Outer Dowsing Offshore Wind

Preliminary Environmental Information Report

Volume 1, Chapter 9: Benthic and Intertidal Ecology

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Abbreviations

Acronym	Expanded name
AC	Alternating Current
BAP	Biodiversity Action Plan
CBRA	Cable Burial Risk Assessment
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CFE	Controlled Flow Excavator
CEA	Cumulative Effects Assessment
CIEEM	Chartered Institute of Ecology and Environmental Management
CSIP	Cable Specification and Installation Plan
DBT	Dibutyltin
DC	Direct Current
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).
DCO	Development Consent Order
DDV	Drop Down Video
DP	Decommissioning Programme
ECC	Export Cable Corridor
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
GES	Good Environmental Status
HADA	Humber Aggregate Dredging Association
HDD	Horizontal Directional Drilling
HRA	Habitats Regulation Assessment
HW	High Water
INNS	Invasive Non-Native Species
JNCC	Joint Nature Conservation Committee

Acronym	Expanded name
JUV	Jack-up vessel
LAT	Lowest Astronomical Tide
LW	Low Water
MarLIN	Marine Life Information Network
MarESA	Marine Evidence based Sensitivity Assessment
MBES	Multibeam Echosounder
MBT	Monobutyltin
MCAA	Marine and Coastal Access Act
MCCIP	Marine Climate Change Impacts Partnership
MCZ	Marine Conservation Zone
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
OESEA	Offshore Energy Strategic Environmental Assessment
O&M	Operation and Maintenance
OSP	Offshore Substation Platform
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
OWF	Offshore Wind Farm
PAH	Polycyclic Aromatic Hydrocarbons
PEIR	Preliminary Environmental Information Report
PEL	Probable Effects Level
PEMP	Project Environmental Management Plan
POSEIDON	Planning Offshore Wind Strategic Environmental Impact Decisions
PSA	Particle Size Analysis
PSD	Particle Size Distribution
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 Sounders
SBP	Sub-Bottom Profiler
SEP	Sheringham Extension Project
SoS	Secretary of State

Acronym	Expanded name
SPA	Special Protection Area
SPM	Suspended Particulate Matter
SPMP	Scour Protection Management Plan
SSC	Suspended Sediment Concentrations
SSS	Side scan sonar
SSSI	Site of Special Scientific Interest
TBT	Tributyltin
TEL	Threshold Effect Levels
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
WTGs	Wind Turbine Generators
ZoI	Zone of Influence

Terminology

Term	Definition
Array area	The area offshore within the PEIR Boundary 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 PEIR boundary.
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.
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.

Term	Definition
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 cables	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.
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.

Term	Definition
Offshore Export Cable Corridor (ECC)	The Offshore Export Cable Corridor (Offshore ECC) is the area within the Preliminary Environmental Information Report (PEIR) Boundary within which the export cable running from the array to landfall will be situated.
Preliminary Environmental Information Report (PEIR)	The PEIR is written in the style of a draft Environmental Statement (ES) and provides information to support and inform the statutory consultation process in the pre-application phase. Following that consultation, the PEIR documentation will be updated to produce the Project's ES that will accompany the application for the Development Consent Order (DCO).
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*.
PEIR Boundary	The PEIR Boundary is outlined in Figure 3.1 of Volume 1, Chapter 3: Project Description and comprises the extent of the land and/or seabed for which the PEIR assessments are based upon.
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. Not all prescribed bodies and interests will be statutory consultees (see non-statutory consultee definition).
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 provides 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

Term	Definition
	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.
Subsea	Subsea comprises everything existing or occurring below the surface of the sea.
Wind turbine generator (WTG)	All the components of a wind turbine, including the tower, nacelle, and rotor.

9 Benthic Subtidal and Intertidal Ecology

9.1 Introduction

9.1.1 This chapter of the Preliminary Environmental Information Report (PEIR) presents the results to date 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.

9.1.2 GTR4 Limited (trading as Outer Dowsing Offshore Wind) hereafter referred to as the 'Applicant', is proposing to develop the Project. The Project will be located approximately 54km from the Lincolnshire coastline in the southern North Sea. The Project will be located approximately 54km from the Lincolnshire coastline in the southern North Sea. The Project will include both offshore and onshore infrastructure including an offshore generating station (windfarm), export cables to landfall, onshore cables, and connection to the electricity transmission network, and ancillary and associated development (see Part 6, Volume 1, Chapter 3: Project Description for full details).

9.1.3 This chapter should be read alongside the following chapters and annexes:

- Part 6, Volume 1, Chapter 3: Project Description;
- Part 6, Volume 1, Chapter 7: Marine Processes;
- Part 6, Volume 1, Chapter 8: Marine Water Quality;
- Part 6, Volume 1, Chapter 10: Fish and Shellfish Ecology;
- Part 6, Volume 2, Appendix 7.2: Physical Processes Modelling Report;
- Part 6, Volume 2, Appendix 9.1: Benthic Ecology Technical Report (Array);
- Part 6, Volume 2, Appendix 9.2: Benthic Ecology Technical Report (ECC);
- Part 6, Volume 1, Chapter 18: Infrastructure and Other Marine Users
- Part 6, Volume 2, Appendix 9.3: Intertidal Technical Report; and
- Part 6, Volume 2, Appendix 9.4: Marine Conservation Zone Assessment.

9.2 Statutory and Policy Context

9.2.1 This section highlights relevant legislation as well as national and local policy that is relevant to benthic subtidal and intertidal ecology. The Planning Act 2008, Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended) and the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (collectively referred to as 'the EIA Regulations'), and the Environment Act 2021 are considered along with the legislation relevant to benthic subtidal and intertidal ecology.

9.2.2 In undertaking the assessment, the following legislation has been considered:

- The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017;

- The Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended);
- The Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention; 1979);
- EU Council Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna (the 'Habitats Directive')[1];
- The Conservation of Habitats and Species Regulations 2017 (as amended);
- The Conservation of Offshore Marine Habitats and Species Regulations 2017;
- Marine and Coastal Access Act 2009; and
- The Wildlife and Countryside Act 1981 (as amended).

9.2.3 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 and Climate Change (DECC), 2011a);
- Draft revised Overarching NPS EN-1 (Department for Energy Security and Net Zero (DESNZ) 2023a));
- The National Policy Statement for Renewable Energy Infrastructure (NPS EN-3, DECC, 2011b);
- Draft National Policy Statement for Renewable Energy Infrastructure (EN-3) (DESNZ, 2023b); and
- The United Kingdom (UK) Marine Policy Statement (MPS; HM Government, 2011).

Marine Strategy Framework Directive

9.2.4 The Marine Strategy Framework Directive (2008/56/EC) (MSFD), adopted in July 2008, has also been considered in the Project assessment for benthic and intertidal ecology. The overarching goal of the Directive is to achieve 'Good Environmental Status' (GES) by 2020 across Europe's marine environment. To this end, Annex I of the Directive identifies 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 have been addressed in the Project assessment.

[1] The Habitats Directive (Council Directive 92/43/EEC) and certain elements of the Wild Birds Directive (Directive 2009/147/EC) (known as the Nature Directives) were transposed into domestic law by the 2017 Regulations. Following the UK's exit from the EU the Regulations were updated by the Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019 to reflect that the UK was no longer part of the EU. Any references to Natura 2000 in the 2017 Regulations and in guidance now refers to the new national site network.

East Inshore and East Offshore Coast Marine Plans

9.2.5 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.

9.2.6 The relevant legislation and planning policy for offshore renewable energy Nationally Significant Infrastructure Projects (NSIPs), specifically in relation to benthic subtidal and intertidal ecology is 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) for Energy (NPS EN-1) (Department for Energy and Climate Change (DECC), 2011a)	Paragraph 5.3.3 states: "Where the development is subject to EIA the applicant should ensure that the [Environmental Statement] (ES) clearly sets out any effects on internationally, nationally, and locally designated sites of ecological or geological conservation importance, on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity. The applicant should provide environmental information proportionate to the infrastructure where EIA is not required to help the Infrastructure Planning Commission (IPC) [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 9.4).
NPS EN-1 (DECC, 2011a)	Paragraph 5.3.12 states: "The SoS is bound by the duties in relation to Marine Conservation Zones (MCZs) imposed by sections 125 and 126 of the 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.
Draft revised Overarching NPS EN-1 (Department for Energy Security and Net Zero (DESNZ), 2023a)	Paragraph 5.4.7 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	Designated sites within the region have been identified in section 9.4 as appropriate, and any potential impacts to features of the sites have been assessed in section 9.7.

Legislation/Policy	Key Provisions	Section where comment addressed
	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 scientific interest, and any broader impacts on the national network of SSSIs.	
The NPS for Renewable Energy Infrastructure (NPS EN-3) (DECC, 2011b) and Draft revised NPS for Renewable Energy Infrastructure EN-3 (DESNZ, 2023b)	Paragraph 2.6.64 states: "Assessment of offshore ecology and biodiversity should be undertaken by the applicant for all stages of the lifespan of the proposed offshore wind farm [OWFs] and in accordance with the appropriate policy for offshore wind farm EIAs". Paragraph 3.8.115 of the Draft revised NPS EN-3 states: "Applicant 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, [Habitats Regulation Assessments (HRAs)] and MCZ assessments".	Consideration of the construction, operation and decommissioning phases of the scheme are set out in section 9.7.
NPS EN-3 (DECC, 2011b) and Draft revised NPS EN-3 (DESNZ, 2023b)	Paragraph 2.6.65 states: "Consultation on the assessment methodologies should be undertaken at early stages with the statutory consultees as appropriate". Paragraph 3.8.118 of the Draft revised NPS EN-3 states: "Applicants should consult at an early stage of pre-application with relevant statutory consultees, as appropriate, on the assessment methodologies, baseline data collection, and potential avoidance, mitigation and compensation options 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 9.3.
NPS EN-3 (DECC, 2011b) and Draft revised NPS EN-3 (DESNZ, 2023b)	Paragraph 2.6.66 (and Paragraph 2.24.7 of the Draft revised NPS EN-3) states: "Any relevant data that has been collected as part of post-construction ecological	Relevant data collected as part of post-construction monitoring from other OWFs has informed the assessment

Legislation/Policy	Key Provisions	Section where comment addressed
	monitoring from existing, operational [OWFs] should be referred to where appropriate".	of section 9.7. 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.
NPS EN-3 (DECC, 2011b)	Paragraph 2.6.67states: "The assessment should include the potential for the scheme to have both positive and negative effects on marine ecology and biodiversity".	An assessment of both the positive and negative effects of the Project is provided in section 9.7.
NPS EN-3 (DECC, 2011b) and Draft revised NPS EN-3 (DESNZ, 2023b)	Paragraph 2.6.81 states: "An assessment of the effects of installing cable across the intertidal zone should include information, were relevant, about: ▪ potential loss of habitat". Paragraph 3.8.138 of the Draft revised NPS EN-3 states: "Applicant assessment of the effects of installing cable across the intertidal/coastal zone should demonstrate compliance with mitigation measures identified by The Crown Estate in any plan-level HRA produced as part of its leasing round and include information, where relevant, about: ▪ potential loss of habitat".	An assessment of the effects from all development phases on benthic and intertidal habitats and species in the vicinity of the Project is provided section 9.7. These assessments included all likely effects from temporary and permanent habitat loss and the effects of changes in physical processes.
NPS EN-3 (DECC, 2011b) and Draft revised NPS EN-3 (DESNZ, 2023b)	Paragraph 2.6.113 states: "Where necessary, the assessment on the subtidal environment should include: ▪ loss of habitat due to foundation type including associated seabed preparation, predicted scour, scour protection, and altered sedimentary processes". Paragraph 3.8.16 the Draft revised NPS EN-3 states:	

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".	
NPS EN-3 (DECC, 2011b) and Draft revised NPS EN-3 (DESNZ, 2023b)	Paragraph 2.6.81 states: "An assessment of the effects of installing cable across the intertidal zone should include information, where relevant, about: ▪ disturbance during cable installation and removal (decommissioning)". Paragraph 3.8.138 of the Draft revised NPS EN-3 states: "Applicant assessment of the effects of installing cable across the intertidal/coastal zone should demonstrate compliance with mitigation measures identified by The Crown Estate in any plan-level HRA produced as part of its leasing round and include information, where relevant, about: ▪ disturbance during cable installation, maintenance/repairs and removal (decommissioning)".	An assessment of the effects of benthic and intertidal disturbances throughout the whole of the development can be found in section 9.7), with specific reference to construction vessels and anchors and habitat disturbance within the intertidal zone found in Table 9.10.
NPS EN-3 (DECC, 2011b) and Draft revised NPS EN-3 (DESNZ, 2023b)	Paragraph 2.6.113 states: "Where necessary, the assessment on the subtidal environment should include: ▪ habitat disturbance from construction vessels' extendible legs and anchors". Paragraph 3.8.116 of the Draft NPS EN-3 states: ▪ habitat disturbance from construction and maintenance/repair vessels' extendable legs and anchors".	
NPS EN-3 (DECC, 2011b) and Draft revised NPS EN-3 (DESNZ, 2023b)	Paragraph 2.6.81 states: "An assessment of the effects of installing cable across the intertidal zone should include information, where relevant, about:	Consideration of the specific effects of increased suspended sediment load and the associated sediment deposition on benthic and

Legislation/Policy	Key Provisions	Section where comment addressed
	▪ increased suspended sediment loads in the intertidal zone during installation". Paragraph 3.8.138 of the Draft revised NPS EN-3 states: "Applicant assessment of the effects of installing cable across the intertidal/coastal zone should demonstrate compliance with mitigation measures identified by The Crown Estate in any plan-level HRA produced as part of its leasing round and include information, where relevant, about: ▪ increased suspended sediment loads in the intertidal zone during installation and maintenance/repairs".	intertidal ecology are set out in section 9.7.
NPS EN-3 (DECC, 2011b) and Draft revised NPS EN-3 (DESNZ, 2023b)	Paragraph 2.6.113 states: "Where necessary, the assessment on the subtidal environment should include: ▪ increased suspended sediment loads during construction". Paragraph 3.8.116 of the Draft NPS EN-3 states: ▪ "increased suspended sediment loads during construction and from maintenance/repairs".	
NPS EN-3 (DECC, 2011b) and Draft revised NPS EN-3 (DESNZ, 2023b)	Paragraph 2.6.81 states: "An assessment of the effects of installing cable across the intertidal zone should include information, where relevant, about: ▪ predicted rates at which the intertidal zone might recover from temporary effects". Paragraph 3.8.138 of the Draft revised NPS EN-3 states: "Applicant assessment of the effects of installing cable across the intertidal/coastal zone should demonstrate compliance with mitigation measures identified by The Crown Estate in any plan-level HRA produced as part of its leasing	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 9.7.

Legislation/Policy	Key Provisions	Section where comment addressed
	round and include information, where relevant, about: ▪ predicted rates at which the intertidal zone might recover from temporary effects, based on existing monitoring data".	
NPS EN-3 (DECC, 2011b) and Draft revised NPS EN-3 (DESNZ, 2023b)	Paragraph 2.6.113 states: "Where necessary, the assessment on the subtidal environment should include: ▪ predicted rates at which the subtidal zone might recover from temporary effects". Paragraph 3.8.116 of the Draft NPS EN-3 states: "Applicant assessment of the effects on the subtidal environment should include: ▪ predicted rates at which the subtidal zone might recover from temporary effects".	
NPS EN-3 (DECC, 2011b)	Paragraph 2.6.114 states: "The applicant should not have to assess the effects of the cables on intertidal and subtidal habitat during the operational phase of the [OWF]."	Consideration of the indirect disturbance of Electromagnetic Fields (EMF) generated by inter-array and export cables and effects on protected species are set out in section 9.7.
Draft revised NPS EN-3 (DESNZ, 2023b)	Paragraph 3.8.166 states: "Applicant assessment of the effects on the subtidal environment should include: ▪ potential impacts from EMF on benthic fauna."	
Draft revised NPS EN-3 (DESNZ, 2023b)	Paragraph 3.8.166 states: "Applicant assessment of the effects on the subtidal environment should include ▪ protected sites".	Consideration of protected sites and the potential effects on the relevant habitats associated with the construction, operation and decommissioning are set out in section 9.7. Reference to Natura 2000 sites and their features are also made in the Part 7, Document 7,1: Report to Inform Appropriate Assessment (RIAA).
NPS EN-3 (DECC, 2011b) and Draft	Paragraph 2.6.119 states:	Where considered appropriate, and where

Legislation/Policy	Key Provisions	Section where comment addressed
revised NPS EN-3 (DESNZ, 2023b)	"Construction and decommissioning methods should be designed appropriately to minimise effects on subtidal habitats, taking into account other constraints. Mitigation measures which the [SoS] should expect the applicants to have considered may include: ▪ surveying and micrositing of the export cable route to avoid adverse effects on sensitive habitat and biogenic reefs; ▪ 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 might be minimised on subtidal surfaces, to encourage species colonisation on the structures". Paragraph 3.8.251 of the Draft revised NPS EN-3 states: "Mitigation measures which applicants are expected to have considered may include: ▪ surveying and micrositing of the turbines, or re-routing of the export and inter-array cables to avoid adverse effects on sensitive/protected habitats, biogenic reefs, or protected species; ▪ burying cables at a sufficient depth, taking into account other constraints, to allow the seabed to recover to its natural state; and ▪ the used of anti-fouling paint might be minimised on subtidal surfaces, to encourage species colonisation on the structures".	effects associated with the project may be considered significant in the absence of mitigation, mitigation has been considered during the assessment, in section 9.5.
NPS EN-3 (DECC, 2011b) and Draft revised NPS EN-3 (DESNZ, 2023b)	Paragraph 2.6.68 states: "The [SoS] should consider the effects of a proposal on marine ecology and biodiversity taking into account all relevant information made available to it". Paragraph 3.11.42 of the Draft revised NPS EN-3 states:	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 9.7.

Legislation/Policy	Key Provisions	Section where comment addressed
	"The Secretary of State should consider the effects of a proposed development on marine ecology and biodiversity taking into account all relevant information made available by the applicant, SNCBs and any other relevant party".	
NPS EN-3 (DECC, 2011b) and Draft revised NPS EN-3 (DESNZ, 2023b)	Paragraph 2.6.69 states: "The designation of an area as Natura 2000 site does not necessarily restrict the construction or operation of [OWFs] in or near that area". Paragraph 3.11.46 of the Draft NPS EN-3 states: "The designation of an area as a protected site (including HRA sites, MCZs and SSSIs) does not necessarily restrict the construction or operation of tidal stream arrays in, near, or through that area. However, where adverse effects on site integrity/conservation objectives are predicted the Secretary of State should consider the extent to which the effects are temporary or reversible, and the timescales for recovery".	Natura 2000 sites (including HRA sites, MCZs and SSSIs) have been considered during the Project assessment with potential effects on the relevant habitats described in section 9.7.
NPS EN-3 (DECC, 2011b) and Draft revised NPS EN-3 (DESNZ, 2023b)	Paragraph 2.6.70 states: "Mitigation may be possible in the form of careful design of the development itself and the construction techniques employed". Paragraph 3.8.233 of the Draft revised NPS EN-3 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 9.7.
NPS EN-3 (DECC, 2011b)	Paragraph 2.6.71 states: "Ecological monitoring is likely to be appropriate during the construction and operational phases to identify the actual impact so that, where appropriate, adverse effects can then be mitigated and	A survey will be undertaken at pre-construction phases of the proposed development in order to determine the location, extent and composition of any habitats of principal importance.

Legislation/Policy	Key Provisions	Section where comment addressed
	to ensure further useful information to be published relevant to future projects".	
Draft revised NPS EN-3 (DESNZ, 2023b)	Paragraph 3.8.236 states: "Applicants are advised to develop and 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. 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. 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."	As per the embedded mitigation (Table 9.11), benthic monitoring will be undertaken at pre-construction phases of the proposed development in order to determine the location, extent and composition of any habitats of principal importance or Annex 1 habitat. In the event that habitats of principal importance or Annex 1 habitat are identified in the pre-construction survey; post-construction monitoring will also be carried out with focus on these identified habitats.
NPS EN-3 (DECC, 2011b) and Draft revised NPS EN-3 (DESNZ, 2023b)	Paragraph 2.6.85 states: "The [SoS] should be satisfied that cable installation and decommissioning has been designed sensitively taking into account intertidal habitat". Paragraph 3.8.329 of the Draft revised NPS EN-3 states: "The Secretary of State should be satisfied that cable installation and decommissioning has been designed sensitively, considering intertidal/coastal habitats".	Section 9.7 of this chapter present the assessment of the conservation status of intertidal and benthic receptors.
NPS EN-3 (DECC, 2011b) and Draft revised NPS EN-3 (DESNZ, 2023b)	Paragraph 2.6.116 states: "The [SoS] should be satisfied that activities have been designed taking into account sensitive subtidal environmental aspects". Paragraph 3.8.335 of the Draft revised NPS EN-3 states:	

Legislation/Policy	Key Provisions	Section where comment addressed
	"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".	
NPS EN-3 (DECC, 2011b)	Paragraph 2.6.84 states: "The conservation status of intertidal habitat is of relevance to the [SoS]".	Consideration of the potential impacts on sensitive benthic and intertidal habitats are set out in section 9.7.
NPS EN-3 (DECC, 2011b)	Paragraph 2.6.115 states: "The conservation status of subtidal habitat is of relevance to the [SoS]".	
NPS EN-3 (DECC, 2011b) and Draft revised NPS EN-3 (DESNZ, 2023b)	Paragraph 2.6.86 states: "Where adverse effects are predicted during the installation or decommissioning of cables, in coming to a judgement, the [SoS] should consider the extent to which the effects are temporary or reversible". Paragraph 3.8.368 of the Draft revised NPS EN-3 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 9.7 of this chapter includes the duration and reversibility of effects in the assessment of effects.
Draft revised NPS EN-3 (DESNZ, 2023b)	Paragraph 3.328 states: "The [SoS] 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 9.7, in accordance with the cable design and specification as presented in

Legislation/Policy	Key Provisions	Section where comment addressed
		Part 6, Volume 1, Chapter 7: Marine Processes.
Marine Strategy Framework Directive (MSFD) (2008)	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 9.7 and 9.8 of this chapter.
MSFD (2008)	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 9.7.
MSFD (2008)	Descriptor 4 – Elements of marine food web: "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 9.9.
MSFD (2008)	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 9.8.
MSFD (2008)	Descriptor 7 – Alteration of 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 9.9.
MSFD (2008)	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 9.9.
MSFD (2008)	Descriptor 10 – Marine litter:	A Project Environmental Management Plan (PEMP) will

Legislation/Policy	Key Provisions	Section where comment addressed
	"Properties and quantities of marine litter do not cause harm to the coastal and marine environment."	be produced post-consent and followed to cover the 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 9.8.
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 Part 6, Volume 2, Appendix 9.1: Benthic Ecology Technical Report (Array) and Part 6, Volume 2, 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 Section 9.7. 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

Legislation/Policy	Key Provisions	Section where comment addressed
		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 9.4 and assessed in section 9.7.

9.3 Consultation

9.3.1 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 Part 6, Volume 1, Chapter 6: Consultation Process.

9.3.2 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 PEIR.

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 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 will be secured through conditions within the deemed Marine Licence (dML).
Scoping Opinion (the 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 9.7. 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).

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
Scoping Opinion (the 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 9.7
Scoping Opinion (the Inspectorate, 9 September 2022) Comment ID: 3.3.4	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 9.7.
Scoping Opinion (the 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 Management Plan will be developed to accompany the ES. Specific mitigation measures for scouring are detailed within Table 9.11).
Scoping Opinion (the Inspectorate, 9 September 2022) Comment ID: 3.3.5 and 3.3.88	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 9.8.
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 PEIR Boundary, geophysical survey data has been collected as set out in section 9.4. Geophysical data informed the location of ground-truth site specific characterisation. Additional pre-construction geophysical data is to be collected and will subsequently be used to help inform any micro-siting that might be required to avoid sensitive habitats including biogenic reefs where practicable.
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 Project array and offshore ECC, collected in 2022. However, 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 of variable

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
		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) Comment ID: 3.2.5	The MMO requires changes in physical processes (e.g., scour, current regimes) and the spread of INNS associated with the installation of OWF subsea infrastructure to be scoped in and assessed.	Both these impacts have been scoping into this assessment. An assessment of changes in physical processes resulting from the presence of the OWF subsea infrastructure on benthic species as well as the spread of INNS during O&M is provided in section 9.7.
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 SAC. Additional mitigation measures include that windfarm infrastructure will be micro-sited around Annex I habitat (*S. spinulosa* reef) as far as practicable (section 9.5).
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 9.7. 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 9.5.
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	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 Interlink have informed the wider study area and impacts of

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	proximity of existing data should be taken account of.	OWF construction activities, as detailed in section 9.4.
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 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. Furthermore, it is proposed that less destructive trenchless techniques are utilised at landfall (which may include HDD), which allow ducts to be installed under an obstruction without breaking open the ground and digging a trench.
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 CBRA will be undertaken after geotechnical investigations to inform engineering works. Cable burial will be the preferred option for cable protection, and this will minimise any impacts associated with habitat loss (section 9.5). The results of the CBRA will be included within the final ES.
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.	Mitigation measures that have been adopted as part of the evolution of the project design are detailed within section 9.5. This includes the development of a PEMP and MPCP to manage marine pollution and best practice guidelines will be followed and implemented through the implementation of a Biosecurity Plan to minimise marine INNS introduction/spread.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	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.	
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 was collected across the Project array and offshore ECC at representative habitats and with adequate 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 can also be applied to understand natural change and its associated.
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 Interlink have informed the wider study area and impacts of OWF construction activities, as detailed in section 9.4.
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 of variable sources to build a comprehensive characterisation. Where data is older than 10 years it has 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 was used to identify conservation features and designated sites (Figure 9.6) and the Cefas OneBenthic Tool was used to identify ecology and substrates across the benthic ecology study area (Figure 9.2). EMODnet (2022) data provided the best regional mapping data, presenting EUNIS Level 4 data across the area of interest (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 9.7.
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 9.7. 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).
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 9.4).
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 assessment is	The Project's site-specific data has 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 have relied on historic data and broadscale habitat data of variable sources and dates to build a

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	required before we can provide comment of the sufficiency of the surveys.	comprehensive picture and assist in the temporal understanding of the region although will not be 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 Interlink have been included to inform the wider study area or general impacts from OWFs. An appraisal of this validity is provided in section 9.4.

9.4 Baseline Environment

Benthic Subtidal and Intertidal Study Area

9.4.1 For the purposes of this report, the benthic subtidal and intertidal study areas (Figure 9.1) have been defined by the following:

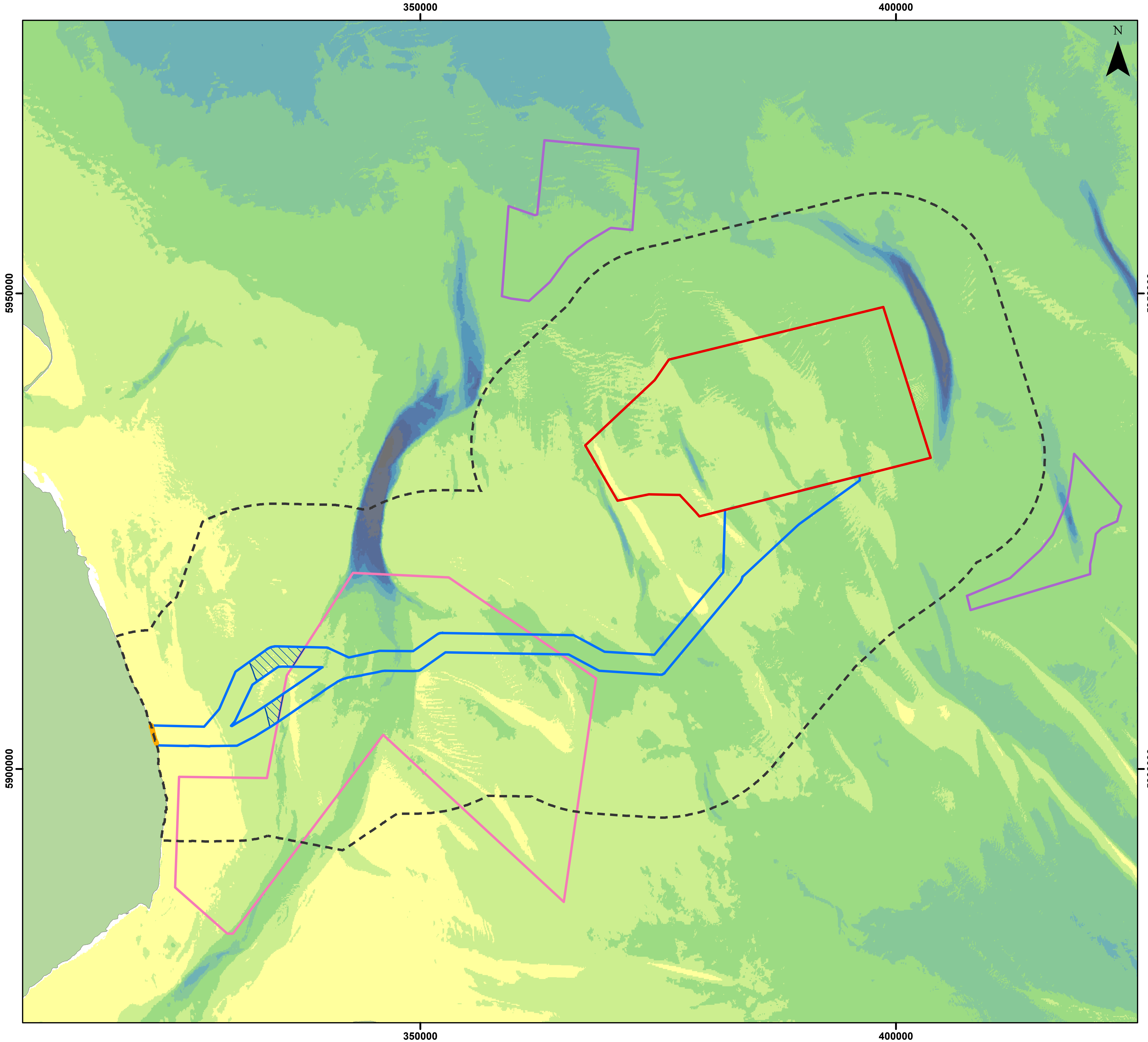
- The PEIR boundary is defined as the array area, along with the offshore ECC and where landfall lies within the Lincolnshire coast between Anderby Creek and Chapel St Leonards.
- The benthic subtidal ecology study area is defined by a buffer of approximately 10km at landfall to 15km from the offshore 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 (Part 6, Volume 2, Appendix 7.2: Physical Processes Modelling Report). 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 PEIR boundary.

9.4.2 Habitats landward of MHWS have been considered in the onshore ecology assessment (Part 6, Volume 1, Chapter 21: Onshore Ecology and Part 6, Volume 1, Chapter 22 Onshore Ornithology).

9.4.3 The study area for the Cumulative Effects Assessment (CEA) is defined by the wider (up to) 15km buffer surrounding the PEIR boundary, 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.

Compensation Areas

9.4.4 Areas of search for potential compensation measures associated with the Project have been provided in Figure 9.1, with the baseline conditions in these areas detailed in Volume 2, Appendix 10.1. The compensation areas will be assessed within the Environmental Statement (ES) following refinement of the proposed areas and once details of the works to be undertaken have been finalised.

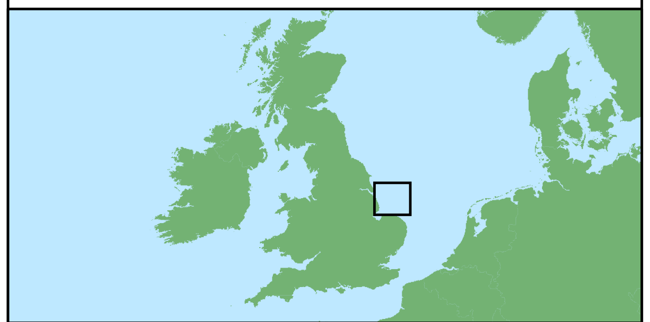


Legend

- Array Area
- Offshore Export Cable Corridor
- ORCP Search Area
- Artificial Nesting Structure Search Area
- Biogenic Reef Restoration Search Area
- Benthic Ecology Study Area
- Intertidal Study Area

Depth (m)

- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 90
- 90 - 100



Coordinate System: WGS 1984 UTM Zone 31N

0 10 20 km

Scale: 1:375,000

Preliminary Environmental Information Report

Benthic and Intertidal Study Area

Figure 9.1

OUTER DOWSING OFFSHORE WIND

Date: 24/04/2023
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Data Sources

9.4.5 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 large parts of the Project benthic subtidal and intertidal ecology study area and wider region (Table 9.3 and Figure 9.2).

9.4.6 Site-specific surveys for the Project were undertaken to provide an up-to-date characterisation of the habitats and species occurring within the PEIR Boundary. The subtidal surveys were conducted between 3 and 13 April 2022 (array) and 17 and 26 July 2022 (ECC) by Benthic Solutions Limited 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).

9.4.7 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) Part 6, Volume 2, Appendix 9.3: Intertidal Technical	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 PEIR Boundary.

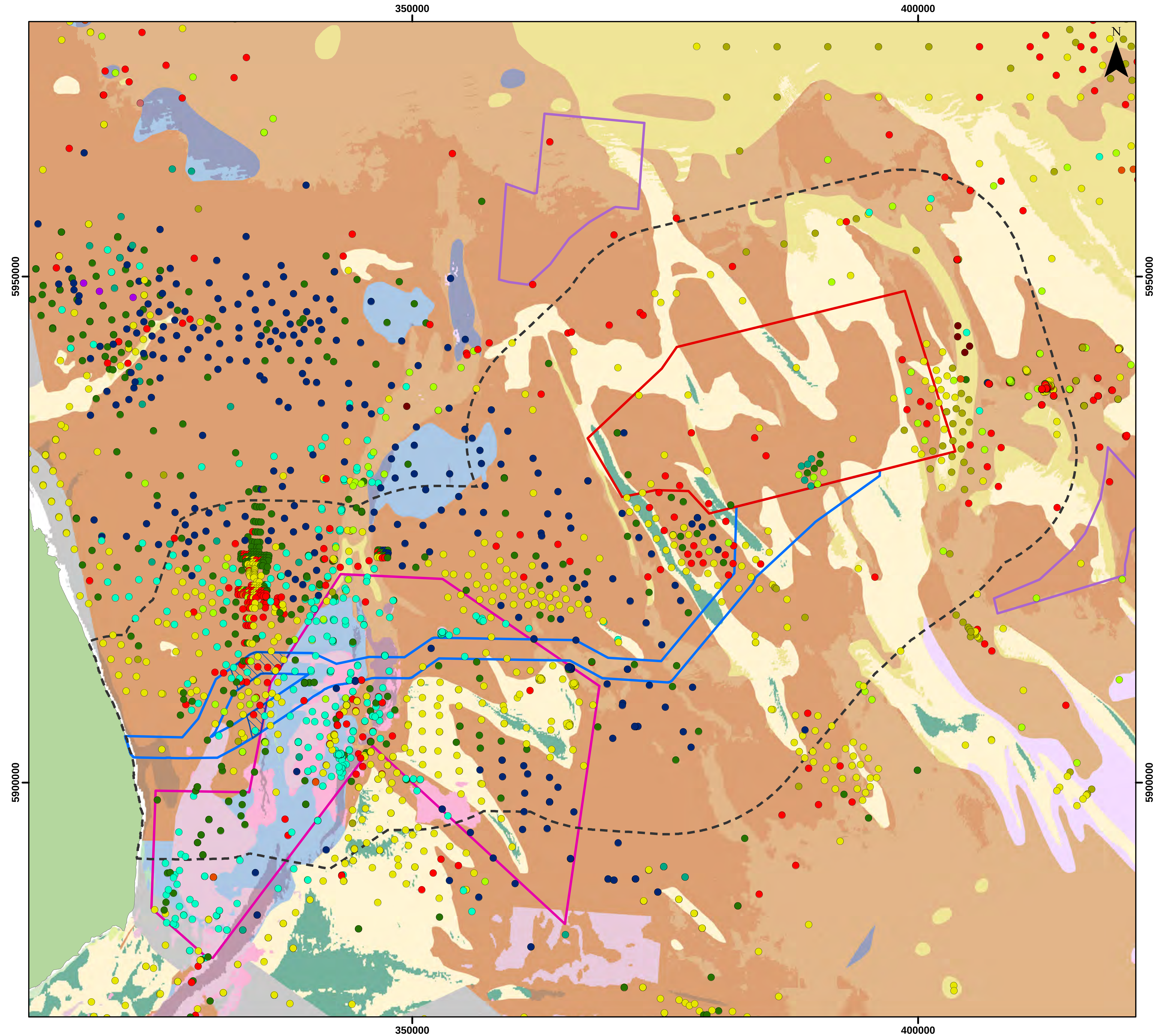
Source	Summary	Spatial coverage of data in relation to the benthic and intertidal study area
Report based on Outer Dowsing Offshore Wind Project – Phase I Intertidal Survey (APEM, 2022).	Intertidal Phase I walkover survey carried out landward to mean low water springs (MLWS) to determine the intertidal 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 PEIR Boundary.
Existing Project Data		
Lynn and Inner Dowsing OWFs (Various datasets) including: Pre-construction characterisation surveys (AMEC, 2002); *Sabellaria 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,	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

Source	Summary	Spatial coverage of data in relation to the benthic and intertidal study area
Geophysical and Benthic Survey (EGS International, 2015).		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.
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.
Race Bank Offshore Wind Farm, Environmental Statement (Centrica Energy, 2009)	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.
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.

Source	Summary	Spatial coverage of data in relation to the benthic and intertidal study area
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 Project array 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 Project array, 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.
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.
Publicly Available Datasets		

Source	Summary	Spatial coverage of data in relation to the benthic and intertidal study area
EMODnet (2022) broad scale seabed habitat map for Europe.	EUNIS Level 4 model, detailing biological zone and substrate.	Complete modelled coverage 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)	Collates time-series data collected around active dredging licence area including: Areas 514/1, 2, 3, 4; Areas 106/1, 2, 3 and 400; Area 493; Areas 481, 2; Area 1805; Area 197; and Areas 515/1, 2.	Provides coverage of the benthic subtidal and intertidal ecology study area.
Planning Offshore Wind Strategic Environmental Impact Decisions (POSEIDON) Project[2]	Strategic environmental baseline data and spatial models for key benthic 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.	Lot 1 data includes the North Sea and whilst this data is not available for inclusion within PEIR. The project outputs will be monitored and included for submission at ES, if available.

[2] POSEIDON Benthic Storyboard (cefas.co.uk)



Legend

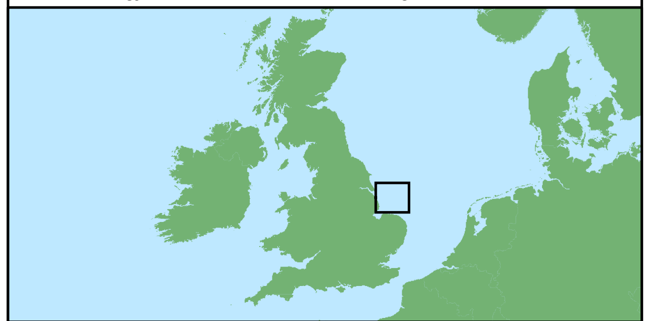
- Array Area
- Offshore Export Cable Corridor
- ORCP Search Area
- Artificial Nesting Structure Search Area
- Biogenic Reef Restoration Search Area
- Benthic Ecology Study Area

EUSeaMap 2021 (EMODnet, 2021)

- A4.2: Atlantic and Mediterranean moderate energy circalittoral rock
- A4.27: Faunal communities on deep moderate energy circalittoral rock
- A5.13: Infralittoral coarse sediment
- A5.14: Circalittoral coarse sediment
- A5.15: Deep circalittoral coarse sediment
- A5.23 or A5.24: Infralittoral fine sand or Infralittoral muddy sand
- A5.25 or A5.26: Circalittoral fine sand or Circalittoral muddy sand
- A5.27: Deep circalittoral sand
- A5.33: Infralittoral sandy mud
- A5.35: Circalittoral sandy mud
- A5.37: Deep circalittoral mud
- A5.43: Infralittoral mixed sediments
- A5.44: Circalittoral mixed sediments
- A5.45: Deep circalittoral mixed sediments
- A5.6: Sublittoral biogenic reefs
- A5.61: Sublittoral polychaete worm reefs on sediment
- A5.611: [Sabellaria spinulosa] on stable circalittoral mixed sediment
- No EUNIS habitat assigned

OneBenthic Faunal Data Points (Cefas)

A1	B1b	D2a
A2a	C1a	D2b
A2b	C1b	D2c
B1a	D1	D2d



Coordinate System: WGS 1984 UTM Zone 31N

0 10 20 km

Scale: 1:350,000

Preliminary Environmental Information Report

The Location of Existing Data Across the Project Benthic Ecology Study Area

Figure 9.2

OUTER DOWSING OFFSHORE WIND

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Contains ESRI Basemapping; EMODnet 2020 bathymetry

Document Path: G:\GIS\GIS_Projects\0152 Outer Dowsing EIA\GIS\Figures\PEIR\Benthic Ecology\ODOW_0152_BE_Fig3.2_Existing_Data.mxd

Existing Environment

9.4.8 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 PEIR Boundary 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 (Figure 9.1). 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:

- Part 6, Volume 2, Appendix 9.1: Benthic Ecology Technical Report (Array);
- Part 6, Volume 2, Appendix 9.2: Benthic Ecology Technical Report (ECC); and
- Part 6, Volume 2, Appendix 9.3: Intertidal Technical Report.

Bathymetry Seabed Features

Regional Context

9.4.9 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 80 m below the surrounding seabed (Tappin *et al*., 2012).

9.4.10 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 20 m. 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).

9.4.11 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 5 m high lie parallel to the coast (Tappin *et al*., 2012).

Project Array

9.4.12 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) (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 (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).

9.4.13 Regional-scale assessments identify a net north-westerly direction of bedload transport for the Project 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 Project array. Higher values will occur during spring tides and storm conditions, with the greatest concentrations encountered close to the bed.

Offshore Export Cable Corridor

9.4.14 In the eastern part of the ECC, water depths range generally between 10 to 30m (LAT), 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) (Figure 9.1). 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. From around 12km offshore, water depths typically shallow uniformly from around 14m towards the coast (EMODnet, 2022).

9.4.15 Bedload sediment transport in the most offshore part of the offshore ECC is directed towards the northwest, the Project array area. 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.

9.4.16 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).

9.4.17 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).

9.4.18 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

9.4.19 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).

9.4.20 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.

9.4.21 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).

Sediment Characteristics

Regional Context

9.4.22 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).

9.4.23 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 (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.

9.4.24 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).

Project Array

9.4.25 Spatial distribution of EUNIS biotope complexes identified through single point grab sampling and interpretation of SSS data are presented in 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.

9.4.26 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'.

9.4.27 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).

9.4.28 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

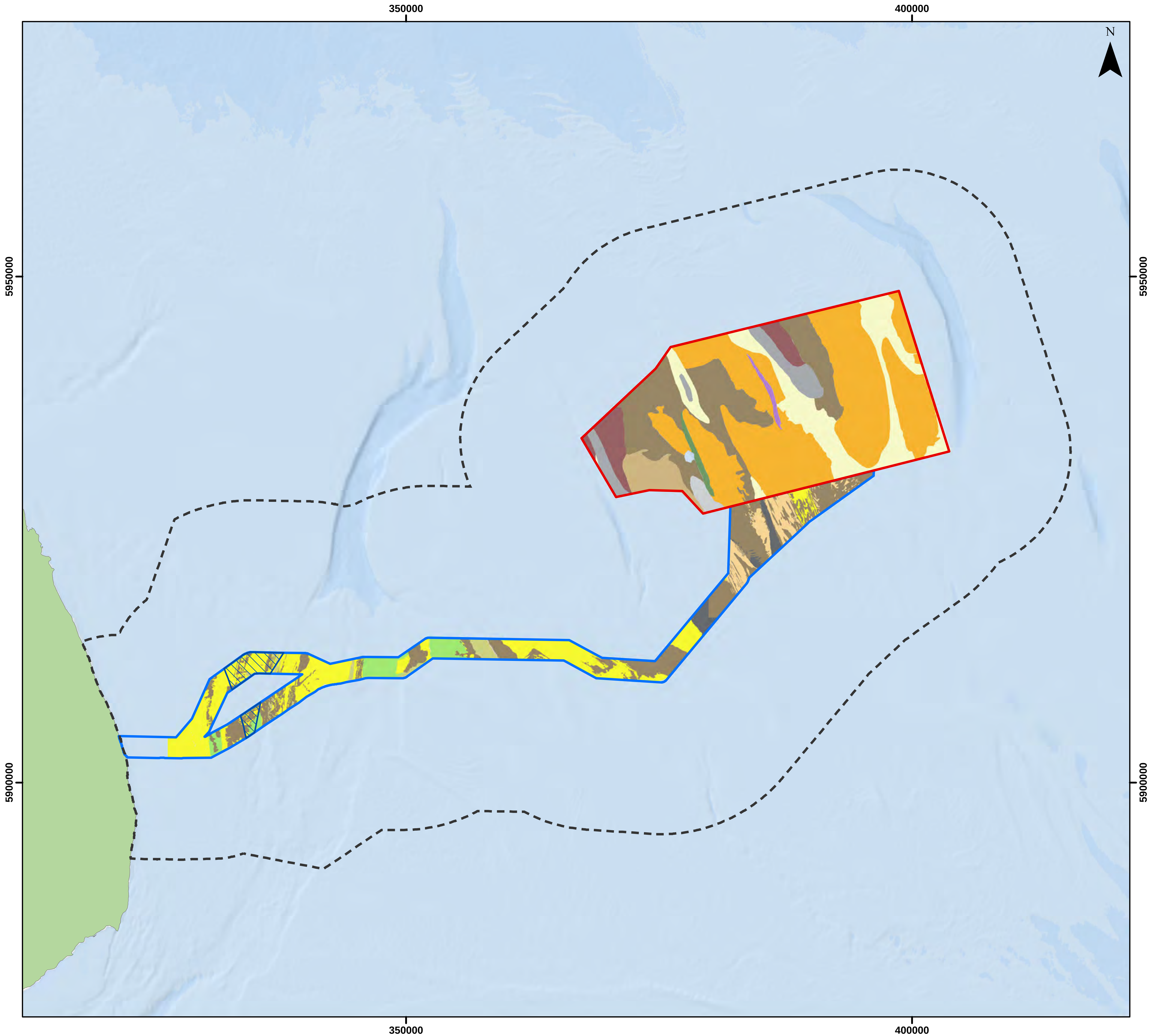
9.4.29 Spatial distribution of EUNIS biotope complexes identified through single point grab sampling and interpretation of SSS data are presented in Figure 9.4. This data demonstrates that the majority of the offshore ECC is dominated by circalittoral coarse and circalittoral mixed sediments.

9.4.30 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).

9.4.31 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 (Figure 9.2) (EMODnet, 2022).

Intertidal

9.4.32 The middle shore habitat of the intertidal featured rippled mobile sand interspersed with coarser gravel and shell fragments (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).

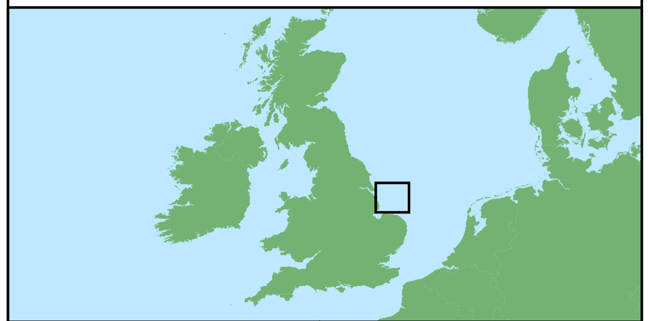


Legend

- Array Area
- Offshore Export Cable Corridor
- ORCP Search Area
- Benthic Ecology Study Area

Seabed Features

- Circalittoral Coarse Sand (sand with shell gravel)
- Circalittoral Coarse Sand (sand with pebbles and cobbles)
- Circalittoral Coarse Sand (sand with shell, pebbles and cobbles)
- Circalittoral Coarse Sand (sand with small pebbles)
- Circalittoral Coarse Sand with patches of Circalittoral Mixed Sediment
- Circalittoral Fine Sand
- Circalittoral Mixed Sediment
- Circalittoral Muddy Sand
- Infralittoral Coarse Sediment
- Infralittoral Fine Sand
- Infralittoral Muddy Sand
- Offshore Circalittoral Coarse Sediment
- Offshore Circalittoral Sand
- Sabellaria spinulosa on stable circalittoral mixed sediment



Coordinate System: WGS 1984 UTM Zone 31N

0 10 20 km

Scale: 1:350,000

Preliminary Environmental Information Report

Geophysical and Seabed Sediment Features Across the Project Benthic and Intertidal Ecology Study Area

Figure 9.3

OUTER DOWSING OFFSHORE WIND

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Revision: 0.1

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Sediment Chemistry

Regional Context

9.4.33 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).

9.4.34 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 significant 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 (Part 6, Volume 1, Chapter 8: Marine Water Quality).

9.4.35 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.

Project Array

9.4.36 As presented in Part 6, Volume 2, Appendix 9.1: Benthic Ecology Technical Report (Array) 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.

9.4.37 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 exceeded 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 previously operated by Perenco. However, the overall low PAHs in conjunction with low PCBs, organotins and organochlorine pesticides suggests broadly even distribution of aromatic hydrocarbons across the site.

9.4.38 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).

9.4.39 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.

9.4.40 Further details of sediment contamination are provided in Part 6, Volume 1, Chapter 8: Marine Water Quality and Part 6, Volume 2, Appendix 9.1: Benthic Ecology Technical Report (Array).

Offshore Export Cable Corridor

9.4.41 As presented in Part 6, Volume 2, Appendix 9.2: Benthic Ecology Technical Report (ECC), the following contaminants were recorded as below Cefas Action Level 1:

- Organotins; TBT; DBT; MBT;
- PCB's, sum of ICES 7;
- PCB's, sum of 25 congeners; and
- Dieldrin.

9.4.42 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.

9.4.43 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.

9.4.44 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).

9.4.45 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 Part 6, Volume 1, Chapter 18: Infrastructure and Other Marine Users and further detail of sediment contamination is provided within Part 6, Volume 1, Chapter 8: Marine Water and Sediment Quality and Part 6, Volume 2, Appendix 9.2: Benthic Ecology Technical Report (ECC).

Seabed Habitat and Communities

Regional Context

9.4.46 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 significant coarse components, where a range of microhabitats allow colonisation by a wide array of species (Jones *et al.,* 2004).

9.4.47 The Cefas OneBenthic faunal data (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 bryozoan 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.

9.4.48 The adjacent Triton Knoll ECC subtidal ecology survey overlaps with the wider subtidal ecology study area and offshore 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).

9.4.49 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).

9.4.50 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).

9.4.51 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).

9.4.52 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).

9.4.53 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).

9.4.54 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).

9.4.55 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 (Centrica energy, 2009).

9.4.56 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)	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	*Mediomastus fragilis, Lumbrineris* spp. and venerid bivalves in Atlantic circalittoral coarse sand or gravel	SS.SCS.CCS.MedLumVen
MC12162	*Flustra foliacea*, small solitary and colonial ascidians on tide-swept Atlantic circalittoral bedrock or boulders	CR.HCR.XFa.FluCoAs.SmAs
MC2211	*S. spinulosa* on stable Atlantic circalittoral mixed sediment	SS.SBR.PoR.SspiMx
MB5233	*Nephtys cirrosa* and *Bathyporeia* spp. in Atlantic infralittoral sand	SS.SSa.IFiSa.NcirBat
MC5214	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	SS.SSa.CMuSa.AalbNuc
MB3233	*Moerella* spp. with venerid bivalves in Atlantic infralittoral gravelly sand	SS.SCS.ICS.MoeVen
MB3231	Sparse fauna on highly mobile Atlantic infralittoral shingle (cobbles and pebbles)	SS.SCS.ICS.SSh
MC3213	*Protodorvillea kefersteini* and other polychaetes in impoverished Atlantic circalittoral mixed gravelly sand	SS.SCS.CCS.Pkef
MB3235	*Glycera lapidum* in impoverished Atlantic infralittoral mobile gravel and sand	SS.SCS.ICS.Glap

EUNIS Code (2022)	Biotope Name	JNCC 04.05 Code
MC4214	*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment	SS.SMx.CMx.FluHyd
MB4231	*Crepidula fornicata* with ascidians and anemones on Atlantic infralittoral coarse mixed sediment	SS.SMx.IMx.CreAsAn
MB3237	Dense *Lanice conchilega* and other polychaetes in Atlantic tide-swept infralittoral sand and mixed gravelly sand	SS.SCS.ICS.SLan
MC121A	*Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed Atlantic circalittoral rock	CR.HCR.XFa.Mol
MD4211	Polychaete-rich deep Venus community in offshore mixed sediments (Impoverished or a transition biotope)	SS.SMx.OMx.PoVen
MB3234	*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	*Abra prismatica, Bathyporeia elegans* and polychaetes in Atlantic circalittoral fine sand	SS.SSa.CFiSa.ApriBatPo
MC5211	*Echinocyamus pusillus, Ophelia borealis and Abra prismatica* in Atlantic circalittoral fine sand	SS.SSa.CFiSa.EpusOborApri
MB5236	*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in Atlantic infralittoral compacted fine muddy sand	SS.SSa.IMuSa.FfabMag
MC1251	Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay	CR.MCR.SfR.Pid

Project Array

9.4.57 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 (Figure 9.2).

9.4.58 As detailed in Part 6, Volume 2, Appendix 9.1: Benthic Ecology Technical Report (Array), across the array a total of 4,429 individuals representing 265 taxa were recorded from the 71 macrofaunal grab samples. Benthic subtidal 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 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 Project array. Multivariate indices revealed a relatively heterogeneous benthos, owing to the varying coarseness of seabed sediment in a high energy environment.

9.4.59 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 paragraphs 9.4.88 *et seq*.

9.4.60 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 (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 (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 Figure 9.4 and Table 9.6.

9.4.61 The predominant biotope complex across the Project array 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. spinulos*a, 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*.

9.4.62 '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 feline*, *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).

9.4.63 '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.

9.4.64 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).

9.4.65 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.*

9.4.66 '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*.

9.4.67 '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 Project array

EUNIS Code	Biotope name	JNCC 04.05 Code
Array		
MD52	Atlantic offshore circalittoral sand	SS.SSa.OSa
MC52	Atlantic circalittoral sand	SS.SSa.CfiSa
MB52	Atlantic infralittoral sand	SS.SSa.IfiSa
MC42	Atlantic circalittoral mixed sediment	SS.SMx.CMx
MD32	Atlantic offshore circalittoral coarse sediment	SS.SCS.OCS
MC32	Atlantic circalittoral coarse sediment	SS.SCS.CCS
MB32	Infralittoral coarse sediment	SS.SCS.ICS
MC3211	*Spirobranchus triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles (Impoverished)	SS.SCS.CCS.SpiB
MB5231	Infralittoral mobile clean sand with sparse fauna (Impoverished)	SS.SSa.IfiSa.ImoSa
MC4214	*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment (Intermediate)	SS.SMx.CMx.FluHyd
MC2211	*S. spinulosa* on stable circalittoral mixed sediment	SS.SBR.PoR.SspiMx

9.4.68 As detailed within Part 6, Volume 2, Appendix 9.2, the benthic sediment eDNA dataset recorded 340 taxa across the benthic subtidal and intertidal study area within the PEIR boundary, 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 Project array, 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

9.4.69 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 (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.

9.4.70 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* (Figure 9.4). 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.

9.4.71 As detailed within Part 6, Volume 2, 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.

9.4.72 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).

9.4.73 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.

9.4.74 '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 fornicata*.

9.4.75 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.

9.4.76 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 paragraph 9.4.95 *et seq*.

9.4.77 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*.

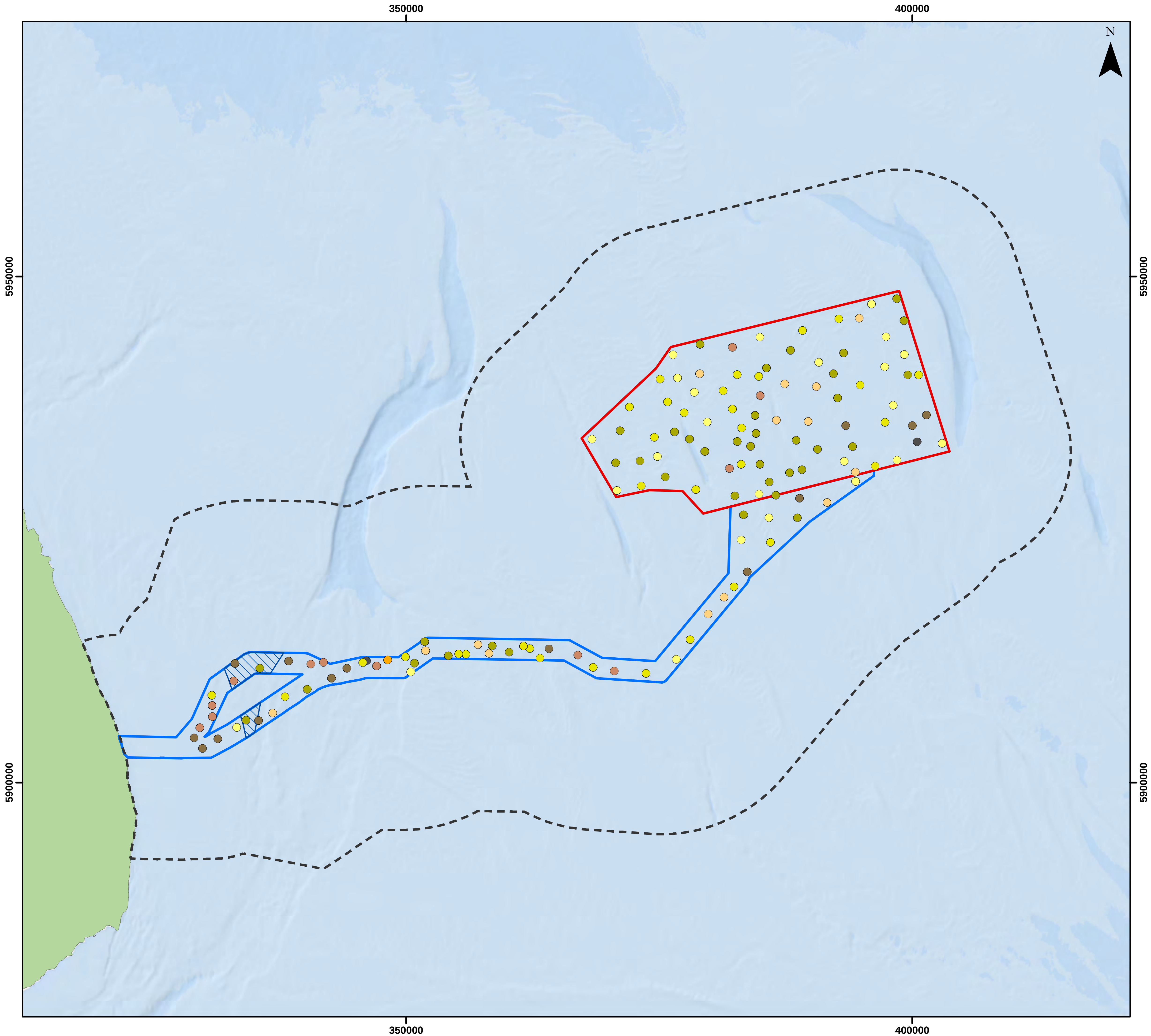
9.4.78 The deeper habitats were dominated by rippled fine to coarse sands and silty sands and identified as the habitat 'Circalittoral muddy sand' (MC52). Further examination of these communities revealed that the presence of Ophiuroidea, Pagurus, Caridea and starfish could support the classification 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	Biotope name	JNCC 04.05 Code
Offshore ECC		
MC32	Atlantic circalittoral coarse sediment	SS.SCS.CCS
MC42	Atlantic offshore circalittoral mixed sediment	SS.SMx.CMx
MC2211	*S. spinulosa* on stable circalittoral mixed sediment	SS.SBR.PoR.SspiMx
MB5	Infralittoral muddy sand	SS.SSa.IMuSa
MC52	Circalittoral muddy sand	SS.SSa.CMuSa
A5.262TMP[3] (EUNIS 2008)	*Ophiura ophiura* on circalittoral muddy sand (Impoverished biotope)	SS.SSa.CMuSa.Ooph
MC3213	*Protodorvillea kefersteini* and other polychaetes in impoverished Atlantic circalittoral mixed gravelly sand (Impoverished biotope)	SS.SCS.CCS.Pkef
MC4214	*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment	SS.SMx.CMx.FluHyd

9.4.79 As detailed within Part 6, Volume 2, Appendix 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 PEIR Boundary. 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.

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

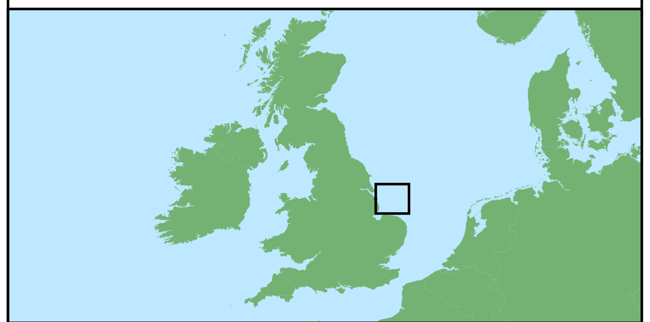


Legend

- Array Area
- Offshore Export Cable Corridor
- ORCP Search Area
- Benthic Ecology Study Area

Folk Classifications

- Sand
- Slightly Gravelly Sand
- Slightly Gravelly Muddy Sand
- Gravelly Sand
- Sandy Gravel
- Muddy Sandy Gravel
- Gravelly Muddy Sand
- Gravel



Coordinate System: WGS 1984 UTM Zone 31N

0 10 20 km

Scale: 1:350,000

Preliminary Environmental Information Report

EUNIS Biotopes Identified from Site-Specific Surveys Across the Study Area

Figure 9.4

OUTER DOWSING OFFSHORE WIND

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Intertidal

9.4.80 As detailed in Part 6, Volume 2, 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; Figure 9.5).

9.4.81 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

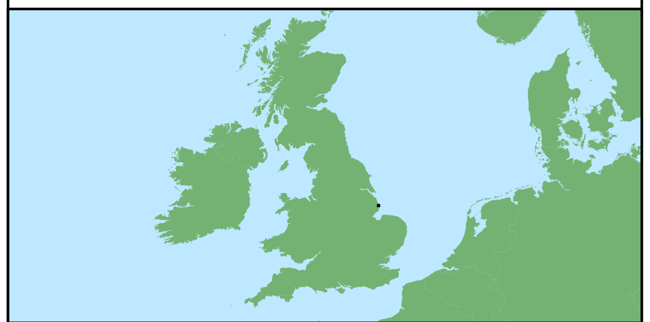
EUNIS Code	Biotope name	JNCC 04.05 Code
Intertidal		
MA5231	Barren Atlantic littoral coarse sand	LS.LSa.MoSa.BarSa
MA5211	Talitrids on the upper shore and strandline	LS.LSa.St.Tal
No corresponding EUNIS code	*Ulva* spp. on freshwater-influenced and/or unstable upper eulittoral rock	LR.FLR.Eph.Ulv
MA5233	Amphipods and *Scolelepis* spp. in Atlantic littoral medium-fine sand	LS.LSa.MoSa.AmSco
MA5241	Polychaetes in Atlantic littoral fine sand	LS.LSa.FiSa.Po

Legend

Offshore Export Cable Corridor

Biotopes (EUNIS)

- MA123F (LR.FLR.Eph.Ulv)
- MA5211 (LS.LSa.St.Tal)
- MA5231 (LS.LSa.MoSa.BarSa)
- MA5233 (LS.LSa.MoSa.AmSco)
- MA5241 (LS.LSa.FiSa.Po)



Coordinate System: WGS 1984 UTM Zone 31N

0 0.25 0.5 km

Scale: 1:7,000

Preliminary Environmental Information Report

Biotopes Identified within the Project Intertidal during the Phase I Survey

Figure 9.5

OUTER DOWSING OFFSHORE WIND

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Compensation Areas

9.4.82 Broadscale regional habitat mapping identified that the Artificial Nesting Structure Search Area to the north of the array area is dominated by circalittoral coarse sediment and deep circalittoral coarse sediment (Figure 9.2). Areas of deep circalittoral sand and circalittoral fine sand or circalittoral muddy sand are found within the northeast corner of the Artificial Nesting Structure Search Area. 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 within the north of the Artificial Nesting Structure Search Area (Figure 9.2).

9.4.83 The Artificial Nesting Structure Search Area to the southeast of the array area has a similar sediment assemblage to the North Artificial Nesting Structure Search Area. Broadscale habitat mapping identified the site to predominantly contain circalittoral coarse sediment, with a band of deep circalittoral sand and circalittoral fine sand or circalittoral muddy sand running through the search area from north to south and light patches of deep circalittoral coarse sediment (Figure 9.2). Faunal clusters D2a, D2c and C1b (as characterised in Section 9.4) were also confirmed within the site (Figure 9.2).

9.4.84 The biogenic reef search area encompasses the Inner Dowsing, Race Bank, and North Ridge SAC. The search area encompasses a wide range of sandbank types and biogenic reef (JNCC and Natural England, 2010) and has therefore been designated for two Annex 1 habitat protected features, including 'reefs' and 'sandbanks which are slightly covered by sea water all the time'.

9.4.85 Biogenic reef created by the Ross worm *S. spinulosa* has consistently been recorded within the site. These reefs are known to support a variety of species including hydroids, sponges, bryozoans, anemones, as well as the commercial species European lobster *Homarus gammarus* and pink shrimp *Pandalus montagui*. Biogenic reefs formed by *S. spinulosa* allow colonisation by species not otherwise associated with the adjacent, looser sediment habitats.

9.4.86 The main sandbank features occur within the Wash Approaches, the Race Bank-North Ridge-Dudgeon Shoal system and at Inner Dowsing. The tops of the sandbanks are characterised by communities of polychaetes and amphipods. The trough areas between these sandbank features are composed of mixed and gravelly sands.

9.4.87 The compensation areas will be assessed within the Environmental Statement (ES) following refinement of the proposed areas and once details of the works to be undertaken have been finalised.

Features of Conservation Interest

9.4.88 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 Habitats Directive, and the transposing 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.

9.4.89 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.

9.4.90 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".

9.4.91 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).

9.4.92 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).

9.4.93 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).

9.4.94 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).

9.4.95 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 the 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).

9.4.96 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).

9.4.97 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).

9.4.98 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).

9.4.99 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.

9.4.100 The Project overlaps with a portion of the Inner Dowsing, Race Bank, and North Ridge SAC which is designated for *S. spinulosa* reefs and 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.

9.4.101 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 (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.

Project Array

9.4.102 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 Part 6, Volume 2, Appendix 9.1: Benthic Ecology Technical Report (Array), paragraph 4.8.2.

9.4.103 *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 Part 6, Volume 2, Appendix 9.1: Benthic Ecology Technical Report (Array), paragraph 4.8.2.

9.4.104 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 Project array.

Offshore Export Cable Corridor

9.4.105 Presence of cobbles at 33 stations in areas classified as 'Atlantic circalittoral mixed sediment' and 'Atlantic circalittoral coarse sediment' (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 Marine Natura 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 Part 6, Volume 2, Appendix 9.2: Benthic Ecology Technical Report (ECC) (paragraph 4.9.2).

9.4.106 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 Part 6, Volume 2, Appendix 9.2: Benthic Ecology Technical Report (ECC) (section 4.9.2).

9.4.107 The lack of unique *S. spinulosa* feature signatures within the SSS and MBES data did not allow for the delineation of these features within the PEIR boundary. Whist the ground-truthing data have concluded that aggregations were classified as 'not a reef', the overall extent of potential *S. spinulosa* features cannot be cross-checked with the geophysical data because of the lack of unique signatures within this data. As a result, a precautionary approach has been applied to this characterisation whereby it will be assumed that *S. spinulosa* reef is located across the PEIR boundary in some form and therefore both direct and indirect impacts will be assessed on this feature.

9.4.108 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' (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.

9.4.109 Sandeels *Ammodytes* spp. were present within the site-specific grab macrofauna, epibenthic trawl datasets and the video analysis. The ocean quahog *Arctica islandica* 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 Part 6, Volume 1, Chapter 10: Fish and Shellfish Ecology.

9.4.110 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).

Non-Native Species

Regional Context

9.4.111 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).

9.4.112 During the Humber REC, four species of marine INNS, 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 as 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).

Project Array

9.4.113 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

9.4.114 *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

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

Designated Sites

9.4.116 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 (Figure 9.).

9.4.117 The Project overlaps with a portion of the Inner Dowsing, Race Bank, and North Ridge SAC which is designated for reefs and sandbanks which are slightly covered by sea water all the time. 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 9.4.103 and 9.4.106, *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. Yet, whilst this conclusion was made within the ground-truth data, the geophysical data did not allow any further delineation on the extent of potential *S. spinulosa* features within the PEIR boundary (as detailed in paragraph 9.4.107). A precautionary approach has therefore been applied whereby the assessment will assume *S. spinulosa* reef to occur within the SAC where the offshore ECC intersects.

9.4.118 The sites that lie in the area of the subtidal ecology study area are identified in Table 9.8. 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 Figure 9.6.

9.4.119 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 Part 6, Volume 2, 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.

9.4.120 The Project spatially overlaps with 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).

9.4.121 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, only sandbanks predominantly made of coarse sediments, sand and mixed sediments are predicted to occur within the PEIR Boundary (Natural England and JNCC, 2016).

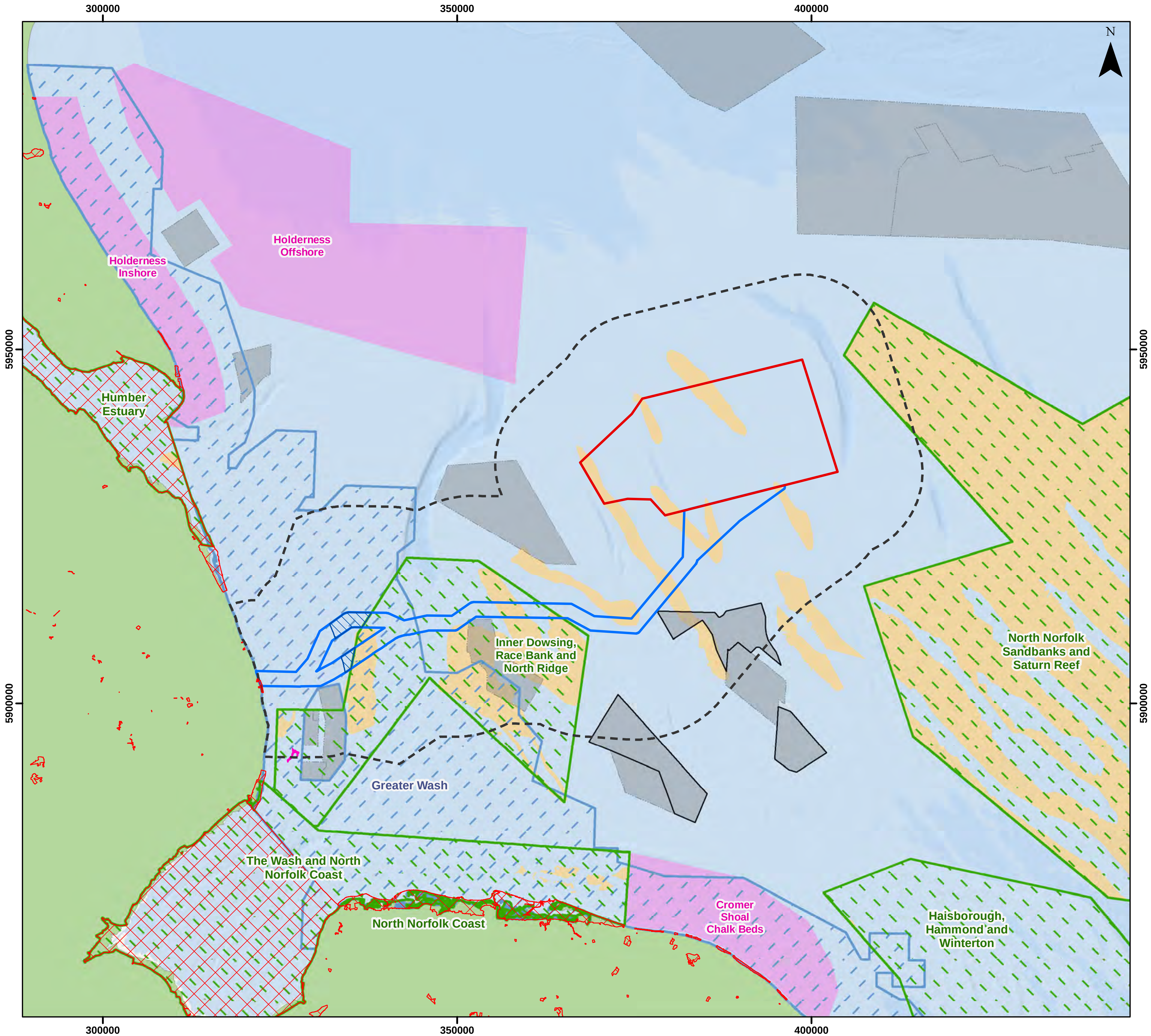
9.4.122 Due to its location 14.4km away from the Project array and outside the subtidal ecology study area, the Holderness Offshore MCZ, which is assigned for the *A. islandica* and broadscale habitat features, has not been evaluated as part of the benthic subtidal and intertidal ecology assessment. An assessment of the potential impacts on MCZs is provided in Part 6, Volume 2, Appendix 9.4: Marine Conservation Zone Assessment.

9.4.123 The Project offshore ECC overlaps with the Chapel Point to Wolla Bank SSSI, which is a nationally designated geological site. Whilst not designated for intertidal ecology, the Project has committed to avoiding any direct impact to this site, with HDD punch-out micro-sited to avoid the feature (Table 9.11).

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

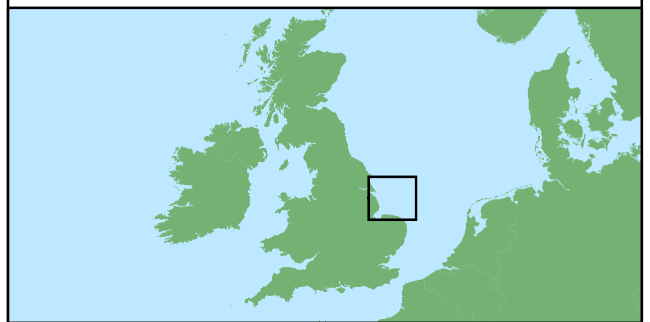
Site	Qualifying features	Distance from the Project
SACs		
Inner Dowsing, Race Bank and North Ridge SAC	Annex I habitat: ▪ Reefs ▪ Sandbanks which are slightly covered by sea water all the time	0km from offshore ECC and 16.7km from Project array.
The Wash and North Norfolk Coast SAC	Annex I habitat: ▪ Reefs ▪ Sandbanks which are slightly covered by sea water all the time	13.4km from offshore ECC and 47.8km from Project array.

Site	Qualifying features	Distance from the Project
	▪ Mudflats and sandflats not covered by seawater at low tide ▪ Large shallow inlet and bays ▪ Salicornia and other annuals colonizing mud and sand ▪ Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) ▪ Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*)	
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 5.8km from Project array.
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 PEIR boundary 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. However, the site covers an area of c. 3,536 km^2. The offshore ECC has a 2.4% overlap and wider subtidal ecology study area has a 23.1% overlap with the total site.



Legend

- Array Area
- Offshore Export Cable Corridor
- ORCP Search Area
- Benthic Ecology Study Area
- Offshore Wind Farms
- Future Wind Farm Extensions
- Special Protection Area
- Special Area of Conservation
- Marine Conservation Zone
- Annex I Sandbank
- Annex I Reefs
- Sites of Special Scientific Interest



Coordinate System: WGS 1984 UTM Zone 31N

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Scale: 1:500,000

Preliminary Environmental Information Report

National and International Conservation Designations of Relevance to Benthic and Intertidal Ecology within the Area of Potential Direct and Indirect Impact of the Project

Figure 9.6

OUTER DOWSING OFFSHORE WIND

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Valued Ecological Receptors (VERs)

9.4.124 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.

9.4.125 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 found within the array and offshore ECC, 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 9.7).

9.4.126 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 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 in the next section, 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.

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 reef	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 PEIR boundary, therefore no national or international importance applied to this habitat within the offshore ECC or the array. Indirect impacts to this habitat within in the wider study area have been assessed (section 9.7). To add an element of precaution as a result of the geophysical data interpretation the assessment will assume *S. spinulosa* reef might occur in some form across the PEIR boundary and therefore direct impacts to this habitat will also be considered.

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[4] (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 (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.
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 (Figure 9.4).	None

[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
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 and offshore ECC (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 PEIR boundary 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 (Figure 9.5).	N/A
Ulva spp. on freshwater-influenced and/or unstable upper eulittoral rock	LR.FLR.Eph.Ulv[5] (JNCC code)	N/A	N/A	Located across the intertidal (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 (Figure 9.5).	N/A

[5] 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
Barren Atlantic littoral coarse sand	MA5231	N/A	N/A	Located across the intertidal and wider study area (Figure 9.5).	N/A
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 Directive	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 with 19.2km^2 of the Annex I sandbank within the SAC (5.3% of the total sandbank) (Figure 9.6).	National – forms part of the National Site Network of designated sites within the UK (Inner Dowsing, Race Bank and North Ridge SAC).
Biogenic reef, *S. spinulosa*	N/A	Annex I Habitats Directive	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 with 70.1km^2 of the SAC (8.3% of the total SAC) (Figure 9.6).	National – forms part of the National Site Network of designated sites within the UK (Inner Dowsing, Race Bank and North Ridge SAC).
Supporting habitats of the 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
Subtidal sandbanks	N/A	Annex I Habitats Directive	Annex I within an SPA Habitats of Principal importance and UK BAP FOCI under the Nature Conservation part (Part 5) of the MCAA 2009	Direct overlap with 85.7km^2 of the SPA (2.4% of the total SPA) (Figure 9.6).	National – forms part of the National Site Network of designated sites within the UK (Greater Wash SPA).
Biogenic reef, including *S. spinulosa* reef	MC2211	Annex I Habitats Directive	Annex I within an SPA Habitats of Principal importance and UK BAP FOCI under the Nature Conservation part (Part 5) of the MCAA 2009	Direct overlap with 85.7km^2 of the SPA (2.4% of the total SPA) (Figure 9.6).	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
Mussel beds	N/A	Annex I Habitats Directive	Annex I within an SPA Habitats of Principal importance and UK BAP FOCI under the Nature Conservation part (Part 5) of the MCAA 2009	Direct overlap with 85.7km^2 of the SPA (2.4% of the total SPA) (Figure 9.6) . No mussel beds were recorded within the PEIR boundary (see Part 6, Volume 2, Appendix 9.1: Benthic Ecology Technical Report (Array) and Part 6, Volume 2, Appendix 9.2: Benthic Ecology Technical Report (ECC)).	National – forms part of the National Site Network of designated sites within the UK (Greater Wash SPA).

Future Baseline

9.4.127 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 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.

9.4.128 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).

9.4.129 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).

9.4.130 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.

9.5 Basis of the Assessment

Scope of the Assessment

Impacts Scoped in for Assessment

9.5.1 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 : Permanent 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.

Impacts Scoped out of Assessment

9.5.2 In line with the Scoping Opinion (the Inspectorate, 2022), and based on the receiving environment, expected parameters of the Project (Part 6, Volume 1, Chapter 3: Project Description), 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.

9.5.3 The cumulative impacts that have been considered in the CIA for all stages of the Project development and those excluded are discussed in section 9.8 and paragraphs 9.8.3 to 9.8.4.

9.5.4 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 PEIR chapter.

Realistic Worst-Case Scenario

9.5.5 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 = 34,127,140m²** **<u>Array Area</u>** **Foundation seabed Preparation** = 860,600 m² ▪ 93 WTGs (jacket foundations with suction buckets) = 762,600m² ▪ Four offshore transformer substations (jacket foundations with suction buckets) = 78,400m² ▪ One accommodation platform= 19,600m² **Jack-up vessels (JUV) and anchoring operations** = 1,035,700m² ▪ 475 JUV operations with a maximum disturbance of 1,500m² per operation = 712,500m² ▪ 388 anchoring operations with a maximum disturbance of 800m² per operation within the array and ECC = 310,400m² ▪ 16 anchoring operations with a maximum disturbance of 800m2 per operation for Offshore Substation Platform (OSP) installation = 12,800m² **Cable seabed preparation and installation in the array area** = 17,091,000m² ▪ Total area of seabed disturbed by sandwave clearance in array = 8,545,500m² ▪ Total area of seabed disturbed by boulder clearance in array = 8,545,500m² **Cable burial** ▪ Total area of seabed disturbed by cable burial in array (total length 351,000m) = 6,318,000m²	The subtidal temporary disturbance relates to seabed preparation for foundations and cables, jack up 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 temporary habitat disturbance in the intertidal area from the trenchless technique is included. It is important to note that trenchless technique exit pits are likely to be located below MLWS.

Potential effect	Maximum design scenario assessed	Justification
	<u>Offshore ECC</u> **Cable seabed preparation in the offshore ECC** = 9,260,000m^2 ▪ Total area of seabed disturbed by sandwave clearance for offshore ECC = 4,630,000m^2 ▪ Total boulder clearance impact area in offshore ECC = 4,630,000m^2 **Cable burial in the offshore ECC** = 5,840,640m^2 ▪ Burial of export cables (total length 514,800m) length = 5,840,640m^2 ▪ The seabed footprint for cable jointing is within the design envelope for seabed preparation and cable installation. **Offshore Substations** = 39,200m^2 ▪ Two Offshore Reactive Compensation Platforms (ORCPs) = 39,200 m^2	
Impact 2: Temporary increase in suspended sediment and sediment deposition	**Total subtidal sediment volume = 40,654,120m^3** **Foundation seabed preparation = 3,715,400m^3** ▪ 93 GBS WTG foundations = 3,375,900m^3 ▪ Four offshore transformer substations (GBS foundations) = 194,000m^3 ▪ One Accommodation platform GBS foundations = 48,500m^3 ▪ Two ORCPs = 97,000m^3 **Sandwave clearance for cable installation in the array = 15,245,280m^3** ▪ Sandwave clearance for array cables resulting in the suspension of 10,108,800m^3 of sediment	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 assumes the largest number

Potential effect	Maximum design scenario assessed	Justification
	▪ Sandwave clearance for interlink cables resulting in the suspension of 3,564,000m^3 of sediment ▪ Sandwave clearance for 128.7km of export cables within the array area resulting in the suspension of 1,572,480m^3 of sediment **Sandwave clearance for cable installation in the offshore ECC = 5,840,640m^3** ▪ Sandwave clearance for 101.4km of export cables within the offshore ECC resulting in the suspension of 5,840,640m^3 of sediment. **Cable trenching = 15,832,800m^3** ▪ Installation of 123.75km of inter-array cables and export cables by mass flow excavation resulting in the suspension of 15,832,800m^3 of sediment. **Total nearshore sediment volume = 20,000m^3** ▪ Four offshore trenchless technique exit pits require excavation of 20,000m^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.	of cables and the greatest burial depth. The MDS for temporary habitat disturbance in the intertidal area from the trenchless technique is included. It is important to note that HDD exit pits are likely to be located below MLWS. 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.
Impact 3: Direct and indirect seabed disturbances leading to the release of	The MDS for seabed disturbance are presented in **Impact 2**.	This scenario represents the maximum total seabed disturbance and therefore the maximum amount of

Potential effect	Maximum design scenario assessed	Justification
sediment contaminants		contaminated sediment that may be released into the water column during construction activities.
Operation and Maintenance		
Impact 1 : Permanent habitat loss/alteration	**Total habitat loss = 5,535,794m²** ▪ Turbine total structure footprint including scour protection, based on 93 GBS (WTG-type) foundations = 1,143,900m² ▪ Structure footprint of four offshore transformer substations (GBS) = 64,968m³ ▪ One Accommodation platform = 16,242m² ▪ Two ORCPs = 32,484m² ▪ Total area of seabed covered by cable protection (export cables and inter-array) required for cable crossings = 320,000m² ▪ Total area of seabed covered by cable protection (export cables and inter-array), assuming 25% of the cable requires protection =3,958,200m²	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 from drilling and drill arisings is of a smaller magnitude than presence of project infrastructure.
Impact 2: Temporary habitat disturbance	**Total direct disturbance to seabed from repair activities= 17,741,760m²** ▪ Total seabed area disturbed by array cable repairs = 150,000m² ▪ Total seabed area disturbed by OSP and accommodation platform repairs = 90,000m² ▪ Total seabed area disturbed by export cable repairs = 7,650,000m² ▪ Total seabed area disturbed by export cable reburial = 5,580,000m²	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 anticipated during operation.

Potential effect	Maximum design scenario assessed	Justification
	▪ Total seabed area disturbed by interlink cable reburial =1,800,000m^2 ▪ Total seabed area disturbed by interlink cable repairs = 60,000m^2 ▪ Total seabed area disturbed by WTG repairs = 2,411,760m^2 **Total direct disturbance to seabed from replacement activities= 7,641,500m^2** ▪ Total seabed disturbance from array cable remedial burial = 5,250,000m^2 ▪ Total seabed disturbance from OSP and accommodation platform component replacement = 67,500m^2 ▪ Total seabed disturbance from OSP and accommodation platform foundation anode replacement = 63,000m^2 ▪ Total seabed disturbance from ECC remedial burial = 5,580,000m^2 ▪ Total seabed disturbance from ECC repairs = 765,000m^2 ▪ Total seabed disturbance from ECC repairs jacking up activities = 76,500m^2 ▪ Total seabed disturbance from interlink cable remedial burial = 1,800,000m^2 ▪ Total seabed disturbance from interlink cable repairs = 60,000m^2 ▪ Total seabed disturbance from interlink cable repairs jacking up activities = 9,000m^2	
Impact 3: Colonisation of the WTGs and scour/cable protection	**Total surface area of introduced hard substrate in the water column = 7,933,384m^2** ▪ Total area of introduced hard substrate at seabed level = 7,514,102m^2 ▪ Total surface area of subsea portions of WTG foundations in contact with the water column: 407,282m^2 ▪ Total surface area of subsea portions of OSS foundations in contact with the water column: 12,000m^2	Maximum scenario for introduced hard substrate is as for the maximum scenario for loss of habitat.

Potential effect	Maximum design scenario assessed	Justification
Impact 4: Increased risk of introduction or spread of marine INNS	**Total area of introduced hard substrate = 7,933,384m²** (calculated from **Impact 3** above) ▪ Total of 2216 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 OWF subsea infrastructure e.g., scour effects, changes in wave/tidal current regimes and resulting effects on sediment transport.	See MDS presented in Volume 1, Chapter 7: Marine Processes	
Impact 6: EMF effects generated by inter-array and export cables	▪ Up to 351km of inter-array cables, operating up to 132kV ▪ Up to 123.75km of interlink cables, operating up to 132kV. ▪ Up to 514.8km of export cable, operating at +/-320kV ▪ 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 of 34,129,640m².	MDS is identical (or less) to that of the construction phase.

Potential effect	Maximum design scenario assessed	Justification
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 = **40,654,120**m^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 = **40,654,120**m^3	MDS is identical (or less) to that of the construction phase.

Embedded Mitigation

9.5.6 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, and landfall are described separately.

Table 9.11: Embedded mitigation relating to benthic and intertidal ecology

Project phase	Mitigation measures embedded into the project design
Construction	
Cable Burial Risk Assessment (CBRA)	A detailed CBRA will be undertaken to inform front end engineering works. Cable burial will be the preferred option for cable protection, and this will minimise any impacts associated with habitat loss.
Offshore cables	Where practicable, cable burial will be the preferred means of cable protection.
Offshore cables	Cable burial will be informed by the cable burial risk assessment (CBRA) – which will take account of the presence of designated sites - and detailed within the Cable Specification and Installation Plan (CSIP). An outline CSIP will be prepared in support of the Application, which will be finalised post-consent.
Landfall	In the intertidal zone no permanent rock protection will be employed. The installation of the offshore export cables at landfall will be undertaken by HDD or other trenchless methods. Any rock protection utilised within the subtidal zone will not exceed LAT.
Landfall	Avoid trenchless punchout in the coastal SSSIs.
Foundations and offshore cable	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.
Pollution prevention	A Project Environmental Management Plan (PEMP) (for the construction and operation phases) and Decommissioning Plan (for the decommissioning phase) will be produced and followed. This will include a Marine Pollution Contingency Plan (MPCP) which will safeguard the marine environment in the event of accidental pollution occurring as a result of Project operations.
Marine INNS control	Relevant best practice guidelines, policy and legislation will be followed 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.
Operation and Maintenance	
Project Design	Development of a Scour Protection Management Plan (SPMP) and Cable Specification and Installation Plan (CSIP) which will consider the need for scour protection.

Project phase	Mitigation measures embedded into the project design
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.
Pollution prevention	Development of, and adherence to, an appropriate PEMP, which will include a MPCP.

Additional Mitigation

9.5.7 Windfarm infrastructure will be micro-sited 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.

9.6 Assessment Methodology

9.6.1 This assessment is consistent with the EIA methodology presented in Part 6, Volume 1, Chapter 5: EIA Methodology.

9.6.2 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.

9.6.3 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 9.12: 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

Magnitude	Description/reason
	of the receptor, and/or slight alteration to key characteristics or features of the particular receptors character or distinctiveness.

9.6.4 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.

9.6.5 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.

9.6.6 For the purposes of this assessment, four sensitivity categories have been defined, each drawing on the four MarLIN MarESA categories[6] and the importance of the receptor. Sensitivity/ importance of the environment is defined in Table 9.13.

Table 9.13: 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

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

Receptor sensitivity/ importance	Definition
	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').

9.6.7 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 9.14: 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)

Assumptions and Limitations

9.6.8 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.

9.6.9 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.

9.6.10 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.

9.6.11 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.

9.6.12 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[7]);
- 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.

9.6.13 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.

9.6.14 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 postconstruction 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.

9.6.15 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).

[7] 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.

9.7 Impact Assessment

Construction

9.7.1 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.

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

Impact 1: Temporary Habitat Disturbance

Array and Offshore ECC

9.7.3 The total maximum area of temporary loss/disturbance of subtidal habitat due to construction activities is described in Table 9.10Table 9.10. This equates to approximately 4.6% of the total seabed area within the Project array and offshore ECC. 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.

9.7.4 Of the total area of temporary habitat loss described in a maximum of approximately 0.9km^2 is predicted to be temporarily lost/disturbed within the Project array 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 0.2% of the total seabed area within the Project array.

9.7.5 Of the total area of temporary habitat loss described in Table 9.10, a maximum of approximately 15.1km^2 will be temporarily disturbed within the subtidal areas of the offshore ECC as a result of seabed preparation, OSP installation, export cable installation, burial and jointing. This equates to approximately 6.4% of the total seabed area within the offshore ECC.

9.7.6 As described in section 9.4 and in Part 6, Volume 2, Appendix 9.1: Benthic Ecology Technical Report (Array), Part 6, Volume 2, Appendix 9.2: Benthic Ecology Technical Report (ECC), and Part 6, Volume 2, 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 common 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.

9.7.7 The impact on benthic habitats is predicted to be of local spatial extent (i.e., restricted to discrete areas within the PEIR boundary, 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.

9.7.8 The offshore ECC passes directly through the Inner Dowsing, Race Bank and North Ridge 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 5.3% 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 (Part 6, Volume 1, Chapter 7: Marine Processes).

9.7.9 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 (Part 6, Volume 1, Chapter 7: Marine Processes). 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 is 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 Inner Dowsing, Race Bank and North Ridge SAC.

9.7.10 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).

9.7.11 The sediment characteristics and macrofauna of offshore sandbanks were studied before and after 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, significant 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). Further demonstrating how resilient and well-adapted the sandbanks are to physical disturbances. 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).

9.7.12 The SAC is also designated for *S. spinulosa* reef, yet whilst this was not recorded during the ground-truth site-specific ground-truth investigations of the PEIR boundary according to the Gubbay *et al.* (2007) and Hendrick and Foster-Smith (2006) criteria, the geophysical data of the site did not allow any further delineation on the extent of potential *S. spinulosa* features within the PEIR boundary (as detailed in paragraph 9.4.107). A precautionary approach has therefore been applied whereby the assessment will assume *S. spinulosa* reef to occur within the SAC where the offshore ECC intersects and potentially across the wider PEIR boundary.

9.7.13 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 PEIR boundary following review of site-specific data (GEOxyz, 2022b), therefore direct impacts on these features will not be assessed. Impacts to potential *S. spinulosa* reef have been considered further in the subsequent paragraph.

9.7.14 Whilst *S. spinulosa* reef was not recorded during the site-specific ground-truth investigations, a precautionary approach will be applied by undertaking a pre-construction survey for this feature (Table 9.11). If at this stage reef is located across the PEIR boundary, a mitigation plan will be approved by the MMO in consultation with Natural England to identify the most appropriate measures to minimise impacts to potential reef features. For this reason, the magnitude of the potential *S. spinulosa* reef as a designated feature of the Inner Dowsing Race and North Ridge SAC and a supporting habitat of the Greater Wash SPA is therefore, regarded as negligible.

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

Table 9.15: MarESA assessment for the benthic habitats for abrasion/disturbance

Biotope name	Biotope code (EUNIS, 2022)	Sensitivity assessment	Assessment confidence
Biotopes within the PEIR Boundary			
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 component species, or species of interest) or similar features

9.7.16 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).

9.7.17 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, significant effects being discernible (Foden *et al.,* 2011).

9.7.18 Post-construction monitoring at the Gunfleet Sand 3 demonstration project, more than 170 kilometres from the Project PEIR boundary, 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 significant differences in sediment composition and an increase in infaunal abundance, diversity, and biomass (Thanet Offshore Wind Ltd, 2013).

9.7.19 The Lynn and Inner Dowsing OWF post-construction surveys revealed consistency in particle size distributions 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.

9.7.20 Following the completion of the CFE activities, the Hornsea Project One Offshore Wind Farm Year 2 Post-Construction CFE Monitoring Report identified no significant 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).

9.7.21 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.

9.7.22 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).

9.7.23 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.

9.7.24 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 significant 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).

9.7.25 *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.

9.7.26 As shown in Figure 9.2 the EUSeaMap (EMODnet, 2022) data identifies that the sediments of the offshore ECC in the area coinciding with the Inner Dowsing, Race Bank and North Ridge 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 Inner Dowsing, Race Bank and North Ridge SAC, are characterised by circalittoral mixed sediment interspersed with circalittoral coarse sediment and areas of *S. spinulosa* on stable circalittoral mixed sediment (Figure 9.4).

9.7.27 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 are 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).

9.7.28 Inner Dowsing, Race Bank and North Ridge Annex I sandbank habitat occupies a maximum area of 845km^2 with sandbank features classified as average or partially degraded with good prospects of habitat restoration (JNCC and Natural England, 2010). 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 Inner Dowsing, Race Bank and North Ridge SAC is therefore, regarded as medium as per the evidence provided.

9.7.29 The Greater Wash SPA supporting habitats that may lie within the PEIR Boundary include sandbanks. As discussed above, sandbanks are deemed to be of low vulnerability, medium to high recoverability and form part of the National Site Network.

9.7.30 The sensitivity of the majority of benthic subtidal features of the PEIR boundary 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.

9.7.31 The impact of temporary habitat disturbance on the subtidal benthic ecology is considered to be of low magnitude, and the sensitivity of the majority of receptors affected is considered to be worse-case medium. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

9.7.32 In relation to *S. spinulosa* reef, this feature is considered to have a high sensitivity. Combined with the medium magnitude, this would result in a significance of effect of **moderate adverse**. To ensure impacts to this feature are avoided, a precautionary approach will be applied by undertaking a pre-construction survey for this feature. If at this stage reef is located across the PEIR boundary, implementation of mitigation options will be agreed with Natural England to identify the most appropriate measures to minimise impacts to potential reef structures, including option such as micrositing of infrastructure. For this reason, the mitigated magnitude of the potential *S. spinulosa* reef as a designated feature of the Inner Dowsing Race and North Ridge SAC and as a supporting habitat of the Greater Wash SPA is regarded as negligible. The sensitivity of *S. spinulosa* reef to temporary habitat disturbance is high. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

9.7.33 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, however evidence suggests high confidence associated with the resilience 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.

Impact 2: Temporary Increase in Suspended Sediment and Sediment Deposition

Array and Offshore ECC

9.7.34 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 Part 6, Volume 1, Chapter 7: Marine Processes, Volume 2, Appendix 7.1: Physical Processes Technical Baseline and Part 6, Volume 2, Appendix 7.2: Physical Processes Modelling Report which provides the detailed offshore physical environment assessment (including project specific spreadsheet modelling of sediment plumes).

9.7.35 Background surface SSCs within the Project 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, 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, 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.

9.7.36 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 (Part 6, Volume 2, 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.

9.7.37 The release events that have been simulated within the numerical model, as described in Part 6, Volume 2, 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).

9.7.38 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 Part 6, Volume 2, 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.

9.7.39 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.

9.7.40 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 of 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 20 hours 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 600m away from the active disturbance area, reducing to low tens of mm downstream of the disturbance. Sediment deposition is generally not measurable beyond 3km to 5km 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.

9.7.41 Further information on sediment plume distances and modelling are provided in Part 6, Volume 1, Chapter 7: Marine Processes and Part 6, Volume 2, Appendix 7.2: Physical Processes Modelling Report.

9.7.42 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.

9.7.43 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.

9.7.44 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; and

- 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.

9.7.45 Bentonite release during HDD operations will produce low levels of SSC and is likely to be indiscernible from background conditions. This will correspond to low sediment deposition of tens of mm within several hundred metres of the activity and a maximum deposition extent of 500m. The effect of these activities is therefore considered to be restricted to the near-field, temporary, and indiscernible from background conditions.

9.7.46 Taking the above into consideration, the impact of increased SSC and smothering from sediment deposition associated with construction activities is noticeable but temporary, with the majority of effects limited to the near field. The magnitude of impact has therefore been assessed as low.

9.7.47 The indirect impacts from a single release event to the Inner Dowsing, Race Bank and North Ridge SAC are considered to be limited. The higher levels of smothering and deposition impacts that are most likely to significantly disturb benthic communities are considered to be within the immediate vicinity of the works. Whilst this will occur within the SAC where the offshore ECC overlaps (8.3% of the offshore ECC overlaps with the SAC), the magnitude of the impact is considered to be low and the impact is expected to be localised.

9.7.48 The indirect impacts to the supporting habitats of the Greater Wash SPA from a single release event are considered to be limited, as detailed above the smothering and deposition impacts that are most likely to significantly disturb benthic communities are considered to occur within the immediate vicinity of the works. Whilst this will occur within the SPA where the offshore ECC overlaps (2.4% of the offshore ECC overlaps with the SPA), the magnitude of the impact is considered to be low as the impact is expected to be localised.

9.7.49 No impacts to the Wash and North Norfolk Coast SAC and Norfolk Sandbanks and Saturn Reef SAC are expected due to their distance (Table 9.8) from the construction activities, where SSC are not expected to be present in sufficient quantities to negatively impact benthic features and there will be no measurable thickness of deposition. The magnitude to these features is therefore assessed as negligible.

9.7.50 The communities and habitats identified during the benthic subtidal and intertidal ecology study area are typical of the wider southern North Sea. All biotopes identified within the array, offshore ECC and across the wider benthic subtidal and intertidal ecology study area are acclimated to relatively high levels of SSC that occur naturally within this region and consequently, are subject to and able to tolerate variations in SSC and some degree of sediment deposition.

9.7.51 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).

9.7.52 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 9.16.

Table 9.16: 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 PEIR Boundary			
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	Confidence is low for the assessments as they are based on expert judgement.

Biotope name	Biotope code (EUNIS/ JNCC)	Sensitivity assessment	Assessment confidence
		▪ Medium sensitivity to heavy smothering (5-30cm).	
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.
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	MC12162	▪ Not sensitive to changes in SSC and turbidity;	Confidence is medium for the turbidity assessment and low for the smothering

Biotope name	Biotope code (EUNIS/ JNCC)	Sensitivity assessment	Assessment confidence
circalittoral bedrock or boulders		▪ Low sensitivity to light smothering (<5cm); and ▪ Medium sensitivity to heavy smothering (5 – 30cm).	assessments as, although they are based upon published literature, the applicability and agreement between the evidence is low.
Nephtys cirrosa and *Bathyporeia* spp. in Atlantic infralittoral sand	MB5233	▪ 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 turbidity assessment as they are 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.

Biotope name	Biotope code (EUNIS/ JNCC)	Sensitivity assessment	Assessment confidence
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 infralittoral mobile gravel and sand	MB3235	▪ Not sensitive 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.
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-	MC121A	▪ Not sensitive to changes in SSC and turbidity;	Confidence in the turbidity assessment is high as it is based on

Biotope name	Biotope code (EUNIS/ JNCC)	Sensitivity assessment	Assessment confidence
swept moderately wave-exposed Atlantic circalittoral rock		▪ Not sensitive to light smothering (<5cm); and ▪ Low sensitivity to heavy smothering (5 – 30cm).	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 (Impoverished or a transition biotope)	MD4211	▪ 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.
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.

9.7.53 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).

9.7.54 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).

9.7.55 *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.

9.7.56 Given the importance of *S. spinulosa* as a protected feature of the Inner Dowsing, Race Bank and North Ridge SAC and as a supporting habitat within the Greater Wash SPA, 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* to increases in SSC and deposition.

9.7.57 Sandbanks are a primary feature of the Inner Dowsing, Race Bank and North Ridge 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.

9.7.58 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) are not sensitive to changes in SSC and turbidity with a medium sensitivity to light smothering (according to the MarESA and MarLIN benchmarks).

9.7.59 Overall, it is predicted that the sensitivity of the subtidal receptors located across the benthic subtidal and intertidal ecology study area are 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 significant in EIA terms.

9.7.60 According to the evidence provided above the features of the Inner Dowsing, Race Bank and North Ridge SAC and supporting habitat of the Greater Wash SPA that lie within the benthic subtidal ecology study area (which include mussel beds, *S. spinulosa* reef and sandbank features) have a maximum sensitivity of medium and a medium magnitude. The significance of the residual effect is therefore concluded to be **minor adverse**, which is significant in EIA terms.

9.7.61 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

9.7.62 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). Part 6, Volume 1, Chapter 7: Marine Processes provides a full description of the physical assessment, with a summary of the MDS associated with the impact. As detailed in Table 9.10 presents MDS associated with increases in SSC and deposition is associated with cable installation.

9.7.63 Those Project activities in the intertidal which has the potential to result in the greatest disturbance of seabed sediments are:

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

9.7.64 The scenario that results in the greatest impact in the intertidal area is cable installation using HDD techniques, 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 9.7.44 *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 the 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.

9.7.65 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 9.17: 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 PEIR boundary			
Barren Atlantic littoral coarse sand	MA5231	▪ Not sensitive to changes in SSC and turbidity;	Confidence is low for all assessments as they are based on similar

Biotope name	Biotope code (EUNIS/ JNCC)	Sensitivity assessment	Assessment confidence
		▪ Not sensitive to light smothering (<5cm); and ▪ Not sensitive to heavy smothering (5 – 30cm)	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.
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			
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

Biotope name	Biotope code (EUNIS/ JNCC)	Sensitivity assessment	Assessment confidence
			pressures and expert judgement.

9.7.66 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.

9.7.67 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.

9.7.68 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.

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

9.7.69 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.

9.7.70 The results of the sediment contaminant survey that has been undertaken across the PEIR boundary (see Part 6, Volume 2, Appendix 9.1: Benthic Ecology Technical Report (Array) and Part 6, Volume 2, Appendix 9.2: Benthic Ecology Technical Report (ECC)) revealed that across the array area the contaminants were predominantly recorded as below Cefas Action Level 1 (see paragraphs 9.4.36 *et seq*). 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.

9.7.71 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).

9.7.72 Similar results were recorded across the offshore ECC (see paragraphs 9.4.41 *et seq*). Two stations recorded contaminants exceeding the TEL threshold for PAH's however, none exceeded the PEL threshold.

9.7.73 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.

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

9.7.75 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.

9.7.76 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.

9.7.77 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 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.

Operations and Maintenance

9.7.78 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.

Impact 1: Permanent Habitat Loss/Alteration

9.7.79 The presence of the WTG and OSP 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 (for the 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 habitat loss and a potential adverse effect (due to the potential shift in the baseline condition), although it is noted that this also comprises potential beneficial effects, providing new habitats for different faunal assemblages to colonise, resulting in a likely increase in biodiversity and biomass.

9.7.80 Table 9.10 identifies the MDS foundation, scour and cable protection footprint. The total habitat loss arising from these components would be 5.5km^2, which equates to approximately 0.8% of the subtidal habitat within the PEIR Boundary.

9.7.81 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.

9.7.82 Where the offshore ECC crosses the Inner Dowsing, Race Bank and North Ridge SAC, 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. However, whilst this permanent loss of habitat might occur within the SAC where the offshore ECC overlaps, this is only a discrete location (8.3% of the offshore ECC overlaps with the SAC) 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.

9.7.83 Similarly, the offshore ECC spatially overlaps with sandbank and *S. spinulosa* reef, supporting habitats of the Greater Wash SPA. However, whilst this permanent loss of habitat might occur within the SAC where the offshore ECC overlaps, this is only a discreet 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.

9.7.84 No permanent habitat loss will occur in the intertidal area of the offshore ECC as cable protection will be restricted to the subtidal zone.

9.7.85 The species and habitats identified during the characterisation study are typical of the wider region (as previously discussed in section 9.4). All biotopes identified within the PEIR Boundary 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.

9.7.86 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.

9.7.87 Overall, for habitats outside the Inner Dowsing, Race Bank, and North Ridge 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 array areas and offshore ECC 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.

9.7.88 Within the location of the Inner Dowsing, Race Bank, and North Ridge SAC the magnitude is regarded as low, rather than negligible, due to the due to the conservation status of the benthic resources. The sensitivity of the benthic resource is deemed high because the sandbank feature and potential *S. spinulosa* reef has no resistance to permanent habitat loss/change from cable protection. The significance of this effect is therefore concluded to be **moderate adverse** significance, which is significant in EIA terms.

9.7.89 In relation to *S. spinulosa* reef a precautionary approach will be applied by undertaking a pre-construction survey for this feature. If at this stage reef is located across the PEIR boundary, implementation of mitigation options will be agreed with Natural England to identify the most appropriate measures to minimise the use of cable protection and its impacts to potential reef structures, such as micrositing of infrastructure. For this reason, the magnitude of the potential *S. spinulosa* reef as a designated feature of the Inner Dowsing Race and North Ridge SAC and as a supporting habitat of the Greater Wash SPA is regarded as negligible. The sensitivity of *S. spinulosa* reef to temporary habitat disturbance is high. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

9.7.90 A preliminary CBRA has been undertaken by the Project for the section of the cable route which passes through the Inner Dowsing, Race Bank and North Ridge SAC. This is helping to further define the approach to cable installation as well as informing the requirement or otherwise for cable protection material over the designated sandbank features within the SAC site and the type, design and installation process for any such protection.

9.7.91 The Project intends to discuss the outcomes of the CBRA with stakeholders throughout the remaining pre-application period, principally through the EPP, in determining the Project design including (where a need is identified) such options for alternative, feasible cable installation and protection techniques that would demonstrably avoid any significant effects to the sandbanks. Future phases of the Project design will subsequently inform the ES that will accompany the DCO Application, and which will set out in full the assessment of the potential impacts on the on the SAC sandbank features.

Impact 2: Temporary Habitat Disturbance

9.7.92 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 2.4% of the array and offshore ECC combined).

9.7.93 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.

9.7.94 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 array and offshore ECC.

9.7.95 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 paragraph 9.7.15 *et seq*., 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. Paragraph 9.7.51 *et seq*., detail 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.

9.7.96 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.

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

9.7.97 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 0.8km^2, which accounts for approximately 0.1% of the total PEIR boundary.

9.7.98 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 the Project array and offshore ECC (where cable protection is laid).

9.7.99 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.

9.7.100 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.

9.7.101 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).

9.7.102 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.

9.7.103 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, in areas where infrastructure is not removed.

9.7.104 The sensitivity of Inner Dowsing, Race Bank, and North Ridge 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.

9.7.105 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 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.

9.7.106 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.

Impact 4: Increased Risk of Introduction or Spread of Marine INNS due to the Presence of Infrastructure and Vessel Movements may Affect Benthic and Intertidal Ecology and Biodiversity

9.7.107 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 in and out of the array and offshore ECC has the potential to impact upon benthic subtidal and intertidal ecology and biodiversity locally and in the broader region.

9.7.108 Table 9.10 presents the MDS for new hard substrate habitat that will be introduced into the array and offshore ECC, 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.

9.7.109 As detailed within Table 9.11, embedded environmental measures which include a PEMP with a biosecurity plan will ensure that the risk of potential introduction and spread of marine INNS from increased vessel activity is minimised.

9.7.110 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 Suffolk coast are the Turkish crayfish *Astacus leptodactylus*, 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).

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

9.7.112 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.

9.7.113 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 and SPA features is also 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.

9.7.114 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.

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

9.7.115 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.

9.7.116 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.

9.7.117 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.

9.7.118 Part 6, Volume 1, Chapter 7: Marine Processes 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 significant changes to sediment transport and consequently will not have any significant impacts on benthic subtidal and intertidal ecology. The magnitude of this impact is therefore considered to be negligible.

9.7.119 As detailed within paragraph 9.7.15 *et seq*., 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. Paragraph 9.7.51 *et seq*., detail 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.

9.7.120 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.

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

9.7.121 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 (Part 6, Volume 1, Chapter 3: Project Description). 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.

9.7.122 Impacts from changes in EMFs arising from cables, are not considered to result in a significant effect 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 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.

9.7.123 It is considered unlikely that EMFs will result in a significant 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 considered to be negligible, indicating that any behavioural response of benthic fauna is likely to be discernible or barely discernible over a very small area, that does not threaten benthic subtidal ecology features, undermine regional ecosystem functions or diminish biodiversity.

9.7.124 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 Part 6, Volume 1, Chapter 10: Fish and Shellfish Ecology.

9.7.125 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.

9.7.126 However, evidence of sensing, responding to, or 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, 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. Therefore, it is considered that it is unlikely that there would be any impacts to crustaceans from EMF. Taking this into consideration, any effects on marine invertebrates are anticipated to only occur in the immediate vicinity of the cable.

9.7.127 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).

9.7.128 One recent study examined the difference in invertebrate communities along an energised and nearby unenergised 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.

9.7.129 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.

9.7.130 The sensitivity of benthic receptors is therefore considered to be low, reflecting that the receptor has a high resistance and ability to tolerate the impacts of EMF over the approximate 35-year operational lifetime of the Project.

9.7.131 The Project will include measures to bury or protect cables (Table 9.11), therefore any behavioural responses of benthic receptors are likely to be mitigated. Overall, it is predicted that the sensitivity of the benthic subtidal and intertidal receptors found within the PEIR boundary is low and the magnitude is negligible. The residual effect significance is therefore **negligible**, not significant in EIA terms.

Decommissioning

9.7.132 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.

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

Impact 1: Temporary Disturbance

9.7.134 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.

9.7.135 The total maximum area of temporary habitat disturbance due to jack-up vessels and cable removal during decommissioning has not been fully quantified but is likely to closely reflect that assessed for the construction phase (see paragraph 9.7.4 *et seq*.).

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

9.7.137 The sensitivities of the species to disturbance are described in paragraph 9.7.15 *et seq*. The magnitude of the impact has been assessed as low, with the maximum sensitivity of the receptors being medium. Therefore, the significance of effects from direct disturbance occurring as a result of decommissioning activities is **minor adverse**, which is not significant in EIA terms.

Impact 2: Temporary Increase in Suspended Sediment and Sediment Deposition

9.7.138 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 9.7.52 *et seq*. and for the intertidal habitats in paragraph 9.7.65 *et seq*.

9.7.139 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**, which is significant in EIA terms.

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

9.7.140 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 paragraph 9.7.76 *et seq*.

9.7.141 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** which is not significant in EIA terms.

9.8 Cumulative Effects Assessment

9.8.1 This cumulative effects assessment (CEA) for benthic and intertidal ecology has been undertaken in accordance with the methodology provided in Part 6, Volume 2, Appendix 5.1: Offshore Cumulative Effects Assessment.

9.8.2 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 Part 6, Volume 2, Appendix 5.1: Offshore Cumulative Effects Assessment of this PEIR screened in a number of projects and plans as presented in Table 9.18.

Table 9.18: Projects considered within the benthic and intertidal ecology cumulative effects assessment

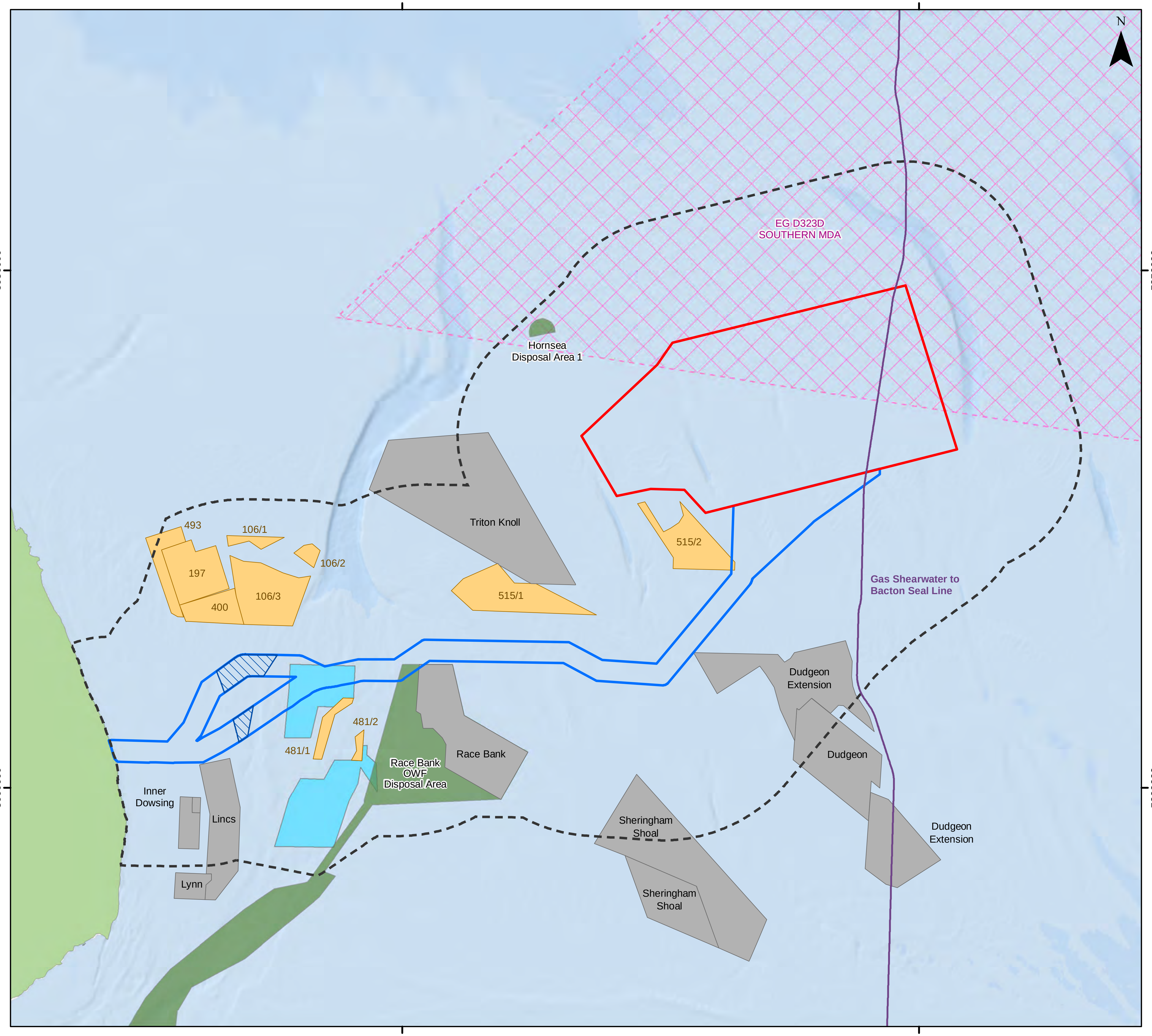
Development type	Project	Status	Data confidence assessment/phase	Tier
Offshore Wind Farm	Sheringham Shoal Extension	Submitted Application	High - Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate	Tier 1[8]
Offshore Wind Farm	Dudgeon Extension	Submitted Application	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[9]
Offshore Wind Farm	Lincs	Active/In Operation	High - Third party project details published in the public	Tier 1

[8] Tier 2 criteria include projects on the Planning Inspectorate's Programme of Projects where a scoping report has been submitted (Planning Inspectorate, 2019).

[9] 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).

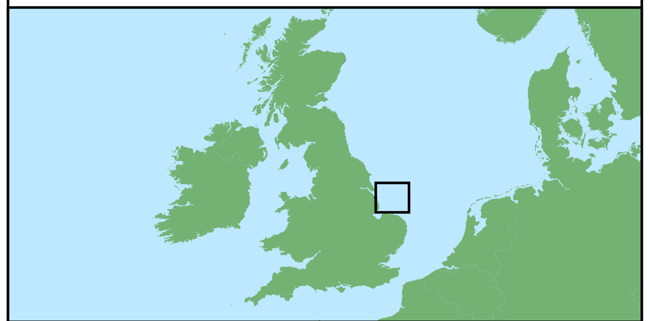
Development type	Project	Status	Data confidence assessment/phase	Tier
			domain and confirmed as being 'accurate' by The Crown Estate	
Offshore Wind Farm	Triton Knoll	Active/In Operation	High - Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate	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
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

Development type	Project	Status	Data confidence assessment/phase	Tier
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
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	Under Construction	Medium – Third party project details published in the public domain but not confirmed as being 'accurate'	Tier 1



Legend

- Array Area
- Offshore Export Cable Corridor
- ORCP Search Area
- Benthic Ecology Study Area
- Offshore Wind Farm Sites Aggregate
- Area
- Provisional Aggregates Area (2103)
- Open Disposal Area
- Military Practice Area
- Subsea Pipeline



Coordinate System: WGS 1984 UTM Zone 31N

0 10 20 km

Scale: 1:350,000

Preliminary Environmental Information Report

Projects Screened into the CIA for Benthic and Intertidal Ecology Impacts within the Benthic Study Area

Figure 9.7

OUTER DOWSING OFFSHORE WIND

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Document Path: G:\GIS\GIS_Projects\0152 Outer Dowsing EIA\GIS\Figures\PEIR\Benthic Ecology\ODOW_0152_BE_Fig3.7_Cumulative_Projects.mxd

9.8.3 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 Project boundary 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.

9.8.4 Therefore, the CEA has only considered the temporary increase in SSC and sediment deposition during construction. 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 9.19: 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 or maintenance of the Project, there is potential for cumulative SSC and sediment deposition to occur within the wider subtidal ecology study area.

Cumulative Temporary Increases in SSC and Associated Deposition

9.8.5 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, the discussion presented here is qualitative. 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.

9.8.6 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 is currently in construction and is expected to be in service by the end of 2023, therefore 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.

9.8.7 Aggregate Area 515/2 ('Outer Dowsing') is located approximately 1.1km from the Project array area, and 0km from the offshore ECC, as shown in Figure 9.7. In addition, Area 481/1 ('Inner Dowsing') is located 1.3km south of the offshore ECC, and Areas 5.15/1, 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 Figure 9.7, and an application is expected shortly for a production licence. Area 2103, also overlapping the offshore ECC (see 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. Area 2103 may be incorporated into future assessments as more information becomes available.

9.8.8 On the basis of sediment plume modelling presented in Part 6, Volume 1, Chapter 7: Marine Processes, 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).

9.8.9 As detailed by the numerical modelling within Part 6, Volume 1, Chapter 7: Marine Processes 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 (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.

9.8.10 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.

9.8.11 The impact of increased SSC and deposition is considered to be of low, and the sensitivity of receptors affected is considered to be a worst-case medium for benthic receptors. The significance of the effect is therefore concluded to be **minor adverse**, which is significant in EIA terms.

9.9 Inter-Relationships

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

9.9.2 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.

9.9.3 A description of the process to identify and assess these effects is presented in Part 6, Volume 1 Chapter 5: EIA Methodology, with a summary of assessed inter-relationships provided in Table 9.20 below.

Table 9.20: 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 decommissioning phases.	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 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 in such a way as to result in combined effects of greater significance than the assessments presented for each

Project phase(s)	Nature of inter-related effect	Assessment alone	Inter-related effects assessment
			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.			

9.9.4 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.

9.10 Transboundary Effects

9.10.1 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.

9.11 Conclusions

9.11.1 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.

9.11.2 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. Where the offshore ECC overlaps the Inner Dowsing, Race Bank and North Ridge SAC and Greater Wash SPA, additional mitigation and/or compensation measures will be explored where impacts are expected to result in potentially significant impacts. Potential additional mitigation measures discussed within this chapter include micro-siting windfarm infrastructure around potential Annex I habitat (*S. spinulosa* reef). 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).

9.11.3 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.

9.11.4 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.

9.11.5 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. The potential effects to intertidal and subtidal benthic ecology receptors are therefore concluded as not significant in terms of the EIA Regulations.

9.11.6 Table 9.21 presents a summary of the significant impacts assessed within this PEIR, any mitigation and the residual effects.

Table 9.21: 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	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	Negligible significance of effect	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Operation and Maintenance			
Permanent habitat loss/ alteration	Subtidal: Minor significance of effect Designated sandbanks: Not assessed	Not Applicable – no additional mitigation identified Not assessed	No significant adverse residual effects Not assessed
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 current regimes and resulting effects on sediment transport	Minor significance of effect	Not Applicable – no additional mitigation identified	No significant adverse residual effects

Description of effect	Effect	Additional mitigation measures	Residual impact
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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