as Wentworth (1922) sediment descriptions which ranged from ‘fine sand’ to ‘pebble’.
38. Sediment descriptions using the Folk description (1954) categorised the seabed of the main array area as predominantly sandy gravel (29 stations), followed by gravelly sand (19 stations) and sand (18 stations), with the remaining stations described as slightly gravelly sand (seven stations), muddy sandy gravel (three stations), gravelly muddy sand (three stations) and gravel (one station).

39. Broadscale regional habitat mapping, detailing biological zone and substrate (EMODnet, 2022), supports the site-specific data, identifying the dominant habitats across the array as predominantly circalittoral coarse sediments, with circalittoral fine sand or circalittoral muddy sand.

Offshore Export Cable Corridor

40. Spatial distribution of EUNIS biotope complexes identified through single point grab sampling and interpretation of SSS data are presented in Volume 2, Figure 9.4. This data demonstrates that the majority of the offshore ECC is dominated by circalittoral coarse and circalittoral mixed sediments.
41. Sands and gravel dominated the seabed sediments, with the proportion of each varying across the study area. Sediment descriptions using the Folk description (1954) categorised the seabed as predominantly gravelly sand (12 stations), with stations described as gravelly muddy sand, slightly gravelly sand, sand, slightly gravelly muddy sand, gravel, sandy gravel and muddy sandy gravel each typifying stations. The sediments recorded along the offshore ECC are typical of the southern North Sea, which is reported to comprise of a mix of sand and gravel (Jones *et al*., 2004).
42. Broadscale regional habitat mapping confirmed variable sediment characteristics across the offshore ECC, including infralittoral coarse sediment, circalittoral coarse sediment, sublittoral polychaete worm reefs on sediment, *S. spinulosa* on stable circalittoral mixed sediment, sublittoral biogenic reefs, deep circalittoral coarse sediment, circalittoral fine sand or circalittoral muddy sand and infralittoral fine sand or infralittoral muddy sand (Volume 2, Figure 9.2) (EMODnet, 2022).

Intertidal

43. The middle shore habitat of the intertidal featured rippled mobile sand interspersed with coarser gravel and shell fragments (Volume 2, Figure 9.5). The middle to low shore consisted of fine to medium sand, with occasional channels carrying runoff from the upper shore. The foreshore is subject to annual beach replenishment as part of the Lincolnshire coast flood defence strategy which involves dredging subtidal sand for redistribution on the foreshore (Environment Agency, 2021).

9.5.2.13 Sediment Chemistry

Regional Context

44. Historically in the southern North Sea sediment contamination levels have been elevated beyond natural background levels as a consequence of anthropogenic activities. Anthropogenic contaminant inputs to the marine environment include marine transportation, coastal oil refineries, accidental shipping pollution, industrial waste and dredge spoils, sewage waste and agriculture run-off (OSPAR, 2000). However, environmental controls introduced over recent years have resulted in the reduction of concentrations for many contaminants (OSPAR, 2022).

45. Sediments with larger particle sizes (e.g., sands) tend to be less likely to be associated with elevated concentrations of anthropogenic contaminants compared to fines. Hydrocarbons, in particular, are often closely correlated to the spatial distribution of fine sediment types (such as muds and silts). Metal concentrations in sediments are generally higher in the coastal zone and around estuaries, decreasing offshore, indicating that river input and run-off from land are important sources. As noted above, the sediments within the benthic subtidal and intertidal ecology study area have been characterised as predominately sands and gravels. As such it is not expected that these will contain highly elevated concentrations of anthropogenic contaminants (Chapter 8: Marine Water Quality (Document Reference 6.1.8).
46. The baseline characterisation at neighbouring SEP and DEP (Fugro, 2020a; Fugro, 2020b) tested surface sediments for a range of contaminants. The results revealed that there were elevated levels of arsenic in six samples, although below levels in which adverse biological effects are expected to occur. For the most part, contaminants that will have an anthropogenic source (i.e., organic compounds and heavy metals) were found to be at low levels (Fugro, 2020). Arsenic is known to occur at high levels in seabed sediments in several parts of the North Sea, including a wide area of the Humber Estuary, (Whalley *et al*., 1999), have been attributed to historical disposal of arsenical wastes.

Array area

47. As presented in document reference 6.3.9.1 the following contaminants were recorded as below Cefas Action Level 1:
    - Organotins; tributyltin (TBT); dibutyltin (DBT); monobutyltin (MBT);
    - Polychlorinated biphenyls (PCBs), sum of ICES 7;
    - PCB's, sum of 25 congeners; and
    - Dieldrin.
48. The total Polycyclic Aromatic Hydrocarbons (PAHs) were generally low across the survey area with one station in exceedance of the Threshold Effect Level (TEL) for acenaphthene and phenanthrene. The concentration recorded did not exceed the Probable Effect Levels (PEL) thresholds. The station for which the two contaminants exceed the TEL, is in close proximity to Pickerill-B, a decommissioned gas platform. However, the overall low PAHs in conjunction with low PCBs, organotins and organochlorine pesticides suggests broadly even distribution of aromatic hydrocarbons across the site.
49. Seven stations recorded metal concentrations exceeding Cefas Action Level 1 including arsenic at four stations and nickel at three stations. The arsenic concentrations recorded in this study (4.9mg/kg to 37.3mg/kg) were within the range of <0.15mg/kg to 135mg/kg reported for the southern North Sea (Whalley *et al*., 1999).
50. Total organic carbon (TOC) was relatively low across the survey area and indicated an organically deprived environment, with lower TOC concentrations recorded on the crests of sandbanks.

51. Further details of sediment contamination are provided in Chapter 8: Marine Water Quality (Document Reference 6.1.8) and Part 6, Volume 2, Appendix 9.1: Benthic Ecology Technical Report (Array) (Document Reference 6.3.9.1).

Offshore Export Cable Corridor

52. As presented in Appendix 9.2: Benthic Ecology Technical Report (ECC) (Document Reference 6.3.9.1), the following contaminants were recorded as below Cefas Action Level 1:
    - Organotins; TBT; DBT; MBT;
    - PCBs, sum of ICES 7;
    - PCBs, sum of 25 congeners; and
    - Dieldrin.
53. Of the full suite of contaminants analysed at the 28 stations within the ECC, 26 had PAHs below the TEL threshold. Of the remaining two stations which recorded contaminants exceeding the TEL threshold, none exceeded the PEL threshold. TEL thresholds were exceeded at these stations for:
    - Dibenzo(a, h)anthracene;
    - Naphthalene; and
    - Phenanthrene.
54. When compared to the United States Environmental Protection Agency (US EPA) Effects Range Low (ERL) and Effect Range Median (ERM) thresholds only one of these stations had a PAH above the ERL threshold, with the ERL exceeded for fluorene.
55. Twelve stations recorded metal concentrations exceeding Cefas Action Level 1. The following metals were recorded above Cefas Action Level 1, but less than Action Level 2, within the offshore ECC:
    - Arsenic (at eight stations);
    - Chromium (at one station); and
    - Nickel (at four stations).
56. These recorded concentrations are consistent with those within marine sediments in the wider North Sea. However, when considering the contaminant levels present at each of the stations, both within the array and offshore ECC, it is important to note that this area has many oil and gas facilities within it. Further detail of the oil and gas facilities is provided in Volume 1, Chapter 18: Infrastructure and Other Marine Users (Document Reference 6.1.18) and further detail of sediment contamination is provided within Volume 1, Chapter 8: Marine Water and Sediment Quality (Document Reference 6.1.8) and Volume 3, Appendix 9.2: Benthic Ecology Technical Report (Document Reference 6.3.9.2).

Regional Context

57. The benthic communities of the southern North Sea are generally defined by the substrata of the seabed. Mobile sand dominated habitats are generally considered to be species poor and are characterised by robust species such as annelid worms and fast burrowing bivalves (Barne *et al*., 1998, Jones *et al*., 2004). Epibenthic flora and fauna normally occur on mixed substrata with appreciable coarse components, where a range of microhabitats allow colonisation by a wide array of species (Jones *et al*., 2004).
58. The Cefas OneBenthic faunal data (Volume 2, Figure 9.2) presents a biologically informed habitat map which utilises a comprehensive dataset of macrofaunal data (33,198 samples from 777 surveys) sourced from data acquired from both governmental and non-governmental sectors. The OneBenthic habitat map demonstrates that the macrofaunal assemblages across the benthic subtidal and intertidal ecology study area were characterised by the following groupings:

- Group A1 was widespread across the study area. This group is represented by a faunal assemblage with relatively higher numbers of characterising taxa including Balanidae, Styelidae, Spionidae, Terebellidae, Syllidae, Porcellanidae, Polynoidae, Sabellariidae, Capitellidae, Serpulidae, Nermetea, Cirratulidae, Mytilidae, Phyllodocidae, Nematoda, Alcyonidiidae, Galatheidae, Romancheinidae, Pholoidae, Amphiuridae and Electridae. This group is likely to be located on a mixed and coarse sediment community.
- Group A2a was abundant across the foreshore area of the study area. This group is characterised by a similar assemblage to A1 but includes Lumbrineridae and Semelidae. This group is likely to be located on a variety of sandy substrates.
- Group A2b was minimal across the study area. This group is represented by a faunal assemblage with relatively high numbers of taxa including the family of polychaete worms Syllidae, Serpulidae, Terebellidae, Spionidae, Sabellariidae, Polynoidae, Capitellidae, Lumbrineridae, Cirratulidae, Phyllodocidae, Maldanidae, Sabellidae, the echinoderm family Amphiuridae, the decapod crustacean Porcellanidae, the ascidian tunicate family Styelidae, the nematode family Nemertea and the bryozoan Romancheinidae. Due to the diversity of this group and the occurrence of bryozoans it is likely this group is representative of a mixed and coarse sediment community.
- Group C1a was widespread across the study area, and is characterised by the polychaetes Spionidae, Terebellidae, Serpulidae, Syllidae, Capitellidae, Cirratulidae, Lumbrineridae, Sabellariidae, Nemertea, Glyceridae and the nematode family Nemertea. This group is likely to be located on a variety of sandy substrates.
- C1b faunal clusters were identified throughout the study area; this group is likely to be found on a variety of sandy substrates and is characterised by a similar assemblage to C1a but includes the amphipod family Ampeliscidae as well as the polychaetes Phyllodocidae, Polynoidae, Scalibregmatidae, and Pholoidae.

- Group D1 was recorded in a small cluster in the eastern study area; this group is dominated by polychaetes and bivalves with characterising species including Spionidae, Montacutidae, Semelidae, Nephtyidae, Capitellidae, Cirratulidae, Amphiuridae, Oweniidae, Nermetea, Pholoidae and Nuculidae and is typically found in muddy sands.
- Faunal cluster D2a was widespread across the study area and is represented by a faunal assemblage that is characterised by low numbers of taxa including the polychaetes Spionidae, Glyceridae, Terebellidae, Capitellidae, Phyllodocidae and the nematode family Nemertea. This group is likely to be located on a variety of sandy substrates.
- Faunal cluster D2b was recorded twice across the study area and is characterised by low numbers of taxa commonly Spionidae, Amphiuridae, Nephtyidae, Lumbrineridae, Oweniidae, Cirratulidae, Capitellidae, Nemertea, Semelidae and Ampharetidae. This group is likely to be located where there are higher percentages of mud, and is common off the Humber Estuary, and in deeper waters of the northern North Sea.
- Group D2c was widespread across the study area and is represented by a faunal assemblage that was characterised by low numbers of polychaetes including Nephtyidae, Spionidae and Opheliidae. All of which are typically found in sands and muddy sands.
- Group D2d was widespread across the further offshore area and is represented by a faunal assemblage that was characterised by low numbers of taxa including Spionidae, Bathyporeiidae, Nephtyidae, Magelonidae, Tellinidae. This group dominates in areas of high sand.

59. The adjacent Triton Knoll ECC subtidal ecology survey overlaps with the wider subtidal ecology study area, offshore ECC and the biogenic reef restoration areas located to the north of the ECC. Results from habitat mapping, grab and DDV data across the Triton Knoll study area identified a species-rich community of polychaetes such as *Mediomastus fragilis* and *Lumbrineris* spp., and Nemertea, venerid bivalves and amphipods and an epifaunal community including dense colonies of bryozoans in the northern area (RWE, 2015). In the southern Triton Knoll study area, the species composition is dominated by bivalves and impoverished polychaete communities, with an epifaunal community dominated by tube worm *Spirobranchus triqueter*, barnacles, bryozoans, and coralline algae crusts (RWE, 2015a).
60. Results of the Triton Knoll OWF habitat mapping (RWE, 2011) identified a number of dominant and widespread biotopes (JNCC Marine Habitat Classification) listed and described below:
    - *Mediomastus fragilis, Lumbrineris* spp. and venerid bivalves in Atlantic circalittoral coarse sand or gravel (EUNIS 2022 code: MC3212);
    - *Flustra foliacea*, small solitary and colonial ascidians on tide-swept Atlantic circalittoral bedrock or boulders (EUNIS 2022 code: MC12162); and
    - *Spirobranchus triqueter* on stable Atlantic circalittoral mixed sediment (EUNIS 2022 code: MC2211).
61. Other biotopes recorded in discrete patches included (RWE, 2011):
    - *Nephtys cirrosa* and *Bathyporeia* spp. in Atlantic infralittoral sand (EUNIS 2022 code: MB5233);

- *Abra alba* and *Nucula nitidosa* in Atlantic circalittoral muddy sand or slightly mixed sediment (EUNIS 2022 code: MC5214);
- *Moerella* spp. with venerid bivalves in Atlantic infralittoral gravelly sand (EUNIS 2022 code: MB3233);
- Sparse fauna on highly mobile Atlantic infralittoral shingle (cobbles and pebbles) (EUNIS 2022 code: MB3231); and
- *Protodorvillea kefersteini* and other polychaetes in impoverished Atlantic circalittoral mixed gravelly sand (EUNIS 2022 code: MC3213).

62. Biotopes identified across the Triton Knoll intertidal included (RWE, 2015b):
    - Barren or amphipod-dominated mobile sand shores (EUNIS code: MA523);
    - Barren littoral coarse sand (EUNIS code: MA5231) ;
    - Amphipods and *Scolelepis* spp. in littoral medium-fine sand (EUNIS code: MA5233); and
    - Polychaete/amphipod dominated fine sand shores (EUNIS code: MA524); including impoverished variants of *Nephtys cirrosa* dominated littoral fine sand (EUNIS code: MA5413).
63. The biotope communities identified above are typical of the faunal assemblages previously described for the southern North Sea. This is supported by the recent baseline survey for DEP that coincides with the Project subtidal ecology study area and identified biotopes MB3233, MB5233 and '*Crepidula fornicata* with ascidians and anemones on Atlantic infralittoral coarse mixed sediment' (MB4231) (Equinor, 2022). SEP baseline survey identified a combination of MB4231 and MC2211 assigned to most stations that featured coarse mixed sediment. Other biotopes present included MC12162, MB5233, 'Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay' (MC1251) and 'Polychaete-rich deep Venus community in offshore mixed sediments' (MD4211) which were recorded in the southern area of the SEP OWF outside of the Project subtidal ecology study area (Equinor, 2022).
64. The Dudgeon OWF post-construction surveys identified additional biotopes including *'Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment' (MC4214), 'Dense *Lanice conchilega* and other polychaetes in tide-swept Atlantic infralittoral sand and mixed gravelly sand' (MB3237), and '*Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed Atlantic circalittoral rock' (MC121A) (Equinor, 2019).
65. Closer inshore the Inner Dowsing, Lincs and Lynn OWFs revealed three dominant species, species including *S. spinulosa* and bryozoans *Conopeum reticulum* and *Crisia aculeata* with MC2211 as the predominant biotope (Lincs Wind Farm Ltd, 2010). The shallow water of the Inner Dowsing OWF included '*Glycera lapidum* in impoverished Atlantic infralittoral mobile gravel and sand' (MB3235) as well as MC3213 (RWE, 2015).
66. Race Bank OWF benthic survey reported the majority of the area as MC4214 and MB3233, with an additional biotope '*Hesionura elongata* and *Microphthalmus similis* with other interstitial polychaetes in Atlantic infralittoral mobile coarse sand' (MB3234) identified in small patches across the Race Bank study area which is within the wider subtidal ecology study area, and south of the biogenic reef restoration areas (Centrica Energy, 2009).

67. Additional biotopes identified in the Hornsea OWFs to the northeast of the Project study area, include '*Abra prismatica, Bathyporeia elegans* and polychaetes in Atlantic circalittoral fine sand' (MC5212), '*Echinocyamus pusillus, Ophelia borealis* and *Abra prismatica* in Atlantic circalittoral fine sand' (MC5211) and '*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in Atlantic infralittoral compacted fine muddy sand' (MB5236) (Smart Wind Limited, 2015; Orsted, 2018; 2022).

Table 9.4: Biotopes found across the Projects subtidal ecology study area and wider region informed by other OWFs

EUNIS Code (2022)	EUNIS Code (2012)	Biotope Name	JNCC 04.05 Code
Biotopes identified across the subtidal ecology study area including Triton Knoll Electrical System (RWE, 2011), Sheringham Shoal and Dudgeon OWF (Equinor, 2022ab), Race Bank OWF (Centrica energy, 2009) Lincs and Inner Dowsing OWFs (Lincs Wind Farm Ltd, 2010).			
MC3212	A5.142	*Mediomastus fragilis, Lumbrineris* spp. And venerid bivalves in Atlantic circalittoral coarse sand or gravel	SS.SCS.CCS.MedLumVen
MC12162	A4.1342	*Flustra foliacea*, small solitary and colonial ascidians on tide-swept Atlantic circalittoral bedrock or boulders	CR.HCR.Xfa.FluCoAs.SmAs
MC2211	A5.611	*S. spinulosa* on stable Atlantic circalittoral mixed sediment	SS.SBR.PoR.SspiMx
MB5233	A5.233	*Nephtys cirrosa* and *Bathyporeia* spp. In Atlantic infralittoral sand	SS.Ssa.IfiSa.NcirBat
MC5214	A5.261	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	SS.Ssa.CmuSa.AalbNuc
MB3233	A5.133	*Moerella* spp. with venerid bivalves in Atlantic infralittoral gravelly sand	SS.SCS.ICS.MoeVen
MB3231	A5.131	Sparse fauna on highly mobile Atlantic infralittoral shingle (cobbles and pebbles)	SS.SCS.ICS.SSh
MC3213	A5.143	*Protodorvillea kefersteini* and other polychaetes in impoverished Atlantic circalittoral mixed gravelly sand	SS.SCS.CCS.Pkef
MB3235	A5.135	*Glycera lapidum* in impoverished Atlantic infralittoral mobile gravel and sand	SS.SCS.ICS.Glap
MC4214	A5.444	*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment	SS.SMx.CMx.FluHyd
MB4231	A5.431	*Crepidula fornicata* with ascidians and anemones on Atlantic infralittoral coarse mixed sediment	SS.SMx.Imx.CreAsAn
MB3237	A5.137	Dense *Lanice conchilega* and other polychaetes in Atlantic tide-swept	SS.SCS.ICS.Slan

EUNIS Code (2022)	EUNIS Code (2012)	Biotope Name	JNCC 04.05 Code
		infralittoral sand and mixed gravelly sand	
MC121A	A4.138	*Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed Atlantic circalittoral rock	CR.HCR.Xfa.Mol
MD4211	A5.451	Polychaete-rich deep Venus community in offshore mixed sediments (impoverished or a transition biotope)	SS.SMx.Omx.PoVen
MB3234	A5.134	*Hesionura elongata* and *Microphthalmus similis* with other interstitial polychaetes in Atlantic infralittoral mobile coarse sand	SCS.ICS.HeloMsim
Additional biotopes identified across the wider region including SEP (Equinor, 2022) and Hornsea OWFs (Smart Wind Limited, 2015; Orsted, 2018; 2022)			
MC5212	A5.252	*Abra prismatica, Bathyporeia elegans* and polychaetes in Atlantic circalittoral fine sand	SS.Ssa.CfiSa.ApriBatPo
MC5211	A5.251	*Echinocyamus pusillus, Ophelia borealis and Abra prismatica* in Atlantic circalittoral fine sand	SS.Ssa.CfiSa.EpusOborApri
MB5236	A5.242	*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in Atlantic infralittoral compacted fine muddy sand	SS.Ssa.ImuSa.FfabMag
MC1251	A4.231	Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay	CR.MCR.SfR.Pid

Array area

68. EUSeaMap (EMODnet, 2022) data corresponds to Cefas (2015) data, which show the array to be dominated by coarse sands with areas of fine and muddy sands; with faunal cluster D2c most prevalent and faunal clusters A1, A2a, A2b, C1a, C1b, D2a, and D2d dispersed throughout the array (Volume 2, Figure 9.2).

69. As detailed in Volume 3, Appendix 9.1: Benthic Ecology Technical Report (Array) (Document Reference 6.3.9.1), across the array a total of 4,429 individuals representing 265 taxa were recorded from the 71 macrofaunal grab samples. Of the 265 taxa recorded, 37 were colonial epifauna, nine were solitary epifauna and 228 were infaunal. Benthic subtidal infaunal community structure and composition was generally dominated by Annelida, that comprised most of the enumerated taxa composition (37.7%), followed by Mollusca (22.7%), Arthropoda (18.6%), Echinodermata (1.3%) and Chordata (0.2%). Other infaunal phyla comprised 4.8% of the taxa composition and were represented by Cnidaria, Hemichordata, Foraminifera, Phoronida, Platyhelminthes, Nemertea and Nematoda. Univariate indices indicated a variable but overall, fairly diverse community structure across the Array area. Multivariate indices revealed a relatively heterogeneous benthos, owing to the varying coarseness of seabed sediment in a high energy environment.
70. Similarly, epibenthic composition identified from the epibenthic trawl survey reflected the sand and gravel dominated sediments, mirrored the phylum identified in the grab sampling and recorded 4,866 individuals across 91 species. Further analysis using multivariate statistics revealed epifaunal differences between sand dominated sandbank crest habitats, while the coarse sediment habitats were differentiated based on the presence/absence of *S. spinulosa*. The presence of *S. spinulosa* is further discussed in Section 9.5.2.15.
71. There was a clear spatial distribution in the habitat types present within the array which is reflected by sediment character. By combining and considering collectively the macrofaunal data, DDV data, PSA data and geophysical data, seven biotope complexes and four impoverished biotopes within the array were identified (Volume 2, Figure 9.4). However due to impoverished communities or lack of clear differentiation in acoustic facies across the circalittoral mixed and coarse sediment areas, only biotope complexes could be mapped (Volume 2, Figure 9.4). The EUNIS classification hierarchy to biotopes (to a maximum level five) was mainly based on depth, sediment type and species composition. The EUNIS habitat codes (and corresponding JNCC 04.05 biotope code) identified are presented in Volume 2, Figure 9.4 and Table 9.6
72. The predominant biotope complex across the Array area was 'Atlantic circalittoral coarse sediment' (MC32) with patches of 'Atlantic circalittoral mixed sediment' (MC42) which was recorded predominantly across the array. MC32 additionally characterised the western region of the array with variable densities of shell debris, cobbles and pebbles. These stations generally had higher richness and diversity than those of the predominantly sandy stations and were characterised by *M. fragilis, G. lapidum, P. kefersteini, Spiophanes bombyx*, *Amphipholis squamata, S. spinulosa, Nemertea, S. triqueter, Balanus crenatus* and *H. falcata*. Further analysis of these communities determined that the biotope complex can be further defined as an impoverished form of the biotope '*Spirobranchus triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles' (MC3211) due to the presence of hermit crab *Pagurus bernhardus* and soft coral *Alcyonium digitatum*.

73. ‘Atlantic circalittoral mixed sediment’ (MC42) did not occur in isolation but formed intermediate habitats of coarse and mixed sediments prevalent to the east, centre and west of the survey area, with a general absence of megaripples and sand waves. These habitats showed strong conformity to the biotope ‘*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment’ (MC4214) with characterising species such as *F. foliacea*, hydroids (*H. falcata; Nemertesia* sp.), *A. rubens*, dahlia anemone *Urticina felina, Pagurus* sp., *A. diaphanum, A. digitatum, S. triqueter, V. spinosa* and *B. crenatus*. Areas of *S. spinulosa* aggregations forming over pebbles and cobbles conformed to an intermediate habitat of the biotope ‘*S. spinulosa* on stable circalittoral mixed sediment’ (MC2211).
74. ‘Atlantic offshore circalittoral coarse sediment’ (MD32) was limited to the deepest extents of the westernmost canyon feature with impoverished fauna, limiting possible assignment to the level five circalittoral coarse sediment biotopes.
75. Habitats dominated by rippled homogeneous medium to very coarse sands were identified as ‘Atlantic Infralittoral fine sand’ (MB52) which due to the homogenous sands had limited fauna. Due to the generally impoverished fauna the infralittoral fine sand biotope complex could be further refined to the biotope ‘Infralittoral mobile clean sand with sparse fauna’ (MB5231).
76. Similarly, the deeper habitats dominated by rippled homogenous fine to coarse sands were identified as ‘Atlantic circalittoral fine sand’ (MC52) and fauna was limited to Chordata, and epifauna including *Pagurus* sp., starfish *Asterias rubens, Vesicularia spinosa*, Sertulariidae and sand mason worm *Lanice conchilega*.
77. ‘Atlantic offshore circalittoral sand’ (MD52) was limited to the spatial extent of the eastern canyon, which was dominated by rippled heterogeneous coarse sands with variable shell fragments. The sand dominated sediment of the canyon was scoured by bottom currents given the presence of megaripples and sand waves. Characterising fauna included Chordata, *Pagurus* sp., *A. rubens*, shrimp Caridea sp brittle stars Ophiuroidea sp., sea chervil *Alcyonidium diaphanum*, *F. foliacea,* Sertulariidae and *V. spinosa*.
78. ‘Infralittoral coarse sediment’ (MB32) was associated with the crests of a sandbank to the southwestern area of the array, with fauna limited to low abundances and diversities of Annelida, Nemertea, Nematoda and Mollusca.

Table 9.5: Biotopes identified across the Array area

EUNIS Code (2022)	EUNIS Code (2012)	Biotope name	JNCC 04.05 Code
Array			
MD52	A5.27	Atlantic offshore circalittoral sand	SS.Ssa.Osa
MC52	A5.25	Atlantic circalittoral sand	SS.Ssa.CfiSa
MB52	A5.23	Atlantic infralittoral sand	SS.Ssa.IfiSa
MC42	A5.44	Atlantic circalittoral mixed sediment	SS.SMx.CMx
MD32	A5.15	Atlantic offshore circalittoral coarse sediment	SS.SCS.OCS
MC32	A5.14	Atlantic circalittoral coarse sediment	SS.SCS.CCS
MB32	A5.13	Infralittoral coarse sediment	SS.SCS.ICS

EUNIS Code (2022)	EUNIS Code (2012)	Biotope name	JNCC 04.05 Code
MC3211	A5.141	*Spirobranchus triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles (impoverished)	SS.SCS.CCS.SpiB
MB5231	A5.231	Infralittoral mobile clean sand with sparse fauna (impoverished)	SS.Ssa.IfiSa.ImoSa
MC4214	A5.444	*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment (intermediate)	SS.SMx.CMx.FluHyd
MC2211	A5.61	*S. spinulosa* on stable circalittoral mixed sediment	SS.SBR.PoR.SspiMx

79. As detailed within Benthic Ecology Technical Reports (document refs 6.3.7.1 and 6.3.7.2), the benthic sediment eDNA dataset recorded 340 taxa across the array area and offshore ECC, with 1,150 haplotypes (a distinct combination of alleles inherited together from a single parent) recorded from the 19 samples analysed (GEOxyz, 2022c). Haplotype data provides an indication of genetic variability within a single species population. Across the array area, 16 eDNA samples were obtained for further analysis, and results corroborated the macrofaunal analysis, with Annelida, Arthropoda, and Mollusca being the most abundant. The results revealed a greater number of taxa in the 'Atlantic circalittoral coarse sediment,' which contained more organic rich sediments and a higher content of gravel, pebble, and cobble. However, the results indicated a more diverse community including richer Cnideria and Porifera communities as well as taxa including Ochrophyta, Myzozoa, Nematoda, Ciliophora, Chlorophyta, Haptophyta, Bigyra, Chytridiomycota, Cryptophyta, Choanozoa, Cercozoa, Platyhelminthes, Amoebozoa, Ascomycota, Chordata, Heliozoa, Nemertea and Oomycota which were not identified in the macrofaunal grab samples. Some faunal groups that were identified from macrofauna analysis were not identified from eDNA, likely due to a combination of primer target specificities, eDNA database gaps and the smaller size of eDNA samples, which highlights the complementary nature of these biodiversity analyses.

Offshore Export Cable Corridor

80. EUSeaMap (EMODnet, 2022) data corresponds with the Cefas (2015) data, which show the offshore ECC to predominantly coarse sands with areas of polychaete worm reefs, biogenic reefs, mixed sediments and fine or muddy sands (Volume 2, Figure 9.2). Faunal clusters are diverse, with A2a, C1a, C1b, D2a, and D2c concentrating in the inshore region and A1, D2c extending along the ECC.
81. SSS data showed areas of 'mottled' reflectivity sediment across the majority of the survey, indicating areas dominated by mixed sediments with patches of *S. spinulosa* (Volume 2,Figure 9.3). Coarser sediment areas composed of sand, shell gravel, pebbles and cobbles, was present across most stations along the ECC survey area but most prevalent in the offshore eastern area of the ECC. The sediment heterogeneity resulted in greater hard surface availability and lead to increased colonisation by a range of epibenthic species.

82. As detailed within Appendix 9.2: Benthic Ecology Technical Report (ECC), across the offshore ECC the macrofaunal dataset comprised 366 taxa and 6,352 individuals. Benthic subtidal community structure and composition were generally dominated by Annelida, which comprised most of the enumerated taxa composition (21%), followed by Arthropoda (17.7%), Mollusca (9%) and Echinodermata (1.8%). Other phyla comprised 2.2% of the taxa composition and were represented by Cnidaria, Nematoda, Nemertea, Platyhelminthes and Phoronida.

83. By combining and considering collectively the macrofaunal data, DDV data, PSA data and geophysical data collectively one habitat complex, three biotope complexes and four biotopes were identified within the offshore ECC (Table 9.6).

84. The majority of stations identified predominantly coarse sediment classified as 'Circalittoral coarse sediment' (MD321). Analysis of the habitat identified two variants of circalittoral coarse sediment: sand with shell, pebbles and cobbles which were more prevalent in the offshore area of the ECC and sand with shell gravel that was found across all extents of the offshore ECC. MD321 stations featured heterogenous sediments with variable densities of cobbles and pebbles which resulted in greater hard surface availability and increased colonisation by epibenthic species. Sessile epifauna included hydroids (*Vesicularia spinosa*, Sertulariidae, *Nemertesia* sp.), sea chervil *Alcyonidium diaphanu*, hornwrack *F. foliacea*, dahlia anemone *Urticina felina*, sand mason worm *L. conchilega*, barnacles Cirripedia sp. and porifera. Further evaluation of these communities revealed similarities with the biotope '*P. kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand' (MC3213) with presence of *P. kefersteini*, Nemertea, *Chaetozone zetlandica, Exogone verugera* and *G. lapidum*, however, due to an impoverished species abundance the overarching habitat classification was kept at circalittoral coarse sediment.

85. 'Circalittoral mixed sediments' (MC42) were widespread across the offshore ECC but occurred less frequently in the offshore area. This level four habitat had the highest species richness, with mobile fauna including *A. rubens*, sun starfish *Crossaster popposus* and brittle stars Ophiuroidea sp., queen scallops *Aequipecten opercularis*, common whelk *Buccinum undatum*, and crabs (hermit crabs *Pagurus* sp., edible crab *Cancer pagurus*, spider crabs *Hyas* sp., swimming crab *Necora puber* and harbour crabs *Liocarcinus* sp.). Sessile organisms were limited to the variable cobbles and pebbles and included *Nemertesia* sp., anemones *Actinaria* sp., soft corals *Alcyonium digitatum*, *U*. felina, Cirripedia sp., *F. foliacea*, Porifera, *V. spinosa*, Haleciidae, Bryozoa *A. diaphanum*, Sertulariidae, L*. conchilega*, *S. spinulosa* and slipper limpet Crepidula fornicate.

86. The 'Circalittoral mixed sediment habitat' showed strong conformity to the biotope '*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment' (MC4214) with 11 characterising species.

87. The biotope '*S. spinulosa* on stable circalittoral mixed sediment' (MC2211), was recorded across 11 stations from the inshore to the central section of the offshore ECC. This biotope had the highest species diversity and was characterised by aggregations of *S. spinulosa* and variable coverage of *A. diaphanum, F. foliacea, Pagurus* sp., *Nemertesia* and *A. rubens*. Further detail on the occurrence of *S. spinulosa* is provided in Section 9.5.2.15.

88. The 'Infralittoral muddy sand' (MB5) habitat was dominated by homogeneous fine sands and associated with the presence of sandbanks in the eastern region of the offshore ECC connecting to the array. Due to the homogeneous sand with negligible hard substrate, conspicuous fauna was limited to frequent observations of *A. diaphanum*.

89. The deeper habitats were dominated by rippled fine to coarse sands and silty sands and identified as the habitat 'Circalittoral muddy sand' (MC52). Further examination of these communities revealed that the presence of Ophiuroidea, *Pagurus*, Caridea and starfish could support the classification of the biotope *'Ophiura ophiura* on circalittoral muddy sand' (A5.262TMP), however in an impoverished form, thus confidence in the classification is limited.

Table 9.6: Biotopes identified across the offshore ECC

EUNIS Code (2022)	EUNIS Code (2012)	Biotope name	JNCC 04.05 Code
Offshore ECC			
MC32	A5.14	Atlantic circalittoral coarse sediment	SS.SCS.CCS
MC42	A5.44	Atlantic offshore circalittoral mixed sediment	SS.SMx.CMx
MC2211	A5.61	*S. spinulosa* on stable circalittoral mixed sediment	SS.SBR.PoR.SspiMx
MB5	A5.23	Infralittoral muddy sand	SS.Ssa.ImuSa
MC52	A5.25	Circalittoral muddy sand	SS.SSa.CmuSa
A5.262TMP[2] (EUNIS 2008)	A5.262	*Ophiura ophiura* on circalittoral muddy sand (impoverished biotope)	SS.SSa.CmuSa.Ooph
MC3213	A5.143	*Protodorvillea kefersteini* and other polychaetes in impoverished Atlantic circalittoral mixed gravelly sand (impoverished biotope)	SS.SCS.CCS.Pkef
MC4214	A5.444	*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment	SS.SMx.CMx.FluHyd

[2] No new corresponding 2022 EUNIS code for this biotope.

90. As detailed within Benthic Ecology Technical Report (document ref. 6.3.9.2) three benthic sediment eDNA samples were acquired along the offshore ECC. The highest number of taxa (102) and highest haplotype count per sample (184) recorded in the offshore ECC was identified at the station furthest offshore (GEOxyz, 2022c). The central station along the offshore ECC had the lowest taxa, number of haplotypes and diversity across the array area and offshore ECC. The eDNA data corroborated sediment analysis with results identifying mixed sediment and yielded similar trends to the morphological taxonomic analysis of macrofauna. A number of the phylum and species recorded through eDNA analyses were considered to represent pelagic organisms, such as Myzozoa and Ochrophyta, which make up much of the plankton (i.e., diatoms and dinoflagellates). The presence of these phyla in the eDNA highlights the effectiveness of the method at sampling the species of the wider survey area; both capturing species of mainly benthic origin but also from groups not found in the sediments.

Intertidal

91. As detailed in Appendix 9.3: Intertidal Technical Report, the majority of the intertidal survey area was characterised by clean, mobile sand with low faunal diversity, five biotopes were identified across the intertidal survey area during the Phase I habitat mapping (Table 9.7; Volume 2, Figure 9.5).
92. The upper shore was divided between the biotope 'Talitrids on the upper shore and strand-line' (MA5211) and areas of barren sand that was assigned to 'Barren Atlantic littoral coarse sand' (MA5231). The middle shore included the spionid polychaete *Scolelepis* spp., the amphipod *Haustorius arenarius* and the mysid shrimp *Gastrosaccus spinifer* and was identified as the biotope 'Amphipods and *Scolelepis* spp. in Atlantic littoral medium-fine sand' (MA5233). The middle to low shore was assigned to the biotope 'Polychaetes in Atlantic littoral fine sand' (MA5241). On the middle shore at the northernmost extent of the survey area is the Anderby Main Drain outfall, which is a man-made structure comprised of concrete and steel pilings reinforced with rock armour at its seaward end. This structure represented the only hard substrate within the survey area, which supported an assemblage of the ephemeral green algae *Ulva* spp. and was assigned to the biotope '*Ulva* spp. On freshwater-influenced and/or unstable upper eulittoral rock' (MA123G).

Table 9.7: Biotopes found across the Intertidal

EUNIS Code (2022)	EUNIS Code (2012)	Biotope name	JNCC 04.05 Code
Intertidal			
MA5231	A2.221	Barren Atlantic littoral coarse sand	LS.Lsa.MoSa.BarSa
MA5211	A2.211	Talitrids on the upper shore and strandline	LS.Lsa.St.Tal
MA123GA1.451	A1.451	*Enteromorpha* spp. on freshwater-influenced and/or unstable upper eulittoral rock	LR.FLR.Eph.Ulv

EUNIS Code (2022)	EUNIS Code (2012)	Biotope name	JNCC 04.05 Code
MA5233	A2.223	Amphipods and *Scolelepis* spp. in Atlantic littoral medium-fine sand	LS.Lsa.MoSa.AmSco
MA5241	A2.231	Polychaetes in Atlantic littoral fine sand	LS.Lsa.FiSa.Po

9.5.2.14 Compensation Areas

93. Broadscale regional habitat mapping identified that the ANS area to the north of the array area is dominated by circalittoral coarse sediment (MC32) and deep circalittoral coarse sediment (A5.14) (Volume 2, Figure 9.2). A faunal cluster that is characterised by low numbers of taxa including the polychaetes Spionidae, Glyceridae, Terebellidae, Capitellidae, Phyllodocidae and the nematode family Nemertea (D2a) was also identified adjacent to the northern ANS Area (Volume 2, Figure 9.2).
94. The ANS area to the southeast of the array area has a similar sediment assemblage to the northern ANS Area. Broadscale habitat mapping identified the site to be predominantly contain circalittoral coarse sediment (MC32), with a band of deep circalittoral sand (A5.27) and circalittoral fine sand (A5.25) or circalittoral muddy sand (A5.26) running through the area from north to south and light patches of deep circalittoral coarse sediment (Volume 2, Figure 9.2). Faunal clusters D2a, D2c and C1b (as characterised in Section 9.5.1) were also confirmed within the site (Volume 2, Figure 9.2).
95. The biogenic reef areas are located throughout the IDRBNR SAC. The biogenic reef creation areas have been selected to avoid any overlap with the known extent of any designated features of the SAC as detailed within the Benthic Compensation Strategy Roadmap (document reference 7.2.1). These areas are characterised by mixed and coarse sediments as depicted in Volume 2, Figure 9.2. Faunal clusters included A2a, D2a, C1a and A1 (as characterised in Section 9.5.1).

9.5.2.15 Features of Conservation Interest

96. Annex I habitats are defined under the Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora; more commonly referred to as the EC Habitats Directive (1992) as amended. Under the Conservation of Habitats and Species Regulations 2017 and Conservation of Offshore Marine Habitats and Species Regulations 2017, species and habitats that fall into specific categories are eligible for legal protection from activities that have the potential to damage them. Annex I habitats are protected through a network for Special Areas of Conservation (SACs) that aims to establish a network of important high-quality conservation sites that will make a significant contribution to conserving the habitats listed in Annex I. Outside of SACs, many of these habitats are protected by other legislation, such as the Natural Environment and Rural Communities (NERC) Act 2006.
97. Designated and non-designated ‘reef’ (biogenic and geogenic) and ‘sandbanks slightly covered by seawater all the time’ have been recorded across the benthic subtidal and intertidal ecology study area.
98. Guidance for geogenic reef states:

> *“When determining whether an area of the seabed should be considered as Annex I stony reef, if a ‘low’ is scored in any of the four characteristics (composition, elevation, extent or biota), then a strong justification would be required for this area to be considered as contributing to the Marine Natura site network of qualifying reefs in terms of the EU Habitats Directive”.*

99. Stony reef assessment guidance measures composition, elevation and extent to interpret the 'reefiness' of stony features (Irving 2009, Jenkins *et al*., 2015). The guidance concluded that a reef should be elevated above flat sea floor, have an area of at least 25m^2 and have a composition of no less than 10% coverage of the seabed (Irving, 2009).

100. Stony (geogenic) reef habitats are widespread throughout the UK coast but within the regional area, habitats resemble 'not reef' to 'low resemblance to reef' according to robust analyses against the various Annex I stony reef qualifying criteria and are relatively impoverished (ICES, 2005, Smart Wind Limited, 2015; Orsted, 2018; 2020, Equinor, 2022). At the adjacent Triton Knoll OWF, 49 locations were assessed for geogenic reef habitats though only one small area to the northwest of the Triton Knoll site boundary satisfied the criteria and was classified as Annex I stony reef habitat (RWE, 2015). This is supported by pre-construction surveys conducted throughout the Triton Knoll study area. Both the site and the cable route were evaluated for the presence of stony reefs, and the results showed that neither the site nor the cable route had an Annex I stony reef present, despite the stony nature of the substrata in certain locations (RPS, 2011; GoBe, 2014). Stony reef is not a feature of the IDRBNR SAC.

101. Informing the wider study area, the Viking Link Interlink recorded four areas of potential Annex I stony reef identified with 'medium' 'reefiness' close to the Lincolnshire inshore area, outside of the Humber Estuary (Prysmian Group, 2021). The nearshore stations recorded areas of 15,524m^2 and 6,344m^2 stony reef, and slightly further offshore, stations recorded an extent of 51,454m^2 and 26,689m^2 stony reef which extended fully across the offshore ECC (Prysmian Group, 2021). Additionally, surveys undertaken following deployment of the Controlled Flow Excavation (CFE) tool on Hornsea Project One identified a discrete station primarily consisting of coarse sediments with small patches of stony reef (Orsted, 2020).

102. A biogenic reef formed by *S. spinulosa* reef is a habitat of principal importance and listed under Annex I of the Habitats Directive. *S. spinulosa* aggregations with less than 10% cover, less than 25m^2 area, and less than 2cm elevation do not qualify as reef; ranges above these figures can be classified as low, medium, or high reef (Gubbay, 2007). *S. spinulosa* is prevalent in the southern North Sea, with reefs more commonly found in association with more stable sedimentary deposits (Pearce, 2014). *S. spinulosa* reef can be extremely ephemeral in nature and has been recorded 'disappearing' in areas where a seemingly stable habitat has previously been established, such as Saturn Reef in the southern North Sea (Pearce, 2014).

103. A review of historical surveys revealed that *S. spinulosa* aggregations were found in many of the OWF surveys in the wider region but ranged from 'not reef' to 'low reef' as per the referenced guidance (Envision, 2005; Smart Wind Limited, 2015; Orsted, 2018, 2020; Equinor, 2022). The Humber Aggregate Dredging Association Regional Environmental Characterisation (REC) predicted areas of high potential *S. spinulosa* 'reefiness' across the infralittoral areas of the Humber and Outer Wash Region (HADA, 2012). Additionally, the Humber REC identified aggregations of *S. spinulosa* associated with Silver Pit (Tappin *et al*., 2011). *S. spinulosa* aggregations were noted by the Viking Link Interlink, but they were not quantified as reef (Prysmian Group, 2021).

104. The most extensive biotope mapped in the Triton Knoll OWF study area was MC2211, however only a portion of the area mapped included *S. spinulosa* aggregations as reefs and no *S. spinulosa* aggregations were identified during the site-specific surveys (RWE, 2011; 2015). Pre-construction benthic surveys recorded *S. spinulosa* in low-lying intertwined tubes, in a veneer structure rather than an elevated reef structure, forming small and discontinuous clumps throughout the Triton Knoll ECC area (Triton Knoll OWF Limited, 2019). Using the 'reefiness' assessment, the majority of the area was categorised as 'not a reef,' with smaller, sporadic areas being categorised as 'occasional low reef' (Triton Knoll OWF Limited, 2019). The combined imagery, SSS, MBES, and derivative geophysical datasets, however, show that any *S. spinulosa* elevations are limited to sporadic and small clumps, rather than continuous or extensive features, and that such occurrences could only be found within the geophysical data at the very highest (most detailed) scale (Triton Knoll OWF Limited, 2019). It was therefore determined that no pertinent NERC or Annex I reef features were present within the Triton Knoll OWF Order Limits that would necessitate micrositing (Triton Knoll OWF Limited, 2019).

105. Following Triton Knoll OWF post-cable installation monitoring, the majority of samples from the post-construction surveys were identified as the biotope MC2211, which showed that the seabed communities recorded were generally concurring with those recorded during the pre-construction surveys (Precision Marine Survey Ltd, 2021). There was no reduction in *S. spinulosa* habitat that was previously designated as 'Low Reef' and at some transects, the post-construction survey's proportion of records for 'Low Reef' was higher, which could indicate higher recoverability at these locations (Precision Marine Survey Ltd, 2021). Overall, the post cable installation survey findings show that the quantity and quality of the low 'reefiness' *S. spinulosa* habitat (as well as any associated benthic communities) within the designated study area were largely comparable to pre-construction data (Precision Marine Survey Ltd, 2021). Whilst some differences were noticeable, including variation in the sediment parameters, particularly increased silt content, these changes as well as observed changes in *S. spinulosa* density were likely to reflect natural spatial and temporal variability in these relatively heterogeneous and variable habitats given the patchy nature of the *S. spinulosa* aggregations in this area (Precision Marine Survey Ltd, 2021).

106. Post-construction monitoring at Lincs OWF revealed minimal differences in *S. spinulosa* aggregations, including in elevation and patchiness (EGS, 2016). At Thanet OWF where development microsited around areas of *S. spinulosa* reef, post-construction surveys noted a positive growth of reef features which was attributed to the reduction in destructive bottom fishing activities as a result of the presence of the OWF and associated cable infrastructure (Pearce *et al*., 2014).

107. The presence of *S. spinulosa* biotopes in historical data indicates a wide distribution throughout this part of the southern North Sea, indicating that aggregations are prevalent in this area and are also likely to be ephemeral. Although the surveyed sites only resemble 'no reef' to 'low reef' according to the guidance, it is concluded that ephemeral reefs have the potential to occur within the Project if suitable conditions prevail.

108. The Project overlaps with a portion of the IDRBNR SAC which is designated for Annex I biogenic reef (*S. spinulosa* reefs) and Annex I 'Sandbanks which are slightly covered by sea water all the time'. Further detail on *S. spinulosa* encountered during site-specific surveys is presented in the subsequent sections.

109. Shallow sandy sediments comprising Annex I sandbanks are typically colonised by a burrowing fauna of worms, crustaceans, bivalve molluscs and echinoderms. Mobile epifauna at the surface of the sandbank may include shrimps, gastropod molluscs, crabs and fish. Sand-eels *Ammodytes* spp., an important food for birds, typically live in these sandy sediments.

110. The Project benthic subtidal and intertidal ecology study area is situated between five other areas delineated as sandbanks; however, these sandbanks do not form part of any designated SACs (Volume 2, Figure 9.3). The higher proportions of sandy sediment to the east of the array, along with the relatively shallow water depths in this area, provides further evidence for the expected presence of Annex I sandbank habitat beyond the southern and northern edges of the array area.

Array area

111. One location of cobble habitat was recorded in the southern extent of the array and scored 'low' resemblance to Annex I habitat 'reef', as per the qualifying criteria set out in regulatory guidance (Irving, 2009 and Golding *et al*., 2020). Whilst the station had epifauna present at sufficient densities to be considered 'possible reef with sand veneer', the mean reef species count did not meet Annex I stony reef criteria. A detailed assessment of Annex I stony reef is presented within Appendix 9.1: Benthic Ecology Technical Report (Array), paragraph 4.8.2.

112. *S. spinulosa* was present at two stations within the array (station 76 and 79a) but was typically limited to encrusting hard substrates such as cobbles and pebbles along the transect. The presence of *S. spinulosa* aggregations in the southeast array area indicated conformance to the biotope '*S. spinulosa* on stable circalittoral mixed sediment' (MC2211). However, the aggregations were not reef forming and unlikely to constitute 'reef' (Gubbay, 2007) as detailed within Appendix 9.1: Benthic Ecology Technical Report (Array), paragraph 4.8.2.

113. Other than those discussed above, there was no evidence of any Annex I habitats or Annex II species, OSPAR threatened and/or declining species and habitats (OSPAR, 2021; and ICUN, 2022), or habitats and species listed under Section 41 of the NERC Act (2006), were observed within the Array area.

Offshore Export Cable Corridor

114. Presence of cobbles at 33 stations in areas classified as 'Atlantic circalittoral mixed sediment' and 'Atlantic circalittoral coarse sediment' (Volume 2, Figure 9.4) and aggregations of cobbles recorded along four transects were assessed for the potential to constitute Annex I habitat 'Reef', in line with criteria for the evaluation of stony reef. These patches of stony habitat were scored as 'Not a reef' or 'Low resemblance' to stony reef, as per the qualifying criteria set out in regulatory guidance (Irving, 2009; and Golding *et al*., 2020). Additional to setting out the reef qualifying criteria thresholds, this guidance also suggests that *'when determining whether an area of the seabed should be considered as Annex I stony reef, if a 'low' is scored in any of the four characteristics (composition, elevation, extent or biota), then a strong justification would be required for this area to be considered as contributing to the Marine Natura site network of qualifying reefs in terms of the EU Habitats Directive'*. This suggests that the patches identified during this survey would not be considered as contributing to the national site network. One station in the central section of the offshore ECC had epifauna present at sufficient densities to be considered 'possible reef with sand veneer' or 'reef with sand veneer' according to Golding *et al*., (2020) criteria; however, the lack of mean reef species restricted the confident assignment of Annex I stony reef. Further details of the assessment are presented in Appendix 9.2: Benthic Ecology Technical Report (ECC) (paragraph 4.9.2).

115. Individuals of *S. spinulosa* were identified within the benthic grab samples at 28 stations within the offshore ECC. The highest abundance recorded was 857 individuals at a station in the central area of the offshore ECC. The DDV data also presented aggregations at eight stations across the ECC, owing to the presence of *S. spinulosa* aggregations, these transects were further assessed in relation to their 'reefiness' potential. All *S. spinulosa* aggregations were classified as 'Not a reef' in line with the criteria in Gubbay *et al*., (2007), Hendrick and Foster-Smith (2006) and Limpenny *et al*., (2010) and the methods in Jenkins *et al*., (2015) and appeared highly fragmented. Further details of the assessment are presented in Appendix 9.2: Benthic Ecology Technical Report (ECC) (Section 4.9.2).

116. As detailed in Table 9.3 a *S. spinulosa* review was undertaken by Envision with the principal objectives of identification and evaluation of *S. spinulosa* reefs within the offshore ECC, using project specific and third-party data sources (which included site specific geophysical, benthic sample, and regional seabed monitoring data). The methodological framework integrates geophysical data with benthic sample data through geospatial statistical analyses. Seabed characteristics such as rugosity, backscatter variability, and bathymetry are used to predict the distribution of seabed habitats. The study also reviewed *S. spinulosa* distribution, abundance, and reef suitability, considering data from the JNCC and habitat suitability modelling. The full methodologies and results are presented within the report (document reference 6.9.3.3).

117. The review revealed that the data from the environmental baseline and habitat assessment survey found no *S. spinulosa* reef to occur with the offshore ECC or where the offshore ECC intersects with the IDRBNR SAC. Examination of other sample data show there to be elevated numbers of *S. spinulosa* in the area but analysis of video and imagery records in accordance with guidance (Gubbay, 2007) show these have been assessed as 'not-reef' due to reduced elevation from the surrounding seabed and patchiness of distribution. Geophysical data, SSS and multi-beam bathymetry concur with this assessment and whilst SSS suggests areas of variable seafloor in and adjacent to areas where *S. spinulosa* are found in relatively high abundances bathymetry does not support reef systems being present. The habitats of '*S. spinulosa* on stable circalittoral mixed sediment' (MC2211), are predicted to occur in several areas of the offshore ECC, predominantly in the mid and near shore section, which are supported by sample data showing elevated abundance of *S. spinulosa.* However, these areas are attributed as 'not reef' as the sample data do not indicate the presence of reef.

118. Owing to the ephemeral nature of *S. spinulosa* reef habitat the Project has committed to pre-construction surveys, as set out in the In Principle Monitoring Plan (Document Reference 8.3). This will ensure provision of an appropriately contemporary dataset (i.e. less than 2 years old) with which to finalise any required micrositing to avoid such features, should these be found to comprise 'reef' rather than ephemeral crust habitats. As detailed in paragraphs 105 *et seq*., there is historic and current evidence that *S. spinulosa* in this area is patchy and ephemeral in nature, not presenting as well-developed reef, in the evidence. Owing to this, and the 2 km wide offshore ECC, the Project would expect to be able to microsite around any patches of reef that might appear within the pre-construction survey.

119. The offshore ECC crosses six sandbank areas which have been delineated by the JNCC (2020); 'Additional Bank 93', 'Additional Bank 97', 'Additional Bank 96', 'Additional Bank 8' 'Inner Dowsing North' and 'Race Bank and North Ridge' (Volume 2, Figure 9.). The 'Inner Dowsing North' and 'Race Bank and North Ridge' both form part of the 'Inner Dowsing, Race Bank and North Ridge' SAC's.

120. Sandeels *Ammodytes* spp. were present within the site-specific grab macrofauna, epibenthic trawl datasets and the video analysis. The Ocean quahog (*Arctica islandica*) a bivalve species afforded protected status under the OSPAR Commission were observed at four stations, by video analysis and still photographs; however, no adult or juvenile specimens were recovered in the trawl or grab datasets. A detailed assessment on fish and shellfish species is provided in Chapter 10: Fish and Shellfish Ecology (Document Reference 6.1.10).

121. Other than those discussed above, there was no evidence of any other habitats of principal importance, species or other habitats listed as Features of Conservation Interest (FOCI) (Natural England and JNCC 2010); no other species or habitats listed under Section 41 of the NERC Act (2006); no additional species or habitats listed on the OSPAR (2008; 2021) list of threatened and/or declining species and habitats were recovered in the samples; and no species on the International Union for Conservation of Nature (IUCN) Global Red List of threatened species (IUCN 2022).

9.5.2.16 Non-Native Species

Regional Context

122. Key marine pathways include commercial shipping, recreational boating and aquaculture for the transportation and introduction of marine INNS in the UK (Defra, 2015). The single highest potential risk pathway for the introduction of marine INNS involves vessel operations, which may involve discharge of ballast water at a site or via transportation on vessel hulls (Carlton, 1992; Pearce *et al*., 2012).

123. During the Humber REC, four species of marine INNS were found, although these species were not widespread or abundant, including the soft-shelled clam *Mya arenaria*, acorn barnacle *Elminius modestus*, mud shrimp *Monocorophium sextonae* and the slipper limpet *C. fornicata* which was the most abundant (Tappin *et al*., 2011). However, abundances of C. *fornicata* were considerably lower than other areas such as the south coast (James *et al*., 2010). With only 159 individuals recorded over the Humber REC survey, *C. fornicata* was concluded to not be likely to have an impact on native species unlike in the other locations, such as off the South Coast, where it has had a negative impact on oyster populations (Tappin *et al*., 2011). Additionally, the species is likely to be close to its temperature tolerance threshold within the region, as *C. fornicata* is vulnerable to cold temperatures; and there have been reports of population declines after cold winters (Thieltges *et al*., 2004).

Array area

124. The marine INNS *C. fornicata* was recorded at three stations across the array, with five individuals identified from one grab sample and four individuals recorded across two transects.

Offshore Export Cable Corridor

125. *C. fornicata* was recorded at 18 stations across the offshore ECC most notably with 130 individuals identified at one station in the central offshore ECC and 101 individuals in one station in the inshore area.

Intertidal

126. No non-native invasive species were observed during the Phase I intertidal survey.

9.5.2.17 Designated Sites

127. The nature designations which have been included for consideration in the benthic and intertidal ecology assessment comprise sites within the National Site Network (i.e., SACs and Special Protection Areas (SPAs) with benthic subtidal and intertidal ecology features or nationally designated sites (i.e., MCZs and SSSIs). This section identifies designated sites that have the potential to interact with the Project and therefore fall within the benthic subtidal and intertidal ecology study area (Volume 2, Figure 9.6).

128. The Project overlaps with a portion of the IDRBNR SAC which is designated for reefs and sandbanks which are slightly covered by sea water all the time both of which are assessed as being in unfavourable condition (Natural England, 2019). The most recent updated Conservation Advice Package for the site (Natural England, 2023) has also been referred to during the current assessment. The offshore ECC may pass across two of the designated sandbank features within the SAC, the North Ridge sandbank and the Inner Dowsing sandbank. The SAC is also designated for *S. spinulosa* reef. As documented in paragraphs 115 *et seq*., *S. spinulosa* was found across the offshore ECC but these were not considered to constitute reef according to the Gubbay *et al*., (2007) and Hendrick and Foster-Smith (2006) criteria.

129. As detailed in paragraph 118, on account of the ephemeral nature of *S. spinulosa* reef habitat the Project has committed to pre-construction surveys, as set out in the In Principle Monitoring Plan (Document Reference 8.3). This will ensure provision of an appropriately contemporary dataset with which to finalise any required micrositing to avoid such features, should these be found to comprise 'reef' rather than ephemeral crust habitats.

130. The sites that lie in the area of the subtidal ecology study area are identified in Table 9.8. also summarises the qualifying features that relate to seabed habitats and benthic subtidal and intertidal ecology and the distance from the closest part to the Project. The location of designated sites is presented in Volume 2, Figure 9.6.

131. An assessment of direct impacts and indirect impacts (e.g., changes in SSC and sediment deposition) as informed through the physical processes modelling presented in Appendix 7.2: Physical Processes Modelling Report, has been undertaken on relevant benthic subtidal and intertidal ecology features within sites that have the potential to be affected by the Project. Those benthic subtidal and intertidal ecology and seabed habitat features of designated sites within the wider subtidal ecology study area have been screened into the assessment for indirect impacts.

132. The Offshore ECC spatially overlaps with a small proportion of the Greater Wash SPA which is classified for the protection of red-throated diver *Gavia stellata*, common scoter *Melanitta nigra*, and little gull *Hydrocoloeus minutus* during the non-breeding season, and for breeding Sandwich tern *Sterna sandvicensis*, common tern *Sterna hirundo* and little tern *Sternula albifrons* (JNCC, 2020).

133. The SPA includes a range of marine habitats that support ornithological features, including intertidal mudflats and sandflats, subtidal sandbanks and biogenic reef, including *S. spinulosa* reefs and mussel beds (JNCC, 2020). However, of the area of the SPA which overlaps with the Order Limits, only sandbanks which are predominantly made of coarse sediments, sand and mixed sediments are predicted to occur (Natural England and JNCC, 2016).

134. Due to its location 0.05km away from a proposed ANS area the Holderness Offshore MCZ, which is assigned for the *A. islandica* and broadscale habitat features, has been evaluated as part of the benthic subtidal and intertidal ecology assessment. An assessment of the potential impacts on MCZs is also provided in Appendix 9.4: Marine Conservation Zone Assessment.

135.

Table 9.8: National and international conservation designations of relevance to benthic subtidal and intertidal ecology within the area of potential direct and indirect impact of the Project

Site	Qualifying features	Distance from the Project
SACs		
Inner Dowsing, Race Bank and North Ridge SAC	Annex I habitat: ▪ Reefs ▪ Sandbanks which are slightly covered by sea water all the time	0km from offshore ECC and biogenic reef areas and 17.3km from Array area. 30km from nearest ANS.
North Norfolk Sandbanks and Saturn Reef SAC	Annex I habitat: ▪ Reefs ▪ Sandbanks which are slightly covered by sea water all the time	17.7km from offshore ECC and 5.99km from Array area. 0.02km from nearest ANS area. 44.1km from the biogenic reef areas.
SPAs		
Greater Wash SPA	The area of the SPA includes a range of marine habitats, including intertidal mudflats and sandflats*, subtidal sandbanks and biogenic reef, including *S. spinulosa* reefs and mussel beds. **Whilst the site overlaps with the Order Limits and the secondary ZoI, not all features identified will fall within this overlap. Intertidal mudflats and sandbanks characterise the Humber and Wash Estuary and therefore do not fall within the benthic ecology study area and will not be taken forward to the assessment*.	0km from the offshore ECC and biogenic reef areas. However, the site covers an area of c. 3,536km^2. The offshore ECC has a 2.4% overlap and wider subtidal ecology study area has a 23.1% overlap with the total site. 24.7km from Array area. 24km from nearest ANS area.
MCZs		
Holderness Offshore MCZ	Broad-scale habitat ▪ Subtidal coarse sediment ▪ Subtidal sand ▪ Subtidal mixed sediments Species Feature of Conservation Importance ▪ Ocean quahog (*Arctica islandica*)	14.89km from Array area and 29.8km from the offshore ECC. 30.5km from biogenic reef areas. 0.05km from nearest ANS area.

9.5.2.18 Valued Ecological Receptors (VERs)

136. The value of ecological features is dependent upon their biodiversity, social, and economic value within a geographic framework of appropriate reference (CIEEM, 2016). The most straightforward context for assessing ecological value is to identify those species and habitats that have a specific biodiversity importance recognised through international or national legislation or through local, regional or national conservation plans (e.g., OSPAR, BAP habitats and species, habitats/species of principal importance listed under the NERC Act 2006 and habitats/species listed as features of MCZs). However, only a very small proportion of marine habitats and species are afforded protection under the existing legislative or policy framework and therefore evaluation must also assess value according to the functional role of the habitat or species. For example, some features may not have a specific conservation value in themselves but may be functionally linked to a feature of high conservation value.

137. Table 9.9 presents the VERs, their conservation status and importance within the Project benthic subtidal and intertidal ecology study area and the justification and regional importance of each receptor. Where VERs were recorded within the array, the offshore ECC and compensation areas, they have been assessed within this chapter for direct and indirect impacts. VERs located within the wider subtidal ecology study area have been assessed for indirect impacts only (Section 9.8).

138. Broad-scale habitats of the Holderness Offshore MCZ have been assessed within Section 9.8 for indirect impacts. Broad-scale habitats of the Holderness Offshore MCZ are well represented by the biotopes highlighted within Table 9.9 and therefore the MarLIN MarESA sensitivity assessment on these biotopes within Section 9.8 provides a representative evaluation of the impacts to these features. Indirect impacts on the ocean quahog (*Arctica islandica*) are included within the assessment.

Table 9.9: VERs within the Project benthic and intertidal ecology study area

VER	Representative biotope (EUNIS, 2022)	Protection status	Conservation interest	Distribution within the benthic and intertidal ecology study area	Importance within benthic and intertidal ecology study area and justification
Subtidal					
S. spinulosa on circalittoral sediment	MC2211	Within an SAC: Annex I Habitats Directive	OSPAR List of threatened and/or declining species for the Greater North Sea (OSPAR Region II). FOCI under the Nature Conservation part (Part 5) of the MCAA 2009. Habitats of Principal importance and UK BAP	*S. spinulosa* individuals were recorded at 16 locations within the array area and at 28 stations in the offshore ECC. MC2211 biotope was recorded as an intermediate habitat within the array and across 11 stations from the inshore to central offshore ECC. No reef was recorded during site-specific surveys (GeoXYZ, 2022). *S. spinulosa* reef has been predicted and recorded throughout the wider study area.	*S. spinulosa* habitat was not recorded in reef form within the Order Limits, therefore no national or international importance applied to this habitat within the offshore ECC or the array. Direct and indirect impacts to *S. spinulosa* biotopes has been assessed.

VER	Representative biotope (EUNIS, 2022)	Protection status	Conservation interest	Distribution within the benthic and intertidal ecology study area	Importance within benthic and intertidal ecology study area and justification
Brittlestar dominated communities in sandy mud and muddy sand	A5.262TMP[3] (EUNIS, 2008)	None	Habitats of Principal importance and UK BAP	Located within circalittoral muddy sand habitats across the offshore ECC, however due to impoverished conditions confidence in the biotope classification is low.	Regional – although this habitat is representative of a nationally important marine habitat, the southern North Sea is not a single key geographic area.
Mixed sediments with polychaete and epifaunal communities	MC4214	None	Habitats of Principal importance and UK BAP (subtidal sands and gravels)	Located as an intermediate habitat within coarse and mixed sediments across the array and at numerous points across the offshore ECC (Volume 2, Figure 9.4).	Regional – although this habitat is representative of a nationally important marine habitat, the southern North Sea is not a single key geographic area
Coarse and mixed sediments with moderate to high infaunal diversity and epibenthic communities	MB3231 MB3233 MB3234 MB3235 MB3237 MC3212 MD4211	None	Habitats of Principal importance and UK BAP (subtidal sands and gravels)	Located in the wider subtidal ecology study area informed by other OWFs as identified in Table 9.4.	Regional – although this habitat is representative of a nationally important marine habitat, the southern North Sea is not a key geographic area.

[3] Biotope code not recognised by EUNIS 2022.

VER	Representative biotope (EUNIS, 2022)	Protection status	Conservation interest	Distribution within the benthic and intertidal ecology study area	Importance within benthic and intertidal ecology study area and justification
Impoverished mixed gravelly sands	MC3211 MC3213	None	Habitats of Principal importance and UK BAP (subtidal sands and gravels)	Located at numerous points across the array and offshore ECC (Volume 2, Figure 9.4).	None
Subtidal sands and gravels	MD52 MC52 MD32 MC32 MB32 MB5233	None	Habitats of Principal importance and UK BAP (subtidal sands and gravels)	Located at numerous points across the array, ECC and compensation areas (Volume 2, Figure 9.4).	None
Non-cohesive muddy sands or slightly shelly/gravelly muddy sand characterised by bivalves	MC5214	None	N/A	Located outside of the Order Limits but within the wider subtidal ecology study area as identified in Table 9.4.	Local – Habitat is not protected under any conservation legislation and are found widespread around much of the UK
Littoral sand dominated by polychaetes	MA5241 MA5233 MA5413	N/A	N/A	Located across the intertidal and wider study area (Volume 2, Figure 9.5).	N/A

VER	Representative biotope (EUNIS, 2022)	Protection status	Conservation interest	Distribution within the benthic and intertidal ecology study area	Importance within benthic and intertidal ecology study area and justification
Ulva spp. On freshwater-influenced and/or unstable upper eulittoral rock	LR.FLR.Eph.Ulv[4] (JNCC code)	N/A	N/A	Located across the intertidal (Volume 2, Figure 9.5).	N/A
Talitrids on the upper shore and strandline	MA5211	N/A	N/A	Located across the intertidal and wider study area (Volume 2, Figure 9.5).	N/A
Barren Atlantic littoral coarse sand	MA5231	N/A	N/A	Located across the intertidal and wider study area (Volume 2, Figure 9.5).	N/A

[4] Biotope code not recognised by EUNIS 2022.

VER	Representative biotope (EUNIS, 2022)	Protection status	Conservation interest	Distribution within the benthic and intertidal ecology study area	Importance within benthic and intertidal ecology study area and justification
Exposed to moderately exposed, circalittoral bedrock or boulders dominated by Bryozoa and a variety of slightly scour/silt-tolerant species	MC121A MC12162	N/A	N/A	Located within the wider subtidal ecology study area informed by other OWFs as identified in Table 9.4.	N/A
Medium-coarse sands with gravel, shells, pebbles and cobbles with *C. fornicata* ascidians and anemones	MB4231	N/A	N/A	Located within the wider subtidal ecology study area informed by other OWFs as identified in Table 9.4.	N/A

VER	Representative biotope (EUNIS, 2022)	Protection status	Conservation interest	Distribution within the benthic and intertidal ecology study area	Importance within benthic and intertidal ecology study area and justification
Annex I habitat features of SACs					
Sandbanks which are slightly covered by sea water all the time	N/A	Annex I Habitats Regulations	Annex I within an SAC Habitats of Principal importance and UK BAP FOCI under the Nature Conservation part (Part 5) of the MCAA 2009	Direct overlap of the offshore ECC with 19.2km^2 of the Annex I sandbank within the SAC (5.3% of the total sandbank) (Volume 2, Figure 9.6).	National – forms part of the National Site Network of designated sites within the UK
Biogenic reef, *S. spinulosa*	N/A	Annex I Habitats Regulations	Annex I within an SAC Habitats of Principal importance and UK BAP FOCI under the Nature Conservation part (Part 5) of the MCAA 2009	*S. spinulosa* habitat was not recorded in reef form within the Order Limits.	National – forms part of the National Site Network of designated sites within the UK
Protected features of MCZs					

VER	Representative biotope (EUNIS, 2022)	Protection status	Conservation interest	Distribution within the benthic and intertidal ecology study area	Importance within benthic and intertidal ecology study area and justification
Subtidal sand	Subtidal sand sediment biotopes	MCZ	Protected feature of the MCZ established under the Marine and Coastal Access Act (2009)	Located outside the Order Limits but adjacent to the ANS within the wider subtidal ecology study area.	National.
Subtidal mixed sediments	Subtidal mixed sediment biotopes	MCZ	Protected feature of the MCZ established under the Marine and Coastal Access Act (2009)	Located outside the Order Limits but adjacent to the ANS within the wider subtidal ecology study area.	National.
Subtidal coarse sediments	Subtidal coarse sediment biotopes	MCZ	Protected feature of the MCZ established under the Marine and Coastal Access Act (2009)	Located outside the Order Limits but adjacent to the ANS within the wider subtidal ecology study area.	National.

VER	Representative biotope (EUNIS, 2022)	Protection status	Conservation interest	Distribution within the benthic and intertidal ecology study area	Importance within benthic and intertidal ecology study area and justification
Ocean quahog (*Arctica islandica*)	N/A	MCZ	Protected species of the MCZ established under the Marine and Coastal Access Act (2009)	Located outside the Order Limits but adjacent to the ANS within the wider subtidal ecology study area.	National.
Supporting habitats of the Greater Wash SPA					
Subtidal sandbanks	N/A	Annex I Habitats Regulations	Annex I within an SPA Habitats of Principal importance and UK BAP FOCI under the Nature Conservation part (Part 5) of the MCAA 2009	As for the IDRBNR SAC, direct overlap of the offshore ECC with 19.2km^2 of the Annex I sandbank within the SPA (Volume 2, Figure 9.6). The SAC and SPA protect the same sandbank habitat.	National – forms part of the National Site Network of designated sites within the UK (Greater Wash SPA).

VER	Representative biotope (EUNIS, 2022)	Protection status	Conservation interest	Distribution within the benthic and intertidal ecology study area	Importance within benthic and intertidal ecology study area and justification
Biogenic reef, including *S. spinulosa* reef	MC2211	Annex I Habitats Regulations	Annex I within an SPA Habitats of Principal importance and UK BAP FOCI under the Nature Conservation part (Part 5) of the MCAA 2009	*S. spinulosa* habitat was not recorded in reef form within the Order Limits (see document reference 9.3.3).	National – forms part of the National Site Network of designated sites within the UK (Greater Wash SPA).
Mussel beds	N/A	Annex I Habitats Regulations	Annex I within an SPA Habitats of Principal importance and UK BAP FOCI under the Nature Conservation part (Part 5) of the MCAA 2009	No mussel beds were recorded within the Order Limits (see Appendix 9.1: Benthic Ecology Technical Report (Array) (Document reference 6.3.9.1) and Appendix 9.2: Benthic Ecology Technical Report (ECC) (Document reference 6.3.9.1).	National – forms part of the National Site Network of designated sites within the UK (Greater Wash SPA).

9.5.3 Future Baseline

139. The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 require that "A description of the relevant aspects of the current state of the environment (baseline scenario) and an outline of the likely evolution thereof without implementation of the development as far as natural changes from the baseline scenario can be assessed with reasonable effort on the basis of the availability of environmental information and scientific knowledge" is included within the ES (EIA Regulations, Schedule 4, Paragraph 3). From the point of assessment, over the course of the development and operational lifetime of the Project (operational lifetime anticipated to be approximately 35 years from first power), long-term trends mean that the condition of the baseline environment is expected to evolve. This section provides a qualitative description of the evolution of the baseline environment, on the assumption that the Project is not constructed, using available information and scientific knowledge of marine water quality. A description of the future baseline conditions has been carried out (in the event of no development) and is described within this section.

140. Further to potential change associated with existing cycles and processes, it is necessary to take account of the potential effects of climate change on the marine environment. Variability and long-term changes on physical influences may bring direct and indirect changes to benthic and intertidal habitats and communities in the mid to long term future (UK Offshore Energy Strategic Environmental Assessment 3 (OESEA3), 2016). A strong base of evidence indicates that long-term changes in the benthic subtidal and intertidal ecology may be related to long-term changes in the climate or in nutrients (OESEA3, 2016), with climatic process driving shifts in abundances and species composition of benthic communities (Marine Climate Change Impacts Partnership (MCCIP), 2015). Studies of the benthic subtidal and intertidal ecology over the last three decades have shown that biomass has increased by at least 250% to 400%; opportunistic and short-lived species have increased; and the abundance of long-living sessile animals has decreased (Krönke, 1995; Krönke, 2011). Modelling sea surface temperature in relation to climate change in the UK has shown that the rate of temperature increase over the previous 50 years has been greater in waters off the east coast of the UK compared to the west and this is predicted to continue for the next 50 years (MCCIP, 2013).

141. Furthermore, most literature to date focuses on specifically temperature, with regards to the effects of climate change on marine habitats. Climatic warming also causes deoxygenation within the water column. Over the past 50 years, oxygen content has decreased from 0.06-0.43% (Stramma *et al*., 2010) with a further 7% decrease predicted for the year 2100 (IPCC, 2013). It was concluded from 26 years of monitoring a benthic community within the Firth of Clyde, UK that the benthic communities had been affected by the decreasing levels of oxygen. This finding agreed with other short-term studies (Breitburg *et al*., 2018; Levin *et al*., 2009). Specific changes included changes in morphology, burrow depth, bioturbation and feeding mode (Caswell *et al*., 2018).

142. The current baseline description above provides an accurate reflection of the current state of the existing environment. The earliest possible date for the start of construction is 2027, with an expected operational life of approximately 35 years, and therefore there exists the potential for the baseline to evolve between the time of assessment and point of impact. Outside of short-term or seasonal fluctuations, changes to the baseline in relation to benthic subtidal and intertidal ecology usually occurs over an extended period of time. Based on current information regarding reasonably foreseeable events over the next six years, the baseline is not anticipated to have fundamentally changed from its current state at the point in time when impacts occur. The baseline environment for operational/decommissioning impacts is expected to evolve as described above, with the additional consideration that any changes during the construction phase will have altered the baseline environment to a degree as set out in this chapter.

143. As such, the baseline in the Project study area described above is a 'snapshot' of the present benthic ecosystem within a gradually yet continuously changing environment. Any changes that may occur during the construction, operation and decommissioning of the Project should be considered in the context of both greater variability and sustained trends occurring on national and international scales in the marine environment, and the changes that would be expected to occur naturally in the absence of the Project.

9.6 Basis of the Assessment

9.6.1 Scope of the Assessment

9.6.1.9 Impacts Scoped in for Assessment

144. The following impacts have been scoped into this assessment:

- Construction:
  - Impact 1: Temporary habitat disturbance;
  - Impact 2: Temporary increase in suspended sediment concentration (SSC) and sediment deposition; and
  - Impact 3: Direct and indirect seabed disturbance leading to the release of sediment contaminants.
- Operation and maintenance:
  - Impact 1 : Long-term habitat loss/alteration ;
  - Impact 2: Temporary habitat disturbance;
  - Impact 3: Colonisation of the WTGs and scour/cable protection;
  - Impact 4: Increased risk of introduction or spread of INNS;
  - Impact 5: Changes in physical processes resulting from the presence of the OWF subsea infrastructure e.g., scour effects, changes in wave/tidal current regimes and resulting effects on sediment transport; and
  - Impact 6: EMF effects generated by inter-array and export cables.

- Decommissioning:
  - Impact 1: Temporary habitat disturbance;
  - Impact 2: Temporary increase in SSC and sediment deposition; and
  - Impact 3: Direct and indirect seabed disturbance leading to the release of sediment contaminants.

9.6.1.10 Impacts Scoped out of Assessment

145. In line with the Scoping Opinion (the Planning Inspectorate, 2022; outlined in Section 0) and based on the receiving environment, expected parameters of the Project (Chapter 3: Project Description (Document Reference 6.1.3), and expected scale of impact/potential for a pathway for effect on the environment, the following impacts have been scoped out of the assessment:

- Construction:
  - Impact 1: Accidental pollution event.
- Operation and maintenance:
  - Impact 1: Accidental pollution event.
- Decommissioning:
  - Impact 1: Accidental pollution event.

146. The cumulative impacts that have been considered in the CIA for all stages of the Project development and those excluded are discussed in section 9.9.

147. Transboundary impacts for all stages of the Project development have been scoped out in agreement with stakeholders and the Scoping Opinion (the Inspectorate, 2022). No other potential impacts have been scoped out from further assessment in this Environmental Statement chapter.

9.6.2 Realistic Worst-Case Scenario

148. The following section identifies the MDS in environmental terms, defined by the project design envelope. The MDSs assessed for benthic and intertidal ecology are described in Table 9.10. These scenarios will be taken forward to assess the realistic worst-case scenario for each of the identified potential impacts.

Table 9.10: Maximum design scenario for benthic subtidal and intertidal ecology for the Project alone

Potential effect	Maximum design scenario assessed	Justification
Construction		
Impact 1: Temporary habitat disturbance	**Total subtidal temporary habitat disturbance = 24,959,021m²** **Foundation Seabed Preparation = 972,300 m²** ▪ 100 small WTGs (jacket foundations with suction buckets) = 820,000m² (8,200m² per foundation x 100) ▪ Four small OSS (jacket foundations with suction buckets) = 78,400m² ▪ One accommodation platform (jacket foundations with suction buckets) = 19,600m² ▪ Two ORCPs (jacket foundations with suction buckets) = 39,200m² ▪ Two ANS (GBS foundations) = 15,100m² **Jack-up vessels (JUV) and anchoring operations = 1,160,243m²** ▪ 388 anchoring operations during WTG installation, with a maximum disturbance of 800m² per operation = 310,400m² ▪ 16 anchoring operations a maximum disturbance of 800m² per operation for installation of four OSS, one accommodation platform and two ORCPs = 12,800m² ▪ 16 anchoring operations with a maximum disturbance of 800m² per operation for installation of two ANS = 12,800 m² ▪ JUV operations for installation of 100 small WTGs (1,613m² disturbance per operation) (511 operations) = 824,243m² **Cable seabed preparation = 22,826,478 m²** ▪ Total area of seabed disturbed by sandwave clearance for inter-array cables = 4,047,830m² ▪ Total area of seabed disturbed by boulder clearance for inter-array cables = 7,472,916m²	The MDS for subtidal temporary disturbance relates to seabed preparation for foundations and cables, operations and anchoring operations, and cable installation. It should be noted that where boulder clearance overlaps with sandwave clearance, the boulder clearance footprint will be within the sandwave clearance footprint. The MDS for jacket foundations with suction buckets results in the largest total area of habitat disturbance out of all the available foundation scenarios. An MDS for intertidal temporary habitat disturbance is not included as the HDD exit pits will be designed to a target of 500m below MLWS and as such

Potential effect	Maximum design scenario assessed	Justification
	▪ Total area of seabed disturbed by sandwave clearance for interlink cables = 1,327,219m^2 ▪ Total area of seabed disturbed by boulder clearance for interlink cables =2,450,250 m^2 ▪ Total area of seabed disturbed by sandwave clearance in offshore ECC = 3,214,397m^2 Total area of seabed disturbed by boulder clearance in offshore ECC = 4,313,866m^2 **Cable burial** ▪ Impact will occur fully within combined footprint from sandwave and boulder clearance **Cable burial** ▪ Impact will occur fully within combined footprint from sandwave and boulder clearance **<u>Biogenic reef creation</u>** ▪ Creation of a biogenic reef within the biogenic reef areas	there will be no direct effects on the intertidal.
Impact 2: Temporary increase in suspended sediment and sediment deposition	**Total subtidal sediment volume = <u>34,643,122m^3</u>** **Foundation seabed preparation = 2,432,100m^3** ▪ 100 small WTGs = 2,020,000 m^3; o 50% of which are GBS foundations = 36,300 m^3 per WTG o 50% of which are suction bucket jacket foundations = 4,100 m^3 per WTG ▪ Four small OSS (GBS foundations) = 194,000m^3 ▪ One Accommodation platform (GBS foundations) = 48,500m^3	The MDS for foundation installation results from the largest volume suspended from seabed preparation and presents the worst case for WTG installation. For cable installation, the MDS results from the greatest volume from sandwave clearance and installation. This also

Potential effect	Maximum design scenario assessed	Justification
	▪ Two ORCPs = (GBS foundations) 97,000m^3 (48,500m^3 per offshore platform foundation) ▪ Two ANS = (GBS foundations) = 72,600 m^3 (36,300 m^3 per foundation). **Foundation installation (drill spoil volumes) = 987,400m^3** ▪ 100 WTG foundations (pin pile jacket foundations) = 780,000m^3 ▪ Four small OSS (pin pile jacket foundations) = 109,600m^3 ▪ One Accommodation platform (pin pile jacket foundations) = 27,400m^3 ▪ Two ORCPs (pin pile jacket foundations) = 54,800m^3 ▪ Two ANS (pin pile jacket foundations) = 15,600m^3 **Sandwave clearance for cable installation = 16,134,129m^3** ▪ Sandwave clearance for 377.4km of array cables resulting in the suspension of 7,819,671 m^3 of sediment ▪ Sandwave clearance for 123.75km of interlink cables resulting in the suspension of 2,563,945 m^3 of sediment ▪ Sandwave clearance for 440km of export cables resulting in the suspension of 5,750,513m^3 of sediment **Cable trenching = 15,058,720m^3** ▪ Installation of 377.4km of inter-array cables using mass flow excavation, resulting in the suspension of 6,038,720m^3 of sediment. ▪ Installation of 123.75km of interlink cables using mass flow excavation, resulting in the suspension of 1,980,000m^3 of sediment. ▪ Installation of 440km of export cables using mass flow excavation, resulting in the suspension of 7,040,000m^3 of sediment. **Total nearshore sediment volume = 30,000m^3**	assumes the largest number of cables and the greatest burial depth. The HDD exit pits will be designed to a target of 500m below MLWS and as such there will be no additional effect from intertidal construction activities, however, the assessment considers the potential effects of suspended sediment and sediment deposition on the intertidal from offshore construction. The maximum volume of bentonite which could be released as part of the HDD activities is considered. For this assessment, it is considered that the bentonite would not be captured and is released into the marine environment.

Potential effect	Maximum design scenario assessed	Justification
	▪ Six offshore trenchless technique exit pits require excavation of 30,000m^3 which will be side cast onto the adjacent seabed. Backfilling of exit pits will recover a similar amount from the surrounding seabed, as required. **HDD drilling fluid release** ▪ Maximum volume and mass of drilling fluid released per HDD conduit: 773m^3 fluid (138,000kg bentonite); and ▪ Period of release: 12 hours with estimated release rate of 3,195g/s. **<u>Biogenic reef creation</u>** ▪ Creation of a biogenic reef within the biogenic reef areas	
Impact 3: Direct and indirect seabed disturbances leading to the release of sediment contaminants	The MDS for seabed disturbance are presented in **Impact 2**.	This scenario represents the maximum total seabed disturbance and therefore the maximum amount of contaminated sediment that may be released into the water column during construction activities.
Operation and Maintenance		
Impact 1: Long-term habitat loss/alteration	**Total habitat loss = 4,594,670m^2** ▪ Turbine total structure footprint including scour protection, based on 100 GBS (small WTG-type) foundations = 1,230,000m^2 ▪ Structure footprint of four small OSS (jacket foundations with suction buckets) = 78,400m^2 ▪ One Accommodation platform (jacket foundations with suction buckets) = 19,600m^2 ▪ Two ORCPs platform (jacket foundations with suction buckets) = 39,200m^2	The MDS is defined by the maximum area of seabed lost as a result of the placement of structures, scour protection, cable protection and cable crossings. The MDS also considers that scour protection is required for all foundations. Habitat loss

Potential effect	Maximum design scenario assessed	Justification
	▪ Two ANS (GBS foundations) = 24,600m^2 ▪ Total area of seabed covered by cable protection required for inter-array cable crossings (rock berm) = 240,000m^2 (30 crossings) ▪ Total area of seabed covered by cable protection required for interlink cable crossings (rock berm) = 128,000m^2 (16 crossings) ▪ Total area of seabed covered by cable protection required for export cable crossings (rock berm) = 304,000m^2 (38 crossings) ▪ Total area of seabed covered by inter-array cable protection, assuming 23% of the cable requires protection = 1,031,000m^2 ▪ Total area of seabed covered by interlink cable protection, assuming 19% of the cable requires protection = 279,000m^2 ▪ Total area of seabed covered by export cable protection, assuming 21% of the cable requires protection = 1,220,870m^2 **IDRBNR SAC** ▪ Removable cable protection (mattresses/rock bags) on sandbank features within SAC = 5,760 m^2 ▪ Total cable protection outside sandbank features within the SAC = 227,558 m^2 **<u>Biogenic reef creation</u>** ▪ Creation of a biogenic reef within the biogenic reef areas	from drilling and drill arisings is of a smaller magnitude than presence of project infrastructure. Additional justification for the IDRBNR SAC mitigation is presented within Table 9.12 and Annex A.
Impact 2: Temporary habitat disturbance	**Total direct disturbance to seabed from repair/replacement activities = 6,367,098m^2** ▪ Total seabed area disturbed by WTG maintenance activities (component replacements, anode/ladder replacements, J-tube repairs) = 3,582,000m^2 ▪ Total seabed area disturbed by ANS maintenance activities= 78,858m^2	Defined by the maximum number of jack-up vessel operations and the total cable replacement through life maintenance activities that could have an interaction with the seabed

Potential effect	Maximum design scenario assessed	Justification
	▪ Total seabed area disturbed by offshore platform maintenance activities (OSS, ORCP and accommodation platform) = 313,740m^2 ▪ Total seabed disturbance from array cable repairs or remedial burial = 945,000m^2 ▪ Total seabed disturbance from ECC repairs or remedial burial = 1,111,500m^2 ▪ Total seabed disturbance from interlink cable repairs or remedial burial = 336,000m^2	anticipated during operation.
Impact 3: Colonisation of the WTGs and scour/cable protection	**Total surface area of introduced hard substrate in the water column = 46,221,434m^2** ▪ Total area of introduced hard substrate at seabed level = 4,594,670m^2 ▪ Total surface area of subsea portions of WTG foundations (GBS foundations) in contact with the water column = 40,728,200m^2 ▪ Total surface area of subsea portions of four small OSS (GBS foundations) in contact with the water column = 48,000m^2 ▪ Total surface area of subsea portions of one accommodation platform (GBS foundations) in contact with the water column = 12,000m^2 ▪ Total surface area of subsea portions of two ORCP (GBS foundations) in contact with the water column = 24,000m^2 ▪ Total surface area of subsea portions of two ANS (GBS foundations) in contact with the water column = 814,564m^2	Maximum scenario for introduced hard substrate is as for the maximum scenario for loss of habitat.
Impact 4: Increased risk of introduction or spread of marine INNS	**Total area of introduced hard substrate = 46,221,434m^2** (calculated from **Impact 3** above) ▪ Total of 2,480 annual round trips for all O&M vessels	Maximum scenario for increased risk of introduction or spread of marine INNS is as for the maximum scenario introduced hard substrate.
Impact 5: Changes in physical processes resulting from the presence of the	See MDS presented in Chapter 7: Marine Processes (Document reference 6.1.7)	

Potential effect	Maximum design scenario assessed	Justification
OWF subsea infrastructure e.g., scour effects, changes in wave/tidal current regimes and resulting effects on sediment transport.		
Impact 6: EMF effects generated by inter-array, interlink and export cables	▪ Up to 377.42km of inter-array cables, operating up to 132kV ▪ Up to 123.75km of interlink cables, operating from 66kV – 275kV. ▪ Up to 440km of export cable, operating at up to 275kV ▪ Cable burial depth (Inter-array, interlink and export cable) = 0 – 3m	Maximum scenario for EMF is defined by the maximum length of cables installed.
Decommissioning		
Impact 1: Temporary habitat disturbance	MDS is identical (or less) to that of the construction phase. Temporary habitat disturbance = 24,984,621m^2.	MDS is identical (or less) to that of the construction phase.
Impact 2: Temporary increase in suspended sediment and sediment deposition	MDS is identical (or less) to that of the construction phase. Total subtidal sediment volume = 34,643,122m^3	MDS is identical (or less) to that of the construction phase.
Impact 3: Direct and indirect seabed disturbances leading to the release of sediment contaminants	MDS is identical (or less) to that of the construction phase. Total subtidal sediment volume = 34,643,122m^3	MDS is identical (or less) to that of the construction phase.

9.6.3 Embedded Mitigation

149. Mitigation measures that were identified and adopted as part of the evolution of the project design (embedded into the project design) and that are relevant to benthic and intertidal ecology are listed in Table 9.11. General mitigation measures, which would apply to all parts of the project, are set out first. Thereafter mitigation measures that would apply specifically to benthic and intertidal ecology issues associated with the array, export cable corridor, compensation areas, and landfall are described separately.

Table 9.11: Embedded mitigation relating to benthic ecology

Project phase	Mitigation measures embedded into the project design
Construction	
Cable Burial Risk Assessment (CBRA)	Where possible, subsea cable burial will be the preferred option for cable protection. Cable burial will be informed by the cable burial risk assessment (CBRA) – which will take account of the presence of designated sites – and installation methods will be detailed within the Cable Specification and Installation Plan (CSIP). An outline CSIP has been prepared in support of the Application (document reference 8.5), which will be finalised post-consent.
Cable burial	Cable installation will follow the burial heirarchy, with at least two attempts made to bury cables before cable protection is used.
Landfall	The installation of the offshore export cables at landfall will be undertaken by HDD. The exit pits will designed to be a target 500m offshore of the Mean Low Water Springs (MLWS) mark.
Offshore ECC	Cable protection requirements close to shore will be designed to minimise changes to sediment transport pathways where practicable.
Foundations and offshore cables	Dredged material will be deposited within an area of similar sediment characteristics, in close proximity to the dredge location in order to retain sediment within the sediment transport system. No disposal will take place outside agreed disposal sites along the offshore cable corridor.
Dredge disposal within the SAC	Any material dredged from within the SAC will be deposited back within the SAC.
Pollution prevention	A Project Environmental Management Plan (PEMP) will be developed post-consent and adopted, which will cover the construction and O&M phases of the Project. This will be secured through a Condition in the deemed Marine Licence. The PEMP will include a Marine Pollution Contingency Plan (MPCP), which will provide protocols to cover accidental spills and potential contaminant release, and provide key emergency contact details.
Project Design	A Scour Protection and Cable Protection Management Plan (SPCPMP) and Cable Specification and Installation Plan (CSIP) will consider the need for scour protection and cable protection as well as cable installation methodologies and sand wave clearance/sediment disposal.
Marine INNS control	Relevant best practice guidelines will be followed and implemented through the PEMP, which will be in line with the Outline PEMP (document

Project phase	Mitigation measures embedded into the project design
	8.4) to minimise marine INNS introduction/spread. Any vessels used for the delivery of materials to site will adhere to industry legislation, codes of conduct and/or best practice to reduce the risk of introduction or spread of invasive non-native species. In the event that GBS foundations are selected for use on the Project, a Biosecurity Plan will be developed as part of the PEMP to minimise marine INNS introduction/spread.
Operation and Maintenance	
EMF and cable protection	Where possible, cables will be buried to reduce the impacts of EMF on sensitive receptors and minimise the requirement for additional cable protection.
Decommissioning	
Decommissioning Programme	Development of, and adherence to, a Decommissioning Programme.

9.6.4 Additional Mitigation

150. The mitigation measures summarised in Table 9.11 and Table 9.12 are measures that have been proposed following the assessment of impacts on benthic ecology as detailed within Section 9.8. These additional mitigation measures have been applied to the project to reduce the environmental impact on benthic ecology receptors.

Table 9.12: Additional mitigation relating to benthic and intertidal ecology.

Description	Additional mitigation measures
General	
Removable cable protection on sandbank features within the IDRBNR SAC	Cable protection installed on sandbanks within the IDRBNR SAC will be removable.
Micrositing around *S. spinulosa* habitat	Windfarm infrastructure will be micro-sited around Annex I reef as far as practicable, to avoid where possible direct impacts to these sensitive habitats. A Biogenic Reef Mitigation Plan will be developed post-consent following the pre-construction surveys which will identify any reef and confirm relevant mitigation measures implemented.
No jack-up vessels within the SAC	The use of jack-up vessels will be avoided within the SAC.

9.7 Assessment Methodology

151. This assessment is consistent with the EIA methodology presented in Chapter 5: EIA Methodology (Document Reference 6.1.5).

152. The criteria for determining the significance of effects is a two-stage process that involves defining the magnitude of the impacts and the sensitivity of the receptors. This section describes the criteria applied in this chapter to assign values to the sensitivity of receptors and the magnitude of potential impacts.

153. The magnitude of potential impacts is defined by a series of factors, including the spatial extent of any interaction, the likelihood, frequency and duration of a potential impact. The definitions of magnitude used in the assessment are defined in Table 9.12. Potential impacts have been considered in terms of permanent or temporary, and adverse or beneficial effects. Where an effect could reasonably be assigned more than one level of magnitude, professional judgement has been used to determine which rating is applicable.

Table 9.13: Impact magnitude definitions

Magnitude	Description/reason
High	Fundamental, permanent/irreversible changes, over the whole receptor, and/or fundamental alteration to key characteristics or features of the particular receptors character or distinctiveness.
Medium	Considerable, permanent/irreversible changes, over the majority of the receptor, and/or discernible alteration to key characteristics or features of the particular receptors character or distinctiveness.
Low	Discernible, temporary change, over a minority of the receptor, and/or limited but discernible alteration to key characteristics or features of the particular receptors character or distinctiveness.
Negligible	Discernible, temporary (for part of the Proposed Development duration) change, or barely discernible change for any length of time, over a small area of the receptor, and/or slight alteration to key characteristics or features of the particular receptors character or distinctiveness.

154. In line with the Chartered Institute of Ecology and Environmental Management (CIEEM) guidance (CIEEM 2016), the sensitivities of different biotopes have been classified by the Marine Life Information Network (MarLIN) on the MarESA four-point scale (high – medium – low – not sensitive) (MarLIN, 2019). The scale takes account of the resistance and recoverability (resilience) of a species or biotope in response to a stressor. Specific benchmarks (duration and intensity) are defined for the different impacts for which sensitivity has been assessed (e.g., smothering, abrasion, habitat alteration etc.). Detailed information on the benchmarks used and for further information on the definition of resistance and resilience can be found on the MarLIN website.

155. The CIEEM guidance also considers the importance of ecological features. Ecological features can be important for a variety of reasons and may relate, for example, to the quality, rarity or extent of habitats/species, and/or the extent to which they are threatened throughout their range, or to their rate of decline.

156. For the purposes of this assessment, four sensitivity categories have been defined, each drawing on the four MarLIN MarESA categories[5] and the importance of the receptor. Sensitivity/ importance of the environment is defined in Table 9.13.

[5] MarLIN - The Marine Life Information Network - Marine Evidence based Sensitivity Assessment (MarESA)

Table 9.14: Sensitivity/importance of the environment

Receptor sensitivity/ importance	Definition
High	Equivalent to MarLIN MarESA sensitivity category 'High', whereby: ▪ The habitat or species is noted as exhibiting 'None' or 'Low' resistance (tolerance) to an external factor, whether that arises from natural events or human activities, and is expected to recover only over very extended timescales i.e., >25 years or not at all (resilience is 'Very Low'); or ▪ The habitat or species is noted as exhibiting 'None' or 'Low' resistance (tolerance) to an external factor, whether that arises from natural events or human activities, and is expected to recover only over very extended timescales i.e., >10 or up to 25 years (resilience is 'Low').
Medium	Equivalent to MarLIN MarESA sensitivity category 'Medium', whereby: ▪ The habitat or species is noted as exhibiting 'None' or 'Low' resistance (tolerance) to an external factor, whether that arises from natural events or human activities, and is expected to recover over medium timescales, i.e., > 2 or up to ten years (resilience is 'Medium'); or ▪ The habitat or species is noted as exhibiting 'None' resistance (tolerance) to an external factor, whether that arises from natural events or human activities, and is expected to recover over <2 years (resilience is 'High'); or ▪ The habitat or species is noted as exhibiting 'Medium' resistance (tolerance) to an external factor, whether that arises from natural events or human activities, and is expected to recover over medium to very long timescales, i.e., >2 years or up to 25 years or not at all (resilience is 'Medium', 'Low' or 'Very Low').
Low	Equivalent to MarLIN MarESA sensitivity category 'Low', whereby: ▪ The habitat or species is noted as exhibiting 'Low' or 'Medium' resistance (tolerance) to an external factor, whether that arises from natural events or human activities, and is expected to recover over < 2 years (resilience is 'High'); or ▪ The habitat or species is noted as exhibiting 'High' resistance (tolerance) to an external factor, whether that arises from natural events or human activities, and is expected to recover over medium to very long timescales, i.e. >2 years or up to 25 years or not at all (resilience is 'Medium', 'Low' or 'Very Low').
Negligible	Equivalent to MarLIN MarESA sensitivity category 'Not Sensitive', whereby: ▪ The habitat or species is noted as exhibiting 'High' resistance (tolerance) to an external factor, whether that arises from natural events or human activities, and is expected to recover over short timescales, i.e., <2 years (resilience is 'High').

157. The matrix used for the assessment of significance is shown in Table 9.14. The combination of the magnitude of the impact with the sensitivity of the receptor determines the assessment of significance of effect. For the purposes of this assessment, any effect that is of major or moderate significance is considered to be significant in EIA terms, whether this be adverse or beneficial. Any effect that has a significance of minor or negligible is not considered to be significant in EIA terms. An assessment of the significance of potential effects is described in section 9.7 and 9.8.

Table 9.15: Matrix to determine effect significance

		Magnitude of impact			
		Negligible	*Low*	*Medium*	*High*
Sensitivity of receptor	*Negligible*	Negligible (Not significant)	Negligible (Not significant)	Minor (Not significant)	Minor (Not significant)
	Low	Negligible (Not significant)	Minor (Not significant)	Minor (Not significant)	Moderate (Significant)
	Medium	Minor (Not significant)	Minor (Not significant)	Moderate (Significant)	Major (Significant)
	High	Minor (Not significant)	Moderate (Significant)	Major (Significant)	Major (Significant)

9.7.1 Assumptions and Limitations

158. Grab sampling and video surveys, while providing detailed information on the infauna and epifauna present, cannot cover wide swaths of the seabed and consequently represent point samples that must be interpreted in combination with the geophysical datasets to produce benthic maps that provide comprehensive cover.

159. Classification of survey data into benthic habitats and the production of benthic habitat maps from the survey data, while highly useful for assessment purposes, has two main limitations:

- Difficulties in defining the precise extents of each habitat/biotope, even when using site-specific geophysical survey data to characterize the seabed; and
- There is generally a transition from one habitat/biotope to another, rather than fixed limits and therefore, the boundaries of where one habitat/biotope ends and another starts often cannot be precisely defined.

160. As eDNA is a relatively new way of supplementing baseline characterisation in offshore wind projects, there is not a wealth of literature or protocols available to understand the implications of the data provided. Although eDNA shows great promise in identifying receptors and aiding EIA monitoring, there are potentially some challenges when applied within the context of a more generic EIA framework within marine environments. As a result of these challenges, the use of eDNA is recommended as a proxy for the presence of a receptor and not a direct measure of presence (Hinz *et al*., 2022). For example, one of the challenges is defining a sampling unit and sampling strategy with respect to the survey area which can create challenges in drawing comparisons between different areas, across spatial and temporal scales (Hinz *et al*., 2022). The transport of eDNA fragments in marine environments is also generally unknown and influencing factors such as shedding dynamics, biogeochemical and physical processes need to be well understood to link a fragment of eDNA with a potential receptor's presence (Hinz *et al*., 2022)

161. Consequently, the benthic habitats and biotopes presented in the baseline environment and this chapter should not be considered as definitive, nor should the habitat boundaries be considered to be fixed, they do however represent a robust characterisation of the receiving environment.

162. There are additional limitations inherent within the MarESA sensitivity assessments. These include the assessments not being site-specific and consequently there may be differences in sensitivity within a species in different habitats. These limitations are included within the confidence score assigned to the MarESA assessment, for which the full details and rationale are provided on the MarLIN website, and in the assessment summaries.

163. The overall confidence in the evidence used for the MarESA sensitivity assessments is assessed for three categories: the quality of the evidence/information used; the degree to which the evidence is applicable to the assessment; and the degree of concordance (agreement) between the available evidence. A 'low' confidence score can be applied for the different categories if:

- For quality of the evidence – the assessment is based on expert judgement (i.e., insufficient scientific evidence or grey literature[6]);
- For applicability of the evidence – the assessment is based on proxies for the pressure (e.g., based on natural disturbance events rather than anthropogenic); and
- For the degree of concordance of the evidence – the available evidence does not agree on direction or magnitude of the impact or recoverability.

[6] Grey literature is information produced on all levels of government, academia, business and industry in electronic and print formats not controlled by commercial publishing" i.e., where publishing is not the primary activity of the producing body.

164. The confidence of the sensitivity assessment is based on the confidence of the assessments for the resilience and resistance of each habitat. If the confidence for the resilience or resistance assessment is 'low' or 'not relevant' then the corresponding confidence for the sensitivity assessment will also be low. This is of particular relevance to the quality of the evidence that is available.

165. However, despite the above uncertainties, it should be noted that there is robust data available on the benthic communities present in the study area. The seabed in the area is well studied and surveyed, therefore, the sensitivities of the habitats present are understood, and the post-construction surveys undertaken for the Project can be used to validate the assessments of the likely impacts within this chapter. As such, the available evidence base is sufficiently robust to underpin the assessment presented here.

9.8 Impact Assessment

9.8.1 Construction

166. This section presents the assessment of impacts arising from the construction phase of the Project. The effects of construction of the Project have been assessed on benthic and intertidal ecology in the Project benthic subtidal and intertidal ecology study area. The environmental impacts arising from construction of the Project are listed in Table 9.10 along with the design envelope against which each construction phase impact is assessed.

167. A description of the significance of effects upon benthic and intertidal receptors caused by each identified impact is also provided below.

9.8.1.9 Impact 1: Temporary Habitat Disturbance

168. The total maximum area of temporary loss/disturbance of subtidal habitat due to construction activities is described in Table 9.10. This equates to approximately 2.7% of the total seabed area within the Order Limits. It should be noted that the MDS presents a precautionary approach to temporary habitat disturbance because it counts both the total footprint of seabed clearance as well as cable burial across both the array and offshore ECC. This approach effectively counts the footprint of seabed habitat to be impacted by construction in the same area twice. However, this precautionary approach has been taken because there is some potential for recovery of habitats between the activities due to project timescales. There will be no impacts to the intertidal from temporary habitat disturbance; the landfall will constitute cable installation via Horizontal Directional Drilling (HDD), with exit pits designed to a target of 500m below MLWS, therefore there will be no works occurring within the intertidal.

169. Of the total area of temporary habitat loss described a maximum of approximately 17.4km^2 is predicted to be temporarily lost/disturbed within the Array area as a result of seabed preparations for foundations, jack-up barge operations and the installation and burial of inter-array and interlink cables (including associated anchor placements). This equates to approximately 4.0% of the total seabed area within the Array area.

170. Of the total area of temporary habitat loss described in Table 9.10, a maximum of approximately 7.6km^2 will be temporarily disturbed within the subtidal areas of the offshore ECC as a result of seabed preparation, OSS and accommodation platform installation, export cable installation, burial and jointing. This equates to approximately 3.3% of the total seabed area within the offshore ECC, including within the SAC. Paragraph 177 *et seq*., details the SAC specifically.

171. Of the total area of temporary habitat loss described in Table 9.10, a maximum of approximately 0.03km^2 will be temporarily disturbed within the subtidal areas of the ANS areas as a result of seabed preparation and ANS installation. This equates to approximately 0.02% of the total seabed area within the ANS areas. It is expected that any area of biogenic reef creation will result in a similarly nominal area of temporary habitat loss within the biogenic reef areas.

172. As described in section 9.4 and in Appendix 9.1: Benthic Ecology Technical Report (Array), Appendix 9.2: Benthic Ecology Technical Report (ECC), and Appendix 9.3: Intertidal Technical Report, the benthic habitats comprise macrofaunal assemblages associated with the predominantly coarse and mixed sediment habitats that characterise the array and offshore ECC. Whilst these are considered VERs (see Table 9.9), the majority of benthic habitats that are predicted to receive a direct temporary habitat disturbance of this nature are abundant and widespread throughout the wider region and southern North Sea (as previously detailed in section 9.4). The temporary habitat disturbance during construction activities would therefore have an impact on a very limited footprint, particularly when compared to the overall extent of such habitats, and this loss is not expected to undermine regional ecosystem functions or diminish biodiversity.

173. In relation to UXO detonation, there is currently insufficient certainty at this stage to undertake a quantitative assessment regarding total numbers likely to be encountered, although, based on data from neighbouring Triton Knoll, numbers are expected to be relatively low. Similarly, the size of individual ordnance present is currently unknown, hence quantitative prediction of potential impacts on the seabed are not possible at this stage. As such, the investigation and clearance of UXO is not being consented within the DCO for the Project and a separate Marine Licence application will be made prior to construction. However, a qualitative consideration of the potential likely impacts of UXO clearance at the Project is considered herein as it is considered to be a reasonably foreseeable activity which may be required.

174. The Project has committed to prioritising the use of ‘low order’ disposal techniques, should this be possible, which result in relatively low levels of impact on the seabed. In the study in the Danish Great Belt, Lepper *et al*. (2024) disposed of ordnance containing 340kg of amatol by deflagration, which involves a small charge being fired at the explosive which causes the explosive contents to ignite and burn out without detonating, which resulted in no obvious seabed damage. Consequently, the adoption of ‘low order’ disposal methods is expected to result in low magnitude impacts upon the seabed compared to more destructive ‘high order’ techniques.

175. It is currently the UK Government's position that 'low order' alternatives to 'high order' detonations should be prioritised when developing protocols to clear UXOs. The Project has committed to low order techniques as the primary method for disposal where required. The Project has also committed to detonating UXO outside the SAC where practicable. As such, any impacts from UXO clearance to benthic receptors are expected to be minimal.

176. The impact on benthic habitats is predicted to be of local spatial extent (i.e., restricted to discrete areas within the Order Limits), of a short-term duration (as it is limited to the duration of construction activities), intermittent and with high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

177. The offshore ECC passes directly through the IDRBNR SAC, crossing two of the designated sandbank features within the SAC, the North Ridge sandbank and the Inner Dowsing sandbank. The maximum total area within the SAC that is expected to be disturbed by sandwave clearance is approximately 4.63km^2 which equates to circa 0.55% of the total area of the SAC. The total area of the designated sandbank features intersected by the offshore ECC is approximately 19.2km^2, which equates to circa 4.9% of the designated sandbanks. However, the duration of the impact is limited to the duration of construction activities only, and therefore is considered to be short-term and intermittent. Furthermore, any material dredged from within the SAC will be deposited back within the SAC. Following re-settlement of the deposited sediments, they will be immediately available again for transport at the naturally occurring rate and direction, controlled entirely by natural processes. As such, the sediment will have immediately re-joined the natural sedimentary environment within the local area and so by definition is not 'lost from the system' due to the dredging/spoil disposal process. Due to the dynamic nature of the sandwaves, these morphological features are considered to have moderate levels of recoverability (Chapter 7: Marine Processes (Document Reference 6.1.7)).

178. The patterns of processes governing the overall evolution of the systems (the flow regime, water depths and sediment availability) are at a much larger scale than, and so would not be affected by, the proposed local works. As a result, the proposed clearance is not likely to influence the overall form and function of the system and eventual recovery via natural processes is therefore expected. The rate of recovery would vary in relation to the rate of sediment transport processes, faster infill and recovery rates will be associated with higher local flow speeds and more frequent wave influence (Chapter 7: Marine Processes (Document Reference 6.1.7). Pre- and repeated post-construction monitoring of the Race Bank offshore cable route (DONG Energy, 2017) has demonstrated partial recovery of sandwave crest features, following sandwave clearance, within a four-month period for which data are presently available. The sediment type and distribution are anticipated to return to the pre-impacted state over time, therefore it is considered that will be no adverse effect on the conservation objectives for the sandbanks which are slightly covered by sea water all of the time feature of the IDRBNR SAC.

179. The Great Gabbard Offshore Wind Farm constructed arrays across two sandbanks known as the Inner Gabbard and the Galloper sandbanks, however post-construction monitoring revealed sediment types and distribution remained the same, with only minor changes likely brought on by storm events and the resulting fluctuations in mud content, and faunal communities remained generally similar throughout the survey (CMACS, 2014).

180. The sediment characteristics and macrofauna of offshore sandbanks were studied before and after the construction (2005–2010) of six gravity-based foundations in an OWF in the North Sea (Coates *et al*., 2015). The sandbanks were identified as highly heterogeneous with *Nephtys cirrosa*, *O. borealis* and *G. lapidum* communities predominating with low species abundance and diversity (Coates *et al*., 2015). During construction, appreciable differences in community composition were observed, with a higher total abundance and an overall increase of the opportunistic species *S. bombyx* (Coates *et al*., 2015). From six to eight months post-construction, there were few to no changes in the median sediment grain size, possibly as a result of a quick recovery of the sedimentological characteristics (Coates *et al*., 2015). This further demonstrates how resilient and well-adapted the sandbanks are to physical disturbance. The macrofaunal community rapidly recovered post-construction, with recolonisation of the initial community 1.5 years after construction activities (Coates *et al*., 2015). Overall, the benthic ecosystem quality index indicator had an acceptable status score for the benthic characteristics between the impact and control areas over the course of the long-term monitoring, indicating that dredging had minimal effects on the benthic soft sediment community (Coates *et al*., 2015).

181. The SAC is also designated for *S. spinulosa* reef, yet this was not recorded during the site-specific ground-truth investigations within the Order Limits, according to the Gubbay *et al*. (2007) and Hendrick and Foster-Smith (2006) criteria, as detailed in Section 9.5.2.15.

182. The offshore ECC spatially overlaps with 85.7km^2 of the Greater Wash SPA, which is a total of 2.4% of the SPA. Direct impacts are predicted to occur to supporting habitats including sandbanks. Mussel beds, sandflats and mudflats have not been recorded within the Order Limits following review of site-specific data (GEOxyz, 2022b), including the use of eDNA, therefore direct impacts on these features will not be assessed. Impacts to potential *S. spinulosa* reef have been considered further in the subsequent paragraph.

183. Whilst *S. Spinulosa* reef was not recorded during the site-specific ground-truth investigations, and subsequent analysis undertaken by Envision (document reference 6.9.3.3), due to the ephemeral nature of features a pre-construction monitoring survey will be undertaken (as detailed within the In Principle Monitoring Plan (document reference 8.3)) to determine whether any reef is present within the installation corridors at the post-consent phase. If at this stage reef is located within the Order Limits, a Biogenic Reef Mitigation Plan will be developed by the Project for approval by the MMO in consultation with Natural England. This plan will aim to identify the most appropriate measures to minimise impacts to potential reef features, with the main aim being to micro-site around Annex I reef as far as practicable to avoid, where possible, direct impacts to these sensitive habitats. For this reason, the magnitude of the impact on potential *S. Spinulosa* reef as a designated feature of the IDRBNR SAC and as supporting habitat of the Greater Wash SPA is regarded as Low.

184. The sensitivity of all biotopes that are known to characterise the Array area and offshore ECC (section 9.4) have been assessed according to the detailed MarESA sensitivity assessment (Table 9.15).

Table 9.16: MarESA assessment for the benthic habitats for abrasion/disturbance

Biotope name	Biotope code (EUNIS, 2022)	Sensitivity assessment	Assessment confidence
Biotopes within the Order Limits			
Infralittoral mobile clean sand with sparse fauna	MB5231	Low (based on low resistance and high resilience)	Confidence is high as the assessment is based on peer reviewed papers
S. spinulosa on stable circalittoral mixed sediment	MC2211	Medium (based on low resistance and medium resilience)	Confidence is low as the assessment is based on expert judgement
Ophiura ophiura on circalittoral muddy sand	A5.262TMP (EUNIS 2008)	Low (based on low resistance and high resilience)	Confidence is low as the assessment is based on expert judgement
Protodorvillea kefersteini and other polychaetes in impoverished Atlantic circalittoral mixed gravelly sand	MC3213	Low (based on medium resistance and high resilience)	Confidence is low as the assessment is based on expert judgement
Flustra foliacea and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment	MC4214	Medium (based on low resistance and medium resilience)	Confidence is medium as it is based on some peer reviewed papers but relies heavily on grey literature or expert judgement on feature (habitat, its

Biotope name	Biotope code (EUNIS, 2022)	Sensitivity assessment	Assessment confidence
			component species, or species of interest) or similar features

185. As demonstrated in Table 9.15, the majority of sand and mixed sediment communities were determined as having a low sensitivity to an impact of this nature. These biotopes are typical of high energy environments and are therefore naturally subject to, and tolerant of, high levels of physical disturbance. The communities that predominantly characterise these biotopes include infaunal mobile species such as polychaetes and bivalves. Such species can re-enter the substratum following a temporary habitat disturbance of this nature. The recoverability of such communities is likely to occur as a result of a combination of recruitment from surrounding unaffected areas and larval dispersal, and recovery is likely to occur within one to ten years (based on the MarESA assessments).

186. Further evidence to support recovery is supported by research at aggregate extraction sites, where it was reported that the characteristic recovery time for typical North Sea sandy sediment communities may be two to three years, following cessation of dredging activity (Newell *et al*., 2004). Research indicated that following the initial suppression of species' diversity, abundance and biomass recovery of species' diversity to within 70 – 80% of that in non-dredged areas was achieved within 100 days (Newell *et al*., 2004). Species' abundance also recovered within 175 days (Newell *et al*., 2004). It is important to acknowledge however, that the activities associated with aggregate extraction are different to those associated with OWF construction activities. (i.e., they involve the complete removal of sediment). Data collated from more analogous activities such as the burial of telecommunications cables, as well as the monitoring of OWFs indicate that recovery is rapid with limited, if any, appreciable effects being discernible (Foden *et al*., 2011).

187. Post-construction monitoring at the Gunfleet Sand 3 demonstration project, more than 170 kilometres from the Order Limits, indicated consistency in biotope distribution and particle size composition, and no impacts were detected on a wider scale (Dong Energy, 2015). The absence of any effects supports the localised nature of any impact and/or the return to baseline conditions following the completion of construction activity (Dong Energy, 2015). Post-construction monitoring at the Thanet OWF revealed that temporal comparisons of Particle Size Distribution (PSD) data collected before and after the Thanet OWF construction and operation revealed no marked differences in sediment composition and an increase in infaunal abundance, diversity, and biomass (Thanet Offshore Wind Ltd, 2013).

188. The Lynn and Inner Dowsing OWF post-construction surveys revealed consistency in PSD post-construction and natural sediment changes within mixed sediment communities (EGS, 2011). Whereas post-monitoring of the Lincs OWF revealed differences in sediment composition compared to baseline conditions, with a decrease in the proportion of gravels and an increase in the proportion of sands, bed level changes of up to 30cm and the movement of sandwaves (EGS, 2015). However, these changes were attributed to large-scale physical processes and natural disturbance such as wave action, currents and storm events.

189. Following the completion of the CFE activities, the Hornsea Project One Offshore Wind Farm Year 2 Post-Construction CFE Monitoring Report identified no marked differences in the distribution of habitats, including broad-scale habitats, or in community structure and taxa richness (Orsted, 2020). All stations encountered sediment accretion, however there was no obvious connection to the type of substrate (Orsted, 2020).

190. Abrasion of coarser sediments is likely to disturb epifauna and may damage a proportion of those characterising epifaunal species for coarser sediments. However, opportunistic species are likely to recruit rapidly, and some damaged characterising species may recover or recolonise, resulting in a high resilience.

191. The biotope '*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment' (MC4214) was recorded as an intermediate habitat across the array and at one station in the central offshore ECC (section 9.4). Given the sessile, erect nature of hydroids and bryozoans, damage from physical disturbance is likely to be significant. Scouring by sand, mobile cobbles, and pebbles is an important structuring factor in this biotope (Connor *et al*., 2004), and thus the assemblage may be dependent on rapid recovery as well as scour resistance. The resistance of this biotope is therefore assessed as low and the MarESA describes the sensitivity as medium for abrasion and disturbance (Table 9.15).

192. The biotope '*S. spinulosa* on stable circalittoral mixed sediment' (MC2211) is described as having a 'medium' MarESA sensitivity to a disturbance of this nature. Encrusting *S. spinulosa* and patchy occurrences of potential *S. spinulosa* reef were prevalent across the array and offshore ECC and are known to occur throughout the wider region in both reef and encrusting form (section 9.4). The species is fixed to the substratum, so substratum abrasion and disturbance is likely to lead to mortality. However, *S. spinulosa* is most frequently found in disturbed sediment conditions and is a r-strategist (a life strategy which allows a species to deal with the vicissitudes of climate and food supply by responding to suitable conditions with a high rate of reproduction. R-strategists are continually colonizing habitats of a temporary nature). *S. spinulosa* occurs in high densities on subtidal gravels that would be expected to be disturbed every year or perhaps once every few years due to storms. Areas where *S. spinulosa* had been lost due to winter storms appeared to recolonize up to a maximum thickness of 2.4cm during the following summer (R. Holt, pers. Comm. In Jones *et al*., 2000). Recoverability is therefore expected to be high for the species.

193. Research from the marine aggregate industry revealed that the recovery time for *S. spinulosa* community structure can range from two to seven years, depending on the intensity of dredging (Cooper *et al*., 2007). Samples revealed marked increase in abundance, species count, and total biomass less than a year after dredging operations had concluded (Cooper *et al*., 2007). Additionally, a year after the dredging, there was an abundance of juvenile *S. spinulosa* which may have survived to form a reef, according to SSS data (Cooper *et al*., 2007). Additionally, in a study of the Wash, the more established *S. spinulosa* reef were found in areas of the ground that had been clearly damaged by dredging action and it was hypothesised that the exposed sediments are more suitable for colonisation (Foster-Smith and White, 2001).

194. *S. spinulosa* reefs are often only approximately 10cm thick, surface abrasion can, therefore, severely damage and/or remove a reef and whilst recoverability is expected to be high where this *S. spinulosa* occurs in high densities, a precautionary sensitivity assessment of high has been attributed to *S. spinulosa* reef.

195. As shown in Volume 2, Figure 9.2 the EUSeaMap (EMODnet, 2022) data identifies that the sediments of the offshore ECC in the area coinciding with the IDRBNR SAC are characterised by predominantly circalittoral coarse sediment with patches of circalittoral mixed sediments, sublittoral polychaete worm reefs on sediment, *S. spinulosa* on stable circalittoral mixed sediment and sublittoral biogenic reefs. The site-specific surveys identified that the sediments of the offshore ECC in the area coinciding with the IDRBNR SAC, are characterised by circalittoral mixed sediment interspersed with circalittoral coarse sediment and areas of *S. spinulosa* on stable circalittoral mixed sediment (Volume 2, Figure 9.4).

196. The circalittoral mixed and coarse sediment biotope complexes could not be classified further following analysis of the infaunal data, owing to the paucity of fauna. Circalittoral coarse sediment will naturally be exposed to high levels of physical disturbance and therefore is likely to be highly tolerant of an impact of this nature. A biotope that can be linked with an impoverished coarse sediment community and which was located within the array is '*Spirobranchus triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles' (MC3211). The MC3211 biotope has a high resilience to disturbance of the seabed as bryozoans, *B. crenatus* and *Spirobranchus triqueter* are rapid colonizers and likely to recover quickly, likely within months (MarESA, 2022) and therefore described as having a low sensitivity with a high recoverability (Table 9.15). Additionally, the biotope '*Mediomastus fragilis, Lumbrineris* spp. and venerid bivalves in Atlantic circalittoral coarse sand or gravel' (MC3212) was dominant and widespread across the adjacent Triton Knoll OWF (RWE, 2011). Resilience of this biotope is high as opportunistic species are likely to recruit rapidly and some damaged characterizing species may recover or recolonize and therefore this biotope has a low MarESA sensitivity to abrasion and disturbance. As detailed above, *S. spinulosa* on stable circalittoral mixed sediment is described as having a medium MarESA sensitivity with a high recoverability (Table 9.15).

197. IDRBNR Annex I sandbank habitat occupies a maximum area of 845km^2 with sandbank features classified as being in unfavourable condition (Natural England, 2023). The SAC contains a variety of dynamic sandbanks, with an influx of sediments from the north, thus the inhabiting fauna are therefore likely to be relatively tolerant to temporary habitat disturbances and there is a good chance of renewing the physical structure of the banks and associated benthic communities (JNCC and Natural England, 2010). The likely biotopes present within the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' are deemed to be of low vulnerability, medium to high recoverability and of international value. The sensitivity of the IDRBNR SAC is therefore, regarded as medium as per the evidence provided.

198. The Greater Wash SPA supporting habitats that lie within the Order Limits include sandbanks. As discussed above in relation to the IDRBNR SAC, sandbanks are deemed to be of low vulnerability, medium to high recoverability and form part of the National Site Network.

199. The sensitivity of the majority of benthic subtidal features within the Order Limits is therefore considered to be worst case medium, reflecting that the receptors have some ability to tolerate the potential impacts of temporary habitat disturbance and will potentially recover to an acceptable status over a 10-year period. However, *S. spinulosa* reef is considered to have a high sensitivity to a disturbance of this nature, however, was not recorded in reef form during site specific investigations.

200. The impact of temporary habitat disturbance on the subtidal benthic biotopes present is considered to be of low magnitude, and the sensitivity of the majority of receptors affected is considered to be worse-case medium (including the SAC and SPA, as per the evidence). The significance of the residual effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**.

201. As detailed within Table 9.12, additional mitigation will be applied to any *S. spinulosa* reef located within the Order Limits if recorded during pre-construction surveys. No reef was recorded during baseline characterisation site specific surveys and detailed analysis of geophysical data (further detail presented within Section 9.5.2.15). Implementation of mitigation options will be agreed with Natural England to identify the most appropriate measures to minimise impacts to potential reef structures, such as micrositing of infrastructure, if required. Mitigation measures for *S. spinulosa* reef will be secured through the dMLs and Biogenic Reef Mitigation Plan (document reference 8.22).

202. The MarESA assessments identify that the confidence for the sensitivity of the specified habitats to abrasion/disturbance of the surface is low to medium of the biotopes assessed within Table 9.15. The low confidence associated with MC3213, SS.Ssa.CmuSa.Ooph and MC2211 biotopes is associated with the resistance measure (resistance characteristics indicate whether a receptor can absorb disturbance or stress without changing character (Tyler-Walters *et al*. 2023)), however evidence suggests high confidence associated with the resilience (i.e. recovery) measure. Since the evidence agrees in terms of direction and magnitude of the impact the assessment is considered conservative and robust, particularly with the associated research and evidence provided.

9.8.1.10 Impact 2: Temporary Increase in Suspended Sediment and Sediment Deposition

203. Offshore temporary localised increases in SSC and associated sediment deposition and smothering are expected from foundation and cable installation works (including trenchless technique installation) and seabed preparation works (including sandwave clearance). This assessment should be read in conjunction with Chapter 7: Marine Processes (Document Reference 6.1.7), Appendix 7.1: Physical Processes Technical Baseline (Document Reference 6.3.7.1) and Appendix 7.2: Physical Processes Modelling Report (Document Reference 6.3.7.2) which provides the detailed offshore physical environment assessment (including project specific spreadsheet modelling of sediment plumes).

204. Background surface SSCs within the array area are known to vary seasonally, with higher concentrations occurring during spring tides and storm conditions, with the greatest concentrations encountered close to the bed. Within the array area offshore ECC and most biogenic reef areas and ANS areas, surface SSCs are generally low, with concentrations of up to 5mg/l were recorded between the period 1998 to 2015 (Cefas, 2016). Within the nearshore zone of the offshore ECC and reef areas, SSCs are much higher, being directly under the influence of terrestrial sources from the Humber Estuary and Holderness Cliffs, such that concentrations reach around 60mg/l, between the period 1998 to 2015 (Cefas, 2016). These concentrations also coincide with the winter months when a greater frequency of storm events and fluvial inputs (including storm runoff) can be expected to occur. During the summer months, for example July, maximum values are of the order of 12mg/l (Cefas, 2016). Site specific turbidity data from a metocean buoy currently deployed in the array area show similar concentrations, with surface values of approximately 5mg/l, rising to up to 12mg/l in the mid-water, and up to 18mg/l lower in the water column during the summer months.

205. Table 9.10 presents the MDS associated with increases in SSC and deposition. Seabed preparation for foundations, sandwave clearance for cable installation, cable trenching, drilling for foundations and spoil disposal are all predicted to result in sediment plumes and localised increases in SSC. Site-specific modelling of sediment plumes and deposition (Appendix 7.1: Physical Processes Technical Baseline) from seabed preparation and installation activities along the Project offshore ECC, and within the offshore array area for both spring and neap tides has been undertaken to quantify the potential footprint of the plumes, their longevity and the concentration of SSC as well as the subsequent deposition of plume material on the seabed.

206. The release events that have been simulated within the numerical model, as described in Appendix 7.2: Physical Processes Modelling Report, have been specifically designed to capture the full range of realistic worst-case outcomes as the maximum:

- Sediment plume concentrations;
- Sediment plume extent;
- Vertical deposition depth (bed level change); and
- Horizontal extent of deposition (spatial extent (area) of bed level change).

207. A full assessment of the above, including the methodological approach used to assess the characteristics of sediment plumes and associated changes in bed level arising from settling of material is set out in Appendix 7.2: Physical Processes Modelling Report. To provide a robust assessment, a range of realistic combinations have been considered, based on conservatively representative location (environmental) and project (MDS) specific information, including a range of water depths, heights of sediment ejection/initial resuspension, and sediment types.

208. Those Project activities within the array and offshore ECC which will result in the greatest disturbance of seabed sediments are:

- Pre-lay cable trenching using a Mass Flow Excavation (MFE) tool at the seabed;
- Seabed preparation (sandwave levelling) including spoil disposal via a Trailer Suction Hopper Dredger (TSHD); and
- Foundation installation using drilling techniques; and
- Drilling fluid release during Horizontal Directional Drilling (HDD) operations.

209. The maximum distance and as such the overall spatial extent that any resultant plume might be reasonably experienced can be estimated as the spring tidal excursion distance. Any location beyond the tidal excursion distance is unlikely to experience any measurable change in SSC from a sediment plume. Given the nature of the sediment disturbance (temporary), any impacts are also anticipated to be short-lived, with any deposited material re-worked. Specifically, the numerical modelling for seabed disturbance resulting from MFE, seabed levelling and sandwave clearance indicated that:

- MFE, seabed levelling and sandwave clearance activities may produce sediment plumes with SSC up to thousands of mg/l, however these concentrations will be spatially restricted and short-lived. Elevated SSC may be advected by tidal currents up to 20km away, although these concentrations will be low. In the vast majority of cases, elevated SSC will be indistinguishable from background levels after several tidal cycles from the start of activities and can therefore be considered temporary and localised.
- Associated deposition from sediment plumes is generally in the order of tens to low hundreds of mm within several hundreds of metres from the point of disturbance. Sediment deposition following MFE activities of up to 50mm is expected in the immediate vicinity of the active disturbance. With thicknesses between 5 and 20mm deposited up to several kilometres away from the active disturbance area, reducing to low tens of mm downstream of the disturbance. In some cases, sediment deposition of up to 50mm may occur up to 5km from the disturbance site, although these thicknesses are highly localised, following the tidal direction (i.e. not circular around the source). Sediment deposition is generally not measurable beyond 5km to 8km away from the associated activities and is therefore generally small-scale and restricted to the near field. This deposition is likely to become integrated into the local sediment transport regime and will be redistributed by tidal currents.

210. Further information on sediment plume distances and modelling are provided in Chapter 7: Marine Processes (Document Reference 6.1.7) and Appendix 7.2: Physical Processes Modelling Report (Document Reference 6.3.7.2).

211. Note the sediment plume and deposition modelling takes into consideration a single sediment dispersion event, from the deposition of one hopper load of sediment. As informed by the modelling, a single deposition event will result in the rapid dissipation of the sediment plume and localised deposition impacts. However, due consideration should also be given to the volume of sediment dispersion and deposition during the entire construction phase (as detailed in Table 9.10). It is likely that the sediments being dispersed and deposited locally will be combined during dispersion events and therefore increased deposition and SSC are expected compared to the single event modelling, discussed above.

212. The subsea export cable ducts will be installed underneath the beach using trenchless installation techniques, with HDD techniques identified as the MDS (Table 9.10). The drilling activity utilises a viscous drilling fluid which consists of a mixture of water and bentonite, a non-toxic, naturally occurring clay mineral. The release of drilling fluid and drill cuttings from HDD operations will result in a plume of elevated SSC. The drilling fluid has an overall density and viscosity similar to seawater and so is expected to behave in a similar manner.

213. The results of bentonite release modelling demonstrate that:

- Elevated SSC will be of localised extent and temporary duration, with maximum concentrations of 7.5mg/l occurring within several hundreds of metres of the punch-out in the intertidal. SSC is advected along the coast along the tidal axis to distances of up to 2km, although concentrations at this distance are limited to below 2.5mg/l. All measurable SSC will have dispersed after 15 hours. Considering generally higher background SSC conditions along the coast, these changes are likely to be indiscernible from background conditions.
- Sediment deposition of up to 10mm is predicted within several hundreds of metres of the punch-out, reducing rapidly to below 5mm. The maximum extent of deposition is predicted to be approximately 500m from release, with only thicknesses below 2mm identified at these distances. This deposition is small-scale and highly localised and is likely to be rapidly redistributed by wave action.

214. Furthermore, the creation and recreation of biogenic reef, if required, could involve the deployment of cultch (a growing medium for mussels or oyster, e.g. empty shells) which could result in a small degree of sediment suspended into the marine environment. These would be of a very small scale which is predicted to be indetectable from background levels in the surrounding environment.

215. The contemporary MarESA assessment use annual mean values to determine the sensitivity of habitats to SSCs. As a result of the short-term nature of the construction phase of the proposed project the benchmarks will not be breached, as elevations in SSC created by the construction works will not reach a sufficient scale or magnitude to significantly alter the annual mean values. Consequently, for the purposes of this assessment, reference has been made to the previous MarLIN sensitivity benchmark for short-term acute increases in SSC (i.e., an arbitrary change of 100mg/l for 1 month) together with that for short-term acute changes in turbidity (i.e., a change in two categories of the water clarity scale for a period of one month).

216. The sensitivity of the biotopes with reference to both the contemporary MarESA benchmarks for deposition and SSC, and the now superseded short-term MarLIN benchmarks for elevated SSCs and turbidity, is summarised in Table 9.17

Table 9.17: MarESA assessment for the benthic subtidal habitats for temporary increase in SSC and sediment deposition (changes in suspended solids, smothering and siltation rate)

Biotope name	Biotope code (EUNIS/ JNCC)	Sensitivity assessment	Assessment confidence
Biotopes identified within the Order Limits			
Infralittoral mobile clean sand with sparse fauna	MB5231	▪ Low sensitivity to changes in SSC and turbidity; ▪ Not sensitive to light smothering (<5cm); and ▪ Low sensitivity to heavy smothering (5 – 30cm).	Confidence is low for the SSC and turbidity assessments as they are based on expert judgement. Confidence is high for the smothering assessments as they are based on peer reviewed papers.
S. spinulosa on stable circalittoral mixed sediment	MC2211	▪ Not sensitive to changes in SSC and turbidity; ▪ Not sensitive to light smothering (<5cm); and ▪ Medium sensitivity to heavy smothering (5 – 30cm).	Confidence in the quality of the evidence is high, although the applicability and agreement between the evidence is low to medium.
Ophiura ophiura on circalittoral muddy sand (impoverished biotope)	A5.262TMP (EUNIS 2008)	▪ Not sensitive to changes in SSC and turbidity; ▪ Low sensitivity to light smothering (<5cm); and ▪ Medium sensitivity to heavy smothering (5-30cm).	Confidence is low for the assessments as they are based on expert judgement.
Protodorvillea kefersteini and other polychaetes in impoverished Atlantic circalittoral mixed gravelly sand (impoverished biotope)	MC3213	▪ Not sensitive to changes in SSC and turbidity. ▪ No evidence to sensitivity to smothering.	Confidence is low for the assessments as they are based on expert judgement.

Biotope name	Biotope code (EUNIS/ JNCC)	Sensitivity assessment	Assessment confidence
Flustra foliacea and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment	MC4214	▪ Not sensitive to changes in SSC and turbidity; ▪ Not sensitive to light smothering (<5cm); and ▪ Low sensitivity to heavy smothering (5 – 30cm).	Confidence is low for the SSC and turbidity assessments as they are based on expert judgement. Confidence is medium for the smothering assessments as they are based upon some peer reviewed papers and similar pressures.
Additional biotopes identified across the wider subtidal ecology study area			
Mediomastus fragilis, Lumbrineris spp. And venerid bivalves in Atlantic circalittoral coarse sand or gravel	MC3212	▪ Low sensitivity to changes in SSC and turbidity; ▪ Low sensitivity to light smothering (<5cm); and ▪ Medium sensitivity to heavy smothering (5 – 30cm).	Confidence is low for the SSC and turbidity assessments as these are based on proxies. Confidence is medium for the light smothering assessment, and low for the heavy smothering assessment as, although they are based upon published literature, the applicability and agreement between the evidence is low.
Flustra foliacea, small solitary and colonial ascidians on tide-swept Atlantic circalittoral bedrock or boulders	MC12162	▪ Not sensitive to changes in SSC and turbidity; ▪ Low sensitivity to light smothering (<5cm); and ▪ Medium sensitivity to heavy smothering (5 – 30cm).	Confidence is medium for the turbidity assessment and low for the smothering assessments as, although they are based upon published literature, the applicability and agreement between the evidence is low.
Nephtys cirrrosa and *Bathyporeia* spp. In Atlantic infralittoral sand	MB5233	▪ Low sensitivity to changes in SSC and turbidity;	Confidence is low for the turbidity assessment as they are

Biotope name	Biotope code (EUNIS/ JNCC)	Sensitivity assessment	Assessment confidence
		▪ Not sensitive to light smothering (<5cm); and ▪ Low sensitivity to heavy smothering (5 – 30cm).	based on expert judgement. Confidence in the quality of the evidence is high for the smothering assessments as they are based upon peer reviewed papers.
Abra alba and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	MC5214	▪ Low sensitivity to changes in SSC and turbidity; ▪ Low sensitivity to light smothering (<5cm); and ▪ Medium sensitivity to heavy smothering (5 – 30cm).	Confidence is low for the turbidity assessment as it is based on expert judgement. Confidence in the quality of the evidence is high for the smothering assessments, although the applicability and agreement between the evidence is low to medium.
Moerella spp. with venerid bivalves in Atlantic infralittoral gravelly sand	MB3233	▪ Low sensitivity to changes in SSC and turbidity; ▪ Low sensitivity to light smothering (<5cm); and ▪ Medium sensitivity to heavy smothering (5 – 30cm).	Confidence in the quality of the evidence is high for all assessments, although the applicability and agreement between the evidence is low to medium.
Sparse fauna on highly mobile Atlantic infralittoral shingle (cobbles and pebbles)	MB3231	▪ Not sensitive to changes in SSC and turbidity; ▪ Not sensitive to light smothering (<5cm); and ▪ Not sensitive to heavy smothering (5 – 30cm).	Confidence in the quality of the evidence is high for all assessments, although the applicability and agreement between the evidence is low.
Glycera lapidum in impoverished Atlantic	MB3235	▪ Not sensitive to changes in SSC and turbidity;	Confidence in the quality of the evidence is high for all

Biotope name	Biotope code (EUNIS/ JNCC)	Sensitivity assessment	Assessment confidence
infralittoral mobile gravel and sand		▪ Low sensitivity to light smothering (<5cm); and ▪ Medium sensitivity to heavy smothering (5 – 30cm).	assessments, although the applicability and agreement between the evidence is low to medium.
Crepidula fornicata with ascidians and anemones on Atlantic infralittoral coarse mixed sediment	MB4231	▪ Not sensitive to changes in SSC and turbidity; ▪ Low sensitivity to light smothering (<5cm); and ▪ Low sensitivity to heavy smothering (5 – 30cm).	Confidence is medium for the turbidity assessment as it relies on expert judgement and similar pressures. Confidence is low for the smothering assessments as they are based on expert judgment and proxies for pressures.
Dense *Lanice conchilega* and other polychaetes in Atlantic tide-swept infralittoral sand and mixed gravelly sand	MB3237	▪ Not sensitive to changes in SSC and turbidity; ▪ Not sensitive to light smothering (<5cm); and ▪ Low sensitivity to heavy smothering (5 – 30cm).	Confidence is low for the turbidity assessment and heavy smothering assessments as they rely on expert judgment. Confidence is high for the light smothering assessment as it is based on peer reviewed papers.
Molgula manhattensis with a hydroid and bryozoan turf on tide-swept moderately wave-exposed Atlantic circalittoral rock	MC121A	▪ Not sensitive to changes in SSC and turbidity; ▪ Not sensitive to light smothering (<5cm); and ▪ Low sensitivity to heavy smothering (5 – 30cm).	Confidence in the turbidity assessment is high as it is based on peer reviewed papers. Confidence is low for the smothering assessments as they rely on expert judgement and the use of proxies for pressure.
Polychaete-rich deep *Venus* community in offshore mixed sediments	MD4211	▪ Low sensitivity to changes in SSC and turbidity;	Confidence in the quality of the evidence is high for all assessments, although the applicability and

Biotope name	Biotope code (EUNIS/ JNCC)	Sensitivity assessment	Assessment confidence
(impoverished or a transition biotope)		▪ Low sensitivity to light smothering (<5cm); and ▪ Medium sensitivity to heavy smothering (5 – 30cm).	agreement between the evidence is low to medium.
Hesionura elongata and *Microphthalmus similis* with other interstitial polychaetes in Atlantic infralittoral mobile coarse sand	MB3234	▪ Not sensitive to changes in SSC and turbidity; ▪ Low sensitivity to light smothering (<5cm); and ▪ Medium sensitivity to heavy smothering (5 – 30cm).	Confidence is low for all assessments as they are based on expert judgment, and the applicability and agreement between the evidence is low.

217. The benthic subtidal habitats that characterise the benthic subtidal and intertidal ecology study area are not sensitive or low sensitivity to increases in SSC and turbidity, and light deposition (0-5cm) with a medium sensitivity to heavy deposition (5-30cm). This assessment includes representative biotopes of the broadscale habitat features of the Holderness Offshore MCZ which is adjacent to the northern ANS area.

218. The MarESA sensitivity assessment defines *S. spinulosa* as being 'not sensitive' to increases in SSC and light deposition. *S. spinulosa* tube growth is dependent on the presence of suspended particles, hence increase in suspended sediment could facilitate tube construction and may result in increased populations. However, an increase in siltation may also clog feeding apparatus and heavy levels of deposition are recorded as 'medium' (Table 9.16), but recovery of this species is understood to be almost immediate when the population can recommence feeding and growing. Extrapolating from *Sabellaria alveolata* research reveals that it is probable that *S. spinulosa* can tolerate smothering by sediment for up to several weeks. Whilst feeding and growth will be curtailed during this period recovery of *S. spinulosa* would be almost immediate once the activity ceases (Tillin, 2010).

219. *S. spinulosa* are often found in areas of high-water movement with some degree of sediment transport essential for tube-building and feeding (Pearce *et al*. 2007). Given their preference for turbid waters their tolerance to the suspension and/or settlement of fine material during adjacent construction activity may be high (Tyler-Walters 2008). *S. spinulosa* reefs adjacent to for example aggregate dredging areas appear unimpacted by dredging operations (Pearce *et al*. 2007; Pearce *et al*. 2011). Evidence suggests that given the dynamic sedimentary environments in which sabellariids live, their populations can certainly persevere in turbid conditions in spite of 'typical' natural levels of burial (Last *et al*. 2011) and that recovery from burial events is high.

220. Although not recorded within the Offshore ECC (as described in Section 9.5.2.15), *S. spinulosa* reef is a protected feature of the IDRBNR SAC, North Norfolk Sandbanks and Saturn Reef SAC and a supporting habitat within the Greater Wash SPA and may be present outside the construction corridors, but within the range of potential changes in SSC and sediment deposition predicted from construction activities.

221. Considering the noted tolerance to increases in SSC and sediment deposition and the potential for Annex I habitat within the wider benthic ecology study area, the overall sensitivity value of *S. spinulosa* reef will be assessed as medium, which is considered precautionary based on the limited extent of any predicted heavy smothering and deposition and the high recoverability and resilience of *S. spinulosa* biotopes to increases in SSC and deposition (Table 9.17).

222. Sandbanks are a primary feature of the IDRBNR SAC, North Norfolk Sandbanks and Saturn Reef SAC and supporting habitat of the Greater Wash SPA and have been well represented by the biotopes presented and assessed within this section. Whilst the importance of this habitat is increased due to its designation status the limited footprint and impact to these habitats is regarded as low magnitude.

223. The mussel bed feature of the Greater Wash SPA does not fall within the wider subtidal ecology study area and is not expected to be impacted by increased SSC, sensitivity of the biotopes 'Mussel beds on Atlantic infralittoral sediment' (MB2223) and 'Bivalve reefs in the Atlantic circalittoral zone' (MC223) have a medium sensitivity to light smothering (according to the MarESA and MarLIN benchmarks).

224. In relation to Ocean quahog (*Arctica islandica*) a Species Feature of Conservation Importance within the Holderness Offshore MCZ, the MarLIN MarESA sensitivity assessment[7] details that this species is not sensitive to heavy smothering and siltation and not sensitive to changes in suspended sediment. *A. islandica* occurs in silty sediments in sheltered to wave exposed conditions, where the surface of the sediment is probably regularly mobilized, and where accretion rates are moderate to high. Therefore, increases in turbidity (suspended sediments) and associated deposition may not adversely affect the species, especially as it can avoid sudden changes by burrowing for several days. Therefore, the sensitivity of this species is assessed as negligible.

225. Overall, it is predicted that the sensitivity of the subtidal receptors located across the benthic subtidal and intertidal ecology study area (including broad-scale habitats of the Holderness Offshore MCZ) area is at worst-case medium (to heavy smothering) according to the detailed MarESA assessments and published literature. The impact of increased SSC and deposition is considered to be of low magnitude, and the sensitivity of receptors affected is predicted to be at worst-case medium for all subtidal habitats. The significance of the residual effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**.

[7] https://www.marlin.ac.uk/species/detail/1519

226. According to the evidence provided above the features of the IDRBNR SAC, North Norfolk Sandbanks and Saturn Reef SAC and supporting habitat of the Greater Wash SPA that lie within the benthic subtidal ecology study area (which include potential *S. spinulosa* reef and sandbank features) have a maximum sensitivity of medium and a low magnitude. The significance of the residual effect is therefore concluded to be **minor adverse**, **which is not significant in EIA terms.**

227. The MarESA assessments identify that some aspects of the confidence for the sensitivity of the specified habitats to changes in SSC and for sediment deposition (smothering) is low. The MarESA assessment confidence scores were variable, low confidence scores were predominately due to low confidence for the resistance assessment and also to the applicability for the resilience assessment. The significance of effect has been assessed based on the lowest resistance score of low and resilience of medium as part of the sensitivity assessments. Therefore, while the confidence score is low, the assessment is using the most conservative sensitivity. As such, the assessment of the significance of effects is considered to be robust.

Intertidal

228. Temporary increases in SSC and associated sediment deposition in the intertidal area are expected from the cable installation works and the release of drill cuttings and drilling mud from the trenchless technique, during high water (noting that no works are planned within the intertidal). Chapter 7: Marine Processes (Document Reference 6.1.7) provides a full description of the physical assessment, with a summary of the MDS associated with the impact. Table 9.10 presents the MDS associated with increases in SSC and deposition from cable installation works.

229. Those Project activities within the offshore ECC which have the potential to result in the greatest disturbance of seabed sediments and subsequent impacts to the intertidal are:

- Drilling fluid release during Horizontal Directional Drilling (HDD) operations.

230. Whilst the HDD punch out will be located within the nearshore (subtidal) environment, it is expected that the impact has the potential to reach the intertidal to some extent. As detailed within paragraph 212 *et seq*., the drilling activities utilise a viscous drilling fluid which consists of a mixture of water and bentonite, a non-toxic, naturally occurring clay mineral. The release of drilling fluid and drill cuttings from HDD operations will result in a plume of elevated SSC. However, site specific bentonite release modelling demonstrates that these activities are considered to be restricted to the near-field, temporary, and indiscernible from background conditions. The magnitude of impact is therefore considered to be low.

231. As detailed within the VER table (Table 9.9) none of the biotopes that characterise the landfall location across the intertidal zone are rare or geographically restricted. The impact is also temporally restricted. The magnitude of the impact has been assessed as low on the basis that the impact is of temporary duration, reversible, and localised.

Table 9.18: MarESA assessment for the benthic intertidal habitats for temporary increase in SSC and sediment deposition (changes in suspended solids, smothering and siltation rate)

Biotope name	Biotope code (EUNIS/ JNCC)	Sensitivity assessment	Assessment confidence
Biotopes across the Order Limits			
Barren Atlantic littoral coarse sand	MA5231	▪ Not sensitive to changes in SSC and turbidity; ▪ Not sensitive to light smothering (<5cm); and ▪ Not sensitive to heavy smothering (5 – 30cm)	Confidence is low for all assessments as they are based on similar pressures on the feature
Talitrids on the upper shore and strandline	MA5211	▪ Not sensitive to changes in SSC and turbidity; ▪ Not sensitive to light smothering (<5cm); and ▪ Medium sensitivity to heavy smothering (5 – 30cm)	Confidence is low for all assessments as they are based on similar pressures and expert judgement
Ulva spp. On freshwater-influenced and/or unstable upper eulittoral rock	LR.FLR.Eph.Ulv	▪ Not sensitive to changes in SSC and turbidity; ▪ Low sensitivity to light smothering (<5cm); and ▪ Low sensitivity to heavy smothering (5 – 30cm)	Confidence is high for the SSC and turbidity assessment and medium for the smothering assessments as they are based upon some peer reviewed papers and similar pressures
Amphipods and *Scolelepis* spp. In Atlantic littoral medium-fine sand	MA5233	▪ Low sensitivity to changes in SSC and turbidity; ▪ Not sensitive to light smothering (<5cm); and ▪ Low sensitivity to heavy smothering (5 – 30cm)	Confidence is low for the SSC and turbidity assessment as it is based on proxies for pressures and expert judgement whilst confidence is high for all smothering assessments as they are based on peer reviewed papers.
Polychaetes in Atlantic littoral fine sand	MA5241	▪ Not sensitive to changes in SSC and turbidity; ▪ Not sensitive to light smothering (<5cm); and ▪ Low sensitivity to heavy smothering (5 – 30cm)	Confidence is low to medium for all assessments as they are based on similar pressures and expert judgement.
Additional biotopes identified across the wider study area			

Biotope name	Biotope code (EUNIS/ JNCC)	Sensitivity assessment	Assessment confidence
Nephtys cirrosa dominated littoral fine sand	MA5413	▪ Not sensitive to changes in SSC and turbidity; ▪ Not sensitive to light smothering (<5cm); and ▪ Low sensitivity to heavy smothering (5 – 30cm)	Confidence is low for SSC and heavy smothering assessments and medium for the light smothering assessment as they are based on similar pressures and expert judgement.

232. The intertidal habitats that characterise the Project landfall area have been assessed to have a low sensitivity at most to increases in SSC and turbidity, (both according to the MarESA and MarLIN benchmarks), low sensitivity at most to light deposition (0-5cm) and low sensitivity to heavy deposition (5-30cm) except for MA5211 that had a medium sensitivity (Table 9.17). The sensitivity of the receptors is therefore considered to be in the range from not sensitive to medium according to the EIA assessment values, although Table 9.17 demonstrates that lower levels of sensitivity are recorded for most biotopes. The resilience of all biotopes was assessed as high, with recovery anticipated in <2 years for all the biotopes.

233. Overall, it is predicted that the sensitivity of the intertidal receptors located across the benthic subtidal and intertidal ecology study area are low according to the detailed MarESA assessments and published literature. However, the MarESA assessments do not take into account the site-specific environmental conditions, and in considering these it is unlikely that the effects would be detectable above natural background variability.

234. The impact of increased SSC and deposition is considered to be low magnitude, and the sensitivity of receptors affected is predicted to be low for all intertidal habitats. The significance of the residual effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**.

9.8.1.11 Impact 3: Direct and Indirect Seabed Disturbances Leading to the Release of Sediment Contaminants

235. There is the potential for sediment bound contaminants, such as metals, hydrocarbons and organic pollutants, to be released into the water column and lead to an effect on benthic receptors, as a result of construction activities and associated sediment mobilisation.

236. The results of the sediment contaminant survey that has been undertaken within the Order Limits (see Appendix 9.1: Benthic Ecology Technical Report (Array) (Document reference 6.3.9.1) and Appendix 9.2: Benthic Ecology Technical Report (ECC) Document reference 6.3.9.2) revealed that across the array area the contaminants were predominantly recorded as below Cefas Action Level 1 (see Section 9.5.2.13). PAHs were generally low across the survey area with one station within a canyon feature recorded PAHs that exceeded the TEL threshold, which was hypothesised to be an area of accelerated natural deposition. TEL thresholds were exceeded at this single station for acenaphthene and phenanthrene. The concentration recorded did not exceeded the PEL threshold. The low PAHs in conjunction with low PCBs, organotins and organochlorine pesticides suggests a natural distribution of aromatic hydrocarbons across the site.

237. Seven stations recorded metal concentrations exceeding Cefas Action Level 1 including arsenic at four stations and nickel at three stations. The arsenic concentrations recorded in this study were within the range of that reported for the southern North Sea (Whalley *et al*., 1999).

238. Similar results were recorded across the offshore ECC (see Section 9.5.2.13). Two stations recorded contaminants exceeding the TEL threshold for PAHs however, none exceeded the PEL threshold.

239. Twelve stations recorded metal concentrations exceeding Cefas Action Level 1. The following metals were recorded above Cefas Action Level 1, but less than Action 2, within the offshore ECC. These included arsenic, chromium and nickel.

240. These recorded concentrations are consistent with those within marine sediments in the wider North Sea.

241. The total area that is likely to be disturbed by construction activities, and therefore the potential volume of material disturbed, resulting in the potential release of sediment bound contaminants is small and localised in extent. In addition, the nature of the subtidal sediments is predominantly coarse, typically with low levels of fines adhering to them, reducing the likelihood of these sediments containing high levels of pollutants.

242. Following disturbance as a result of construction activities, the majority of re-suspended sediments are expected to be deposited in the immediate vicinity of the works. The release of contaminants from the small proportion of fine sediments is likely to be rapidly dispersed with the tide and/or currents and therefore increased bioavailability resulting in adverse eco-toxicological effects are not expected.

243. The impact of direct and indirect seabed disturbances leading to the release of sediment contaminants is considered to be of negligible magnitude. Due to the contaminants being below both guideline and action levels where relevant (i.e., levels are below those deemed to have the potential to result in deleterious effects on fauna) and the widespread distribution of the benthic receptors being considered, the sensitivity of all benthic receptors has been assessed as low. The significance of the effect is therefore concluded to be **negligible, which is not significant in EIA terms**.

9.8.2 Operations and Maintenance

244. This section presents the assessment of impacts arising from the operational and maintenance phase of the Project. The effects of O&M from the Project have been assessed on benthic and intertidal ecology in the Project benthic subtidal and intertidal ecology study area. The environmental impacts arising from O&M of the Project are listed in Table 9.10 along with the design envelope against which each operational phase impact has been assessed.

9.8.2.9 Impact 1: Long-term or Permanent Habitat Loss/Alteration

245. The presence of the foundations and the associated scour protection, along with the cable protection measures used at cable crossings and areas where cable burial is not possible, will lead to a change from a sedimentary habitat to one characterised by hard substrate. This will be either a long-term habitat loss (approximately 35-year design life duration of the project) or a permanent change and is therefore considered an impact of the operational phase of the development and potentially beyond. It is assessed here as long-term/permanent habitat loss.

246. Table 9.10 identifies the MDS foundation, scour and cable protection footprint. The total habitat loss arising from these components would be 4.4km^2, which equates to approximately 0.6% of the subtidal habitat within the Order Limits.

247. Whilst the creation of a biogenic reef would be a change in habitat from a sediment habitat to a hard substrate habitat, similar to that from the deployment of scour or cable protection, the biogenic reef would provide a naturally occurring habitat that may have both negative and positive impacts depending on the receptor species.

248. While the impact will be locally significant and comprise a permanent change in seabed habitat within the footprint of the structures and scour and cable protection, the footprint of the area affected is highly localised. A change of subtidal sediment biotopes to rock or artificial hard substratum would alter the character of the biotope leading to reclassification and the loss of the sedimentary community. Furthermore, as the habitats and characterising biotopes are common and widespread throughout the wider region the loss of these habitats would be discernible but slight. The magnitude is therefore assessed as negligible.

249. Where the offshore ECC crosses the IDRBNR SAC and Greater Wash SPA, any cable protection that might occur in this area is expected to be a greater magnitude of effect due to the conservation status of the benthic resources. Furthermore, in the Supplementary Advice on the Conservation Objectives for the IDRBNR SAC, Natural England indicate that where hard infrastructure has been introduced the distribution of natural sandbank biological communities has been reduced (Natural England, 2023).

250. No permanent habitat loss will occur in the intertidal area of the offshore ECC as the cables at landfall will be installed using HDD, with the exit pits being designed to a target of 500m below MLWS and as such there will be no impacts to the intertidal.

251. All biotopes identified within the Order Limits have been assessed according to the MarESA criteria as having no resistance to long-term or permanent habitat loss/change, with recovery assessed as very low as the change at the pressure benchmark is at worst case permanent. The sensitivity of subtidal receptors is therefore considered to be at worst-case high according to the EIA assessment values.

252. A change of subtidal biotopes to artificial rock of hard substratum would alter the character of the biotope leading to reclassification and the loss of the sedimentary community. However, while the impact will be locally significant and comprise a permanent change in seabed habitat within the footprint of the structures and scour and cable protection, the footprint of the area affected is highly localised. Furthermore, as the habitats and characterising biotopes are common and widespread throughout the wider region the loss of these habitats is assessed as barely discernible.

253. Overall, for habitats outside the IDRBNR SAC it is predicted that the sensitivity of the receptor is high, and the magnitude is negligible. As the habitats and characterising biotopes are not geographically restricted to the Project Order Limits and are widespread throughout the southern North Sea the loss of these habitats is assessed as barely discernible and the residual effect is considered to be of **minor adverse significance, which is not significant in EIA terms**.

254. Whilst a permanent loss of habitat might occur within the SAC, where the offshore ECC overlaps, this is only a discrete location (8.3% of the total offshore ECC overlaps with the SAC) and if cable protection is required it will be a very small proportion of total overlap (0.03% of the total SAC could have cable protection).

255. On account of the conservation status of sandbanks within the IDRBNR SAC, additional mitigation measures have been developed (Table 9.12). The mitigation has been developed in line with Natural England's mitigation hierarchy for designated sites (Annex A). The mitigation that has been applied includes the following commitments:

- Should burial not be achieved at the first attempt the burial hierarchy will followed (Table 9.12); and
- Should additional protection be required then mattresses or another form of protection that is equivalent (or less in terms of footprint or impact) and removable at decommissioning, will be used across sandbank features within the IDRBNR SAC.

256. Therefore, where cable protection is required on sandbank features this will be removable at the end of the project lifetime and is therefore considered long-term rather than permanent. The magnitude of the impact is therefore considered to be low, and the impact is expected to be localised.

257. Similarly, the offshore ECC spatially overlaps with sandbank and supporting habitats of the Greater Wash SPA. However, whilst this permanent loss of habitat might occur within the SPA where the offshore ECC overlaps, this is only a discrete location (2.4% of the offshore ECC overlaps with the SPA) and if cable protection is required it will be a very small proportion of total overlap. The magnitude of the impact is therefore considered to be low, and the impact is expected to be localised.

258. The sensitivity of the benthic resource within the IDRBNR SAC and Greater Wash SPA is deemed to be high because the sandbank feature has no resistance to long-term habitat loss/change from cable protection.

259. Based on the low magnitude and high sensitivity of the sandbanks within the SAC, the significance of the effect is concluded to be moderate, which is significant in EIA terms. As detailed in Table 9.12, additional mitigation in the form of a commitment to only using removable cable protection over these designated features reduces the mitigated magnitude of the impact to negligible. Therefore, the significance of the residual effect is concluded to be **minor adverse**, which is **not significant** in EIA terms.

260. As detailed within Table 9.12, additional mitigation will be applied to any *S. spinulosa* reef located within the Order Limits if recorded during pre-construction surveys. No reef was recorded during baseline characterisation site specific surveys and detailed analysis of geophysical data (further detail presented within Section 9.5.2.15). Implementation of mitigation options will be agreed with Natural England to identify the most appropriate measures to minimise impacts to potential reef structures, such as micrositing of infrastructure, if required. Mitigation measures for *S. spinulosa* reef will be secured through the dMLs and Biogenic Reef Mitigation Plan (document reference 8.22)

9.8.2.10 Impact 2: Temporary Habitat Disturbance

261. Temporary subtidal habitat loss will arise from the use of jack-up vessels for operational and maintenance activities as well as from cable maintenance and cable replacement. The total MDS is presented in Table 9.10, which is predicted to arise over the design life of the Project (equating to approximately 0.6% of the array and offshore ECC combined).

262. Cable replacement works will require de-burial and re-burial of a cable or cable sections and along with cable preventative maintenance, including re-burial, will consequently result in increases in SSC and sediment deposition. However, the impacts from these works will be spread over the life span of O&M activities with only a limited number of activities occurring within any one year.

263. Within the IDRBNR SAC additional mitigation is proposed during the operational and maintenance phase, which includes the commitment to avoid the use of jack-up within the SAC (Table 9.12).

264. The magnitude of temporary habitat disturbance from jack-up vessels and cable maintenance activities relating to the Project will have on benthic subtidal receptors is considered to be low, indicating that the disturbance of habitat does not threaten the long-term viability of the benthic resource within the Order Limits.

265. Given that the habitats are common and widespread throughout the wider region (as described in section 9.4, the temporary habitat disturbance during O&M activities would have an impact on a very limited footprint compared to their overall extent. As detailed within Section 9.8.1.9, the habitats directly affected by habitat loss/disturbance have a worst-case sensitivity of medium to a disturbance of this nature, with the MarESA assessment also presented in detail. Section 9.8.1.10 details that the habitats indirectly affected by increased SSC and deposition have a worst-case medium sensitivity to the expected levels of SSC and deposition, with the MarESA assessment also presented in detail.

266. Overall, the impact of temporary habitat disturbance is considered to be low magnitude, and the sensitivity of receptors affected is predicted to be at worst case medium, according to the detailed MarESA assessments and published literature. The significance of the residual effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**.

9.8.2.11 Impact 3: Colonisation of the WTGs and Scour/Cable Protection

267. The introduction of hard substrate will change the type of available habitats within the benthic subtidal ecology study area. However, the amount of introduced substrate is relatively small at approximately 2.4km^2, which accounts for approximately 0.3% of the total Order Limits.

268. Hard substrate habitats are comparatively rare within the Project benthic subtidal and intertidal ecology study area which is dominated by predominantly sedimentary habitats. The introduction of hard substrate, and associated increases in biodiversity, will alter the biotopes that characterise the area at the location of the introduction of the Project infrastructure and will be long term, lasting for the duration of the development. Any effects on benthic subtidal and intertidal ecology, arising from the introduction of hard substrates will likely be localised to where foundation scour protection or cable protection is laid).

269. Whilst the creation and recreation of biogenic reef if required, would be a change in habitat from a sediment habitat to a hard substrate habitat, similar to that from the deployment of scour or cable protection, the biogenic reef could provide a naturally occurring habitat that may have both negative and positive impacts depending on the receptor species.

270. The impact is therefore predicted to be of local spatial extent, long-term duration but reversable once the infrastructure is removed, although it may be that some hard substrate (i.e. cable and/or scour protection) will remain in-situ. The magnitude of the impact is deemed to be negligible, as the habitats and characterising biotopes are not geographically restricted and are typically common and widespread throughout the wider region.

271. The introduction of new hard substrate will represent a potential shift in the baseline condition within a small proportion of the array and offshore ECC. Potential beneficial effects that may occur are associated with the likely increase in biodiversity and biomass, as has been observed at the Egmond aan Zee Offshore Windfarm (Lindeboom *et al*., 2011). Individual species with the potential to benefit from the introduction of hard substrate due to increased substrate for attachment are those which are typical of rocky habitats and intertidal environments.

272. The species potentially introduced may also have indirect and adverse effects through increased predation on, or competition with, neighbouring soft sediment species. However, such effects are difficult to predict. The increased biodiversity associated with the structures could provide benefits at higher trophic levels as the benthic organisms colonising the structures provide an additional food source. Studies at the Horns Rev Offshore Windfarm in Denmark provided evidence that OWF structures are used as successful nursery habitats for *C. pagurus* (BioConsult 2006). However, any direct benefits are only likely to occur on a very localised basis (i.e., near the infrastructure).

273. Given the presence of epifaunal species and colonising fauna within discrete parts of the array and offshore ECC (i.e., associated with coarser sediment habitats), it is predicted that colonisation of hard substrates by common species such as bryozoans and ascidians will occur.

274. The sediment biotopes likely to be affected are deemed to be of low vulnerability and of local to national value. Recoverability following removal of the infrastructure is expected to be high although it may be that some hard substrate (i.e. cable and/or scour protection) will remain in-situ. The sensitivity of these receptors is therefore, considered to be at worst case high.

275. The sensitivity of IDRBNR SAC and supporting habitats of Greater Wash SPA is regarded as high given their protection status. Therefore, the sensitivity is considered to be high, reflecting that at worst-case benthic receptors have 'none' or 'low' resistance (tolerance) to an impact of this nature.

276. While the impact will be locally significant and comprise a long-term or permanent change in seabed habitat within the footprint of the structures and scour and cable protection, the footprint of the area affected and any associated increases and/or changes in biodiversity will be highly localised. As the habitats and characterising biotopes are common and widespread throughout the wider region, the loss of these habitats is assessed as barely discernible.

277. Overall, the impact from colonisation of hard substrates is considered to have a negligible magnitude, and the sensitivity of receptors affected is predicted to be at worst case high. The significance of the residual effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**.

9.8.2.12 Impact 4: Increased Risk of Introduction or Spread of Marine INNS due to the Presence of Infrastructure and Vessel Movements

278. There is a risk that the introduction of hard substrate into a sedimentary habitat will enable the colonisation of the introduced substrate by invasive/non-indigenous species that might otherwise not have had a suitable habitat for colonisation, thereby enabling their spread. This along with the movement of vessels to and from the Order Limits has the potential to impact upon benthic subtidal and intertidal ecology and biodiversity locally and in the broader region.

279. Table 9.10 presents the MDS for new hard substrate habitat that will be introduced into the array, the offshore ECC, and compensation areas which has the potential to provide new habitat for colonisation by marine INNS. In addition, Table 9.10 details the round trips to port during the O&M phase which will contribute to the risk of introduction or spread of marine INNS through ballast water discharge.

280. As detailed within Table 9.11, embedded environmental measures which include a PEMP with a biosecurity plan (in the event that GBS foundations are used) will ensure that the risk of potential introduction and spread of marine INNS from increased vessel activity is minimised.

281. It should be noted that there is a wide-spread presence of marine INNS across the southern North Sea. The marine INNS *C. fornicata* has successfully established to an extent that it outcompetes indigenous species causing large scale habitat changes across coastal areas of the UK (EMU Limited, 2012). Moreover, the most problematic marine INNS off the Lincolnshire coastline are Chinese mitten crab *Eriocheir sinensis*, leathery sea squirt *Styela clava* and wireweed *Sargassum muticum*, demonstrating that the region is not a pristine environment in terms of the absence of marine INNS (Dittel *et al*., 2009; Holdich *et al*., 2009; Macleod *et al*., 2016 and Nehls *et al*., 2006).

282. Embedded measures, including a PEMP (Table 9.11) will, however, ensure that the risk of potential introduction and spread of marine INNS will be minimised as low as practicable.

283. The impacts on biotopes and VER within the array and offshore ECC is predicted to be of low spatial extent (though the introduction of structures may serve as 'stepping stones' and extend the impact beyond a local scale, however based on current scientific knowledge it is not possible to predict whether such a spread will occur and to what extent and which species, if any, this may involve), long term permanent duration, continuous and irreversible. It is predicted that the impact will affect the receptors indirectly. The magnitude of this impact is therefore considered to be negligible.

284. The sensitivity of benthic receptors within the benthic study area to an introduction or spread of marine INNS is deemed to be at worse case 'high', given the lack of evidence for a potential impact of this nature. The sensitivity of nearby SAC, SPA and MCZ features is also regarded as high. Therefore, the sensitivity is considered to be high, reflecting that at worst-case benthic receptors have 'none' or 'low' resistance (tolerance) to an impact of this nature.

285. Overall, the increased risk of introduction or spread of marine INNS is considered to be negligible magnitude, and the sensitivity of receptors affected is predicted to be at worst case high. The significance of the residual effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**.

9.8.2.13 Impact 5: Changes in Physical Processes Resulting from the Presence of the OWF Subsea Infrastructure e.g., Scour Effects, Changes in Wave/Tidal Current Regimes and Resulting Effects on Sediment Transport

286. The presence of foundations, scour protection and cable protection material may introduce changes to the local hydrodynamic and wave regime (Table 9.11), resulting in changes to the sediment transport pathways and associated effects on benthic subtidal and intertidal ecology. Scour and increases in flow rates can change the characteristics of the sediment potentially making the habitat less suitable for some species.

287. The use of correctly designed scour protection at foundations and sufficiently buried cables (Table 9.11) will prevent scour occurring. Scour will therefore only occur if and where scour protection has not been applied.

288. The exact form of cable protection to be used will depend upon local ground conditions, hydrodynamic processes, and the selected cable protection contractor. Where cable protection is used, some scouring is predicted to occur throughout the operational phase at these features. The extent of this scouring is predicted to be local, occurring around the perimeter of rock berms.

289. Chapter 7: Marine Processes (Document Reference 6.1.7) has determined that the impacts on hydrodynamic and wave regimes will be not significant to coastal and physical processes and will therefore not result in any marked changes to sediment transport and consequently will not have any notable impacts on benthic subtidal and intertidal ecology. The magnitude of this impact is therefore considered to be negligible.

290. As detailed within Section 9.8.1.9, the habitats directly affected by habitat loss/disturbance have a worst-case sensitivity of medium to a disturbance of this nature, with the MarESA assessment also presented in detail. Section 9.8.1.10 detail that the habitats indirectly affected by increased SSC and deposition have a worst-case medium (including nearby SAC, SPA and MCZ features) to the expected levels of SSC and deposition, with the MarESA assessment also presented in detail.

291. Overall, the impact from changes in physical processes is considered to be of negligible magnitude, and the sensitivity of receptors affected is considered to be a worst-case medium for all benthic subtidal and intertidal ecology. The significance of the effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**.

9.8.2.14 Impact 6: EMF Effects Generated by Inter-Array and Export Cables During the Operational Phase

292. EMF are generated by the current that passes through an electric cable. It is known that EMF can be detected by fish and elasmobranchs, and it is thought that any benthic invertebrates can also detect EMF. Three types of fields are generated by underwater electric cables: electric fields (E-fields), magnetic fields (B-fields) and induced electric fields (iE-fields). Standard industry practice is for the cables used to have sufficient shielding to contain the E-fields generated and the cable system descriptions for the inter-array and export cables have abided by this (Chapter 3: Project Description (Document Reference 6.1.3). Shielding and/or burial does not reduce the B-fields and it is these fields that allow the formation of iE-fields. As such, further reference here to EMF is limited to B-fields and associated iE-fields.

293. Impacts from changes in EMFs arising from cables, are not considered to result in any appreciable effects on benthic subtidal and intertidal ecology receptors. EMFs are likely to be generated by subsea cables and detectable above background levels in close proximity to the cables. Although burial and external cable protection does not mask EMFs, it increases the distance between species that may be affected by EMFs and the source. As the cable will be buried or protected, as detailed within Table 9.11, any behavioural responses are likely to be mitigated.

294. It is considered unlikely that EMFs will result in a behavioural response that will cause a change in benthic communities within the benthic subtidal and intertidal ecology study area and that any potential negative effects will be confined to a localised area surrounding the cables. Therefore, the magnitude of the impact is considered to be negligible, indicating that any behavioural response of benthic fauna is likely to be indiscernible or barely discernible over a very small area, that does not threaten benthic subtidal ecology features, undermine regional ecosystem functions or diminish biodiversity.

295. The MarESA sensitivity assessments do not consider there to be sufficient evidence to support assessments of impacts of EMF on benthic and intertidal habitats; therefore, a desktop study has been undertaken to describe the typical responses of benthic invertebrates. A detailed assessment on elasmobranch, fish and shellfish species is provided in Chapter 10: Fish and Shellfish Ecology (Document Reference 6.1.10).

296. Typically, the impacts of EMF on marine organisms have focused on electrically sensitive fish and elasmobranchs, with little research focusing on benthic invertebrates, with the few studies using invertebrates focusing on crustaceans (e.g., Woodruff *et al*., 2012). Furthermore, many studies contradict each other or provide inconclusive results (Switzer and Meggitt, 2010), further reducing the available evidence.

297. However, evidence of sensing, responding to, orienting to natural magnetic field cues has been shown for invertebrates including molluscs and arthropods (Boles and Lohmann, 2003; Lohman and Willows, 1987; Ugolini, 2006; Ugolini and Pezzani, 1995). Scott *et al*. (2021) investigated the effects of EMF (strengths 250µT, 500µT and 1000µT) from submarine power cables on edible crab, showed limited physiological and behavioural effects on the crabs exposed to EMF of 250µT. EMF of 500µT or above showed physiological stress in crabs, and changes to behavioural trends, specifically an attraction to EMF. It is to be noted however, that these studies investigated EMF strengths significantly higher than those that receptors will typically be exposed to as a result of offshore wind cables in the marine environment. Specifically, the lowest experimental EMF used in Scott *et al*. (2021) was a factor of 10 higher than that expected for the Project at 1m from the cable, with no impacts identified at this EMF strength. Effects were only noted in these studies using EMF strengths which were a factor of 20 – 1,000 higher than those expected from the Project cables. Taking this into consideration, any effects on marine invertebrates are anticipated to only occur in the immediate vicinity of the cable. Therefore, it is considered that it is unlikely that there would be any impacts to crustaceans from EMF resulting from cables associated with the Project.

298. A laboratory study assessing the effects of environmentally realistic, low-frequency B-field exposure on the behaviour and physiology of the common ragworm *Hediste diversicolor* did not find any evidence of avoidance or attraction behaviours (Jakubowska *et al*., 2019). The polychaetes did, however, exhibit enhanced burrowing activity when exposed to the B-field, with plausible consequences for their metabolism; however, knowledge about the biological relevance of this response is currently absent (Jakubowska *et al*., 2019).

299. One recent study examined the difference in invertebrate communities along an energised and nearby surface laid cables. The study identified that there were no functional differences between the communities on and around the cables up to three years after installation (Love *et al*., 2016). The same study also identified that EMF levels reduce to background levels generally within one metre of the cable.

300. For invertebrate receptor species, it is difficult to translate the patchwork of knowledge about individual-level EMF effects into assessments of biologically or ecologically significant impacts on populations (Boehlert and Gill, 2010). However, given the evidence presented, it is predicted that EMFs have no significant impact on mobile or sessile benthic invertebrates, including if the cable is surface laid.

301. The sensitivity of benthic receptors (including SAC, SPA and MCZ features) is therefore considered to be low, reflecting that the receptors has a high resistance and ability to tolerate the impacts of EMF over the approximate 35-year operational lifetime of the Project.

302. The Project has committed to bury or protect cables (Table 9.11), therefore any behavioural responses of benthic receptors are likely to be mitigated through separation of the cables from the receptors. Overall, it is predicted that the sensitivity of the benthic subtidal and intertidal receptors found within the Order Limits is low and the magnitude is negligible. The residual effect significance is therefore **negligible, and not significant in EIA terms**.

9.8.3 Decommissioning

303. The effects of the decommissioning of the Project have been assessed on benthic and intertidal ecology in the Project benthic subtidal and intertidal ecology study area. The environmental impacts arising from the decommissioning of the Project are listed Table 9.10, along with the design envelope against which each decommissioning phase impact has been assessed.

304. A description of the significance of effect upon benthic and intertidal receptors caused by each identified impact is provided below.

9.8.3.9 Impact 1: Temporary Disturbance

305. Temporary habitat loss/disturbance of subtidal habitat within the Project area will occur as a result of the jack-up vessel operations to remove the foundations and superstructure of the wind farm infrastructure and the removal of the export and array cables and associated cable protection (where this has been proposed to be removed i.e. on sandbank features of the IDRBNR SAC).

306. The total maximum area of temporary habitat disturbance due to jack-up vessels and infrastructure removal during decommissioning has not been fully quantified but is likely to closely reflect that assessed for the construction phase (see Section 9.8.1.9).

307. Given that the habitats are common and widespread throughout the region, this represents a very small footprint compared to their overall extent. The impacts will be temporary and only a single event in each location; therefore, the magnitude of the impact is assessed as low.

308. It is predicted that the temporary habitat disturbance from ORCP and cable removal during decommissioning will affect the SPA and SAC features directly however, the magnitude is low due to the limited duration and reversibility.

309. The sensitivities of the species to disturbance are described in paragraph 185 *et seq*. The magnitude of the impact has been assessed as low, with the maximum sensitivity of the receptors being medium (including within the SAC and SPA as described in Section 9.8.1.9). Therefore, the significance of effects from direct disturbance occurring as a result of decommissioning activities is **minor adverse, and not significant in EIA terms**.

9.8.3.10 Impact 2: Temporary Increase in Suspended Sediment and Sediment Deposition

310. Increases in SSC and sediment deposition from the decommissioning works will be similar to that for construction and are of a similar magnitude. The magnitude of the impact and the sensitivities of the benthic habitats to SSC and sediment deposition are described in detail in paragraph 216 *et seq*. and for the intertidal habitats in paragraph 232 *et seq*.

311. The magnitude of the impact has been assessed as low, with the maximum sensitivity of the receptors being medium. Therefore, the significance of effect from changes in SSC or sediment deposition occurring as a result of decommissioning activities in the subtidal and intertidal area is **minor adverse, and not significant in EIA terms**.

9.8.3.11 Impact 3: Direct and Indirect Seabed Disturbances Leading to the Release of Sediment Contaminants

312. Direct and indirect seabed disturbances leading to the release of sediment contaminants from the decommissioning works will be similar to that for construction and are of a similar magnitude. The magnitude of the impact and the sensitivities of the benthic habitats to direct and indirect seabed disturbances leading to the release of sediment contaminants are described in detail in Section 9.8.1.11.

313. The impact is predicted to be of local spatial extent, short term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low. Due to the contaminants being below both guideline and action levels where relevant (i.e., levels are below those deemed to have the potential to result in deleterious effects on fauna) and the widespread distribution of the benthic receptors being considered, the sensitivity of benthic receptors has been assessed as low. The impact is therefore predicted to be **minor adverse, and not significant in EIA terms**.

9.9 Cumulative Effects Assessment

314. This cumulative effects assessment (CEA) for benthic and intertidal ecology has been undertaken in accordance with the methodology provided in Appendix 5.1: Offshore Cumulative Effects Assessment.

315. The projects and plans selected as relevant to the assessment of impacts to benthic and intertidal ecology are based upon an initial screening exercise undertaken on a long list. Each project, plan or activity has been considered and scoped in or out on the basis of effect-receptor pathway, data confidence and the temporal and spatial scales involved. For the purposes of assessing the impact of the Project on benthic and intertidal ecology in the region, the cumulative effect assessment technical note submitted through the EIA Evidence Plan and forming Appendix 5.1: Offshore Cumulative Effects Assessment of this Environmental Statement screened in a number of projects and plans as presented in Table 9.18.

Table 9.19: Projects considered within the benthic and intertidal ecology cumulative effects assessment

Development type	Project	Status	Data confidence assessment/phase	Tier
Offshore Wind Farm	Sheringham Shoal Extension	Determination	High – Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate	Tier 1[8]
Offshore Wind Farm	Dudgeon Extension	Determination	High – Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate	Tier 1
Offshore Wind Farm	Inner Dowsing	Active/In Operation	High – Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate	Tier 1
Offshore Wind Farm	Lincs	Active/In Operation	High – Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate	Tier 1
Offshore Wind Farm	Triton Knoll	Active/In Operation	High – Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate	Tier 1
Offshore Wind Farm	Dudgeon	Active/In Operation	High – Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate	Tier 1
Offshore Wind Farm	Race Bank	Active/In Operation	High – Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate	Tier 1

[8] Tier 1 criteria include development under construction; permitted or submitted applications, whether under the PA2008 or other regimes, but not yet implemented (Planning Inspectorate, 2019).

Development type	Project	Status	Data confidence assessment/phase	Tier
Offshore Wind Farm	Lynn	Active/In Operation	High – Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate	Tier 1
Aggregate Production Area	Outer Dowsing Westminster Gravels Ltd (515/2)	Operation 01/01/2015 – 31/12/2029	High – Third party project details published in the public domain and confirmed as being 'accurate' by the developer.	Tier 1
Aggregate Production Area	Outer Dowsing Westminster Gravels Ltd (515/1)	Operation 01/01/2015 – 31/12/2029	High – Third party project details published in the public domain and confirmed as being 'accurate' by the developer.	Tier 1
Aggregate Production Area	Hanson Aggregates Marine Ltd (106/2)	Operation	High – Third party project details published in the public domain and confirmed as being 'accurate' by the developer.	Tier 1
Aggregate Production Area	Hanson Aggregates Marine Ltd (106/3)	Operation	High – Third party project details published in the public domain and confirmed as being 'accurate' by the developer.	Tier 1
Aggregate Production Area	Hanson Aggregates Marine Ltd (106/1)	Operation	High – Third party project details published in the public domain and confirmed as being 'accurate' by the developer.	Tier 1
Aggregate Production Area	Hanson Aggregates Marine Ltd (400)	Operation	High – Third party project details published in the public domain and confirmed as being 'accurate' by the developer.	Tier 1
Aggregate Production Area	Tarmac Marine Ltd (197)	Operation	High – Third party project details published in the public domain and confirmed as being 'accurate' by the developer.	Tier 1
Aggregate Production Area	Tarmac Marine Ltd (493)	Operation	High – Third party project details published in the public domain and confirmed as being 'accurate' by the developer.	Tier 1

Development type	Project	Status	Data confidence assessment/phase	Tier
Aggregate Production Area	Inner Dowsing Tarmac Marine Ltd (481/1)	Operation	High – Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate	Tier 1
Aggregate Production Area	Inner Dowsing Tarmac Marine Ltd (481/2)	Operation	High – Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate	Tier 1
Aggregate Production Area	Inner Dowsing Hanson Aggregates Marine Ltd (Area 1805)	Operational (Exploration and Option Area, application for Extraction expected shortly)	High – Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate	Tier 2
Aggregate Production Area	Aggregate Tender Area (2103)	Tender Area (2021/2022)	Low – no information available	Tier 3
Sea Disposal Site	Race Bank OWF	Open	High – Third party project details published in the public domain and confirmed as being 'accurate' by the developer.	Tier 1
Pipeline	Gas Shearwater to Bacton Seal Line (Shell)	Active/In Operation	High – Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate	Tier 1
Military, Aviation and Radar	D323D Southern Managed Danger Area	Active	High – Third party project details published in the public domain and confirmed as being 'accurate' by the developer.	Tier 1
Subsea Cable	Viking Link Interconnector	Complete/in operation	High – Third party project details published in the public domain but not confirmed as being 'accurate' by The Crown Estate	Tier 1

316. Certain impacts assessed for the project alone are not considered in the cumulative assessment due to:

- The highly localised nature of the impacts (i.e., they occur entirely within the Order Limits only);
- Management measures in place for the Project will also be in place on other projects reducing the risk of impacts occurring; and/or
- Where the potential significance of the impact from the Project alone has been assessed as negligible.

317. Therefore, the CEA has only considered:

- temporary increases in SSC and sediment deposition during construction.

318. The cumulative MDS described in Table 9.19 have been selected as those having the potential to result in the greatest cumulative effect on an identified receptor group. The cumulative impacts presented and assessed in this section have been selected from the details provided in the project description for the Project, as well as the information available on other projects and plans in order to inform a cumulative MDS. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the project design envelope to that assessed here, be taken forward in the final design scheme.

Table 9.20: Cumulative MDS for benthic and intertidal ecology

Impact	Scenario	Justification
Cumulative temporary increase in SSC and sediment deposition	Tier 1: ▪ Operation of OWFs including Inner Dowsing, Lincs, Triton Knoll, Dudgeon, Race Bank, and Lynn ▪ Operation of aggregate production areas including Outer Dowsing Westminster Gravels Ltd (515/2, 515/1), Hanson Aggregates Marine Ltd (106/2, 106/3, 106/1, 400), Tarmac Marine Ltd (197, 493), Inner Dowsing Tarmac Marine Ltd (481/1) and Inner Dowsing Tarmac Marine Ltd (481/2) ▪ Operation of Race Bank OWF ▪ Operation of pipeline Gas Shearwater to Bacton Seal Line (Shell) ▪ Operation of D323D Southern Managed Danger Area ▪ Construction of Sheringham Shoal Extension ▪ Construction of Dudgeon Extension ▪ Viking Link Interconnector Tier 2: ▪ Aggregate Area 1805 (Inner Dowsing Hanson Aggregates Marine Ltd) (Operation). Tier 3: ▪ Aggregate Tender Area 2103 (Operation).	If these intermittent activities overlap temporally with either the construction of the Project, there is potential for cumulative SSC and sediment deposition to occur within the wider subtidal ecology study area.

9.9.1.9 Cumulative Temporary Increases in SSC and Associated Deposition

319. Due to uncertainty associated with the exact timing of other projects and activities, there is insufficient data on which to undertake a quantitative or semi-quantitative assessment. As such and following the guidance from Advice Note Seventeen: Cumulative effects assessment relevant to nationally significant infrastructure projects (the Planning Inspectorate, 2019), the discussion presented here is qualitative[9]. It is considered highly unlikely that each of the identified projects would be undertaking major maintenance works, in particular asset reburial or repairs, as these are infrequent occurrences during the lifetime of developments.

320. Sediment plumes from operational and maintenance activities are generally short-lived, with major maintenance works infrequent. Any impacts from operational offshore windfarm export cables, pipelines, and oil and gas activities are therefore likely to be short-lived and of localised extent, with limited opportunity to overlap with Project-related activities. The Viking Link Interlink has been recently commissioned and any associated maintenance-related impacts are similarly considered to be primarily short-lived and localised. Accordingly, the potential for cumulative interaction with these sites is limited and therefore has not been assessed further.

321. Aggregate Area 515/2 ('Outer Dowsing') is located approximately 1.1km from the array area and 0km from the offshore ECC, as shown in Volume 2, Figure 9.7. In addition, Area 481/1 ('Inner Dowsing') is located 1.3km south of the offshore ECC, and Areas 515/1, 106/3, and 400 are located between 2.5km and 3km north of the offshore ECC. In addition, the Exploration and Option Area 1805 ('Inner Dowsing') overlaps with the offshore ECC, as shown in Volume 2, Figure 9.7, and an application is expected shortly for a production licence. Area 2103, also overlapping the offshore ECC (see Volume 2, Figure 9.7) has been selected by TCE within the 2021/22 marine aggregates tender round and is subject to the outcome of a plan-level HRA. Due to uncertainty associated with the timing, possible extent, or license outcome of Tender Area 2103, this area has not been assessed further.

322. On the basis of sediment plume modelling presented in Chapter 7: Marine Processes (Document Reference 6.1.7), it can reasonably be assumed that sediment plumes may be advected this distance from the Project infrastructure. This means that in theory, should Project construction related activities be occurring at the same time as aggregate extraction, there could be the potential for cumulative changes in SSC and bed levels. According to figures provided by British Marine Aggregate Producers Association (BMAPA) for the last five years, dredging intensity within these Areas located within the Humber Region primarily ranges from low (<15 minutes) to medium (15 minutes to 75 minutes), with only a small proportion dredged at a high intensity (>75 minutes).

[9] https://infrastructure.planninginspectorate.gov.uk/legislation-and-advice/advice-notes/advice-note-17/

323. As detailed by the numerical modelling within Chapter 7: Marine Processes (Document Reference 6.1.7) the levels of sediment dispersion are high, however almost all sediment plumes are indistinguishable from background levels after 20 hours. Given the short-lived nature of the sediment plumes, alongside the location of other infrastructure (Volume 2, Figure 9.7), there is not anticipated to be a notable overlap with concentrated sediment plumes created from other industry activities. Any overlap expected with aggregate dredging activities is likely to be temporary and restricted to the near-field, with the magnitude of this change being assessed as low.

324. Full discussion of the sensitivity of benthic subtidal and intertidal ecology receptors to increased SSC and sediment deposition is discussed in 9.7.51 *et seq*., which conclude that the habitats that have the potential to be indirectly affected by increased SSC and deposition within the benthic subtidal and intertidal ecology study area have a worst case medium sensitivity to the expected levels of SSC and deposition.

325. The impact of increased SSC and deposition is considered to be low, and the sensitivity of receptors affected is considered to be a worst-case of medium for benthic receptors. The significance of the effect is therefore concluded to be **minor adverse, and not significant in EIA terms**.

9.10 Inter-Relationships

326. Inter-related effects consider impacts from the construction, operation or decommissioning of the Project on the same receptor (or group).

327. Such inter-related effects include both:

- Project lifetime effects: i.e., those arising throughout more than one phase of the project (construction, operation, and decommissioning) to interact to potentially create a more significant effect on a receptor than if just one phase were assessed in isolation; and
- Receptor led effects: Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor (or group). Receptor-led effects might be short term, temporary or transient effects, or incorporate longer term effects.

328. A description of the process to identify and assess these effects is presented in Chapter 5: EIA Methodology (Document Reference 6.1.5), with a summary of assessed inter-relationships provided in Table 9.20 below.

Table 9.21: Summary of assessed inter-relationships

Project phase(s)	Nature of inter-related effect	Assessment alone	Inter-related effects assessment
Project-lifetime effects			
Construction, O&M and decommissioning	Temporary habitat loss across all three project phases	Impacts were assessed as being Not Significant in the construction, O&M and	When habitat loss or disturbance is considered additively across all phases, although the total area of habitat affected is larger, the habitats affected are typically widespread. Furthermore, all benthic habitats are

Project phase(s)	Nature of inter-related effect	Assessment alone	Inter-related effects assessment
		decommissioning phases.	predicted to recover to the baseline condition within two to ten years. Therefore, across the project lifetime, the effects on benthic ecology receptors are not anticipated to result in combined effects of greater significance than the assessments presented for each individual phase. There will therefore be no inter-related effects of greater significance compared to the impacts considered alone.
Construction and decommissioning	Indirect impacts to benthic ecology as a result of the temporary increase in SSC and sediment deposition.	Impacts were assessed as being Not Significant in the construction and decommissioning phases.	The majority of the seabed disturbance (resulting in the highest SSC and sediment deposition) will occur during the construction and decommissioning phases, with any effects being short-lived. Due to this, and the recoverability of the species and habitats affected, the interaction of these impacts across all stages of the development is not predicted to result in an effect of any greater significance than those assessed in the individual project phases.
Receptor led effects			
There is the potential for spatial and temporal interactions between the effects arising from habitat loss/disturbance and increased SSC and sediment deposition during the project lifetime. The greatest potential for inter-related effects is predicted to occur through the interaction of both temporary and permanent habitat loss/disturbance from foundation installation/jack-up vessels/anchor placement/scour, indirect habitat disturbance due to sediment deposition and indirect effects of changes in physical processes due the presence of infrastructure in the operational wind farm. With respect to this interaction, these individual impacts were assigned a significance of negligible to minor adverse significance as standalone impacts and although potential combined impacts may arise (i.e., spatial and temporal overlap of direct habitat disturbance), it is predicted that this will not be any more significant than the individual impacts in isolation. This is because the combined amount of habitat potentially affected would be very limited and where temporary disturbance occurs, full recovery of the benthos is predicted. In addition, any effects due to changes in the physical processes are likely to be limited, both in extent and in magnitude, with receptors having low sensitivity to the scale of changes predicted. As such, these interactions are predicted to be no greater in significance than that for the individual effects assessed in isolation.		

329. Overall, the inter-related assessment for the Project does not identify any significant inter-related effects that were not already covered by the topic-specific assessment set out in the preceding chapters. However, certain individual effects were identified that did interact with each other whilst not leading to any greater significance of effect.

9.11 Transboundary Effects

330. Transboundary effects are defined as those effects upon the receiving environment of other European Economic Area (EEA) states, whether occurring from the Project alone, or cumulatively with other projects in the wider area. A screening of potential transboundary effects was undertaken at Scoping which identified that there was no potential for significant transboundary effects to occur in relation to benthic and intertidal ecology.

9.12 Conclusions

331. This chapter has investigated the potential effects on intertidal and subtidal benthic ecology receptors arising from the Project. The range of potential impacts and associated effects has been informed by scoping responses and consultation responses from stakeholders, alongside reference to existing legislation and guidance.

332. The benthic habitat types present in the Project benthic and intertidal ecology study area are widespread in the surrounding area and the impacts of the construction of offshore wind farms and associated infrastructure is well studied. Potential additional mitigation measures discussed within this chapter include micro-siting windfarm infrastructure around potential Annex I habitat (*S. spinulosa* reef) if it develops within the ECC prior to construction. The noted patchy nature of *S. spinulosa* reef formation and the relatively wide offshore ECC, provides confidence that micrositing of the cables will be feasible even were *S. spinulosa* reef to develop. The impacts considered include those brought about directly (e.g., by the presence of infrastructure on the seafloor) and indirectly (e.g., increased SSC from installation methods). Potential impacts considered in this chapter are listed below (Table 9.21).

333. Where the offshore ECC overlaps the IDRBNR SAC and Greater Wash SPA, additional mitigation measures have been proposed where impacts have the possibility to result in potentially significant impacts. Furthermore, a 'Without Prejudice Benthic Compensation Strategy' has been developed and is presented as part of the Application for features of the IDRBNR SAC (document reference 7.6).

334. Cumulative impacts were also considered, and an assessment was carried out examining the potential for interaction of direct and indirect impacts (including the interaction of sediment plumes) as a result of the combined activities of the Project and other activities in the study area. This includes offshore wind farm operations and disposal sites.

335. These potential impacts have been investigated using a combination of methods including analytical techniques and the existing evidence base. In accordance with the requirements of the Rochdale Envelope approach to EIA, the MDS has been defined and considered for each potential impact, thereby providing a likely conservative assessment.

336. Even based on this conservative assessment approach, it has been found that all of the potential impacts arising from the construction, operation and decommissioning of the Project (including cumulatively) on intertidal and subtidal benthic ecology receptors will result in a significance of Minor or Negligible post mitigation. The potential effects to intertidal and subtidal benthic ecology receptors are therefore concluded as not significant in terms of the EIA Regulations.

337. Table 9.21 presents a summary of the significant impacts assessed within this Environment Statement, any mitigation, and the residual effects.

Table 9.22: Summary of potential impacts assessed for benthic and intertidal ecology

Description of effect	Effect	Additional mitigation measures	Residual impact
Construction			
Temporary habitat disturbance	Minor significance of effect	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Temporary increase in SSC and associated sediment deposition	Minor significance of effect	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Direct and indirect seabed disturbances leading to the release of sediment contaminants	Negligible significance of effect	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Operation and Maintenance			
Long-term Habitat Loss/Alteration	Subtidal: Minor significance of effect Annex I sandbanks of IDRBNR SAC: Moderate significance of effect	Not Applicable – no additional mitigation identified. See Table 9.12	No significant adverse residual effects Annex I sandbanks of IDRBNR SAC: Minor (No significant adverse residual effects)
Temporary habitat disturbance	Minor significance of effect	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Increased risk of introduction or spread of INNS	Minor significance of effect	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Colonisation of hard substrates	Minor significance of effect	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Changes in physical processes resulting from the presence of the OWF subsea infrastructure e.g., scour effects, changes in wave/tidal	Minor significance of effect	Not Applicable – no additional mitigation identified	No significant adverse residual effects

Description of effect	Effect	Additional mitigation measures	Residual impact
current regimes and resulting effects on sediment transport			
EMF effects generated by inter-array and export cables	Negligible significance of effect	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Decommissioning			
Temporary habitat disturbance	Subtidal: Minor significance of effect	Not Applicable – no additional mitigation identified	Subtidal: No significant adverse residual effects
Temporary increase in SSC and associated sediment deposition	Subtidal: Minor significance of effect Intertidal: Minor significance of effect	Not Applicable – no additional mitigation identified	Subtidal: No significant adverse residual effects Intertidal: No significant adverse residual effects
Direct and indirect seabed disturbances leading to the release of sediment contaminants	Minor significance of effect	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Cumulative			
Temporary increases in SSC and associated deposition	Subtidal: Minor significance of effect	Not Applicable – no additional mitigation identified	Subtidal: No significant adverse residual effects

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Annex A – Natural England Advised Mitigation for the IDRBNR SAC

1. Natural England has produced strategic aims and objectives for offshore wind impact mitigation (Natural England, 2021) based around the impact 'mitigation hierarchy' of avoid, mitigate, and compensate, outlined by CIEEM (2018) with the aim of "development leaving nature in a better state, including through emerging mechanisms for nature improvement and enhancement".
2. As part of the pre-application consultation process, Natural England advised that the impacts on sensitive features of the IDRBNR SAC could be avoided, reduced and mitigated by implementing (but not exclusively) a number of mitigation measures. The suggested mitigation measures and detail of whether these measures could be implemented and, where relevant, where these measures have been secured for the DCO application by the Project are outlined in Table 0-1 below.

Table 0-1 Natural England suggested mitigation measures

Mitigation measure	Implemented by the Project and justification if not
Avoid Designated Sites – e.g., Hornsea Three altered their project design to remove infrastructure from Markham's Triangle MCZ	This has not been implemented - the choice of cable route followed a comprehensive site selection process, details of which are provided in Volume 1, Chapter 4: Site Selection and Consideration of Alternatives. Due to existing infrastructure, only cable routes which had gone north from the array area could have theoretically avoided the IDRBNR SAC, however, these routes were deemed infeasible as this would have required extensive cable crossings in shallow, inshore waters, that would have been likely deemed a navigational hazard, to reach the landfall location. All routes leaving from the south of the array area could not avoid routing through the SAC, therefore the Project selected the route which had the least impact on the SAC (i.e. shortest route, avoiding known areas of biogenic reef, noting it would not have been possible to avoid all areas of sandbank habitat).
Reduce the number of export cables though the use of high voltage direct current (HV/DC) system or coordinated approach with other projects – e.g., Hornsea Three, Norfolk Vanguard and Norfolk Boreas projects	Implemented in part – the Project has committed to the use of HVAC cable technology only. HVAC cabling has been used for the majority of UK offshore windfarms, including all those commissioned to date. The supply chain for HVDC technology is currently much more constrained and so could compromise the construction schedule; HVDC also requires a significantly more costly solution for technical and regulatory compliance. Implemented in part – the Project has committed to the use of high voltage alternating current (HVAC)

Mitigation measure	Implemented by the Project and justification if not
	cable technology only. HVAC cabling has been used for the majority of UK OWFs, including all those commissioned to date. The supply chain for HVDC technology is currently much more constrained and so could compromise the construction schedule; HVDC also requires a significantly more costly solution for technical and regulatory compliance. During design discussions, and in line with the mitigation hierarchy, the number of HVAC cables required has been reduced from six to four; this number is comparable to the number of HVDC cables used in similar sized projects, e.g. Norfolk Vanguard. It should also be noted that HVDC systems may have a reduced number of circuits compared to HVAC, however this does not necessarily result in a reduced number of cables as multiple cores are required to form a circuit which as a minimum would be 2 circuits with 2 single core cables and a sperate FOC each, this results in a minimum of 6 separate cables. Although likely to be in bundled configuration, there the possibility that they may not be and installed in separate trenches instead, especially through challenging areas or depending on contractor capability. In addition any subsea joint, pull-in, landfall or repair will be separated out a minimum of 150m either side where applicable resulting in additional remedial protection and likelihood of unburied cable. The use of HVAC technology also helps to reduce impacts associated with onshore infrastructure, specifically in relation to the size of the substation.
Reduce the number of cable crossings within a designated site to avoid the requirement for cable protection – e.g., Hornsea Three	Yes – the cable routing for the Project ensures that there are no cable crossings required within the SAC.
Cutting and removing sections of disused cables to avoid cable crossings – e.g., Norfolk projects	Yes – if any disused cables are identified during pre-construction works, these will be cut to avoid the need for a cable crossing.
Micro siting cables around reef and other features of ecological importance – all projects post Lincs OWF consent (2008)	Yes – the Project has committed to micro-siting the cable around known *S. spinulosa* reef. This commitment is secured through the Outline Biogenic Reef Mitigation Plan (document reference 8.22).

Mitigation measure	Implemented by the Project and justification if not
Sand wave levelling to reduce risk of free spanning cables and requirement for external cable protection – all projects since 2016 have included an element of this	Yes – sand wave levelling prior to cable installation to reduce the risk of later cable exposure and spanning is embedded into the project design.
Adoption of the reburial hierarchy with external cable protection being the last resort – all projects	Yes – this is embedded into the project design. Laying the cables following sandwave levelling should reduce the requirement for reburial.
At the pre-consent stage, finalise CBRA using geotechnical data to focus cable protection requirements to areas where cables are likely to be sub-optimally buried (e.g. areas with mixed sediment) – all projects since Norfolk Vanguard	Yes – all offshore cables will be buried to a sufficient depth below the seabed, as far as practicable, with target burial depth determined by the findings of a CBRA as part of the final project design process.
Use of guard vessels and/or advance mapping to avoid sub-optimally buried/surface laid cables negating the need for physical cable protection e.g., the Lincs cable in the Wash	This has not been implemented - the Project cannot commit to this measure; the final choice of cable route and installation methodology aims to facilitate the greatest chance of cable burial.
Requirement to install cable protection with the minimal footprint e.g., pinning – TWT cable corridors work	This has not been implemented – the Project cannot commit to this measure at this stage; cable protection must be sufficient to ensure the integrity of the asset. Additionally, the Applicant has not been able to obtain a copy of this report and as such cannot directly evaluate the measures proposed within it.
Requirement to install cable protection with the greatest likelihood of removal e.g., rock bags at the Norfolk projects	Yes – the Project has committed to only using removable cable protection over the sandbanks within the SAC (secured within the Outline Scour Protection and Cable Protection Management Plan (document reference 8.21)).
Not using jack up barges/vessels along export cable routes through benthic SACs – e.g., Norfolk projects	Yes – this measure is embedded into the project design.
No cable protection in fisheries byelaw areas to avoid hindering reef recovery, noting that cable may still go through the outskirts of these areas – e.g., Norfolk projects	Yes – this measure is embedded into the project design. Whilst the ECC includes an area to be managed as reef, this will be avoided for all construction works, as detailed within the Outline Biogenic Reef Mitigation Plan (document reference 8.22).
Design rock armouring to mirror the structure and function of geogenic reef – this was advised for the Viking Link interconnector	Yes – whilst not directly relevant for the biogenic reef feature in the SAC, the option for ecologically designed rock protection has been included within the project design envelope; the final design for any rock protection will be discussed with the MMO and

Mitigation measure	Implemented by the Project and justification if not
	its advisors pre-construction, where agreement will be sought on whether the use of ecological rock protection is appropriate based on evidence at the time.
Detonation of UXO outside of designated sites to avoid the creation of a crater – suggested for Dudgeon Extension Project (DEP) and Sheringham Shoal Extension Project (SEP)	The Project is not including UXO clearance within its DCO Application. The feasibility of this measure would be a decision for an EOD expert in the field and would be dependent on this being safe and feasible. However where possible UXOs will be detonated outside the SAC. It should also be noted that low order detonation will be the primary measure for UXO clearance as per the current MMO and SNCB advice, which will minimise any seabed impacts from an UXO clearance.