Hornsea Project Four

Volume A2, Chapter 2: Benthic and Intertidal Ecology

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01	N/A	N/A	Document submitted at application.
02	Throughout	Throughout	Instances of 'long term' changed to 'permanent'.
02	31-32	2.7	Additional consideration given to *Amphiura filiformis* and associated biotope.
02	32	2.7	Additional consideration given to *Sabellaria spinulosa* and associated biotope.
02	44-46	Table 2.9	*Amphiura filiformis* and *Sabellaria spinulosa* added to table of Valued Ecological Receptors
02	Throughout Section 2.11	2.11	Consideration of *Sabellaria spinulosa* added to assessments.

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A5.2.3	Marine Conservation Zone Assessment

Glossary

Term	Definition
Array cables (inter-array cables)	Cables which connect the wind turbines to each other and to the offshore substation(s).
Benthic ecology	Benthic ecology encompasses the study of the organisms living in and on the sea floor, the interactions between them and impacts on the surrounding environment.
Biotope	A region of habitat associated with a particular ecological community.
Commitment	A term used interchangeably with mitigation and enhancement measures. The purpose of Commitments is to reduce and/or eliminate Likely Significant Effects (LSEs), in EIA terms. Primary (Design) or Tertiary (Inherent) are both embedded within the assessment at the relevant point in the EIA (e.g. at Scoping, Preliminary Environmental Information Report (PEIR) or ES). Secondary commitments are incorporated to reduce LSE to environmentally acceptable levels following initial assessment i.e. so that residual effects are acceptable.
Cumulative effects	The combined effect of Hornsea Four in combination with the effects from a number of different projects, on the same single receptor/resource. Cumulative impacts are those that result from changes caused by other past, present or reasonably foreseeable actions together with Hornsea Four.
Drop Down Video (DDV)	A survey method in which imagery of habitat is collected, used predominantly to survey marine environments.
Design Envelope	A description of the range of possible elements that make up the Hornsea Four design options under consideration, as set out in detail in the project description. This envelope is used to define Hornsea Four for Environmental Impact Assessment (EIA) purposes when the exact engineering parameters are not yet known. This is also often referred to as the "Rochdale Envelope" approach.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIP).
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of the impact with the importance, or sensitivity, of the receptor or resource 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.
EUNIS habitat classification	A pan-European system which facilitates the harmonised description and classification of all types of habitat, through the use of criteria for habitat identification.
Export cables	Cables that transfer power from the offshore substation(s) or the converter station(s) to shore.
Export cable corridor (ECC)	The specific corridor of seabed (seaward of Mean High Water Springs (MHWS)) and land (landward of MHWS) from the Hornsea Four array area to the Creyke Beck National Grid substation, within which the export cables will be located.
Geophysical	Relating to the physics of the earth.
Habitats of principal importance	Habitats of principal importance (Section 41 of the 2006 Natural Environmental and Rural Communities (NERC) Act)
Holocene	The Holocene is the current geological epoch. It began approximately 11,650 calibrated years before present, after the last glacial period, which concluded with

Term	Definition
	the Holocene glacial retreat. The Holocene and the preceding Pleistocene together form the Quaternary period.
Hornsea Project Four Offshore Wind Farm	The term covers all elements of the project (i.e. both the offshore and onshore). Hornsea Four infrastructure will include offshore generating stations (wind turbines), electrical export cables to landfall, and connection to the electricity transmission network. Hereafter referred to as Hornsea Four.
HVAC booster station(s)	Offshore HVAC booster station(s) are required in HVAC transmission systems only; they are not required in HVDC transmission systems. If required for Hornsea Four, they would be located entirely offshore.
Interconnector cables	Cables that may be required to interconnect the offshore substations in order to provide redundancy in the case of cable failure elsewhere, or to connect to the offshore accommodation platforms in order to provide power for operation.
Intertidal	The area of the shoreline which is covered at high tide and uncovered at low tide.
Maximum design scenario (MDS)	The maximum design parameters of each Hornsea Four asset (both on and offshore) considered to be a worst case for any given assessment.
Megafauna	Large animals of a particular region, habitat or geological period.
Megaripples	An extensive undulation of the surface of a sandy beach or seabed, typically tens of meters from crest to crest and tens of centimetres in height.
Mini-hamon grab	Comprises of a stainless-steel box shaped sampling scoop mounted in a triangular frame, ideal for sampling seabed sediments, as well as sampling for benthic macrofauna.
Mitigation	A term used interchangeably with Commitment(s) by Hornsea Four. Mitigation measures (Commitments) are embedded within the assessment at the relevant point in the EIA (e.g. at Scoping, PEIR or ES).
Mollusca	Phylum of invertebrates which have a soft unsegmented body, commonly protected by a calcareous shell.
Offshore accommodation platform(s)	Used to accommodate multiple O&M staff for a number of weeks at a time and to allow spares and tools to be stored within the array area.
Offshore substation(s)	One or more offshore substations to convert the power to higher voltages and/or to HVDC and transmit this power to shore.
Orsted Hornsea Project Four Ltd	The Applicant for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO).
Planning Inspectorate (PINS)	The agency responsible for operating the planning process for Nationally Significant Infrastructure Projects (NSIPs).
Report to Inform Appropriate Assessment	A process which helps determine likely significant effects and (where appropriate) assesses adverse impacts on the integrity of European conservation sites and Ramsar sites. The process consists of up to four stages of assessment: screening, appropriate assessment, assessment of alternative solutions and assessment of imperative reasons of over-riding public interest (IROPI) and compensatory measures.
SACFOR	An abundance scale used for both littoral and sublittoral taxa from 1990 onwards.
Scour and cable protection	In order to prevent seabed scour around foundation structures and cables, cable protection may be placed on the seabed to protect from current and wave action.
Side Scan Sonar (SSS)	Side-imaging sonar used to create an image of the seafloor.
Single-beam and multi-beam echo sounders (SBES and MBES)	A type of sonar which transmits soundwaves, using the time taken between emission and return to establish a depth. This can be done using singular or multiple beams.
Subtidal	The region of shallow waters which are below the level of low tide.

Term	Definition
Wind turbine	All of the components of a wind turbine, including the tower, nacelle, and rotor
Wind turbine foundation	The wind turbines are attached to the seabed with a foundation structure typically fabricated from steel or concrete.

Acronyms

Acronym	Definition
AfL	Agreement for Lease
AGDS	Acoustic Ground Discrimination System
BAC	Background Assessment Concentrations
BAP	Biodiversity Action Pan
BC	Background Concentrations
BRAG	Black, Red, Amber, and Green
CEA	Cumulative Effects Assessment
CFE	Controlled Flow Excavation
CIEEM	Chartered Institute of Ecology and Environmental Management
CPEMMP	Construction Project Environmental Management and Mitigation Plan
DCO	Development Consent Order
DMRB	Design Manual for Roads and Bridges
DTI	Department of Trade and Industry
DDV	Drop Down Video
EA	Environment Agency
ECC	Export Cable Corridor
EEA	European Economic Area
EIA	Environmental Impact Assessment
EMF	Electromagnetic Fields
EPA	Environmental Protection Agency
ES	Environmental Statement
EUNIS	European Nature Information System
FOCI	Feature of Conservation Importance
GBS	Gravity Base Structure
GC	Gas Chromatography
GES	Good Environmental Status
HDD	Horizontal Directional Drilling
HVAC	High Voltage Alternating Current
ISQG	Interim Sediment Quality Guideline
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
JUV	Jack Up Vessel
LAT	Lowest Astronomical Tide
LSE	Likely Significant Effect
LOD	Limit of Detection
MarLIN	Marine Life Information Network
MarESA	Marine Evidence based Sensitivity Assessment
MBES	Multi-beam echo sounders
MCA	Maritime and Coastguard Agency
MCAA	Marine and Coastal Access Act

Acronym	Definition
MCCIP	Marine Climate Change Impacts Partnership
MCZ	Marine Conservation Zone
MDS	Maximum Design Scenario
MHWS	Mean High Water Spring
MINNS	Marine Invasive Non-Native Species
MLWS	Mean Low Water Spring
MMO	Marine Management Organisation
MPA	Marine Protected Area
MPCP	Marine Pollution Contingency Plan
MPS	Marine Policy Statement
MSFD	Marine Strategy Framework Directive
NERC	Natural Environment Research Council
NN	Nutrient Nitrogen
NOx	Nitrogen Oxides
NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
OSS	Offshore Substation
OWF	Offshore Wind Farm
PAH	Polycyclic Aromatic Hydrocarbons
PEIR	Preliminary Environmental Information Report
PINS	Planning Inspectorate
PSA	Particle Size Analysis
PSD	Particle Size Distribution
REC	Regional Environmental Characterisation
RIAA	Report to Inform Appropriate Assessment
rMCZ	Recommended Marine Conservation Zone
RPSS	Route Planning and Site Selection
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SBES	Single-beam Echo Sounders
SBP	Sub-Bottom Profiler
SD	Standard Deviation
SEA	Strategic Environmental Assessment
SoS	Secretary of State
SPA	Special Protected Area
SPM	Suspended Particulate Matter
SSC	Suspended Sediment Concentrations
SSS	Side Scan Sonar
SSSI	Sites of Special Scientific Interest
THC	Total Hydrocarbon
TOC	Total Organic Carbon
UCM	Unresolved Complex Mixture
UKOOA	United Kingdom Offshore Operators Association
VER	Valued Ecological Receptor
WHPS	Well Head Protection Structure
WTG	Wind Turbine Generator

Units

Unit	Definition
g	gram
km	Kilometre
km^2	Square kilometre
m	Metre
m^2	Square metre
ppm	Parts per million

2.1 Introduction

2.1.1.1 Orsted Hornsea Project Four Limited (hereafter the Applicant) is proposing to develop the Hornsea Project Four Offshore Wind Farm (hereafter Hornsea Four) which will be located approximately 69 km from the East Riding of Yorkshire in the Southern North Sea and will be the fourth project to be developed in the former Hornsea Zone (please see **Volume A1, Chapter 1: Introduction** for further details on the former Hornsea Zone. Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network (please see **Volume A1, Chapter 4: Project Description** for full details on the Project Design).

2.1.1.2 The Hornsea Four Agreement for Lease (AfL) area was 846 km^2 at the Scoping phase of project development. In the spirit of keeping with Hornsea Four's approach to Proportionate Environmental Impact Assessment (EIA), the project has due consideration to the size and location (within the existing AfL area) of the final project that is being taken forward to Development Consent Order (DCO) application. This consideration is captured internally as the "Developable Area Process", which includes Physical, Biological and Human constraints in refining the developable area, balancing consenting and commercial considerations with technical feasibility for construction.

2.1.1.3 The combination of Hornsea Four's Proportionality in EIA and Developable Area process has resulted in a marked reduction in the array area taken forward at the point of DCO application. Hornsea Four adopted a major site reduction from the array area presented at Scoping (846 km^2) to the Preliminary Environmental Information Report (PEIR) boundary (600 km^2), with a further reduction adopted for the Environmental Statement (ES) and DCO application (468 km^2) due to the results of the PEIR, technical considerations and stakeholder feedback. The evolution of the Hornsea Four Order Limits is detailed in **Volume A1, Chapter 3: Site Selection and Consideration of Alternatives** and **Volume A4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure**.

2.1.1.4 This chapter of the ES presents the results of the EIA for the potential impacts of Hornsea Four on benthic subtidal and intertidal ecology. Specifically, this chapter considers the potential impact of Hornsea Four seaward of Mean High Water Springs (MHWS) during its construction, operation and maintenance, and decommissioning phases.

2.1.1.5 This assessment is based on the characteristics of the development as currently proposed (**Volume A1, Chapter 4: Project Description**), and on a characterisation of the receiving environment as defined in detail within **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report**. The technical report includes a detailed characterisation of the benthic subtidal and intertidal study area, based on the existing literature, including for the former Hornsea Zone, and site-specific surveys undertaken for Hornsea Four.

2.2 Purpose

2.2.1.1 The primary purpose of this ES is to support the DCO application for Hornsea Four under the Planning Act 2008 (the 2008 Act).

2.2.1.2 The ES has been finalised following the completion of the pre-application consultation (see **Volume B1, Chapter 1: Consultation Report** and **Table 2.4**) and will accompany the application to the Planning Inspectorate (PINS) for Development Consent.

2.2.1.3 This ES chapter:

- Summarises the existing environmental baseline established from site specific surveys, desk studies, and incorporating agreements made during consultation with relevant stakeholders to date;
- Presents the potential environmental effects on benthic subtidal and intertidal ecology arising from Hornsea Four, based on the information gathered and the analysis and assessments undertaken to date;
- Identifies any assumptions and limitations encountered in compiling the environmental information; and
- Highlights any necessary monitoring and/or mitigation measures which could avoid, prevent, reduce or offset the possible environmental effects identified in the EIA process.

2.3 Planning and Policy Context

2.3.1.1 Planning policy on offshore renewable energy Nationally Significant Infrastructure Projects (NSIPs), specifically in relation to benthic subtidal and intertidal ecology, is contained in the Overarching National Policy Statement (NPS) for Energy (EN-1; DECC 2011a) and the NPS for Renewable Energy Infrastructure (EN-3, DECC 2011b).

2.3.1.2 NPS EN-3 and NPS EN-1 include guidance on what matters are to be considered in the assessment. These are summarised in **Table 2.1**. NPS EN-3 also highlights factors relating to the determination of an application and in relation to mitigation. These are summarised in **Table 2.2** below.

Table 2.1: Summary of NPS EN-1 and EN-3 policy relevant to benthic subtidal and intertidal ecology and consideration of the Hornsea Four assessment.

Summary of NPS EN-1 and EN-3 provisions	How and where considered in the ES
"Sites of Special Scientific Interest (SSSIs) that are not incorporated within internationally designated sites should be provided with a high degree of protection" (Paragraph 5.3.10 of NPS EN-1). *"Where a proposed development within or outside a SSSI is likely to have an adverse effect on an SSSI (alone or together with other developments) development consent should not normally be granted. If after mitigation an adverse effect is still likely then consent should only be given where the benefits (including need) for a development outweighs the impacts on the SSSI in question and also the wider SSSI network. The Secretary of State (SoS) should use requirements and/ or planning obligations to mitigate the harmful aspects of the development, and where possible, ensure the*	Through the Route Planning and Site Selection (RPSS) process, the guiding principles of site selection (using a proportional approach) included avoiding key sensitive features (**Volume A4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure**). Flamborough Head SSSI is partially within Flamborough and Filey Coast Special Protection Area (SPA) and Flamborough Head Special Area of Conservation (SAC), which lie outside the Hornsea Four Order Limits (as per commitment Co2 and Co86 - **Table 2.11**). It should be noted that through the Evidence Plan process that 'Vegetated sea cliffs of the Atlantic and Baltic Coasts' of the Flamborough Head SAC and 'Sea Cliffs' that form the feature of the Flamborough Head SSSI were screened out of the assessment as these are regarded as terrestrial features of interest (OFF-ME&P-5.2). This is considered in **Section 2.7.2** of this chapter.

Summary of NPS EN-1 and EN-3 provisions	How and where considered in the ES
conservation of the site's biodiversity or geological interest" (Paragraph 5.3.11 of NPS EN-1).	
"The SoS is bound by the duties in relation to Marine Conservation Zones (MCZs) imposed by sections 125 and 126 of the Marine and Coastal Access Act (MCAA) 2009" (Paragraph 5.3.12 of NPS EN-1).	The Hornsea Four Order Limits do not cross any MCZs (Co44 and Co45 - **Table 2.11**). An MCZ assessment is presented within **Volume A5, Annex 2.3: Marine Conservation Zone Assessment**), with a summary of the relevant habitats presented within this chapter for completeness.
"Applicants should assess the effects on the offshore ecology and biodiversity for all stages of the lifespan of the proposed offshore wind farm (OWF)" (Paragraph 2.6.64 of NPS EN-3).	The potential effects on offshore ecology and biodiversity associated with the construction, operation and decommissioning of Hornsea Four have been assessed (**Section 2.11**).
"Consultation on the assessment methodologies should be undertaken at an early stage with the statutory consultees as appropriate" (Paragraph 2.6.65 of NPS EN-3).	Consultation with relevant statutory and non-statutory stakeholders has been carried out from the early stages of Hornsea Four (**Section 2.4**).
"Any relevant data that has been collected as part of post-construction ecological monitoring from existing, operational OWFs should be referred to where appropriate" (Paragraph 2.6.66 of NPS EN-3).	Post-construction monitoring from other OWFs has informed the assessment of Hornsea Four (**Section 2.11**). The Marine Management Organisation (MMO) have produced a review (MMO 2014) on post-construction monitoring for OWFs within which it is noted that there have been limited effects arising on benthic communities from certain impacts. Where appropriate, this chapter cross-refers to those studies, either individually or through reference to the MMO review.
"Applicants should assess the potential for the scheme to have both positive and negative effects on marine ecology and biodiversity" (Paragraph 2.6.67 of NPS EN-3).	Both the positive and negative effects of Hornsea Four on marine ecology and biodiversity have been assessed (**Section 2.11**).
"Applicants should assess the effects on the subtidal environment from habitat loss due to foundations and seabed preparation, predicted scour, scour protection and altered sedimentary processes (Paragraph 2.6.113 of NPS EN-3) *and effects on the intertidal zone"* (Paragraph 2.6.81 of NPS EN-3).	The assessment has considered effects from all development phases on benthic and intertidal habitats and species in the vicinity of Hornsea Four. These assessments included all likely effects from temporary and permanent habitat loss and the effects of changes in physical processes (**Section 2.11**)
"Applicants should assess the effects on the benthic environment from extendible legs and anchors of construction vessels (Paragraph 2.6.113 of NPS EN-3) *and habitat disturbance in the intertidal zone during cable installation and removal (decommissioning)"* (Paragraph 2.6.81).	The Hornsea Four assessment has considered the effects of the subtidal and intertidal disturbances throughout all stages of the development (**Section 2.11**)
"Applicants should assess the effects of increased suspended sediment leads during construction on subtidal habitats (Paragraph 2.6.113 of NPS EN-3) *and intertidal habitats"* (Paragraph 2.6.81 of NPS EN-3).	The likely rates of recovery of benthic species/ habitats have been assessed for each impact discussed, and have been used to inform each assessment of the significance of the effect (**Section 2.11**)
"Applicants should include environmental appraisal of array and cable routes and installation methods" (Paragraph 2.6.113 of NPS EN-3).	Effects of cable installation, including maximum design scenario (MDS) for cable installation methodologies, on benthic ecology are assessed for all stages of the development (**Section 2.11**)

Table 2.2: Summary of NPS EN-3 policy on decision making relevant to this benthic ecology chapter.

Summary of EN-3 provisions	How and where considered in the ES
Biodiversity	
"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 2.6.68).	The impacts on benthic ecology, as a component of biodiversity and an element of marine ecology, have been described and considered within this assessment for Hornsea Four (**Section 2.11**).
"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 2.6.69).	Sites within the National Site Network are considered in **Volume B2.2 Report to Inform Appropriate Assessment** (RIAA) with potential effects on the relevant habitats described in **Section 2.11**.
"Mitigation may be possible in the form of a careful design of the development itself and the construction techniques employed" (Paragraph 2.6.70).	Where appropriate, and where effects associated with the project may be considered significant in the absence of mitigation, mitigation has been considered during the Hornsea Four assessment. A number of embedded primary commitments relevant to the project design have also been adopted (**Table 2.11**).
"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 to ensure further useful information to be published relevant to future projects" (Paragraph 2.6.71).	As per commitment Co84, 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 (Section 41 of the 2006 Natural Environmental and Rural Communities (NERC) Act) (**Table 2.11**). In the event that habitats of principal importance are identified in the pre-construction survey; post-construction monitoring will also be carried out with focus on these identified habitats.
Benthic and intertidal Ecology	
"The conservation status of intertidal habitat (Paragraph 2.6.84) *and benthic habitat* (Paragraph 2.6.115) *is of relevance to the SoS".*	The conservation status of intertidal and subtidal benthic receptors has been considered throughout this assessment (**Section 2.11**).
"The SoS should be satisfied that activities have been designed taking into account sensitive benthic environmental aspects (Paragraph 2.6.116) *and intertidal habitats"* (Paragraph 2.6.85).	The assessment has identified potential impacts on sensitive benthic and intertidal habitats and valued ecological receptors (**Section 2.11**).
"Where adverse effects are predicted, in coming to a judgement, the SoS should consider the extent to which the effects are temporary or reversible (Paragraph 2.6.117), *this includes the installation and decommissioning of cables"* (Paragraph 2.6.86).	The duration and reversibility of effects has been considered in the assessment of effects (**Section 2.11**).
"Where it is proposed that the offshore export cables are armoured and buried at a sufficient depth to minimise heat effects, the effects of heat on sensitive species from cable infrastructure during operation are unlikely to be a reason for the SoS to refuse to grant consent for a development" (Paragraph 2.6.118).	The nature, potential burial depth, and installation of export cables has been considered in the assessment (**Section 2.11**) and in accordance with the cable design as presented in **Volume A1, Chapter 4: Project Description**.

Summary of EN-3 provisions	How and where considered in the ES
Biodiversity	
"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."	The effects on biological diversity has been described and considered within the assessment for Hornsea Four alone and the cumulative effects assessment (Section 2.11).
"Descriptor 2 – Non-indigenous species: Non-indigenous species introduced by human activity are at levels that do not adversely alter the ecosystems."	The potential for effects associated with non-indigenous species on benthic species and habitats that may be attributable to Hornsea Four are assessed in Section 2.11.
"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."	The effects on benthic and intertidal ecology, inclusive of the interlinkages with interdependent ecological receptors described in other chapters is integral within this chapter and the wider ES with inter-relationships described where appropriate.
"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."	The effects on benthic subtidal and intertidal ecology, inclusive of any risk to ecological integrity, have been described and considered within the assessment for Hornsea Four alone and the Cumulative Effects Assessment (CEA) (Section 2.11 and Section 2.12).
"Descriptor 7 – Alteration of hydrographical conditions: Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems."	The potential for permanent alterations to hydrographical conditions that may be attributable to Hornsea Four to adversely affect marine ecosystems is assessed within Section 2.11.
"Descriptor 8 – Contaminants: Concentrations of contaminants are at levels not giving rise to pollution effects."	The effects of contaminants on benthic and intertidal habitats and species have been assessed in Section 2.11.
"Descriptor 10 – Marine litter: Properties and quantities of marine litter do not cause harm to the coastal and marine environment."	A Construction Project Environmental Management and Mitigation Plan (CPEMMP) will be produced for Hornsea Four (Co111) (Table 2.11). The CPEMMP will include planning for accidental spills, address all potential contaminant releases and include key emergency contact details (e.g. Environment Agency (EA), Natural England and Maritime and Coastguard Agency (MCA)). A Decommissioning Programme (Co181) will be developed to cover the decommissioning phase (Section 2.8.2).

2.3.2 Other Relevant Plans and Policies

2.3.2.1 The Marine Policy Statement (MPS) and the East Inshore and East Offshore Coast Marine Plans (MMO 2014) are also relevant to benthic ecology. The relevant provisions of these policies are summarised in Table 2.3 along with details as to how these have been considered within the Hornsea Four assessment.

Table 2.3: Summary of Marine Policy Statement and Marine Plan policies relevant to benthic ecology.

Policy	Key provisions	How and where considered in the ES
MPS	*"The high-level objective of 'Living within environmental limits' covers the points relevant to benthic ecology, this requires, that:* *• Biodiversity is protected, conserved and where appropriate recovered and loss has been halted;* *• Healthy marine and coastal habitats occur across their natural range and are able to support strong, biodiverse biological communities and the functioning of healthy, resilient and adaptable marine ecosystems; and* *• Our oceans support viable populations of representative, rare, vulnerable, and valued species."*	Measures designed to protect, and conserve benthic ecology features of ecological importance are outlined in **Table 2.11**.
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 affecting the ecosystem of the East Marine Plan areas and adjacent areas are considered within **Section 2.12**.
East Inshore and East Offshore Marine Plans – MPA1	*"Any impacts on the overall marine protected area (MPA) network must be considered in strategic level measures and assessments, with due regard given to any current agreed advice on an ecologically coherent network."*	Designated nature conservation sites with relevant qualifying benthic features screened into the Hornsea Four assessment (**Volume A5, Annex 2.1: Benthic Ecology Technical Report**) have been described in **Section 2.7.2**. The predicted changes to benthic ecology have been considered within **Section 2.11**.

2.3.2.2 The Marine Strategy Framework Directive (MSFD), adopted in July 2008, has also been considered in the Hornsea Four 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 Hornsea Four are listed in **Table 2.2**, including a brief description of how and where these have been addressed in the Hornsea Four assessment.

2.4 Consultation

2.4.1.1 Consultation is a key part of the DCO pre-application process. Consultation regarding benthic subtidal and intertidal ecology has been conducted through Evidence Plan Technical Panel meetings, the EIA scoping process (Orsted 2018) and formal consultation informed on the PEIR. An overview of the project consultation process is presented within **Volume A1, Chapter 6: Consultation**.

2.4.1.2 Agreements made with consultees within the Evidence Plan process are set out in the topic specific Evidence Plan Logs which are appendices to the Hornsea Four Evidence Plan (**B1.1.1: Evidence Plan**), an annex of the Hornsea Four Consultation Report (**B1.1: Consultation Report**). All agreements within the Evidence Plan Logs have unique identifier codes which have been used throughout this document to signpost to the specific agreements made (e.g. OFF-ME&P-2.1).

2.4.1.3 A summary of the key issues raised during consultation, specific to benthic subtidal and intertidal ecology is outlined below in **Table 2.4**, together with how these issues have been considered in the production of this ES.

Table 2.4: Consultation responses.

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
MMO, Natural England and Cefas	12 September 2018, Marine Processes and Ecology Technical Panel Meeting One	It was noted that consideration of cleaning turbines during operations and maintenance were starting to be considered by the regulator and should be considered within the Hornsea Four assessment.	This activity is considered in the Impact Register (**Volume A4, Annex 5.1: Impacts Register**).
MMO, Natural England and Cefas	12 September 2018, Marine Processes and Ecology Technical Panel Meeting One	It was advised that high levels of arsenic within the muds across the former Hornsea Zone exist and therefore this may need consideration. However, no supporting evidence has been provided for this comment.	A full contaminant assessment has been undertaken across the Hornsea Four Order Limits (**Section 2.7.1**). The full results are presented within **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report**.
MMO, Natural England and Cefas	12 September 2018, Marine Processes and Ecology Technical Panel Meeting One	Point raised that EUSeaMap predictions have been inaccurate and where possible, other data would be used to attempt to 'ground-truth' the EUSeaMap predictions.	A fully comprehensive and representative ground-truth survey strategy was developed through the Evidence Plan process. Site-specific data overrides large scale habitat mapping project data where these data has been combined through the predictive habitat mapping process (full methods presented within **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report**).
PINS	26 November 2018, Scoping Opinion	PINS did not agree that Hornsea Four could scope out a number of impacts.	All impacts listed by PINS have been fully assessed in **Section 2.11**.
MMO	26 November 2018, Scoping Opinion	Point raised that site-specific particle size data is required for assessing sand eel preferred habitat and coastal processes impacts with regard to seabed levelling and suspended sediment impacts and will also be	The assessment of Particle Size Analysis (PSA) for sandeel preference is presented in **Volume A2, Chapter 3: Fish & Shellfish Ecology**.

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
		necessary to inform mitigation commitment Co83.	
MMO	26 November 2018, Scoping Opinion	MMO stated that site-specific information on habitats and species is required to provide confidence in the assessments, with particular reference to the lack of site-specific data from most of the export cable route and western part of the array.	An additional comprehensive seabed survey of the offshore export cable corridor (ECC) was undertaken in June 2019, including the collection of particle size data. The combined and updated 2018-2019 survey data is described in **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report** and within **Section 2.7**, and the assessment has been updated in light of the new data.
MMO	26 November 2018, Scoping Opinion	Advised that there is currently insufficient information on the introduction or spread of invasive non-native species due to the presence of subsea infrastructure and vessel movements due to a lack of post construction monitoring data to date.	Increased risk of introduction or spread of Marine Invasive Non-Native Species (MINNS) due to presence of subsea infrastructure and vessel movements (e.g. ballast water) and the effects on benthic ecology and biodiversity have been included within the assessment (**Section 2.11**).
MMO	26 November 2018, Scoping Opinion	MMO advised that where information from European Marine Observation and Data Network (EMODnet) has been used to infill data gaps, it may not represent the actual habitats present and reduces confidence in the final assessments.	This is understood and has been considered within the data limitations of the predictive habitat model. However, where site specific data have been collected this will always override large scale habitat maps (**Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report**).
MMO	26 November 2018, Scoping Opinion	The MMO notes that data from the western part of the array area and the majority of the cable route are absent, therefore further survey effort will be required to ensure confidence in the predictions made within the ES.	An additional comprehensive seabed survey of the offshore ECC was undertaken in June 2019, including the collection of particle size data. The combined and updated 2018-2019 survey data is described in **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report** and within **Section 2.7**, and the assessment has been updated in light of the new data.

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
MMO	26 November 2018, Scoping Opinion	The MMO advised that site specific data should be collected to avoid sensitive habitats through micro-siting.	Site specific data for the Hornsea Four Order Limits has been collected and used in describing the baseline environment, as detailed in Section 2.7.
MMO	26 November 2018, Scoping Opinion	The MMO stated that there should be clearer presentation of contaminant data collection and analyses, with reference to Cefas Action Level and OSPAR guidelines. They also note that contaminant data is required from within the ECC.	A full contaminant assessment has been undertaken across the Hornsea Four Order Limits (Section 2.7.1). The full results are presented within Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report.
EA	26 November 2018, Scoping Opinion	The EA advised that given the close proximity to the Holderness MCZ, they recommend that a sediment management plan is put in place to reduce the potential for smothering benthic habitats. Sediment sampling within the footprint of the cable path is also recommended, which would allow for mitigation for the potential release of Environmental Quality Substances, if they are present.	Indirect impacts on MCZ features are assessed fully within the MCZ assessment (Volume A5, Annex 2.3: Marine Conservation Zone Assessment) and within Section 2.11. Sediment samples have been collected within the offshore ECC (as detailed in Section 2.6.2) and the results have been presented and used to update the final MCZ assessment.
Natural England	26 November 2018, Scoping Opinion	Natural England stated that the commitment to avoid MCZs/rMCZs 'where practical' is not sufficient to enable impacts to Holderness Inshore MCZ and Holderness Offshore rMCZ to be scoped out at this stage.	There will be no direct impact on MCZs as the project will not overlap with these sites (as set out in Co44 and C045 - Table 2.11). However, any potential indirect impacts have been assessed as part of the ES assessment (Section 2.11), with further assessment undertaken as part of the MCZ assessment (Volume A5, Annex 2.3: Marine Conservation Zone Assessment).
Natural England	26 November 2018, Scoping Opinion	Natural England stated there was a need to present more detail on the cable burial risk assessment and regarding foundations and cable route micro-sitting (Co84) as well as the ECC and cable landfall avoiding all statutory marine designated areas (Co86), these measures should be secured through conditioning on dML/DCO.	Details on how commitments relevant to benthic ecology are secured are set out Table 2.11.
Natural England	26 November 2018, Scoping Opinion	Natural England advised that scoping out impacts where the sensitivity of the receptor might be high, by assuming the majority is low does not represent a worst-case	An additional comprehensive seabed survey of the offshore ECC was undertaken in June 2019, including the collection of

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
		scenario (WCS) approach. If there is the possibility of highly sensitive habitats to be present this is the WCS that needs to be taken forward in the absence of further information, and therefore should not be scoped out while information is not yet available.	particle size data. The combined and updated 2018-2019 survey data is described in **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report** and within **Section 2.7**, and the assessment has been updated in light of the new data.
MMO and Cefas	12 December 2018, Marine Processes and Ecology Technical Panel Meeting Two	It was noted that predictive habitat mapping is used by Cefas and that consultees agree with the Hornsea Four approach in principle but would need to see more detail on the methodology.	A technical note was provided to consultees and methodologies agreed. The full results of the predictive habitat model process are presented within **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report**.
MMO and Cefas	12 December 2018, Marine Processes and Ecology Technical Panel Meeting Two	It was advised that the samples should be representative of all sediment types present.	A fully comprehensive and representative survey strategy has been developed through the Evidence Plan process. Full methodologies are detailed within **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report**.
MMO and Natural England	6 and 12 March 2019, Responses to Benthic and Intertidal Technical Note, Natural England and the MMO	Advice and comment were provided on the Hornsea Four Benthic & Intertidal Ecology Baseline Strategy.	All comments were addressed via the Evidence Plan process and the final baseline data strategy was subsequently agreed with all consultees.
MMO, Natural England and Cefas	30 April 2019, Marine Processes and Ecology Technical Panel Meeting Three	It was requested that recent geophysical data be prioritised in the predictive habitat model. It was also requested that Cefas synthesis data be used.	All site-specific survey data has been prioritised in the predictive habitat model. Cefas synthesis data has been incorporated into the model (as detailed within **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report**).
Natural England	Section 42 consultation	The consultee commented that it was not clear how relevant components of the project were calculated and requested the assumptions behind the project's maximum parameters design so these can be fully understood.	**Volume A1, Chapter 4: Project Description** has been updated to provide further detail on the assumptions and calculations behind Hornsea Four's MDS parameters.
Natural England	Section 42 consultation	The consultee stated that the assumption behind the Worst-Case Scenario (WCS) was not always clear and in cases there were	Additional clarity on the MDS and the assumptions behind the calculations have been provided

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
		miscalculations or inconsistencies with project description.	within Table 2.12 and within Volume A1, Chapter 4: Project Description.
Natural England	Section 42 consultation	Natural England noted that up to date PSA data for the ECC was still lacking at PEIR.	An additional comprehensive seabed survey of the offshore ECC was undertaken in June 2019, including the collection of particle size data. The combined and updated 2018-2019 survey data is described in Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report and within Section 2.7, and the assessment has been updated in light of the new data.
Natural England	Section 42 consultation	Natural England stated that some impacts and projects have been screened out of the CEA that need to be screened in.	All relevant impacts have been screened into the CEA. The CEA has also been updated to include Viking Link, Dogger Bank A & B export cables and Hornsea Project Two export cables (Section 2.12).
Natural England	Section 42 consultation	Natural England expressed concerns on the methodology of the assessment, whereby not enough evidence was provided where the significance of an effect could be concluded as either minor or moderate.	The assessment has been updated to included additional evidence to support all conclusions made within the impact assessment (Section 2.11).
Natural England	Section 42 consultation	The consultee did not agree that no benthic and intertidal monitoring for the construction, operation or decommissioning phases of Hornsea Four is considered necessary.	Pre-construction monitoring surveys will be undertaken to determine the location, extent and composition of any habitats of principal importance (Co84), as set out within F2.7: Outline Marine Monitoring Plan.
Natural England	Section 42 consultation	The consultee requested clarification for the study area buffers used for the assessment.	Additional marine processes modelling was undertaken (as presented in Appendix C of Volume A5, Annex 1.1: Marine Processes Technical Report), the results of which have been used to define a study area around both the array area and the offshore ECC in relation to the appropriate tidal cycles.
Natural England	Section 42 consultation	Clarification was requested on whether to separate documents will be produced for a Project Environmental Management and	The Marine Pollution Contingency Plan will form part of the wider CPEMMP. The relevant

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
		Mitigation Plan (PEMMP) and a Marine Pollution Contingency Plan (MPCP)	commitment (Co111) has been updated to reflect this as detailed in Table 2.11.
Natural England	Section 42 consultation	The EA suggested that a sediment management plan is put in place to reduce the potential for smothering benthic habitats.	Section 2.11.1 describes impacts associated with smothering of benthic habitats. The conclusions of this assessment failed to identify a need for a Sediment Management Plan.
Natural England	Section 42 consultation	The consultee commented that geophysical data could be used to establish areas where boulder and sandwave clearance would be necessary so that the project would not have to apply a blanket 100% of cover of cable installation for these activities which Natural England believes to be an unnecessary stretching of the Rochdale envelope approach.	Volume A1, Chapter 4: Project Description has been updated to provide further detail on the assumptions and calculations behind Hornsea Four's MDS parameters. The combined 2018 and 2019 geophysical survey data is presented in Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report.
Natural England	Section 42 consultation	The consultee expressed concern that the total area of introduced hard substrate considered for colonisation and introduction of invasive species is the same area considered for long-term habitat loss/ change from the presence of foundations, scour protection and cable protection. This implies that the hard surface provided by the submerged portion of the turbines has not been considered as an area available for colonisation or propagation of invasive species.	The introduction of hard substrate, provided by the submerged portion of the wind turbines, is included within the assessment Section 2.11.1.
Natural England	Section 42 consultation	The consultee expressed that vague language used in commitments Co48, Co83 and Co84.	The wording of these commitments has been updated as presented in Table 2.11 and within the Commitments Register (Volume A4, Annex 5.2: Commitments Register).
Natural England	Section 42 consultation	The consultee expressed concerns about drawing on results presented in the Marine Geology, Oceanography and Physical Processes assessment, on account of a number of concerns with the marine processes assessment at PEIR.	The assessment presented in Volume A2, Chapter 1: Marine Geology, Oceanography and Physical Processes has been updated based on new marine processes modelling (Appendix C of Volume A5, Annex 1.1: Marine Processes Technical Report).

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
Natural England	Section 42 consultation	The consultee expressed that further detail should be presented on sediment disposal at Bridlington A.	Further evidence for sediment disposal in Bridlington A is provided in the CEA assessment (Section 2.12).
Natural England	Section 42 consultation	Natural England expressed the need for clarification with regards to background traffic growth across projects result in cumulative nutrient nitrogen deposition which may impact Saltmarsh in the Humber estuary, as detailed within interrelated effects.	As detailed within Section 2.16, impacts on the Humber Estuary have been considered in Volume B2.2: Report to Inform Appropriate Assessment.
Natural England	Section 42 consultation	The consultee requested clarification on the presence of effects only relating to operations and maintenance (O&M) phase being present in interrelated impacts assessment.	The inter-related assessment has been updated as necessary to remove effects that only occur within the operations and maintenance phase (Section 2.16).
MMO	Section 42 consultation	MMO expressed concerns that two potential impacts had not been considered within the assessment: • Temporary habitat loss due to foundation drilling deposits should be assessed; and • Impacts on the habitats outside the array and cable corridor should be assessed in relation to increased suspended sediment.	The MDS for temporary habitat disturbance has been assessed. The largest impact area is associated with seabed preparations for Gravity Base Structures (GBS) (Table 2.12). Impacts to habitats and predicted habitats within the Hornsea Four benthic subtidal ecology study area have been assessed in relation to increased suspended sediment (paragraph 2.11.1.19 *et seq.*).
MMO	Section 42 consultation	MMO expressed concern that the operational phase of the development considers long term loss/change from the presence of foundations, scour and cable protection. There is uncertainty regarding the capacity for scour and rock protection to be removed following decommissioning of the wind farm. The MMO queries whether these should be considered as permanent loss of habitat. Furthermore, the decommissioning phase assessment states that cable protection will be left *in-situ*.	Rock protection has been assessed as permanent habitat loss (Section 2.11.2). In relation to decommissioning, the removal of rock protection is considered the MDS in relation to temporary habitat disturbance and loss of introduced habitat, however the necessity to remove cables and rock protection will be reviewed at the time of decommissioning.
MMO, Natural England and Cefas	13 May 2021, Hornsea Four Evidence Plan Marine Ecology &	MMO expressed concern in regard to the impact from GBS. Cefas also expressed this concern in relation to permanent habitat loss. Natural England raised concerns in	The maximum number of GBS within the MDS has been reduced in line with comments received from the MMO and Natural

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
	Processes Meeting 4	regard to rock protection and also noted the likelihood of colonisation of this benthic environment is quite low but believed that colonisation may occur around the edges of the GBS.	England, and the assumptions behind MDS calculations have been provided within **Table 2.12** and within **Volume A1, Chapter 4: Project Description**. Rock protection has been assessed as permanent habitat loss (**Section 2.11.2**). Colonisation of GBS is considered for the operation and maintenance phase (**Section 2.11.2**).

2.5 Hornsea Four Benthic Subtidal and Intertidal Ecology Study Area

2.5.1.1 For the purposes of this report, the Hornsea Four benthic subtidal and intertidal study areas (**Figure 2.1**) have been defined by the following:

- The Hornsea Four Order Limit is defined as the Hornsea Four array area (hereafter array area) along with the Hornsea Four offshore ECC (hereafter offshore ECC), where landfall area lies within the Holderness coast between Bridlington and Skipsea;
- The Hornsea Four benthic subtidal ecology study area is defined by a 10 km buffer surrounding the array area, and a 14 km buffer around the offshore ECC, to represent the tidal ellipse distance, in order to incorporate the maximum distance sediments may travel in one tidal cycle (**Appendix C** of **Volume A5, Annex 1.1: Marine Processes Technical Report**); and
- The Hornsea Four benthic intertidal ecology study area is defined by the intertidal habitats up to the MHWS mark within the Hornsea Four Order Limits.

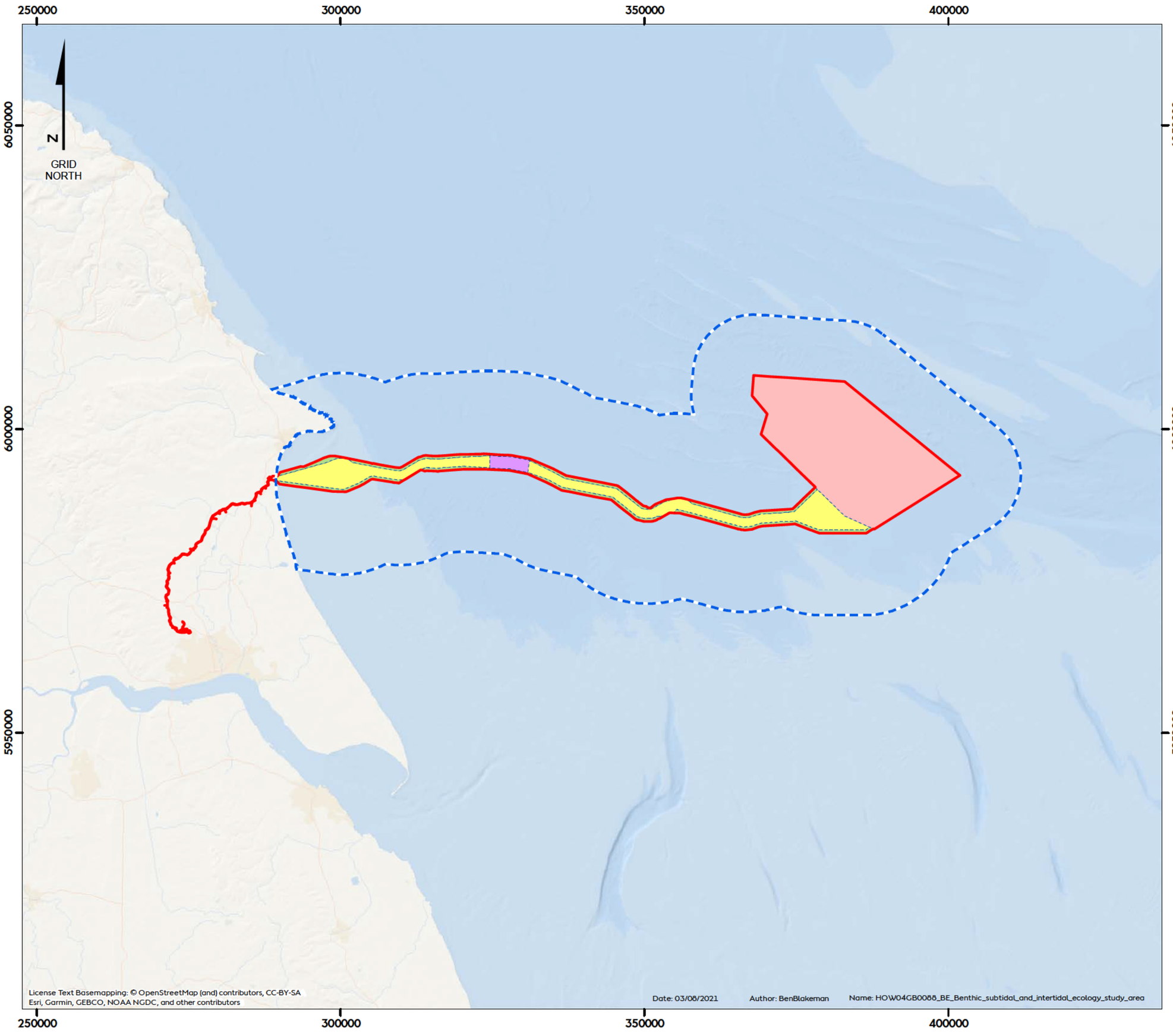
2.5.1.2 Habitats landward of MHWS have been considered in the onshore ecology assessment (see **Volume A3, Chapter 3: Ecology and Nature Conservation**).

2.5.1.3 The study area for the CEA is defined by the wider 10 km buffer surrounding the array area, and a 14 km buffer around the offshore ECC, to incorporate the maximum distance suspended sediments will travel in one tidal cycle and therefore the indirect impacts on benthic subtidal ecology arising from Hornsea Four that could interact cumulatively with impacts from other plans or projects.

Hornsea Four

Figure 2.1

Hornsea Four benthic and intertidal ecology study area



REV	REMARK	DATE
—	First Issue	17/06/2019
A	Updated following PEIR consultation, for DCO	03/08/2021

Date: 03/08/2021 Author: BenBlakeman Name: HOW04GB0088_BE_Benthic_subtidal_and_intertidal_ecology_study_area

Benthic subtidal and intertidal ecology study area
Document no: HOW04GB0088
Created by: BPHB
Checked by: AdB
Approved by: LK

GoBe Ørsted

2.6 Methodology to inform the Benthic and Intertidal Ecology Baseline

2.6.1 Desktop Study

2.6.1.1 The Hornsea Four array area is located within the former Hornsea Zone, for which extensive data and knowledge regarding benthic ecology is already available. This data has been acquired through zonal studies and from the surveys and characterisations undertaken for Hornsea Project One Offshore Windfarm (hereafter Hornsea Project One), Hornsea Project Two Offshore Windfarm (hereafter Hornsea Project Two), and Hornsea Project Three Offshore Windfarm (hereafter Hornsea Three). It was therefore proposed that the benthic ecology characterisation of the Hornsea Four array area be completed, in the first instance and as a basis for providing the appropriate regional context, using a combination of desktop data and information sources, and historic survey data collected as part of the characterisations of the former Hornsea Zone, existing Hornsea projects, as well as other relevant data sets such as, for example, sampling completed for Dogger Bank A and B.

2.6.1.2 A detailed desktop review was carried out to establish the baseline information available on benthic and intertidal resources within the Hornsea Four benthic subtidal and intertidal ecology study area and the wider Southern North Sea area surrounding Hornsea Four, for contextualisation. The key data sources are summarised in **Table 2.5**. Further detail is presented within **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report**.

2.6.1.3 Fully comprehensive site-specific data has been collected across the Hornsea Four Order Limits, as presented in **Section 2.6.2**.

Table 2.5: Key sources of benthic and intertidal ecology data.

Source	Summary	Coverage of Hornsea Four
Hornsea Zonal Characterisation Survey (2010)	Drop-down video (DDV) and grab sampling gear were deployed across the former Hornsea Zone in a regular grid pattern applying a 5 km x 5 km spacing to optimise sampling of the full range of habitats within the former Hornsea zone. An epibenthic beam trawl was also deployed at 11 stations within the Hornsea Four array area.	Stratified random sampling across the Hornsea Four array area.
Hornsea Project One Array Survey (2010 - 2011)	An infill survey was undertaken at the Hornsea Project One array area deploying DDV and grab sampling gear. Epibenthic beam trawls were also deployed at a number of stations.	There is overlap between the Hornsea Project One survey area and the Hornsea Four array area, furthermore the data provides some regional context with regards to benthic habitat distribution.
Hornsea Project Two Array Survey (2012)	DDV and grab sampling gear were deployed across the Hornsea Project Two zone with an epibenthic beam trawl also deployed at a number of stations.	The survey targeted Hornsea Project Two although five sampling stations were located on the periphery of the Hornsea Four array area and additional data providing more regional context.
Dogger Bank A and B ES (Forewind 2013)	The Dogger Bank A and B ES, submitted as part of the DCO application, presented an analysis of geophysical Acoustic Ground	The inshore area of the Dogger Bank A and B ECC coincides with the Hornsea

Source	Summary	Coverage of Hornsea Four
	Discrimination System (AGDS) data ground-truthed with benthic grab samples and DDV to characterise the offshore array and ECC to a landfall location on the Holderness coast.	Four offshore ECC for approximately 16 km from the landfall search area.
Humber Regional Environmental Characterisation (REC) (Tappin et al. 2012)	Regional characterisation of wider Humber area including geophysical data, grab, epifaunal beam trawl and DDV ground truthing.	No overlap with Hornsea Four array area or offshore ECC. Closest sampling locations are located just beyond the southern boundary of the Hornsea Four array area. Dataset provides a regional context for site-specific information.
Technical reports for Strategic Environmental Assessment (SEA) Areas 2 and 3 (Department of Trade and Industry (DTI) 2001a; DTI 2001b);	Description of survey data published in the SEA for Area 2 (northern North Sea) and Area 3 (southern North Sea).	Broadscale data with regional coverage.
UKSeaMap (2018)	European Nature Information System (EUNIS) Level 4 model, detailing biological zone and substrate.	Complete coverage up to MHWS.
Spatial Models of Seabed Sediment Composition (Stephens et al. 2015)	Sediment model detailing multiple different sediment classifications, including Folk and EUNIS substrate.	Complete coverage up to 0 m depth (unspecified what datum this refers to in Cefas publication).

2.6.2 Site-Specific Data Collection

2.6.2.1 Although the desktop data review provides an important and useful source of evidence in relation to the surrounding areas of seabed and the wide region, sampling within the Hornsea Four array and ECC areas is limited. Site-specific baseline characterisation surveys have been conducted within the Hornsea Four Order Limits in 2018 and 2019. **Table 2.6** and **Figure 2.2** present details of the site-specific survey data collected. A full description of the survey methodology and sample analysis is presented within **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report** and its associated appendices.

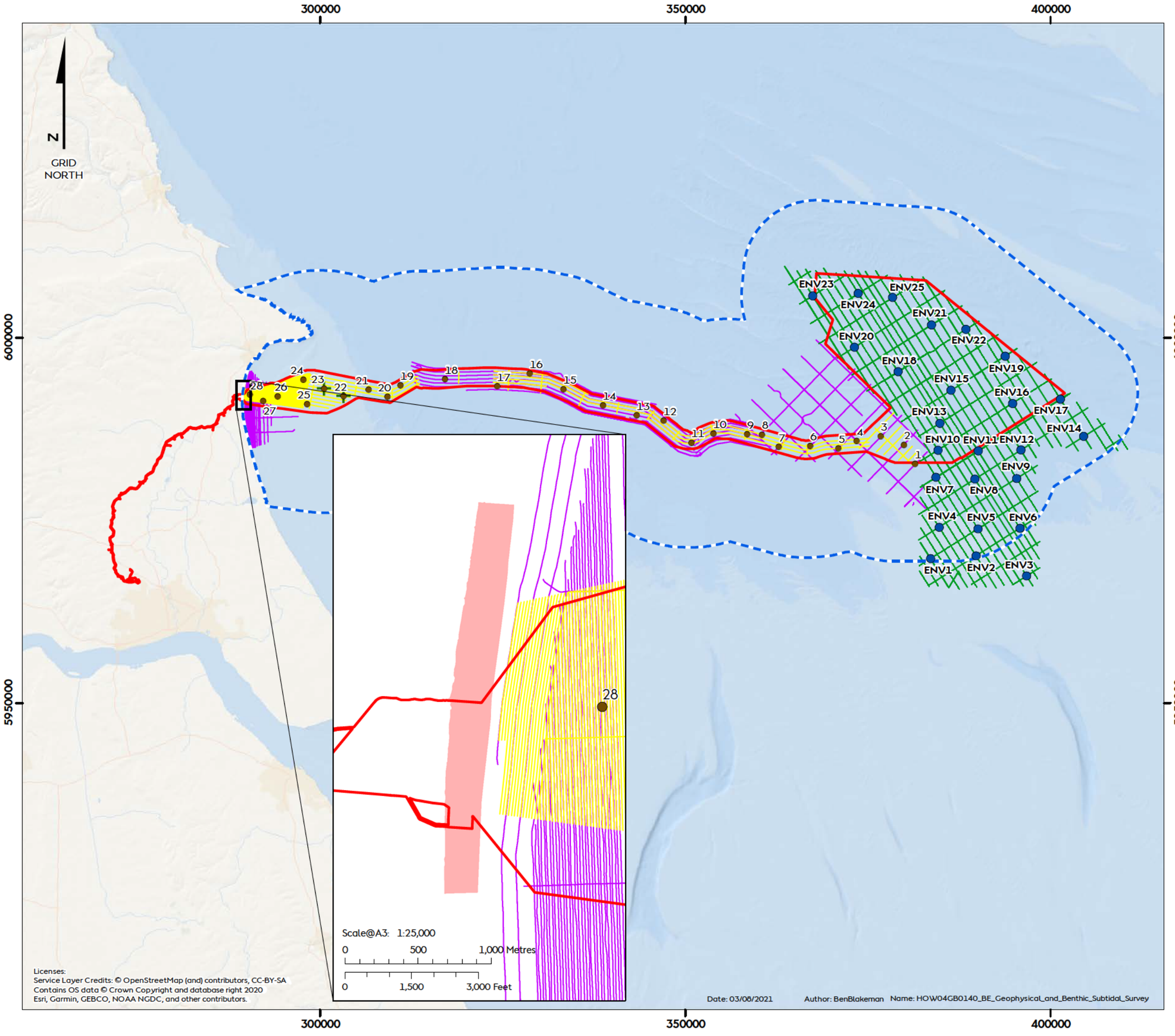
Table 2.6: Hornsea Four site specific benthic and intertidal survey data.

Title	Summary	Coverage of Hornsea Four
Hornsea Four Geophysical Survey, 2018 **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report; Appendix A (array) and B (ECC)**	Geophysical survey using single-beam and multi-beam echo sounders (SBES and MBES), side scan sonar (SSS), magnetometer and a sub-bottom profiler (SBP).	Array area and partial coverage of offshore ECC (**Figure 2.2**).
Hornsea Four Array Area Benthic Survey, 2018 **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report; Appendix A**	A total of 664 images were collected across 21 benthic sample locations (**Figure 2.2**). Benthic sediment grab samples were collected with 0.1 m^2 mini-Hamon grab at all 21 locations. All benthic grab samples were subject to infaunal species analysis, PSA and contaminants analysis.	Array area (**Figure 2.2**).
Hornsea Four Intertidal Survey, 2019 **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report; Appendix C**	Phase I walkover survey carried out landward to mean low water springs (MLWS). Phase I survey data including description of biotope distribution and the extent of sub-features.	Coverage of Hornsea Four intertidal zone from Bridlington to Skipsea (**Figure 2.2**).
Hornsea Four Offshore ECC Geophysical Survey, 2019 **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report; Appendix E**	Geophysical survey carried out to complete the 2018 coverage of offshore ECC using SBES and MBES, SSS, magnetometer and SBP.	Partial coverage of the offshore ECC to complete data gaps in 2018 data (**Figure 2.2**).
Hornsea Four ECC Benthic Subtidal Survey, 2019 **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report Appendix D**	Benthic sediment DDV and grab samples collected at 28 locations, with 0.1 m^2 mini-hamon grab. All benthic grab samples were subject to infaunal species analysis, PSA and contaminants analysis.	Representative coverage across the offshore ECC (**Figure 2.2**).
Hornsea Four Annex 1 Habitat Assessment Survey, 2020 **Appendix D8: Annex 1 Habitat Assessment Survey of Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report Appendix D**	An additional DDV survey was commissioned at two stations within the offshore ECC (ECC_22 and ECC_23) to investigate the presence and extent of potential Annex I stony reef.	Stations ECC_22 and ECC_23 on the offshore ECC (**Figure 2.2**).

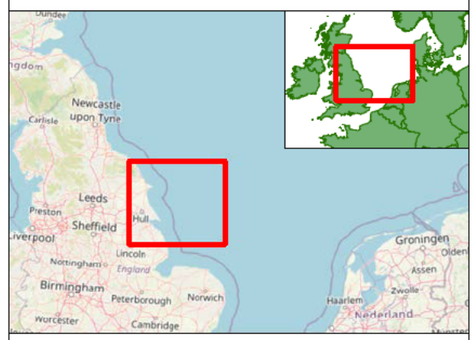
Hornsea Four

Figure 2.2

Site specific geophysical and benthic subtidal and intertidal survey campaigns



- Order Limits
- Study Area (14km from ECC and 10km from Array Area)
- Benthic Grab and DDV Samples (Gardline, 2018)
- Benthic Grab and Samples (BSL, 2019)
- Stony Reef Assessment Stations (Ocean Ecology, 2020)
- Array Geophysical Survey Lines (Gardline, 2018)
- ECC Geophysical Survey Lines (Bibby, 2018)
- Geophysical Survey Lines 2019 (Bibby, 2019)
- Extent of Intertidal Phase 1 Biotope Survey



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:500,000

0 10 20 Kilometres

0 5 10 Nautical Miles

REV	REMARK	DATE
--	First Issue	08/05/2019
A	Updated following PEIR consultation, for DCO	03/08/2021

Geophysical and Benthic Subtidal Survey
Document no: HOW04GB0140
Created by: BPHB
Checked by: AdB
Approved by: LK

GoBe Ørsted

2.6.3 Predictive Habitat Modelling

2.6.3.1 The Hornsea Four predictive habitat model was developed by GoBe Consultants Ltd., and is presented as part of the **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report**, in order to provide the most up to date full coverage knowledge on the distribution of sediments, biological zones and biotopes across the Hornsea Four benthic subtidal ecology study area, taking into account all publicly available datasets and those data collected for Hornsea projects and Dogger Bank A and B. The model was initially developed to address the data gaps identified during the drafting of the PEIR, when there was incomplete site-specific survey data across the offshore ECC. Since the production of the PEIR, additional site-specific data has been collected. However, as the model collates available physical and biological point data across the wider Hornsea Four benthic subtidal ecology study area, it has been retained to understand the occurrence of potential biotopes to support the application and the assessment of impacts on the subtidal benthic ecology.

2.6.3.2 The full methodologies and results of the model are presented within Section 7 of **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report**.

2.7 Baseline Environment

2.7.1 Existing Baseline

2.7.1.1 A detailed baseline description of benthic subtidal and intertidal ecology resources across the Hornsea Four benthic subtidal and intertidal ecology study areas, and wider Southern North Sea, is presented within **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report**. A summary of the existing baseline is presented within this section.

Subtidal Environment

Sediment composition and seabed features

2.7.1.2 The array area is predominantly characterised by well-sorted medium or fine homogenous sands, whereas sediments across the offshore ECC were more heterogeneous with increased coarse and mixed sediments.

2.7.1.3 The Particle Size Distribution (PSD) data (expressed as percentage distribution by weight) of the surface sediments from the 47 stations within the Hornsea Four offshore ECC and array area include the percentage composition of the silt and clay (<0.063 mm), sand (0.063 mm to <2 mm) and gravel (≥ 2 mm) at each station.

2.7.1.4 PSD of the sediments sampled from stations within the Hornsea Four array area determined that the sediments were dominated by the sand fraction '≥63 µm to <2 mm'. This resulted in the majority of stations across the Hornsea Four array area being classified as sand under the Folk classification (Folk 1954).

2.7.1.5 Across the offshore ECC, PSD was more variable with the mean sediment fraction ranging from 0.087 mm at ECC_04 to 3.089 mm at ECC_23, demonstrating the variability in the proportions of silts, sands and gravels. According to the Folk classification the dominant sediment types throughout the offshore ECC were 'muddy sand' and 'sand', although sand

with gravel were also present, particularly towards the inshore portion of the offshore ECC.

2.7.1.6 The predictive habitat model identified that most of the array area and the adjacent offshore portion of the offshore ECC could be characterised as circalittoral sand and muddy sand. Discrete patches of mixed and coarse sediment were attributed to the array area. Within the nearshore element of the offshore ECC mixed and coarse sediments were more dominant.

2.7.1.7 The seabed sediments that characterise the Hornsea Four Order Limits are typical of the wider Southern North Sea, where large areas of similar well-sorted medium or fine sands were recorded offshore (Tappin et al. 2011; DECC 2016; Cefas 2019). Nearshore reports of a heterogeneous distribution of sediments ranging from sand and mixed sediments to muddy sand sediments are characteristic of the wider area (Forewind 2013; Premier Oil 2018).

2.7.1.8 The results of the geophysical data analysis identified that sand megaripples were the most frequently observed bedforms across the array area, while sandwaves were also common. These features were also observed in the offshore portion of the ECC leading into the array area. The offshore ECC crosses the southern part of the sandbank feature Smithic Sands; further detail on this feature is presented in **paragraph 2.7.1.34**. The inshore section of the offshore ECC also encompasses a boulder field (**Figure 2.3**) with densities ranging from 0.9 to 1.8 boulders per 100 m^2. Maximum boulder sizes were approximately 3.0 x 1.8 x 0.5 m (L x W x H).

2.7.1.9 Smithic Bank is a sandbank feature formed by a supply of sediment which arrives into Bridlington Bay having been brought around Flamborough Head by currents that flow north to south (Williams 2018). The sandbank feature does not form a qualifying feature of any SAC, SPA or Ramsar site. Further detail on this sandbank feature is presented within the **Volume A5, Annex 1.1: Marine Processes Technical Report**.

Sediment contamination

2.7.1.10 Total hydrocarbon (THC) concentrations (comprising total n-alkanes, pristane, phytane, unresolved complex mixture (UCM) and polycyclic aromatic hydrocarbons (PAH)) ranged from 1.6 µg g^{-1} at Station ENV23 to 8.6 µg g^{-1} at Station ENV17, with a mean value of 4.7 µg g^{-1} (±1.8 standard deviations (SDs)) across the array area. Gas Chromatography (GC) traces across the array area were generally indicative of background levels of hydrocarbons in areas of historic oil and gas exploration and suggested a mixture of petrogenic and pyrogenic sources.

2.7.1.11 It has previously been shown that benthic macrofauna suffer adverse effects when THC concentrations are in excess of 50 µg g^{-1} (United Kingdom Offshore Operators Association (UKOOA) 2001; Kjeilen-Eilertsen et al. 2004; UKOOA 2005) and as such, this value represents the threshold above which hydrocarbons are expected to have a 'significant environmental impact'. Kingston (1992) also reported that benthic macrofauna suffer adverse effects, namely reduced diversity, when THC is in excess of 50 µg g^{-1} to 60 µg g^{-1}, and that specific sensitive species may be impacted at levels greater than 10 µg g^{-1}. Mair et al. (1987) observed a notable increase in the dominance of opportunistic species at THC

levels in excess of 291.4 µg g^{-1}. The THC concentrations recorded across the array were well below all of these threshold values and therefore, the faunal community was not expected to be influenced by THC concentrations.

2.7.1.12 THC was variable across the offshore ECC, where values ranged from 2.8 µg g^{-1} at ECC_12 to 61.4 µg g^{-1} at ECC_20. THC levels above the UKOOA (2001) 95th percentile of 11.39 mg/kg for THC in the Southern North Sea were found at five stations (ECC_18 to ECC_21, and ECC_08). The higher THC levels observed at stations ECC_18 to ECC_21 are consistent with the elevated Total Organic Carbon (TOC) at those stations.

2.7.1.13 Concentrations of the US Environmental Protection Agency (EPA) 16 PAHs were compared to OSPAR's (Convention for the Protection of the Marine Environment of the North-East Atlantic) background concentrations (BC) and Background Assessment Concentrations (BACs; OSPAR 2005). Comparison to BCs and BACs requires normalisation to 2.5% TOC (OSPAR 2005). Eight US EPA 16 PAHs (Naphthalene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo[a]anthracene, Chrysene and Benzo[a]pyrene) were above their respective BC values at all stations sampled across the array area where values were greater than the limit of detection (LOD). A further two US EPA 16 PAHs (Indeno[123,cd]pyrene and Benzo[ghi]perylene) were above their respective BC values at the majority of stations where values were greater than the LOD. These patterns indicated that concentrations of US EPA PAHs were not representative of a 'pristine' environment, as described by OSPAR (2005), which could be expected considering the extent of oil and gas activities historically and currently present within the wider area. Information derived from molecular weight PAH indices on the origin of US EPA 16 PAHs presented a mix of pyrolytic and petrogenic inputs from the range of indices calculated.

2.7.1.14 Across the offshore ECC, total PAH data were also normalised to the 2.5% TOC content of the sediment at each station to enable comparison of results with the OSPAR BACs. The mean PAH calculated from the data at all stations exceeded the OSPAR BAC threshold. The normalised PAH data displayed a similar spatial pattern to the non-normalised data which showed elevated concentrations at stations ECC-18 to ECC_21. Station ECC_27 (the station closest to the shore) had a comparatively high normalised PAH value of 1.887 µg g^{-1}. It is suggested that the low TOC levels and relatively small proportions of silt and clay at all stations may have led to an exaggeration of the normalised total PAH values when compared to the BAC (OSPAR 2014).

2.7.1.15 Metals concentrations varied across the array area with generally higher concentrations presented at stations ENV16 and ENV17 and lower concentrations at stations ENV1 and ENV23. All metals concentrations were within the Cefas Action Level 1 (AL1), apart from four stations which exceeded this level for arsenic, which indicated that toxicological impacts on the biota were unlikely across the array area. The Canadian Interim Sediment Quality Guideline (ISQG) was exceeded for arsenic at 11 stations, these levels were not exceeded for other metals however (cadmium, chromium, copper, lead, nickel and zinc).

2.7.1.16 Across the offshore ECC metal concentrations were generally low, except for arsenic, which exceeded the Cefas AL1 at 14 stations. The ISQG level for lead was exceeded at two stations, while that for nickel was very slightly exceeded at one station. Metals data across the offshore ECC were normalised (to 52 parts per million (ppm) lithium) to enable comparison of results with OSPAR BCs and BACs (OSPAR 2014). Apart from cadmium (Cd)

and Chromium (Cr), the mean of all other normalised metal concentrations exceeded the BAC levels. However, these exceedances are most likely to be attributable to the relatively low lithium concentrations that were found throughout the offshore ECC and the normalisation process described above. Furthermore, the normalisation procedure using pivot values could not be used for several of the metals as their measured concentrations were below the pivot values (the results of the metal normalisation process have not been applied to the data obtained across the array area as the comparison to Cefas action levels were more insightful). As discussed above, metals were generally present at low concentrations. Therefore, despite the apparent exceedances of the BACs by numerous metal analytes, metal concentrations are considered to be at background levels.

Benthic Subtidal Ecology

2.7.1.17 Across the array area, a total of 2,678 individuals representing 163 taxa were recorded from the 21 macrofaunal samples acquired. Univariate indices indicated a generally diverse and evenly distributed community with a lack of notable dominance structure, across the array area. Benthic subtidal communities across were generally dominated by *Annelida*, *Mollusca* and *Echinodermata*, all of which contributed c.30% of the total individuals identified. Examination of the taxonomic data at each station, highlighted the most abundant taxa, *Abra* and *Amphiura filiformis* to be responsible for much of the variation.

2.7.1.18 Across the offshore ECC, a total of 2,813 individuals representing 259 taxa were recorded from the 26 macrofaunal samples acquired. The greater stability and broader range of ecological niches offered by the mixed substrates that characterise portions the offshore ECC are likely to be the main factors driving the elevated diversity indices. The benthic subtidal communities were dominated by *Annelida*, *Arthropoda*, Mollusca and *Echinodermata* whilst all other phyla accounted for the remaining seven taxa or 2% of individuals.

2.7.1.19 DDV data corroborated the findings of PSA and faunal sample data, indicating a relatively heterogenous benthos across the Hornsea Four Order Limits, which ranged from muddy sand to sandy gravel. Typical epifauna observed included hydroids, bryozoans, molluscs, anthozoans and echinoderms. Free swimming megafauna were limited to demersal teleosts (bony fish) including pleuronectiforms and dragonets. The potential habitats 'seapen and burrowing megafauna community' and 'stony reef' were identified in the data, which is discussed further in **paragraphs 2.7.1.34** *et seq*.

2.7.1.20 Analysis of the benthic ground-truthing works obtained across the Hornsea Four Order Limits identified 11 EUNIS categories. The EUNIS classification hierarchy to biotopes (to a maximum level five) was mainly based on depth, sediment type and species composition. A more detailed explanation of the benthic subtidal ecology and EUNIS classification process across the Hornsea Four Order Limits are presented within **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report** and the associated appendices.

2.7.1.21 The EUNIS habitat codes (and corresponding Joint Nature Conservation Committee (JNCC) 04.05 biotope code) identified are presented in **Table 2.7** and **Figure 2.3**.

Table 2.7: Biotopes found across the Hornsea Four Order Limits (Gardline 2019; GoBe 2020).

EUNIS Code	Biotope Name	JNCC 04.05 Code
A5.14	Circalittoral coarse sediment	SS.SCS.CCS
A5.233	*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand	SS.SSa.IFiSa.NcirBat
A5.242	*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand	SS.SSa.IMuSa.FfabMag
A5.25	Circalittoral fine sand	SS.SSa.CFiSa
A5.251	*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	SS.SSa.CFiSa.EpusOborApri
A5.252	*Abra prismatica, Bathyporeia elegans* and polychaetes in circalittoral fine sand	SS.SSa.CFiSa.ApriBatPo
A5.261	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	SS.SSa.CMuSa.AalbNuc
A5.43	Infralittoral mixed sediment	SS.SMx.Imx
A5.44	Circalittoral mixed sediment	SS.SMx.CMx
A5.443	*Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment	SS.SMx.CMx.MysThyMx
A5.444	*Flustra foliacea* and *Hydrallmania falcata* on tideswept circalittoral mixed sediment	SS.SMX.CMx.FluHyd

2.7.1.22 When considering the epifauna identified within the seabed imagery, and the faunal communities identified during the macrofaunal analysis, it was possible to classify most stations to EUNIS level five. EUNIS habitat code A5.233 is derived from A5.23 (infralittoral fine sand) and corresponds to *Nepthys cirrosa* and *Bathyporeia* spp. in infralittoral sand, this biotope was only found at one station outside the array area. The EUNIS habitat codes A5.251 and A5.252, which are both derived from A5.25, relate to *Echinocyamus pusillus*, *Opheliea borealis* and *Abra prismatica* in circalittoral fine sand and *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand, respectively and were located within the array area. EUNIS code A5.261 is derived from A5.26 (circalittoral muddy sand) and corresponds to *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment. EUNIS habitat code A5.443 is derived from A5.44 (circalittoral mixed sediments) and corresponds to *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediments.

2.7.1.23 Sediment characteristics at stations ENV17 and ENV19 were similar to those described in the EUNIS code A5.443. In addition, macrofaunal communities at these stations were dominated by the brittle star *A. filiformis*. It was noted in the habitat classification for A5.443 that this brittle star species is known to be abundant at some previous sites where this classification has been used (EEA 2018). *A. filiformis* was also dominant at station ENV21, however due to the sediment characteristics and the remaining macrofaunal community it was not possible to characterise this station further than EUNIS level four. The EUNIS classification A5.251 has been used to classify stations ENV4, ENV6 to ENV15 and ENV20. These stations all presented similar sediment profiles of sand with varying small quantities of fine material and were all dominated by the bivalve mollusc *Abra alba*. Due to the high abundance of *A. filiformis* at stations ENV16, ENV17, ENV19 and ENV21 the biotope A5.351, '*Amphiura filiformis*, *Mysella bidentata* and *Abra nitida* in circalittoral

sandy mud', will also be taken through to the ecological impact assessment and is presented within the table of valued ecological receptors (VERs) (**Table 2.9**).

2.7.1.24 A5.242, '*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand' dominated the offshore portion of the ECC. The main characterising taxa *Fabulina fabula* and *Magelona* spp were found in sediments at all 14 stations that were sampled within the habitat type, while *Bathyporeia spp.* amphipods were captured at all but two stations.

2.7.1.25 The sediments across stations allocated to EUNIS habitat code A5.444 were heterogenous with varying proportions of silt and clay, sand and gravel, with stations ECC_17 and ECC_23 being additionally characterised by the presence of cobbles and boulders. However, collectively the sediment types mostly resembled circalittoral mixed sediments. Given the heterogeneity of the sediments, the infaunal communities were also variable, with this group reflecting the most diverse faunal group. Despite the infaunal variability of these stations, dominant infauna included the polychaete worms *Sabellaria spinulosa*, *Lumbrineris cingulate* and the saltwater clam *Hiatella arctica*. Analysis of the epifaunal assemblages revealed that characteristic taxa were broadly similar and ultimately informed the habitat type assignment. At stations ECC_19 and ECC_20 *Sabellaria spinulosa* individuals were recorded at relatively high densities (102 and 109 individuals were sampled, respectively), whilst the evidence suggests that these stations don't represent reef habitat, this species has been added to the table of VERs on account of its ecological importance (**Table 2.9**).

2.7.1.26 The two major characterising epifaunal species within A5.444 '*Flustra foliacea* and *Hydrallmania falcata* on tideswept circalittoral mixed sediment' communities were frequently observed in the benthic imaging. Other characterising epifaunal species that were recorded included the soft coral *Alcyonium digitatum*, the barnacle *Balanus crenatus*, robust bryozoans *Alcyonidium diaphanum* and *Vesicularia spinosa* as well as the tube worm polychaetes *Sabella pavonia* and *Lanice conchilega*.

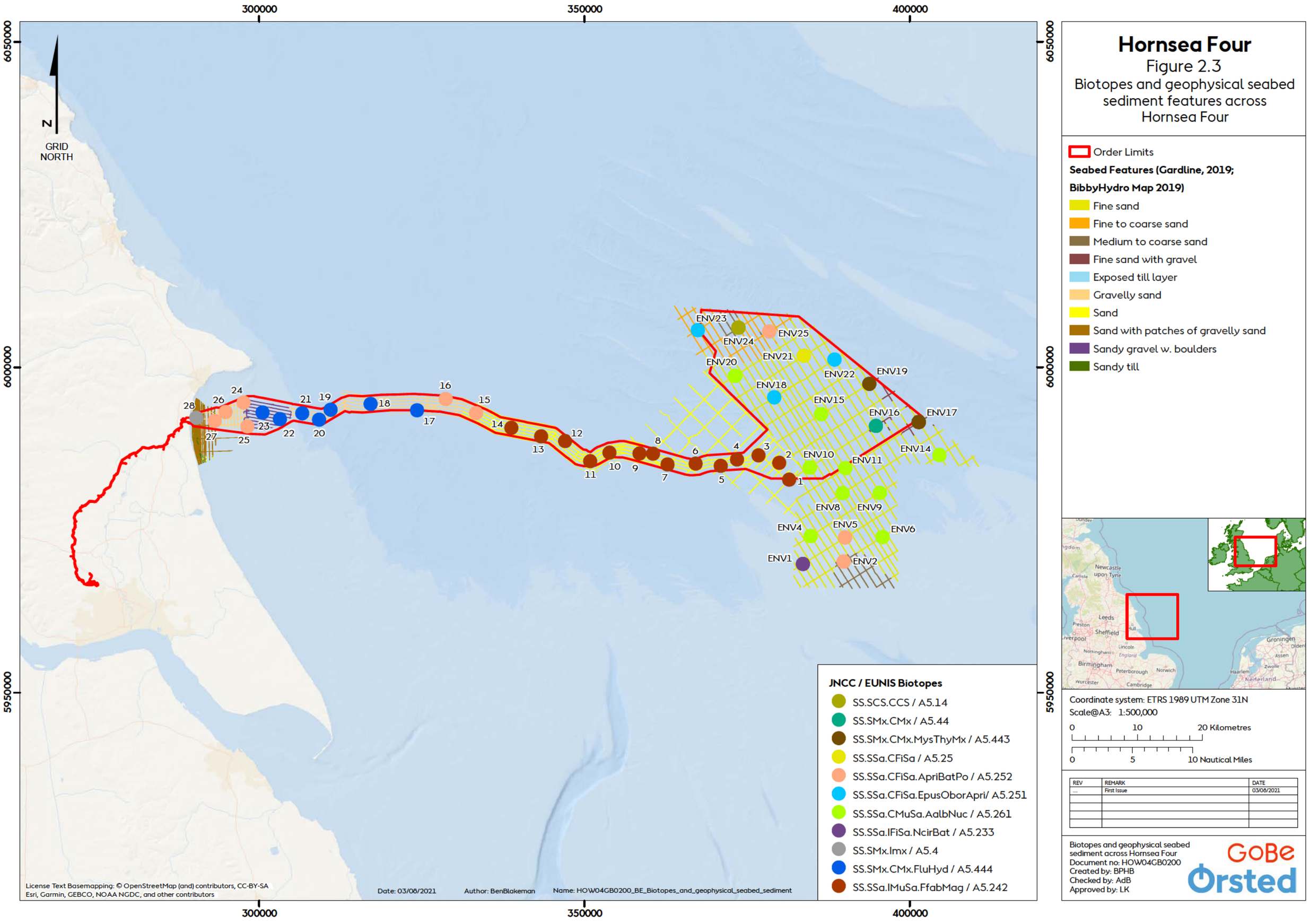
2.7.1.27 EUNIS habitat classification to level four could only be achieved at a number of stations, due to the lack of biological community level information from the ground-truthing investigations. EUNIS code A5.25 corresponds to clean fine sands in depths of over 20 m and was noted at station ENV21. Station ENV16 was classified as EUNIS code A5.44 which corresponds to circalittoral mixed sediments generally below 20 m, whilst station ENV24 was classified as EUNIS code A5.14 which corresponds to circalittoral coarse sediments. Station ECC_28 was classified by the habitat code A5.43, which corresponds to Infralittoral mixed sediment.

2.7.1.28 Overall, the wide range of observed EUNIS classifications supported the conclusion that the habitats across Hornsea Four Order Limits varied in accordance with the heterogenous sandy sediments encountered. The varying gravel and fines components and their effects on the faunal community were noted on final EUNIS classifications.

Hornsea Four

Figure 2.3

Biotopes and geophysical seabed sediment features across Hornsea Four



Date: 03/08/2021 Author: BenBlakeman Name: HOW04GB0200_BE_Biotopes_and_geophysical_seabed_sediment

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Biotopes and geophysical seabed sediment across Hornsea Four
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Habitat mapping

2.7.1.29 To address the data gaps identified at PEIR (when there was incomplete site-specific survey data across the offshore ECC), full coverage modelling of benthic subtidal habitats was undertaken across the Hornsea Four benthic subtidal ecology study area. The model collated all available physical and biological point data across the area of interest to help understand the occurrence of potential biotopes over the wider study area and, as such, has been retained to support the application and the assessment of impacts on the subtidal benthic ecology.

2.7.1.30 The full details and results of the model can be found in **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report**. The biotope prediction results (**Figure 2.4** to **Figure 2.7**) reveal that a few additional biotopes to the ones identified through site-specific surveys (**Table 2.7**) are predicted to potentially occur across Hornsea Four benthic subtidal ecology study area, albeit showing varying degrees of modelled coverage.

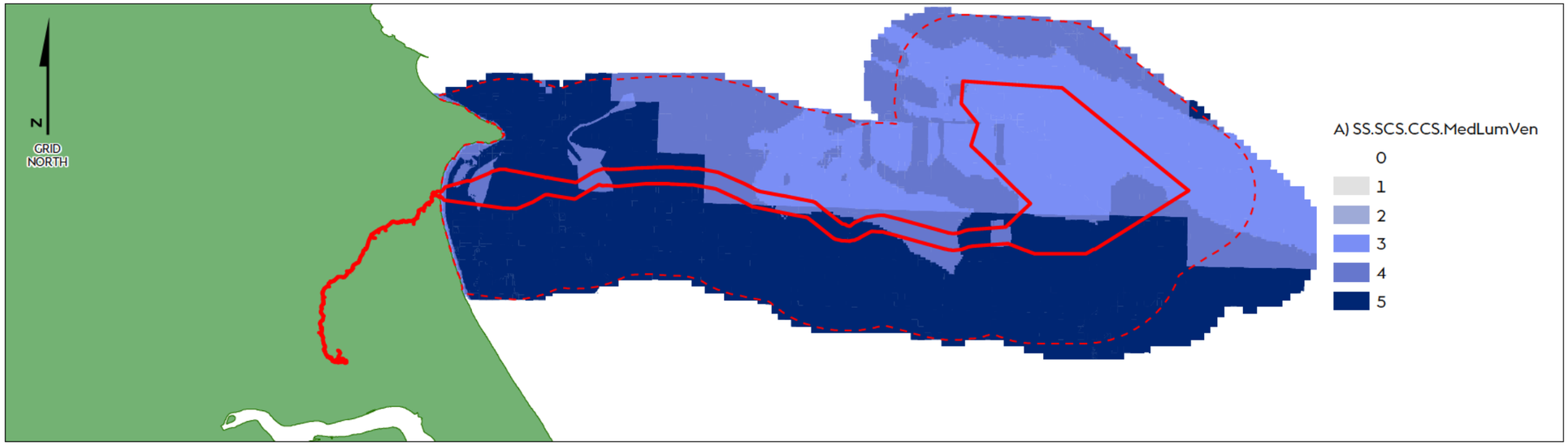
2.7.1.31 The additional EUNIS biotopes include A5.142, '*Mediomastus fragilis, Lumbrineris spp.* and venerid bivalves in circalittoral coarse sand or gravel'; A5.133, '*Moerella* spp. with venerid bivalves in infralittoral gravelly sand'; A5.351, '*Amphiura filiformis, Mysella bidentate* and *Abra nitida* in circalittoral sandy mud' and A5.451, 'Polychaete-rich deep *Venus* community in offshore mixed sediments'. These benthic communities have been included within the baseline habitats for assessment within this chapter.

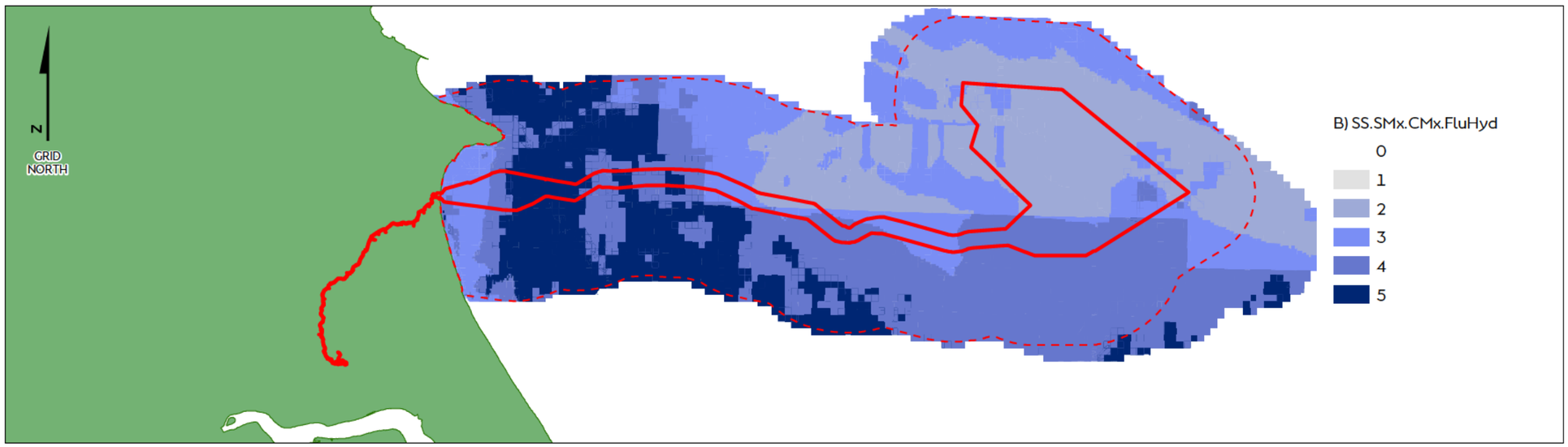
2.7.1.32 The habitat model (**Figure 2.4** to **Figure 2.7**) reveals that each of the biotopes has differing but also overlapping habitat requirements in some instances, which is likely to be reflective of the homogeneity of ecological conditions across some of the site, particularly in the offshore section of Hornsea Four benthic subtidal ecology study area.

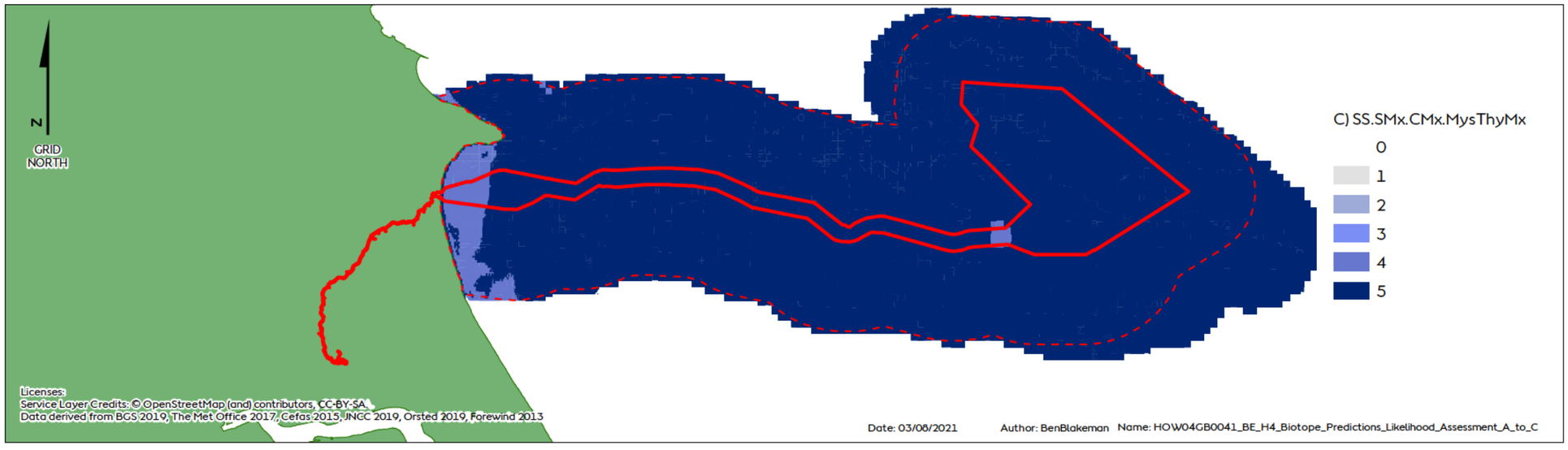
Hornsea Four

Figure 2.4

Hornsea Four biotope predictions: likelihood assessment (1 of 4)

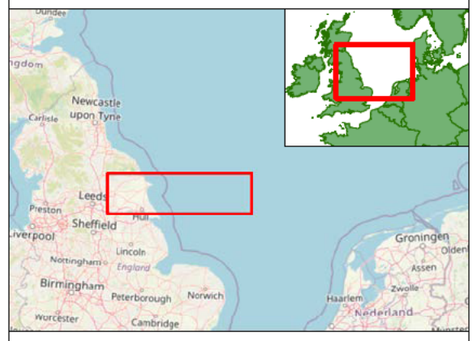






Order Limits

Benthic Study Area



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H4 Biotope Predictions:
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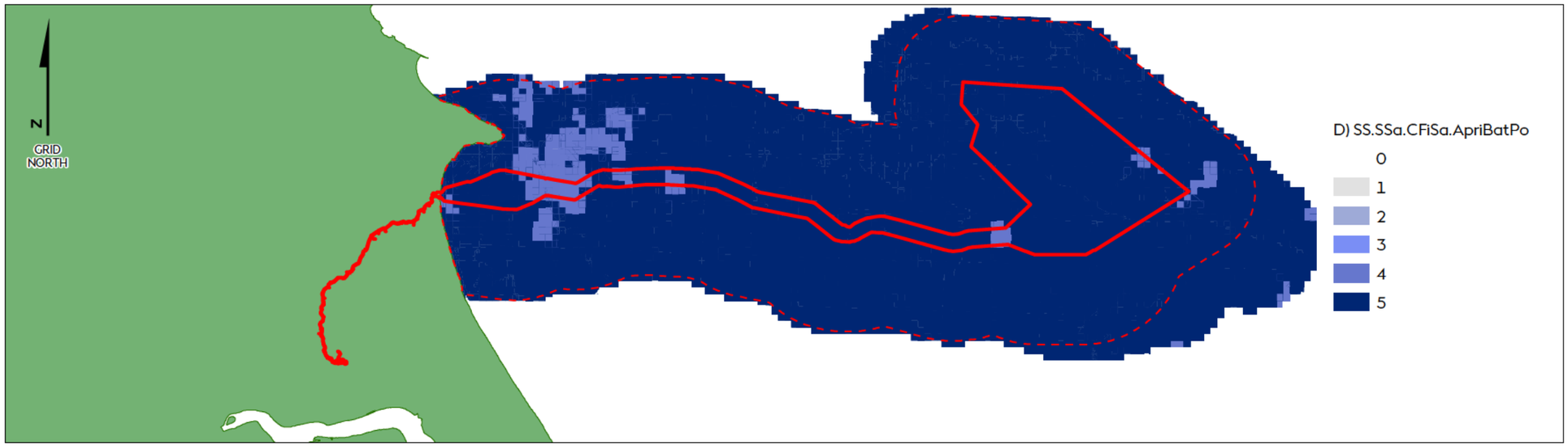
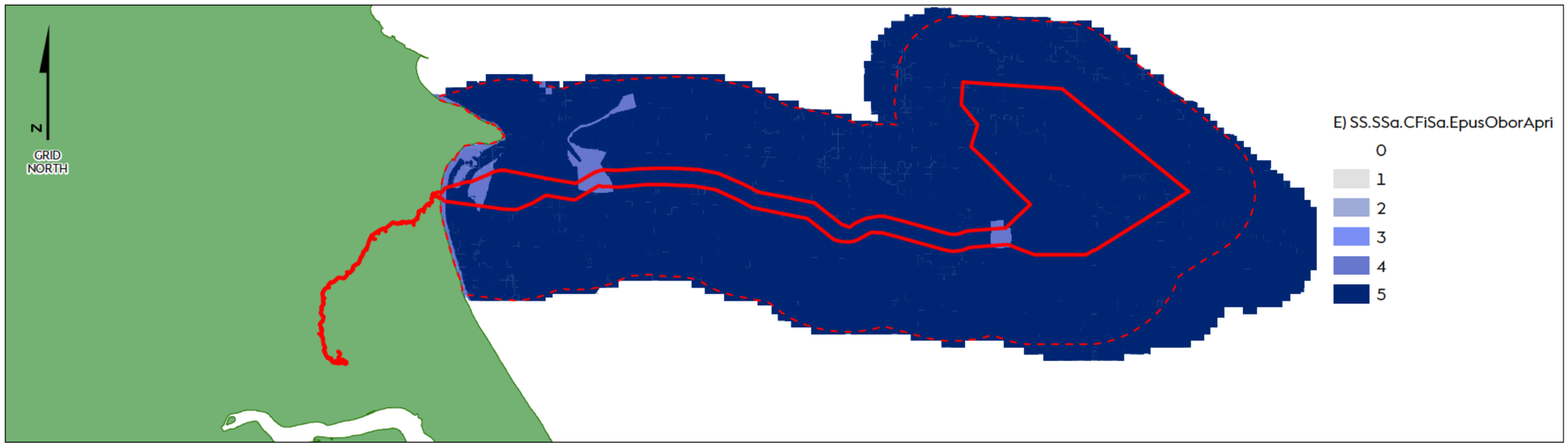
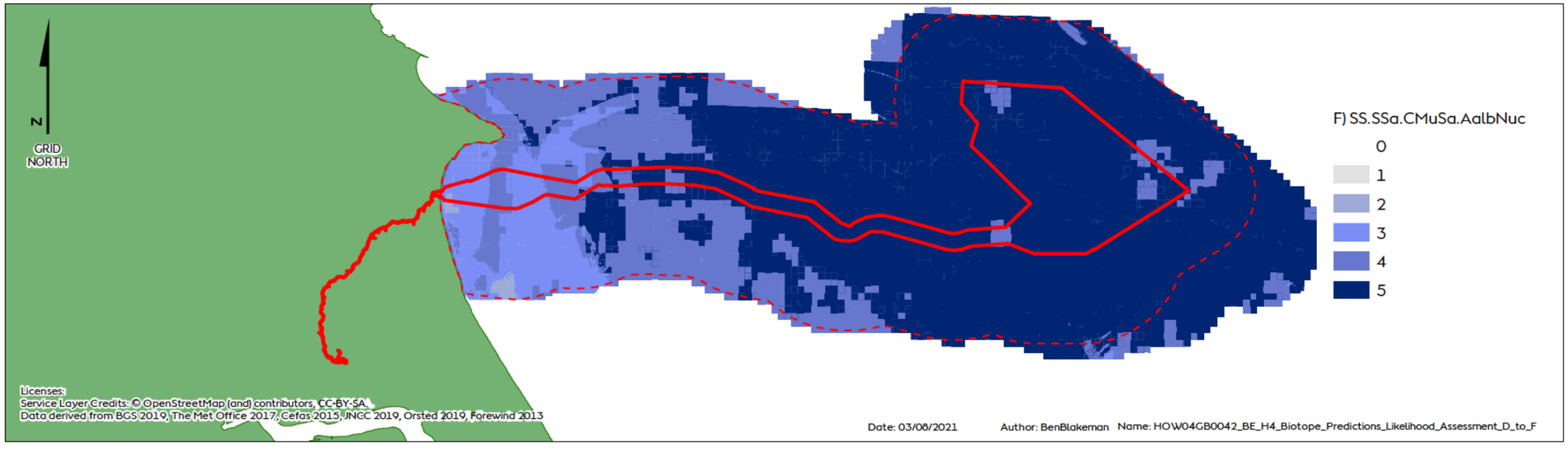






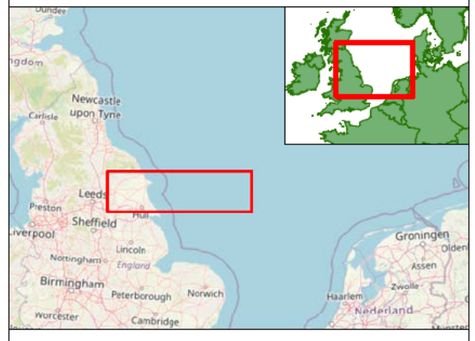
Hornsea Four

Figure 2.5

Hornsea Four biotope predictions: likelihood assessment (2 of 4)

Order Limits

Benthic Study Area



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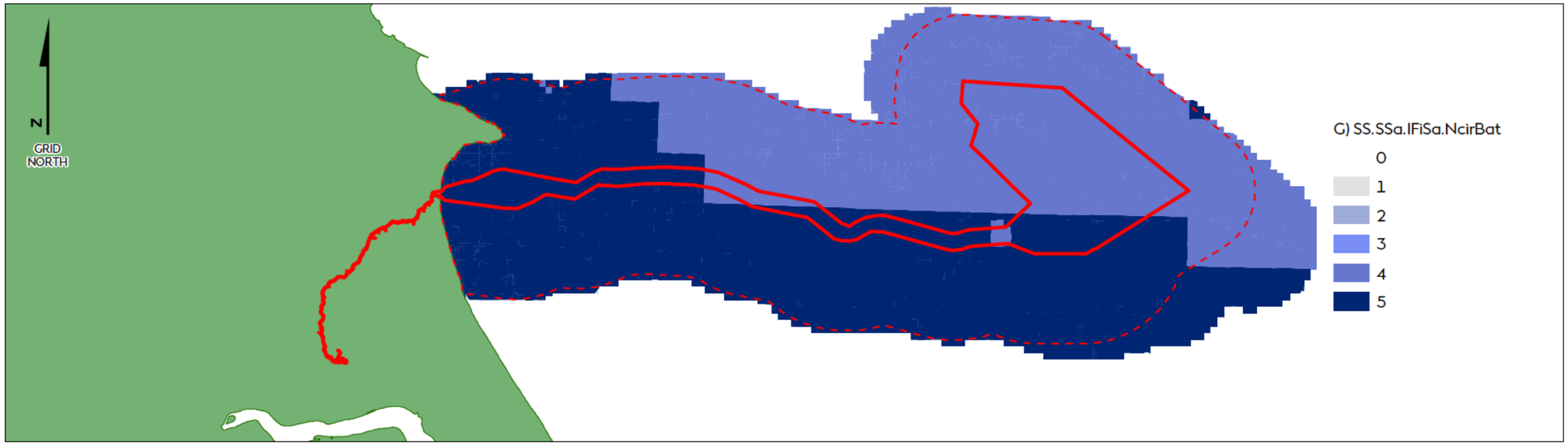
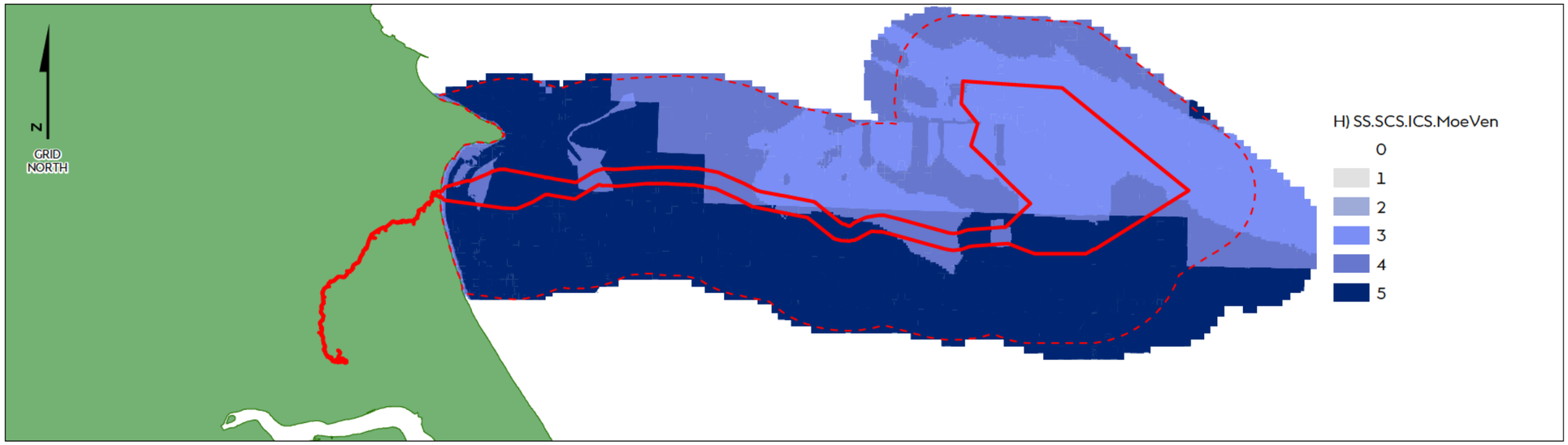
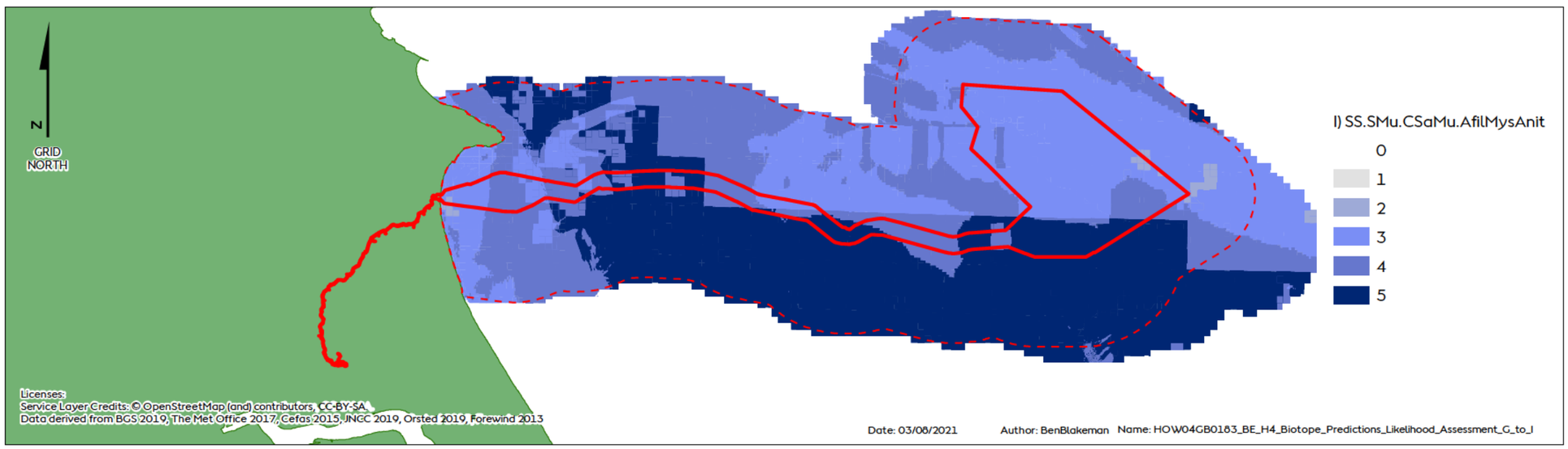






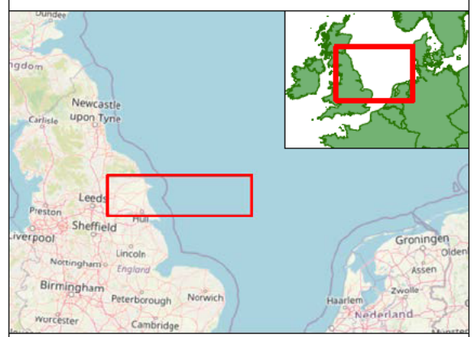
Hornsea Four

Figure 2.6

Hornsea Four biotope predictions: likelihood assessment (3 of 4)

Order Limits

Benthic Study Area



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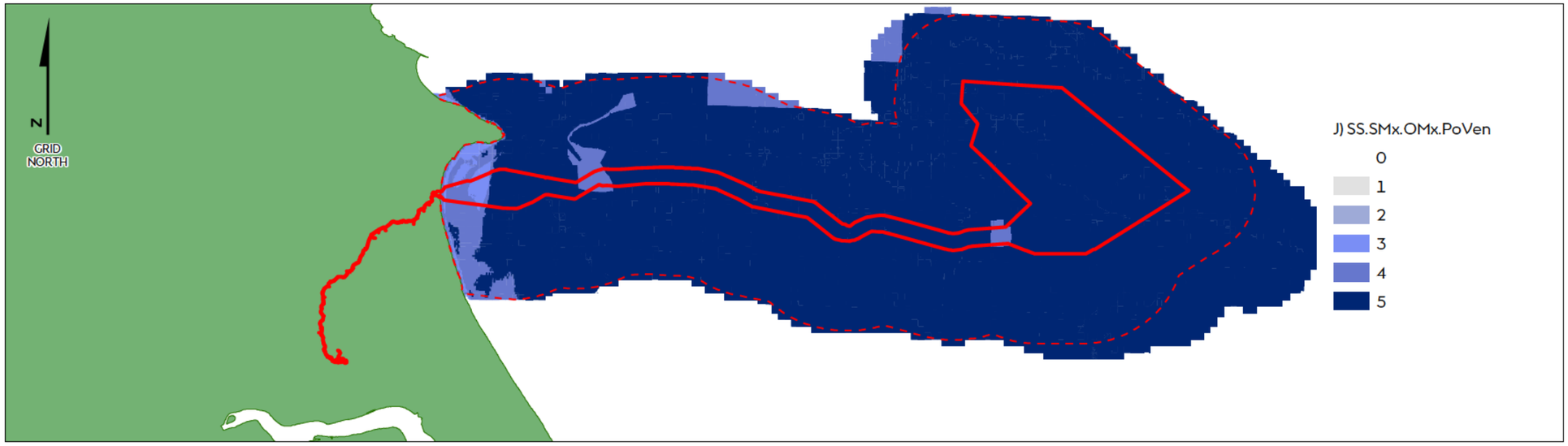
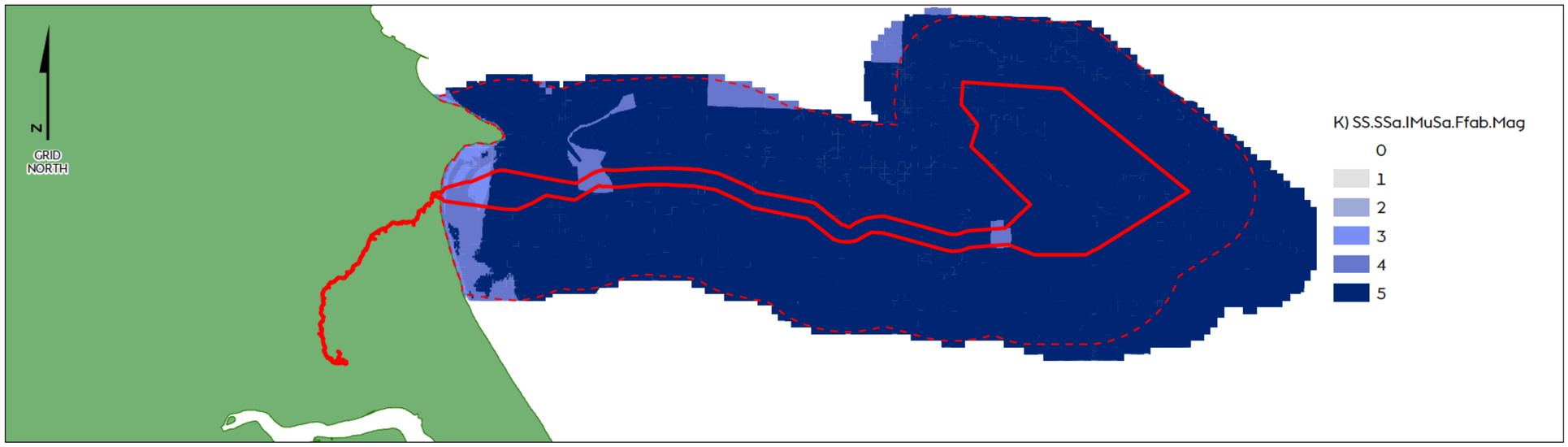




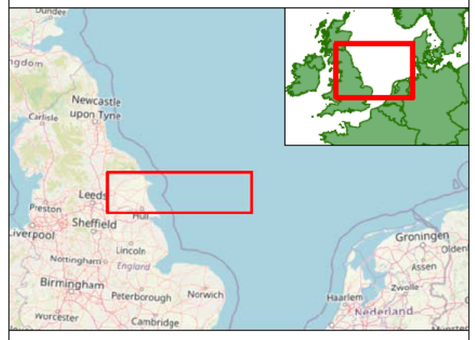
Hornsea Four

Figure 2.7

Hornsea Four biotope predictions: likelihood assessment (4 of 4)

Order Limits

Benthic Study Area



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Date: 03/08/2021 Author: BenBlakeman Name: HOW04GB0184_BE_H4_Biotope_Predictions_Likelihood_Assessment_J_to_K

Intertidal Environment

2.7.1.33 The biotope that characterised the intertidal area during the Phase I walkover survey along the Holderness Coast between Bridlington and Skipsea was EUNIS biotope A2.221, 'barren littoral coarse sand' (Figure 2.8), which is typical of clean sands in areas of high hydrodynamic energy, as seen along this portion of coastline (Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report).

Figure 2.8: Coarse Littoral Sand on upper shore T1 Site location number (left). Coarse littoral sand with cobbles and pebbles on top, T1 mid-shore (right) (Figure 3 within Appendix C of Volume 5, Annex 2.1 (Intertidal Foreshore Survey Report) identifies a map of the transect location). Photographs were collected on the 22nd of March 2019 during the Phase I habitat survey.

Features of Conservation Interest

2.7.1.34 As presented in Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report, individuals of the tube building worm *Sabellaria spinulosa* were identified within the benthic grab samples at five stations within the offshore ECC (ECC_17 to ECC_21), although these were not recorded in numbers that would constitute reef (Gubbay 2007). The only aggregation observed in the DDV footage was a small patch encrusting a pebble that would not itself be classified as a habitat of principal importance. Detailed review of the SSS and multibeam bathymetry datasets acquired within the Hornsea Four Order Limits (Gardline 2019; Bibby HydroMap 2019) found no evidence of the distinctive signatures which would typically be associated with the presence of biogenic reefs.

2.7.1.35 Stations closest to landfall (in water depth less than 20 m) were characterised by mobile clean sand substrates. These substrates are a sediment depository known as the sandbank feature Smithic Bank and are formed by a supply of sediment which arrives into Bridlington Bay having been brought around Flamborough Head by currents that flow north to south (Williams 2018). The sandbank feature does not form a qualifying feature of any SAC, SPA, Ramsar site or MCZ. The Flamborough Head SAC N2k Standard data form states its representativity is grade D i.e. no need to establish conservation objectives or conservation measures. This is reflected in the conservation objectives for the Flamborough Head SAC – which does not include subtidal sandbanks as a qualifying feature. In terms of benthic ecology, communities found on sandbank crests are predominantly those typical of mobile sediment environments and tend to have low diversity. Troughs or areas between banks generally contain more stable gravelly sediments and support diverse infaunal and epifaunal communities. Here sediment movement is reduced and therefore the areas support an abundance of attached

bryozoans, hydroids and sea anemones. The benthic and epifaunal communities typical of such features fall into the category of sublittoral sands and gravels that have been identified across the site.

2.7.1.36 As detailed within the **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report**, four discrete patches of stony reef habitat were recorded as present across a portion of the offshore ECC following the Annex I habitat assessment investigations (OEL 2020) that were commissioned following the identification of potential stony reef during the offshore ECC characterisation study (GoBe 2020). These discrete patches of stony habitat were scored as 'low' resemblance to Annex I stony reef, as per the qualifying criteria set out in regulatory guidance (Irving 2009). Additional to setting out the reef qualifying criteria thresholds, this guidance also suggests that "*when determining whether an area of the seabed should be considered as Annex I stony reef, if a 'low' is scored in any of the four characteristics (composition, elevation, extent or biota), then a strong justification would be required for this area to be considered as contributing to the Marine Natura site network of qualifying reefs in terms of the EU Habitats Directive*". This suggests that the patches identified during this survey would not be considered as contributing to the National Site Network unless there is strong justification. Based on these results and evidence from geophysical studies across the site (Bibby Hydro Map 2019), the area of 'Sandy gravel with boulders' encompassing stations ECC_22 and ECC_23 is expected to comprise a patchy mosaic of stony substrate surrounded by gravels and coarse sands, rather than extensive areas of unbroken stony reef. This habitat is typical of the wider region and has been recorded within several other development projects in the region including Dogger Bank A and B (Forewind 2013) and the Tolmount to Easington Pipeline (Premier Oil 2018).

2.7.1.37 Burrows were observed in the sediments throughout the Hornsea Four Order Limits however, no sea pens were observed in any of the seabed imagery acquired (Gardline 2019). Application of the SACFOR (super-abundant, abundant, common, frequent occasional, rare, present) abundance scale revealed scores that ranged from 'rare' to 'occasional' at stations ENV11 and ENV19 and 'rare' to 'frequent' at station ENV1 (which is located outside Hornsea Four Order Limits). At all other stations, SACFOR densities were not sufficient to be classified as showing similarities to a 'sea pen and burrowing megafauna communities' habitat as listed under the OSPAR (2010) list of threatened and/or declining species and habitats. Further details of this assessment are presented in **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report**.

2.7.1.38 Visible fauna in seabed imagery included an individual specimen of a sand eel (*Ammodytidae*). Members of the *Ammodytes* genus (specifically *Ammodytes marinus* and *Ammodytes tobianus*) are listed as a priority species under UK Post 2010 Biodiversity Framework (JNCC and Defra 2012) and listed under the NERC Act (2006).

2.7.1.39 Within the full macrofaunal data set, the presence of three juvenile ocean quahog (*Arctica islandica)*, a species of conservation importance, were recorded. A single individual was identified at stations ENV6, ENV15 and ENV25, respectively. The identification of *A. islandica* within the fauna data set corroborates the presence of *A. islandica* individuals tentatively identified from the sieved grab samples. *A. islandica* is a long-lived species with a slow growth rate and is listed on the OSPAR list of threatened and/or declining species and habitats (OSPAR 2008), as well as being listed under the MCZ guidance as a species feature of conservation importance (FOCI) (Natural England and JNCC 2010). Additionally,

a single lesser sandeel (*Ammodytes tobianus*) was identified at station ENV2 with a biomass of 1.8 g. *A. tobianus* is a species which is listed under Section 41 of the NERC Act (2006) that were deemed to require action in the UK Biodiversity Action Plan (BAP) and continue to be regarded as a conservation priority in the subsequent UK Post-2010 Biodiversity Framework (JNCC and Defra 2012). Further consideration of sandeel is presented within **Volume A2, Chapter 3: Fish and Shellfish Ecology**.

2.7.1.40 Other than those discussed above, there was no evidence of any other habitats of principal importance, species or other habitats listed as 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) 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 2018).

2.7.2 Designated Sites

2.7.2.1 Hornsea Four does not overlap spatially with any designated sites within the National Site Network (i.e. SACs and SPAs) with benthic ecology features or nationally designated sites (i.e. MCZs and SSSIs), as detailed within the Hornsea Four commitments (**Table 2.11**). The sites that lie in the area of potential secondary impact of Hornsea Four are identified in **Table 2.8**. This table also summarises the qualifying features that relate to seabed habitats and benthic ecology and the distance from the closest part of Hornsea Four. The location of designated sites is presented within **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report.**

2.7.2.2 As no designated sites with benthic ecology features directly overlap with Hornsea Four Order Limits, there will be no direct impact assessment on any designated sites. An assessment of indirect impacts (e.g. changes in suspended sediment concentrations (SSC) and/or sediment deposition) as determined by the assessment presented in **Volume A2, Chapter 1: Marine Geology, Oceanography and Physical Processes** has been undertaken on relevant benthic ecology features within sites that have the potential to be indirectly affected by Hornsea Four. Those benthic ecology and seabed habitat features of designated sites with a 10 km buffer surrounding the array area, and a 14 km buffer around the offshore ECC study areas have been screened into the assessment.

2.7.2.3 It should be noted that through the Evidence Plan process, it was agreed that 'Vegetated sea cliffs of the Atlantic and Baltic Coasts' of the Flamborough Head SAC and 'Sea Cliffs' that form the feature of the Flamborough Head SSSI could be screened out of the assessment as these are regarded as terrestrial features of interest (OFF-ME&P-5.2).

2.7.2.4 An assessment of the potential impacts on MCZs is provided in **Volume A5, Annex 2.3: Marine Conservation Zones Assessment**. Several of the benthic ecological qualifying broadscale habitat features of the MCZs were found within Hornsea Four (although there is no spatial overlap with the MCZ sites) and have therefore been assessed for both direct and indirect impacts, as per the normal assessment. Where broadscale habitat features were not found within Hornsea Four, these features have only been assessed under the indirect impact assessment.

Table 2.8: National and international conservation designations within the area of potential indirect impact of Hornsea Four.

Site and Status	Qualifying features	Distance from Hornsea Four
Flamborough Head SAC	Annex I habitats: • Chalk Reefs; • Vegetated sea cliffs of the Atlantic and Baltic Coasts; and • Submerged or partially submerged sea caves.	1.2 km distance from the nearshore section of the Hornsea Four ECC.
Holderness Inshore MCZ	• Intertidal sand and muddy sand; • Moderate energy circalittoral rock; • High energy circalittoral rock; • Subtidal coarse sediment; • Subtidal mixed sediments; • Subtidal sand; • Subtidal mud; and • Spurn head (subtidal geological feature).	4.5 km distance from the nearshore section of the Hornsea Four ECC.
Holderness Offshore MCZ	• North Sea Glacial Tunnel valleys; • Subtidal coarse sediment; • Subtidal sand Subtidal mixed sediments; and • Ocean Quahog (*Arctica islandica*).	0.75 km distance from the nearshore section of the Hornsea Four ECC.
Flamborough Head SSSI	• Supralittoral rock.	~4 km distance from the nearshore section of the offshore ECC.

2.7.3 Valued Ecological Receptors (VERs)

2.7.3.1 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/rMCZs (recommended Marine Conservation Zones)). 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.

2.7.3.2 Table 2.9 presents the VERs, their conservation status and importance within the Hornsea Four benthic subtidal and intertidal ecology study area and the justification and regional importance of each receptor.

2.7.3.3 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 August 2026, 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 ecology usually occurs over an extended period of time (considered in Section 2.7.4 below). 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 2.9: VERs within the Hornsea Four benthic subtidal and intertidal ecology study area.

VER	Representative biotope	Protection status	Conservation interest	Distribution within Hornsea Four benthic subtidal and intertidal ecology study area	Importance within Hornsea Four benthic subtidal and intertidal ecology study area and justification
Coarse and mixed sediments with moderate to high infaunal diversity and scour tolerant epibenthic communities	MysThyMx, FluHyd, MedLumVen, MoeVen, PoVen	None	UK BAP priority habitat	This habitat is found within the array area and within the area of coarse sediments within the nearer shore portion of the ECC. Modelling predicted the presence across much of the study area, but predominantly to the south and inshore portion of the offshore ECC.	Regional – although this habitat is representative of a nationally important marine habitat, the Southern North Sea is not a key geographic area.
Sandy sediments with low infaunal diversity and sparse epibenthic communities	ApriBatPo; EpusOborApri; NcirBat, FfabMag	None	UK BAP priority habitat	This habitat is likely to be located across much of the Hornsea Four Order Limits, FfabMag found within the offshore portion of the offshore ECC, ApriBatPo found throughout the whole Hornsea Four Order Limits, EpusOborApri within the array area and NcirBat in the southern offshore area. Modelling predicted the presence of these habitat across much of the Hornsea Four benthic subtidal ecology study area.	Regional – UK BAP with regional distribution from outer Humber to Thames region.
Fine muddy sands with moderate species diversity, characterised by bivalves in areas of moderate to high wave exposure	AalbNuc	None	UK BAP priority habitat	This habitat was found widely spread across the array area. Modelling predicted this habitat across much of the Hornsea Four benthic subtidal ecology study area.	Regional - although this habitat is representative of a nationally important marine habitat, the Southern North Sea is not a key geographic area.
Brittlestar dominated communities in deep muddy sands	AfilMysAnit	None	UK BAP priority habitat	Brittlestars (*A. filiformis*) were found in high abundances at four stations within the array area. This habitat was located in the Hornsea Project One array area. Modelling predicted this habitat across the southern	Regional – although this habitat is representative of a nationally important marine habitat, the Southern North Sea is not a key geographic area.

VER	Representative biotope	Protection status	Conservation interest	Distribution within Hornsea Four benthic subtidal and intertidal ecology study area	Importance within Hornsea Four benthic subtidal and intertidal ecology study area and justification
				portion of the Hornsea Four benthic subtidal study area, largely outside the Hornsea Four Order Limits.	
Sea pen and burrowing megafauna communities	SS.SMu.CFiMu.SpnMeg	None	OSPAR List of Threatened and/or Declining Species and Habitats (Region II – North Sea, Region III – Celtic Sea).	SACFOR 'rare' habitat located across the array area. 'Frequent' habitat located outside the array area at the most southerly sample station.	National - however, it should be noted that this habitat is widespread across the central North Sea, around the south and west coasts of Norway and around the north of the British Isles (OSPAR 2010).
Coarse littoral barren sand	LS.LSa.MoSa.BarSa	None	n/a	Across the whole intertidal ecology study area.	Local – Habitat is not protected under any conservation legislation and are found widespread around much of the UK.
Ocean quahog *Arctica islandica*	N/A	None	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.	Three individuals were found within the array area.	National – UK BAP with nationally important populations close to the Hornsea Four benthic subtidal ecology study area. Ocean quahogs are found all around and offshore from, British and Irish coasts, particularly the Southern North Sea and the English Channel
Ross worm *Sabellaria spinulosa*	N/A	None	When in reef form: OSPAR List of threatened and/or declining species for the Greater North	*Sabellaria spinulosa* individuals were recorded across the ECC at six stations but in relatively high abundances at stations ECC 18 and ECC 20. However, all evidence	None (as there is no evidence of reef habitat).

VER	Representative biotope	Protection status	Conservation interest	Distribution within Hornsea Four benthic subtidal and intertidal ecology study area	Importance within Hornsea Four benthic subtidal and intertidal ecology study area and justification
			Sea (OSPAR Region II). FOCI under the Nature Conservation part (Part 5) of the MCAA 2009. UK BAP priority habitat	suggests that these stations do not represent reef habitat.	
Annex I habitat features of Flamborough Head SAC					
Subtidal chalk reefs	N/A	Annex I Habitats Directive	Annex I 'Reefs' within an SAC. UK BAP priority habitat.	The SAC does not overlap with Hornsea Four Order Limits. However, indirect impacts using a 10 km tidal excursion have been screened into the assessment on a precautionary basis. The 10 km tidal excursion from the offshore ECC overlaps with the SAC.	International – part of European designated sites (Flamborough Head SAC).
Submerged or partially submerged sea caves	N/A	Annex I Habitats Directive	Annex I within an SAC. UK BAP priority habitat.	The SAC does not overlap with Hornsea Four Order Limits. However, indirect impacts using a 10 km tidal excursion have been screened into the assessment on a precautionary basis. The 10 km tidal excursion from the offshore ECC overlaps with the SAC.	International – part of European designated sites (Flamborough Head SAC).

2.7.4 Predicted Future Baseline

2.7.4.1 The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 require that "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 Hornsea Four (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 Hornsea Four is not constructed, using available information and scientific knowledge of benthic ecology.

2.7.4.2 An assessment of the future baseline conditions has been carried out (in the event of no development) and is described within this section. The baseline environment is not static and will exhibit some degree of natural change over time, with or without Hornsea Four in place, due to naturally occurring cycles and processes. Therefore, when undertaking impact assessments, it will be necessary to place any potential impacts in the context of the envelope of change that might occur naturally over the timescale of the project.

2.7.4.3 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 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 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).

2.7.4.4 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).

2.7.4.5 As such, the baseline in the Hornsea Four study area described in **Section 2.7** 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 Hornsea Four 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 Hornsea Four.

2.7.5 Data Limitations

2.7.5.1 Grab sampling and DDV 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.

2.7.5.2 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 biotope, even when using site specific geophysical survey data to characterise the seabed; and
- There is generally a transition from one biotope to another, rather than fixed limits and therefore, the boundaries of where one biotope ends, and another starts often cannot be precisely defined.

2.7.5.3 Consequently, the biotope maps presented in 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.

2.8 Project Basis for Assessment

2.8.1 Impact Register and Impacts not Considered in Detail in this ES

2.8.1.1 Upon consideration of the baseline environment, the project description outlined in **Volume A1, Chapter 4: Project Description**, the Hornsea Four Commitments detailed within **Volume A4, Annex 5.2: Commitments Register** and in response to formal consultation on the PEIR, a single impact is "not considered in detail" in the ES. This impact is outlined, together with appropriate justification for this approach, in **Table 2.10** alongside those impacts that there were agreed to be scoped out during the Scoping process. Further detail is provided in **Volume A4, Annex 5.1: Impacts Register**.

2.8.1.2 In July 2019, Highways England issued an update to the Design Manual for Roads and Bridges (DMRB) significance matrix (see **Volume A1, Chapter 5: Environmental Impact Assessment Methodology**). Impacts resulting in effects on benthic subtidal and intertidal ecology that were formerly assessed within the category medium sensitivity and minor magnitude, as Minor (Not Significant), under the new guidance are now within the significance range of Slight or Moderate and, therefore, require professional judgement. Following a review of the relevant potential impacts, it was considered that the changes do not alter the overall significance of the effects assessed at Scoping and in the PEIR (see **Volume A4, Annex 5.1: Impacts Register**).

Table 2.10: Impacts scoped out of the assessment and justification.

Project activity and impact	Likely significance of effect	Approach to assessment	Justification
Construction phase: Temporary habitat disturbance in the intertidal area from export cable installation (BIE-C-2).	No likely significant effect	Not considered in detail in the ES	Simple assessment at PEIR. Project description refined, with commitment made for Horizontal Directional Drilling (HDD) or other trenchless method underneath the intertidal area (Co187); no temporary habitat disturbance will occur within the intertidal as the two HDD works exit pits will be located within the subtidal area (below MHWS) and will be discrete in nature. Not considered in the ES.
Construction phase: Impacts on benthic ecology from noise arising from foundation installation (BIE-C-5).	No likely significant effect	Scoped Out	Scoped out based on PINS Scoping Opinion (PINS Scoping Opinion, November 2018, ID: 4.3.14). It is generally accepted that the particle motion component of noise is most relevant to benthic species. While there are few studies looking at reactions of benthic invertebrates and in particular polychaetes and infaunal bivalves it is likely that particle motion will dissipate in close proximity to the noise source. In addition, the noise will be temporary in nature and conditions will return to baseline following cessation of piling. The Marine Evidence based Sensitivity Assessment (MarESA) suggest that the potential effects associated with the construction of a wind farm is 'not relevant' for the biotopes present. Therefore, this impact has been scoped out of the assessment.
Construction phase: Accidental release of pollutants (e.g. from accidental spillage/leakage) may affect benthic ecology (BIE-C-7).	No likely significant effect	Scoped Out	Scoped out based on PINS Scoping Opinion (PINS Scoping Opinion, November 2018, ID: 4.3.16). The magnitude of an accidental spill incident will be limited by the size of chemical or oil inventory on construction vessels. In addition, released hydrocarbons would be subject to rapid dilution, weathering and dispersion and would be unlikely to persist in the marine environment. The likelihood of an incident will be reduced by implementation of a project CPEMMP, undertaken in accordance with Co111 (Table 2.11). Furthermore, the biotopes present within the array area and ECC are considered to be tolerant of chemical pressures, as presented within the MarESA assessment. This impact has therefore been scoped out of the assessment.
Construction phase: Nitrogen Oxides (NOx) and Nutrient Nitrogen (NN) deposition may affect intertidal habitats	No likely significant effect	Not considered in detail in the ES	Scoped out. Air quality modelling (Volume A3, Chapter 9: Air Quality) predicts that the project acting alone does not contribute to more than a 1% change to the critical load of NOx and NN. Notwithstanding the project's minimal contributions, the 1% threshold was

Project activity and impact	Likely significance of effect	Approach to assessment	Justification
and ecology (BIE-C-19).			marginally exceeded when considered in-combination. As detailed within Volume B2.2: Report to Inform Appropriate Assessment, it was concluded, with reference to the small area of supporting intertidal habitat affected, the small, temporary contributions to the critical load the project-would not result in Adverse Effects on Site Integrity (AEoI) of the Humber Estuary SAC, SPA and Ramsar. The same conclusion can be drawn in relation to the Humber Estuary SSSI. This impact was not identified during Scoping but was highlighted through the HRA process. After full assessment and conclusion of no AEoI, there was no evidence to trigger the need for inclusion of this impact within the ES. Furthermore, it should be noted that the intertidal area within the Hornsea Four Order Limits is characterised by the biotope A2.221, 'barren littoral coarse sand'. As this biotope is characterised by the lack of species, exposure to contaminants will not result in significant impacts to ecology, as there are no sensitive receptors. This impact has therefore not been considered further in this assessment.
Operation phase: Indirect disturbance to benthic species from Electromagnetic Fields (EMF) generated by inter-array and export cables (BIE-O-12).	No likely significant effect	Scoped Out	Scoped out based on PINS Scoping Opinion (PINS Scoping Opinion, November 2018, ID: 4.3.15). EMFs are likely to increase above background levels in close proximity to the cables only. As the cable will be buried (Co83) or protected across the majority of the array area and ECC, any behavioural responses would be further mitigated. Furthermore, monitoring to date has not recorded any changes in invertebrate behaviour resulting from EMF exposure. However, it is acknowledged that there are limited studies in this field. It is considered that benthic communities are not sensitive to EMF around subsea cables. This impact has therefore been scoped out.
Operation phase: Accidental release of pollutants (e.g. from accidental spillage/leakage) may affect benthic ecology (BIE-O-14).	No likely significant effect	Scoped Out	Scoped out based on PINS Scoping Opinion (PINS Scoping Opinion, November 2018, ID: 4.3.17). Justification as above for construction impact.
Decommissioning phase: Accidental release of pollutants (e.g. from accidental	No likely significant effect	Scoped Out	Scoped out based on PINS Scoping Opinion (PINS Scoping Opinion, November 2018, ID: 4.3.18). Justification as above for construction impact.

Project activity and impact	Likely significance of effect	Approach to assessment	Justification
spillage/leakage) may affect benthic ecology (BIE-D-18).			

Notes:
Grey - Scoped out - Agreement reached between Hornsea Four and the Planning Inspectorate at Scoping
Purple - Impact not Considered in detail in the ES. No likely significant effect at PEIR.

2.8.1.3 Please note that the term "scoped out" in **Table 2.10** relates to the Likely Significant Effect (LSE) in EIA terms and not "scoped out" of the EIA process *per se*. All impacts "scoped out" of LSE are assessed for magnitude, sensitivity of the receiving receptor and conclude an EIA significance in the Impacts Register (see **Volume A4, Annex 5.1: Impacts Register**). This approach is aligned with the Hornsea Four Proportionate approach to EIA (see **Volume A1, Chapter 5: Environmental Impact Assessment Methodology**).

2.8.2 Commitments

2.8.2.1 Hornsea Four has adopted commitments (primary design principles inherent as part of Hornsea Four, installation techniques and engineering designs/modifications) as part of their pre-application phase, to eliminate and/or reduce the LSE arising from a number of impacts (as far as possible). These are outlined in **Volume A4, Annex 5.2: Commitments Register**. Further commitments (adoption of best practice guidance), referred to as tertiary commitments are embedded as an inherent aspect of the EIA process. Secondary commitments are incorporated to reduce LSE to environmentally acceptable levels following initial assessment i.e. so that residual effects are reduced to environmentally acceptable levels.

2.8.2.2 The commitments adopted by Hornsea Four in relation to benthic subtidal and intertidal ecology are presented in **Table 2.11**. The full list of Commitments can be found in **Volume A4, Annex 5.2: Commitments Register**.

Table 2.11: Relevant benthic subtidal and intertidal ecology commitments.

Commitment ID	Measure Proposed	How the measure will be secured
Co2	Primary: A range of sensitive historical, cultural and ecological conservation areas (including statutory and non-statutory designations) have been directly avoided by the permanent Hornsea Four footprint, at the point of Development Consent Order Submission (DCO). These include, but are not restricted to: Listed Buildings (564 sites); Scheduled Monuments (30 sites); Registered Parks and Gardens (Thwaite Hall and Risby Hall); Onshore Conservation Areas (18 sites); Onshore National Site Network (one site); Offshore National Site Network (three sites); Offshore Marine Conservation Zones (two sites); Sites of Special Scientific Interest (two sites); Local Nature Reserves (none have been identified); Local Wildlife sites (33 sites); Yorkshire Wildlife Trust Reserves (none have been identified); Royal Society for the	DCO Works Plan - Onshore (**Volume D1, Annex 4.2: Works Plan – Onshore**); and DCO Works Plan - Offshore (**Volume D1, Annex 4.1: Works Plan – Offshore**)

Commitment ID	Measure Proposed	How the measure will be secured
	Protection of Birds (RSPB) Reserves (none have been identified); Heritage Coast; National Trust land; Ancient Woodland (10 sites and known Tree Preservation Orders (TPOs)); non-designated built heritage assets (334 sites); and historic landfill (none have been identified). Where possible, unprotected areas of woodland, mature and protected trees (i.e. veteran trees) have and will also be avoided.	
Co44	Primary: The Holderness Inshore Marine Conservation Zone (MCZ) will not be crossed by the offshore export cable corridor including the associated temporary works area.	DCO Works Plan - Offshore (**Volume D1, Annex 4.1: Works Plan – Offshore**)
Co45	Primary: The Holderness Offshore MCZ not be crossed by the offshore export cable corridor including the associated temporary works area.	DCO Works Plan - Offshore (**Volume D1, Annex 4.1: Works Plan – Offshore**)
Co48	Primary: Habitats of principal importance (Section 41 of the 2006 Natural Environment and Rural Communities (NERC) Act) will be avoided where possible, informed through the undertaking of survey works pre-construction.	DCO Schedule 11, Part 2 - Condition 13(1)(a)(v) and; DCO Schedule 12, Part 2 - Condition 13(1)(a)(v) (*Pre-construction plans and documentation*)
Co82	Tertiary: A Scour Protection Management Plan will be developed. It will include details of the need, type, quantity and installation methods for scour protection.	DCO Schedule 11, Part 2 - Condition 13(1)(e) and; DCO Schedule 12, Part 2 - Condition 13(1)(e) (*Scour Protection Management Plan*)
Co83	Primary: Where possible, cable burial will be the preferred option for cable protection.	DCO Schedule 11, Part 2 - Condition 13(1)(h) and; DCO Schedule 12, Part 2 - Condition 13(1)(h) (*Cable specification and installation plan*)
Co84	Primary: Presence of habitats of principal importance (Section 41 of the 2006 Natural Environmental and Rural Communities (NERC) Act) will be identified through a review of the latest available benthic datasets and pre-construction surveys. Foundations and cables will be micro-sited around habitats of principal importance wherever reasonably practicable (subject to agreement with the MMO) to an extent not resulting in a hazard for marine traffic and Search & Rescue capability.	DCO Schedule 11, Part 2 - Condition 13(1)(a)(v) and; DCO Schedule 12, Part 2 - Condition 13(1)(a)(v) (*Pre-construction plans and documentation*)
Co86	Primary: The offshore export cable corridor and cable landfall (below MHWS) will not cross the Greater Wash SPA, Flamborough & Filey Coast SPA and the Flamborough Head SAC.	DCO Schedule 1, Part 1 – Authorised Development; and DCO Works Plan - Offshore (**Volume D1, Annex 4.1: Works Plan – Offshore**).

Commitment ID	Measure Proposed	How the measure will be secured
Co111	Tertiary: A Construction Project Environmental Management and Monitoring Plan (CPEMMP) will be developed and will include details of: • a marine pollution contingency plan to address the risks, methods and procedures to deal with any spills and collision incidents of the authorised project in relation to all activities carried out below MHWS; • a chemical risk review to include information regarding how and when chemicals are to be used, stored and transported in accordance with recognised best practice guidance; • a marine biosecurity plan detailing how the risk of introduction and spread of invasive non-native species will be minimised; • waste management and disposal arrangements; • a vessel management plan, to determine vessel routing to and from construction sites and ports, to include a code of conduct for vessel operators; and • the appointment and responsibilities of a company fisheries liaison officer.	DCO Schedule 11, Part 2 - Condition 13(1)(d) and; DCO Schedule 12, Part 2 - Condition 13(1)(d) (*Construction Project Environmental Management and Monitoring Plan*)
Co176	Tertiary: A Cable Specification and Installation Plan will be produced prior to construction of the offshore export cable which will include; details of cable burial depths; a detailed cable laying plan which ensures safe navigation is not compromised; details of cable protection for each cable crossing; and proposals for monitoring of offshore cable.	DCO Schedule 11, Part 2 - Condition 13(1)(h) and; DCO Schedule 12, Part 2 - Condition 13(1)(h) (*Cable specification and installation plan)*
Co181	Tertiary: An Offshore Decommissioning Plan will be developed prior to decommissioning.	DCO Schedule 11, Part 1(6) and; DCO Schedule 12, Part 1 (6) (*General Provisions*)
Co187	Secondary: The installation of the offshore export cables at landfall will be undertaken by Horizontal Directional Drilling or other trenchless methods.	DCO Requirement 17 (Code of construction practice) and; DCO Schedule 12, Part 2 - Condition 13(1)(h) (*Cable specification and installation plan*)
Co188	Secondary: No cable protection will be employed within 350 m seaward of MLWS.	DCO Schedule 11, Part 2 - Condition 13(1)(h) and; DCO Schedule 12, Part 2 - Condition 13(1)(h) (*Cable specification and installation plan*)
Co189	Secondary: The Dogger Bank cable crossing will be positioned east of Smithic Bank (as identified at https://data.gov.uk/dataset/d19f631c-27c0-4c74-804f-d76a4632b702/annex-i-sandbanks-in-the-uk-v2-public) and seaward of 20 m depth contour.	DCO Schedule 11, Part 2 - Condition 13(1)(h) and; DCO Schedule 12, Part 2 - Condition 13(1)(h) (*Cable specification and installation plan*)

Commitment ID	Measure Proposed	How the measure will be secured
Co201	Primary: Gravity Base Structure (GBS) foundations (WTG type) will be utilised at a maximum of 110 of the 180 WTG foundation locations. The location of GBS foundations, if used for WTG, will be confirmed through a construction method statement which will include details of foundation installation methodology.	DCO Schedule 11, Part 2 - Condition 13(1)(c) (*Construction Method Statement*)

2.9 Maximum Design Scenario (MDS)

2.9.1.1 This section describes the MDS parameters on which the benthic subtidal and intertidal ecology assessment has been based. These are the parameters which are judged to give rise to the maximum levels of effect for the assessment undertaken, as set out in **Volume A1, Chapter 4: Project Description**. Should Hornsea Four be constructed to different parameters within the design envelope, then impacts would not be any greater than those set out in this ES using the MDS presented in **Table 2.12**.

Table 2.12: MDS for impacts on benthic subtidal and intertidal ecology.

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario	Justification
Construction			
Temporary habitat disturbance in the Hornsea Four array area and offshore ECC from construction activities (BIE-C-1).	Primary: Co2 Co44 Co45 Co48 Co84 Co86 Co201 Secondary: Co188 Co189	**Temporary habitat disturbance of 75,895,509 m²** **Array Area:** **Foundation seabed preparation = 779,106 m²** • 110 GBS (Wind Turbine Generator (WTG) type) foundations for WTGs = 411,321 m²; • 70 suction bucket jacket (WTG type) foundations for WTGs = 198,870 m². • Six small Offshore Substations (OSS) on suction bucket jacket (small OSS) foundations and three large OSS on GBS (large OSS) foundations = 156,594 m²; and • One accommodation platform on a suction bucket jacket (small OSS) foundation = 12,321 m². **Jack up and anchoring operations = 1,063,200 m²** • WTG installation jack up vessel (JUV) footprint (six legs, 170 m² per foot, four jack-up operations per turbine) = 734,400 m²; • WTG installation vessel anchor footprints (100 m² per anchor, eight anchors per vessel, two anchored vessels per turbine) = 288,000 m²; and • OSS and accommodation platform installation JUV footprint (six legs, 170 m² per foot, four jack-up operations per structure) = 40,800 m². **Cable seabed preparation and installation in the array area = 37,950,000 m²** • Boulder and sandwave clearance in array area (690 km length, 40 m width) = 27,600,000 m²; • Burial of array cables (600 km length, 15 m width) = 9,000,000 m²; and • Burial of inter-connector cables (90 km length, 15 m width) = 1,350,000 m². Note the 15 m cable width is located within the boulder and sandwave clearance 40 m width. **Offshore ECC:** • Foundation seabed preparation for three suction bucket jacket (small OSS) foundations = 36,963 m²; and • OSS installation JUV footprint (six legs, 170 m² per foot, four jack-up operations per structure) = 12,240 m². **Export cable seabed preparation and installation = 36,054,000 m²** • -Boulder and sandwave clearance in offshore ECC (654 km length, 40 m width) = 26,160,000 m²; • -Burial of export cables (654 km length, 15 m width) = 9,810,000 m²; and • Cable jointing (four joints per cable, six cables, 3,500 m² per joint) = 84,000 m². Note the 15 m cable width is located within the boulder and sandwave clearance 40 m width.	The temporary disturbance relates to seabed preparation for foundations and cables, jack up and anchoring operations, and cable installation. It should be noted that the seabed preparation area for foundations is less than the footprint of the foundation scour protection and the footprint of infrastructure is assessed as a permanent impact in O&M (BIE-O-8). 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

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario	Justification
			between the activities due to project timescales. It is important to note that three HVDC converter substations in the array area are mutually exclusive with three HVAC booster stations along the ECC in a single transmission system. As secured by **C1.1 Draft DCO including Draft DML**, a maximum of ten OSS and platforms will be constructed within the Hornsea Four Order Limits, however in order to assess the MDS for both the array and the ECC, the presence of the maximum numbers of OSS and platforms in each area has been considered (ten and three, respectively). As a result, the outcome of the assessment is therefore inherently precautionary.
Temporary increase in SSC and sediment deposition in the Hornsea Four array area and offshore ECC (BIE-C-3).	Primary: Co2 Co44 Co45 Co84 Co86 Co201	**Total volume 12,192,331 m^3.** **WTG Foundations:** • 110 turbines on GBS (WTG type) foundations requiring seabed preparation, resulting in the suspension of 685,794 m^3 of sediment; and • 70 Suction Bucket Jacket (WTG type) foundations requiring seabed preparation, resulting in the suspension of 359,427 m^3 of sediment.	The MDS for foundation installation results from the largest volume suspended from seabed preparation (GBS and suction bucket jacket foundations). For cable installation, the MDS results from the greatest

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario	Justification
	Secondary: Co188 Co189	**OSS Foundations (array):** • Six OSS on suction bucket jacket (small OSS) foundations and three OSS on GBS (large OSS) foundations requiring seabed preparation, resulting in the suspension of 737,130 m^3 of sediment. **Offshore Accommodation Platform Foundations:** • One suction bucket jacket (small OSS) foundation requiring seabed preparation, resulting in the suspension of 57,245 m^3 of sediment. **High Voltage Alternating Current (HVAC) Booster Station Foundations:** • Three six-legged suction bucket jacket (small OSS) foundations requiring seabed preparation, resulting in the suspension of 171,735 m^3 of sediment. **Sandwave Clearance:** • Sandwave clearance for 600 km of array cables resulting in the suspension of 769,000 m^3 of sediment; • Sandwave clearance for 90 km of interconnector cables resulting in the suspension of 115,000 m^3 of sediment; and • Sandwave clearance for 654 km of export cables resulting in the suspension of 834,000 m^3 of sediment. **Cable Trenching:** • Installation of 600 km of array cables by Controlled Flow Excavation (CFE) resulting in the suspension of 3,600,000 m^3 of sediment; • Installation of 90 km of interconnector cables resulting in the suspension of 540,000 m^3 of sediment; • Installation of six export cables by CFE resulting in the suspension of 3,903,000 m^3 of sediment (excluding the part of the export cable within the array); and • Up to 420,000 m^3 of sediment from up to four cable joints per export cable in the ECC, with a provision for 50 % of losses to be made up.	volume from sandwave clearance and installation using energetic means (CFE). This also assumes the largest number of cables and the greatest burial depth. It is important to note that three HVDC converter substations in the array area are mutually exclusive with three HVAC booster stations along the ECC in a single transmission system. As secured by **C1.1 Draft DCO including Draft DML**, a maximum of ten OSS and platforms will be constructed within the Hornsea Four Order Limits, however in order to assess the MDS for both the array and the ECC, the presence of the maximum numbers of OSS and platforms in each area has been considered (ten and three, respectively). As a result, the outcome of the assessment is therefore inherently precautionary.
Temporary increase in SSC and sediment deposition in the	Primary: Co2 Co44 Co45	Eight offshore cofferdam HDD exit pits require excavation of 20,000 m^3 (8 x 2,500 m^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 exit pits will come out below MLWS, so will not directly impact the intertidal.	The MDS for temporary habitat disturbance in the intertidal area from the HDD works is included. It is important to note

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario	Justification
intertidal area (BIE-C-4)	Co84 Co86	HDD Bentonite drilling fluid loss per cable 265 m^3.	that HDD exit pits will be located below MLWS. The maximum volume of bentonite which could be released as part of the landfall activities is considered. For this assessment, it is considered that the bentonite would not be captured and is released into the marine environment.
Direct and indirect seabed disturbances leading to the release of sediment contaminants (BIE-C-6).	None	The MDS for seabed disturbance are presented in BIE-C-3.	This scenario represents the maximum total seabed disturbance and therefore the maximum amount of contaminated sediment that may be released into the water column during construction activities.
Operation			
Permanent habitat loss/ change from the presence of foundations, scour protection and cable protection (BIE-O-8).	Primary: Co2 Co44 Co45 Co48 Co83 Co84 Co86 Co201 Secondary: Co188 Co189	**Habitat change of 3,730,671 m^2**. **Array Area**: • Turbine footprint with scour protection, based on 110 GBS (WTG-type) foundations = 504,540 m^2; • Turbine footprint with scour protection, based on 70 suction bucket jacket (WTG type) foundations = 296,881 m^2. • OSS foundations footprint and scour protection, based on six small (GBS (Box-type)) and three large OSS (GBS (Large OSS)) = 371,250 m^2; • Accommodation platform foundation footprint and scour protection, based on one small OSS foundation (GBS (Box-type)) = 30,625 m^2; • Maximum rock protection area for array cable = 624,000 m^2; • 25% replenishment of scour protection during operation and maintenance phase = 156,000 m^2. • Maximum rock protection area for interconnector cable = 94,000 m^2; • 25% replenishment of scour protection during operation and maintenance phase = 23,500 m^2; and	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. Habitat loss from drilling and drill arisings is of a smaller magnitude than presence of project infrastructure. It is important to note that three HVDC converter substations in the array area

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario	Justification
	Tertiary: Co82 Co176	• Pre- and post-lay rock berm area within array area (32 cable crossings) = 204,000 m^2. **Offshore ECC:** • HVAC booster station foundations footprint and scour protection, based on three small OSS foundations (GBS (Box-type)) = 91,875 m^2; • Maximum rock protection area for the export cable = 792,000 m^2; • 25% replenishment of scour protection during operation and maintenance phase = 198,000 m^2; and • Pre- and post-lay rock berm area, based on 54 cable crossings within the ECC area = 344,000 m^2.	are mutually exclusive with three HVAC booster stations along the ECC in a single transmission system. As secured by **C1.1 Draft DCO including Draft DML**, a maximum of ten OSS and platforms will be constructed within the Hornsea Four Order Limits, however in order to assess the MDS for both the array and the ECC, the presence of the maximum numbers of OSS and platforms in each area has been considered (ten and three, respectively). As a result, the outcome of the assessment is therefore inherently precautionary.
Colonisation of the WTGs and scour/ cable protection may affect benthic ecology and biodiversity (BIE-O-9).	None	**Total surface area of introduced hard substrate in the water column = 4,759,171 m^2** **Total area of introduced hard substrate at seabed level = 3,730,671 m^2 (see BIE-O-8).** **Total surface area of subsea portions of foundations in contact with the water column: 1,028,500 m^2.** • 110 WTGs on GBS (WTG-type) foundations, assuming 15 m diameter cylinder atop a conical/frustum base which tapers at 35 m above seabed level, with a base diameter of 53 m. Average water depth of 47.5 m, giving a per-foundation surface area of 5,650 m^2, with a total area of 621,500 m^2; • 70 WTGs on suction bucket jacket (WTG type) foundations, which has a base diameter of up to 40 m (extending 10 m above the seabed). Average water depth of 47.5 m, giving a per foundation surface area of 2,512 m^2, with a total area of 175,850 m^2. • Six small OSS on GBS (Box-type) foundations, each with a length and width of 75 m at seabed level and at Lowest Astronomical Tide (LAT). Average water depth of 47.5 m, giving a per-foundation surface area of 14,250 m^2, with a total area of 85,500 m^2;	The MDS is defined by the maximum area of structures, scour protection, cable protection and cable crossings introduced to the water column, including surface area of vertical structures. It is important to note that three HVDC converter substations in the array area are mutually exclusive with three HVAC booster stations along the ECC in a single

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario	Justification
		• Three large OSS on GBS (Box-type) foundations, each with a length and width of 150 m at seabed level and at LAT. Average water depth of 47.5 m, giving a per-foundation surface area of 28,500 m^2, with a total area of 85,500 m^2; • One accommodation platform on a GBS (Box-type) foundation (small OSS), with a length and width of 75 m at seabed level and at LAT. Average water depth of 47.5 m, giving a total surface area of 14,250 m^2; and • Three HVAC booster stations on GBS (Box-type) foundations (small OSS), each with a length and width of 75 m at seabed level and at LAT. Average water depth of 51 m in the HVAC Booster Station Search Area, giving a per-foundation surface area of 15,300 m^2, with a total area of 45,900 m^2.	transmission system. As secured by **C1.1 Draft DCO including Draft DML**, a maximum of ten OSS and platforms will be constructed within the Hornsea Four Order Limits, however in order to assess the MDS for both the array and the ECC, the presence of the maximum numbers of OSS and platforms in each area has been considered (ten and three, respectively). As a result, the outcome of the assessment is therefore inherently precautionary.
Increased risk of introduction or spread of Marine Invasive Non-Native Species (MINNS) due to presence of subsea infrastructure and vessel movements (e.g. ballast water) may affect benthic ecology and biodiversity (BIE-O-10).	Tertiary: Co111	**Total surface area of introduced hard substrate in the water column = 4,759,171 m^2 (see BIE-O-9).** **Total of 1,693 vessel return trips per year:** • 260 crew shift transfer visits; • 124 JUV visits; • 1,205 crew vessels wind turbine visits; and • 104 supply vessel accommodation platform visits.	Defined by the maximum surface area introduced into the water column as described in BIE-O-9. MDS with regards to maximum number of vessel movements during O&M activities.
Direct disturbance to seabed from	None	**Direct disturbance to seabed from jack-up vessels and cable maintenance activities = 8,579,812 m^2.**	Defined by the maximum number of jack-up vessel

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario	Justification
jack-up vessels and cable maintenance activities (BIE-O-11).		**WTG O&M activities**: • Component replacement = 378,000 m^2; • Access ladder replacement = 378,000 m^2; • Foundation anode replacement = 378,000 m^2; and • J-Tube repair/ replacement = 108,000 m^2. **Array cable activities:** • Remedial burial of array cables (42 km total length reburied) = 4,200,000 m^2; • Array cable repairs = 363,736 m^2; and • Cable protection replacement = 156,000 m^2. **Offshore substations and accommodation platform activities:** • Offshore substation component replacement = 6,000 m^2; • Access ladder replacement = 90,000 m^2; • Foundation anode replacement = 21,000 m^2; and • J-Tube repair/ replacement = 6,000 m^2. **ECC activities:** • Remedial burial of export cables (14 km total length reburied) = 1,400,000 m^2; • Export cable repairs = 153,548 m^2; and • Cable protection replacement = 198,000 m^2. **Interconnector cable activities:** • Remedial burial of interconnector cables (7 km total length reburied) = 700,000 m^2; • Interconnector cable repairs = 20,028 m^2; and • Cable protection replacement = 23,500 m^2.	operations and maintenance activities that could have an interaction with the seabed anticipated during operation.
Changes to seabed habitats arising from effects on physical processes, including scour effects and changes in the sediment transport and wave regimes resulting in potential effects on benthic	Primary: Co201 Secondary: Co189	See MDS presented in **Volume A2, Chapter 1: Marine Geology, Oceanography and Physical Processes.**	This impact is defined by any anticipated changes to physical processes as defined in **Volume A2, Chapter 1: Marine Geology, Oceanography and Physical Processes**.

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario	Justification
communities (BIE-O-13).			
Decommissioning			
Temporary habitat disturbance from decommissioning of foundations, cables and rock protection (BIE-D-15).	Tertiary: Co181	**Removal of all foundations, cables and rock protection leading to a temporary loss/change of 3,730,671 m²** (see BIE-O-8).	MDS is assumed to be similar to the construction phase, with all infrastructure removed in reverse-construction order. The removal of cables and rock protection is considered the MDS, however the necessity to remove cables and rock protection will be reviewed at the time of decommissioning.
Increased SSC and sediment deposition from removal of foundations, cables and rock protection (BIE- D-16).	None	This impact is a subset of MP-C-2 for structures that are removed from the seabed. The impacts are expected to be equivalent to MP-C-2 apart from the structures that may remain (e.g. cables to be removed but not cable protection measures). See MDS presented in **Volume A2, Chapter 1: Marine Geology, Oceanography and Physical Processes**.	MDS is assumed to be as per the construction phase, with all infrastructure removed in reverse-construction order. The removal of cables is considered the MDS, however the necessity to remove cables will be reviewed at the time of decommissioning.
Loss of introduced habitat from the removal of foundations and rock protection (BIE-D-17).	None	**Total area of introduced hard substrate to be lost = 4,759,171 m²** (see BIE-O-9).	Defined by the maximum surface area introduced as above. Some materials may be left *in situ* and this will be reviewed closer to the time of decommissioning. As such, the MDS assumes the removal of all infrastructure.

2.10 Assessment Methodology

2.10.1 Impact Assessment Criteria

2.10.1.1 The criteria for determining the significance of effects is a two-stage process that involves defining the sensitivity of the receptors and the magnitude of the impacts. This section describes the criteria applied in this chapter to assign values to the sensitivity of receptors and the magnitude of potential impacts. The terms used to define magnitude are based on those used in the DMRB methodology, which is described in further detail in **Volume A1, Chapter 5: Environmental Impact Assessment Methodology**.

2.10.1.2 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 scale (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[1].

2.10.1.3 For the purposes of this assessment, four sensitivity categories have been defined, each drawing on the four MarLIN MarESA categories (**Table 2.13**). Several of the sensitivities in the table have been re-classified since PEIR to improve the match with the MarESA criteria. The values for the MarESA criteria and the assessment sensitivity values are therefore the same (with the addition of the 'very high' value for receptors of international importance), in order to improve the clarity of the assessment.

Table 2.13: Definition of terms relating to the sensitivity of the receptor.

Value	Criteria
Very High	Equivalent to MarLIN MarESA sensitivity category 'High' and with a receptor value of 'international' importance. The habitat or species is noted as exhibiting 'None' or 'low' resistance (tolerance) to an external factor and is expected to recover only over very extended timescales i.e. >25 years or not all (resilience is 'Very Low'); OR > 10 or up to 25 years (resilience is 'Low').
High	Equivalent to MarLIN MarESA sensitivity category 'High' and with a receptor value of national importance. The habitat or species is noted as exhibiting 'None' or 'low' resistance (tolerance) to an external factor and is expected to recover only over very extended timescales i.e. >25 years or not all (resilience is 'Very Low'); OR > 10 or up to 25 years (resilience is 'Low').
Medium	Equivalent to MarLIN MarESA sensitivity category 'Medium' and with a receptor of local/county to international importance. The habitat or species is noted as exhibiting 'None' or 'Low' resistance (tolerance) to an external factor and is expected to recover over medium timescales i.e. > 2 or up to 10 years (resilience is 'Medium'); OR The habitat or species is noted as exhibiting 'None' resistance (tolerance) to an external factor and is expected to recover over <2 years (resilience is 'High'); OR

[redacted]

Value	Criteria
	The habitat or species is noted as exhibiting 'Medium' resistance (tolerance) to an external factor 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' and 'Not Sensitive' and with a receptor of <local/county to national importance. The habitat or species is noted as exhibiting 'Low' or 'Medium' resistance (tolerance) to an external factor 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 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'); OR The habitat or species is noted as exhibiting 'High' resistance (tolerance) to an external factor and is expected to recover over short timescales, i.e. < 2 years (resilience is 'High').

2.10.1.4 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 2.14**.

Table 2.14: Definition of terms relating to magnitude of an impact.

Magnitude	Criteria
Major	Fundamental, permanent / irreversible changes, over the whole receptor, and/or fundamental alteration to key characteristics or features of the particular receptors character or distinctiveness.
Moderate	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.
Minor	Discernible, temporary (throughout project duration) 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 project duration) change, or barely discernible change for any length of time, over a small area of the receptor, and/or slight alteration to key characteristics or features of the particular receptors character or distinctiveness.

2.10.1.5 The significance of the effect upon benthic and intertidal ecology is determined by correlating the magnitude of the impact and the sensitivity of the receptor. The method employed for this assessment is presented in **Table 2.15**. Where a range of significance of effect is presented, the final assessment for each effect is based upon expert judgement.

2.10.1.6 For this assessment, any effects with a significance level of slight or less have been concluded to be not significant in terms of the EIA Regulations.

Table 2.15: Matrix used for the assessment of the significance of the effect.

		Magnitude of impact (degree of change)			
		Negligible	*Minor*	*Moderate*	*Major*
Environmental value (sensitivity)	*Low*	Neutral or Slight (Not Significant)	Neutral or Slight (Not Significant)	Slight (Not Significant)	Slight (Not Significant) or Moderate (Significant)
	Medium	Neutral or Slight (Not Significant)	Slight (Not Significant) or Moderate (Significant)	Moderate or Large (Significant)	Moderate or Large (Significant)
	High	Slight (Not Significant)	Slight (Not Significant) or Moderate (Significant)	Moderate or Large (Significant)	Large or Very Large (Significant)
	Very High	Slight (Not Significant)	Moderate or Large (Significant)	Large or Very Large (Significant)	Very Large (Significant)

2.10.1.7 This chapter summarises the assessments made on the interest features of internationally designated sites protected under the Habitats and Birds Directives and Ramsar Convention, as described within Section 2.7.2 of this chapter (with the assessment on the sites themselves deferred to Volume B2.2 Report to Inform Appropriate Assessment). The RIAA Report has been prepared in accordance with PINS Advice Note Ten: Habitats Regulations Assessment Relevant to Nationally Significant Infrastructure Projects (PINS 2017) and is submitted as part of this DCO Application.

2.10.1.8 With respect to nationally and locally designated sites, where these sites fall within the boundaries of an internationally designated site (e.g. SSSIs which have not been assessed within the RIAA), only the international site has been taken forward for assessment. This is because potential effects on the integrity and conservation status of the nationally designated site are assumed to be inherent within the assessment of the internationally designated site (i.e. a separate assessment for the national site is not undertaken). However, where a nationally designated site falls outside the boundaries of an international site, but within the benthic subtidal ecology and intertidal study area, an assessment of the impacts on the overall site is made in this chapter using the EIA methodology.

2.11 Impact Assessment

2.11.1 Construction Phase

2.11.1.1 The impacts of the offshore construction of Hornsea Four have been assessed on benthic subtidal and intertidal ecology. The environmental impacts arising from the construction of Hornsea Four are listed in Table 2.12 along with the MDS against which each construction phase impact has been assessed. A description of the potential effect on benthic and intertidal ecology receptors caused by each identified impact is given below.

Temporary habitat disturbance in the Hornsea Four array area and offshore ECC from construction activities (BIE-C-1).

Magnitude of impact

2.11.1.2 The total maximum area of temporary loss/disturbance of subtidal habitat due to construction activities described in **Table 2.12** is predicted to be up to approximately 75.9 km^2. This equates to approximately 16% of the total seabed area within the Hornsea Four Order Limits. It should be noted that the MDS presents a precautionary approach to temporary habitat disturbance because it counts both the total footprint of seabed clearance as well as cable burial across both the array and offshore ECC. This approach effectively counts the footprint of seabed habitat to be impacted by construction in the same area twice. However, this precautionary approach has been taken because there is some potential for recovery of habitats between the activities due to project timescales.

2.11.1.3 Of the total area of temporary habitat loss described in **Table 2.12**, a maximum of approximately 38 km^2 is predicted to be temporarily lost/ disturbed within the Hornsea Four array area as a result of seabed preparations for foundations, jack-up barge operations and the installation and burial of inter-array and interconnector cables (including associated anchor placements). This equates to approximately 8% of the total seabed area within the Hornsea Four array area.

2.11.1.4 Of the total temporary habitat loss/disturbance described in **Table 2.12**, a maximum of approximately 36.1 km^2 will be temporarily disturbed within the subtidal areas of the Hornsea Four ECC as a result of seabed preparation, OSS installation, export cable installation, burial and jointing. This equates to approximately 8% of the total seabed area within the Hornsea Four offshore ECC.

2.11.1.5 Given that the benthic habitats that characterise the Hornsea Four Order Limits are common and widespread throughout the wider Southern North Sea region (as described in **Section 2.7** and in **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report**), the temporary habitat disturbance during construction activities would have an impact on a very limited footprint compared to their overall extent.

2.11.1.6 The impact on benthic habitats is predicted to be of local spatial extent (i.e. restricted to discrete areas within Hornsea Four), 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 **minor.**

2.11.1.7 The ocean quahog (*Arctica islandica*) is included as a VER (**Table 2.9**). The total area of permanent habitat loss is considered to represent a very small percentage loss (0.06%) of the total area of the OSPAR Region II (Greater North Sea) within which *A. islandica* is listed as under threat and/or decline. Furthermore, Hornsea Four is committed to avoiding direct impact to the Holderness Offshore MCZ, of which *A. islandica* is a conservation feature. The magnitude of the impact on *A. islandica* is therefore **negligible**. Irrespective of the sensitivity of the receptor, the significance of the impact on *A. islandica is* **not significant** as defined in the assessment of significance matrix (**Table 2.15**) and is therefore not considered further in this assessment.

Sensitivity of the receptor

2.11.1.8 The sensitivity of all biotopes that are known to characterise the Hornsea Four Order Limits and that have been modelled across the Order Limits (**Section 2.7.1**) have been assessed according to the detailed MarESA sensitivity assessments (**Table 2.13**). This assessment has determined that all biotopes have a low to medium sensitivity to a disturbance of this nature. None of the biotopes likely to be affected are rare or geographically restricted. As detailed within the baseline characterisation (**Section 2.7.1**), comparable habitats are distributed within the wider region and southern North Sea. Therefore, given the relatively small spatial scales for the total temporary habitat disturbance outlined above, this loss is not expected to undermine regional ecosystem functions or diminish biodiversity.

2.11.1.9 As demonstrated in **Table 2.15**, the sandy sediment communities were all determined as having a low sensitivity. 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 temporary habitat disturbance. The recoverability of such communities is likely to occur as a result of the 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).

2.11.1.10 Further evidence to support recovery is supported by research at aggregate extraction sites, where it was reported that the characteristic recovery time for typical sand 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).

2.11.1.11 The biotope '*Flustra foliacea and Hydrallmania falcata* on tideswept circalittoral mixed sediment' is described as having a 'medium' MarESA sensitivity to a disturbance of this nature (**Table 2.16**), given the sessile, erect nature of the hydroid and bryozoans. However, this biotope is considered to have a high recovery potential with hydroids exhibiting rapid rates of recovery from disturbance through repair, asexual reproduction and larval colonization (Sparks 1972). New colonies of the same genotype may, therefore, arise through damage to existing colonies (Gili & Hughes 1995). Although colonies may be removed or destroyed, the resting stages may survive attached to the substratum and provide a mechanism for rapid recovery (Cornelius 1995; Kosevich & Marfenin 1986).

2.11.1.12 The biotope '*Amphiura filiformis*, *Kurtiella bidentata* and *Abra nitida* in circalittoral sandy mud' was also described as having a 'medium' sensitivity to a disturbance of this nature, however it was a modelled biotope identified within the wider Hornsea Four benthic subtidal ecology study area and was not found within the Hornsea Four Order Limits

during site-specific investigations. It is therefore unlikely to be directly disturbed by temporary habitat disturbance of this nature. It is noted that recovery of such a population is likely to be species-specific with resilience also recorded as 'medium' within MarESA assessment.

2.11.1.13 It should be noted that the biotope 'seapens and burrowing megafauna in circalittoral fine mud', has a low resilience to an impact of this type; however, it was noted that this biotope was not recorded within the array area itself but burrows typical of the burrowing megafauna associated with this habitat were observed from 'rare' to 'occasional' using the SACFOR abundance scale (Gardline 2019). Whilst this biotope was not recorded, it has been included within the assessment as a precautionary measure. The MarESA resilience assessment states that where the seapens survive impact undamaged, that the biotopes resistance is 'high' and recovery is rapid. However, where a proportion of the population is removed or killed, then the species has a high dispersal potential and long-lived benthic larvae, but larval recruitment is probably sporadic and patchy and growth is slow, suggesting that recovery may take many years. Given the low magnitude of the impact, it is not expected that a large proportion of seapen population would be removed.

Table 2.16: MarESA assessment for the benthic subtidal habitats for abrasion/ disturbance.

Biotope code (JNCC and EUNIS codes)	Biotope name	MarESA sensitivity assessment	Assessment confidence
SS.SSa.IFiSa.NcirBat / A5.233[2]	*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand	Low (based on low resistance and high resilience).	Confidence is high as the assessment is based on published literature, with the baseline assessment using tramping as the impact (however the applicability of this as a low confidence).
SS.SSa.CMuSa.AalbNuc / A5.261[3]	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	Low (based on medium resistance and high resilience).	Confidence is low as the assessment is based on expert judgement and therefore a baseline is not available.
SS.SSa.CFiSa.ApriBatPo / A5.252[4]	*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand	Low (based on medium resistance and high resilience).	Confidence is low as the assessment is based on expert judgement and therefore a baseline is not available.
SS.SSa.CFiSa.EpusOborApri / A5.251[5]	*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	Low (based on medium resistance and high resilience).	Confidence is low as the assessment is based on expert judgement and therefore a baseline is not available.
SS.SMx.CMx.MysThyMx / A5.443[6]	*Mysella bidentata* and *Thyasira spp.* in circalittoral muddy mixed sediment	Low (based on medium resistance and high resilience).	Confidence is low as the assessment is based on expert judgement and therefore a baseline is not available.

[redacted]

Biotope code (JNCC and EUNIS codes)	Biotope name	MarESA sensitivity assessment	Assessment confidence
SS.SMu.CFiMu.SpnMeg / A5.361[7]	Seapens and burrowing megafauna in circalittoral fine mud	Medium (based on medium resistance and low resilience).	Confidence is low as the assessment is based on expert judgement and therefore a baseline is not available.
SS.SMu.CSaMu.AfilMysAnit / A5.351[8]	*Amphiura filiformis*, *Kurtiella bidentata* and *Abra nitida* in circalittoral sandy mud	Medium (based on low resistance and medium resilience).	Confidence is high as the assessment is based on peer reviewed papers (observational or experimental), although the assessment was based on similar pressures on the feature.
SS.SCS.CCS.MedLumVen / A5.142 [9]	*Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel	Low (based on medium resistance and high resilience).	Confidence is high as the assessment is based on peer reviewed papers (observational or experimental), although the assessment was based on similar pressures on the feature.
SS.SCS.ICS.MoeVen / A5.133[10]	*Moerella* spp. with venerid bivalves in infralittoral gravelly sand	Low (based on medium resistance and high resilience).	Confidence is high as the assessment is based on peer reviewed papers (observational or experimental), although the assessment was based on similar pressures on the feature.
SS.SSa.IMuSa.FfabMag / A5.242[11]	*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand	Low (based on medium resistance and high resilience).	Confidence is low as the assessment is based on expert judgement and therefore a baseline is not available.
SS.SMX.CMx.FluHyd / A5.444[12]	*Flustra foliacea and Hydrallmania falcata* on tideswept circalittoral mixed sediment	Medium (based on low resistance and medium resilience).	Confidence is medium as the assessment is based on some peer reviewed papers but relies on grey literature and expert judgement
SS.SMx.OMx.PoVen / A5.451[13]	Polychaete-rich deep *Venus* community in offshore mixed sediments	Low (based on medium resistance and high resilience).	Confidence is high as the assessment is based on peer reviewed papers (observational or experimental), although the assessment was based on similar pressures on the feature.

2.11.1.14 *Sabellaria spinulosa* individuals were located at six stations across the ECC, whilst the evidence suggests that these stations do not represent reef habitat a review of sensitivity on this species has been undertaken on account of its ecological importance. The MarESA sensitivity assessment defines *S. spinulosa* as having a 'moderate' sensitivity to a disturbance of this nature. 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 and polluted conditions and is a r-strategist (a life strategy which allows

[redacted]

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 and in polluted conditions. Areas where *S. spinulosa* had been lost due to winter storms appeared to recolonize up to a maximum thickness of 2.4 cm during the following summer (R. Holt, pers. comm. in Jones et al., 2000). Recoverability is therefore expected to be very high for the species[14].

2.11.1.15 The benthic subtidal habitats that characterise the Hornsea Four array area are deemed to be a maximum of medium vulnerability, a worst-case of low recoverability and of regional to national value. The maximum sensitivity of the receptors is therefore, considered to be **medium** (but in most cases **low**) according to the MarLIN MarESA sensitivity category, which can be directly related to the same values in the Hornsea Four sensitivity matrix (**Table 2.13**).

Significance of the effect

2.11.1.16 Temporary habitat disturbance will represent a local spatial extent, short term intermittent impact, affecting a relatively small portion of the benthic subtidal habitats in the Hornsea Four Order Limits. Most benthic receptors are known to have a high degree of tolerance to this impact, based on MarESA assessments.

2.11.1.17 Overall, it is predicted that the sensitivity of the benthic subtidal biotopes and receptors is **low** to **medium** and the magnitude of the impact is **minor**. The **medium** sensitivity and **minor** magnitude of the impact on benthic receptors could result in either a **slight** (not significant) or **moderate** (significant) effect (as per the matrix in **Table 2.15**). However, taking into account the short-term and localised nature of this impact and the tolerance and recoverability of benthic receptors identified to temporary habitat disturbance of this nature, the significance of effect is deemed **slight** rather than moderate, which is not significant in EIA terms.

2.11.1.18 The MarESA assessments identify that the confidence for the sensitivity of the specified habitats to abrasion/ disturbance of the surface is generally low for all habitats. For SS.SSa.CMuSa.AalbNuc, SS.SSa.CFiSa.ApriBatPo, SS.SMX.CMx.MysThyMx, SS.SSa.IMuSa.FfabMag and SS.SSa.CFiSa.EpusOborApri, the low confidence is associated with the resistance measure, with high confidence associated with the recovery (resilience) of the habitats. For SS.SSa.IFiSa.NcirBat, the only measure which was assessed as having a low confidence score was the applicability of the sensitivity, which originates from a low confidence score for the applicability of the resilience assessment; however, since the evidence agrees in terms of direction and magnitude of the impact this is a conservative and robust assessment. As such, the assessment of the significance of effects as not significant is considered to be robust.

[14] [redacted]

Temporary increase in SSC and sediment deposition in the Hornsea Four array area and offshore ECC (BIE-C-3).

Magnitude of impact

2.11.1.19 Temporary localised increases in SSC and associated sediment deposition are expected from foundation and cable installation works and seabed preparation works (including sandwave clearance). This assessment should be read in conjunction with **Volume A2, Chapter 1: Marine Geology, Oceanography and Physical Process** and **Volume A5, Annex 1.1: Marine Processes Technical Report** which provide a full description of the offshore physical environment assessment (including project specific modelling of sediment plume dynamics).

2.11.1.20 Background surface SSCs closer inshore of the offshore ECC, are known to vary seasonally between 2 to 14 mg/l, reducing offshore to around 2 to 3 mg/l. Surface turbidity is relatively low across the offshore array area, with monthly averaged concentrations typically less than 5 mg/l across the whole year (Cefas 2016). The relatively low concentrations are due to both a low content of fine material in the seabed sediments and the area being distant from any terrestrial sources, such as the Humber Estuary and the Holderness Cliffs.

2.11.1.21 **Table 2.12** presents the MDS associated with increases in SSC and deposition. The MDS for SSC and deposition during the construction phase of Hornsea Four would result in the total release of approximately 12,192,331 m^3 of sediment in the array area and offshore ECC. **Table 2.17** details the maximum sediment plume distance and the peak increases in SSC and deposition that could occur as a result of construction activities.

Table 2.17: Temporary increases in SSC and sediment deposition as a result of construction activities at Hornsea Four.

Construction Impact	Location	Maximum sediment plume distance	Details of increase in SSC and deposition
Sandwave clearance	Nearshore ECC	14 km (springs) and 6 km (neaps)	• SSCs within sediment plumes associated with overspill can be in the order of hundreds of mg/l in the vicinity of the dredger, reducing to tens of mg/l with distance, but also quickly dissipating in time after release; • The deposition of fine sediment under low flow conditions is predicted to be less than 2 mm from overspill; • Dredge spoil disposal plume concentrations remain less than 10 mg/l for all locations 2 km beyond the point of release and are not detectable after about 20 hours; and • The depth of spoil deposition (for all sediments) is typically very small (around 0.1 mm) but reaches 5.9 cm for the spring tide in a confined area and 10 cm for a neap release. These depths of deposition cover a very small area and are due to coarser grained sediments (gravels).
Seabed preparation	Offshore array	7 km (neaps) and	• SSCs within sediment plumes associated with overspill can be in the order of hundreds of mg/l in the vicinity of the dredger, reducing to

Construction Impact	Location	Maximum sediment plume distance	Details of increase in SSC and deposition
for foundations		10 km (springs) along the axis of the tide	tens of mg/l with distance, but also quickly dissipating in time after release; • Dredge spoil disposal plume concentrations will remain less than 2 mg/l, 2 km from the point of release and will not be detectable after 40 hours; and • The depth of spoil deposition after 3 days is typically very small (around 0.1vmm) but reaches 3.8 cm for the neap tide scenario and 2.9 cm for spring tides, in a confined area (where deposition material consists primarily of coarser materials).
	HVAC booster station	7 km (springs) and 12 km (neaps) along the axis of the tide	• SSCs within sediment plumes associated with overspill can be in the order of hundreds of mg/l in the vicinity of the dredger, reducing to tens of mg/l with distance, but also quickly dissipating in time after release; • Dredge spoil disposal plume concentrations will remain under 10 mg/l, 2 km from the point of release and will not be detectable after 60 hours; and • The depth of spoil deposition after 3 days is typically small (0.1 mm) but reaches 0.4 cm for a spring tide, but in a confined area.
Offshore trenching for cables	Offshore ECC	14 km along the axis of the tide	• Within 5 m of trenching very high plume concentrations are expected. SSC could be millions of mg/l. This is only expected to occur while the CFE is active; • At 2 km from the source, the silt content will be approximately 100 mg/l during the trenching period and will fully dissipate and will fully dissipate after around 65 hours; and • The maximum depth of deposition is 7.1 cm on neaps and 5.3 cm on springs, along the trench. The maximum settlement depth reduces exponentially in range from the trench reaching 0.12 m at 50 m and 0.06 m at 100 m.
	Offshore array	10 km along the axis of the tide	• Concentrations of SSC can reach 1,000 mg/l in the vicinity of the trenching with only the silt fraction dispersing away from the trench with plume concentrations of around 100 mg/l up to 2 km; • The maximum depth of deposition is 11.6 cm on neaps and 13.2 cm on springs along the trench; • A wider spread of deposition under spring tides, with the lowest depth of sediment deposition (circa 0.1 mm); and • The silt contribution to the sediment deposition represents 2.3 mm on neaps and 1.6 mm on spring tides.
Drilling at foundations	Offshore array/ /HVAC booster station	10-14 km along the axis of the tide	Results are comparable to sediment plumes and deposition of fines to those presented for sandwave clearance, but considerably less in proportion.

2.11.1.22 To summarise the information presented in Table 2.17, sediment plumes caused by seabed preparation and installation activities are expected to be restricted to well-within the tidal excursion, with plumes expected to occur over a maximum distance of 14 km

from the source. Sediment plumes are expected to quickly dissipate after cessation of the activities, due to settling and wider dispersion with the concentrations reducing quickly over time to background levels. Sediment deposition will consist primarily of coarser sediments deposited close to the source, with a small proportion of silt deposition (reducing exponentially from source).

2.11.1.23 Taking the above into consideration, the impact of increased SSC and deposition from construction activities is expected to be short-term, intermittent and of localised extent (within one tidal excursion) and reversible. All biotopes and VERs are distributed widely throughout the Southern North Sea, and therefore taking the wider environment into context, the magnitude of the impact on all VERs is assessed as being **minor**.

2.11.1.24 Increased SSC and deposition are likely to occur where the ECC is in relatively close proximity to the Flamborough Head SAC and the Holderness Offshore and Inshore MCZs. Any fine material being dispersed by construction works is likely to be widely distributed and will quickly form part of the background concentration of Suspended Particulate Matter (SPM) in the nearshore and therefore is unlikely to settle in measurable thickness locally. The magnitude of impact on these protected features is therefore, considered to be **minor**.

Sensitivity of the receptor

2.11.1.25 The species and habitats identified during the characterisation study are typical of the wider region. All biotopes identified within the Hornsea Four Order Limits and across the wider benthic subtidal ecology study area have been assessed according to the MarESA criteria as having a medium to high resilience to changes in SSC and light to heavy smothering. The recoverability of benthic communities is likely to occur as a result of the combination of recruitment from surrounding unaffected areas and larval dispersal. Recovery is likely to occur within <two to ten years depending on the depth of burial, with areas that are affected by lighter levels of deposition recovering within two years (based on the MarESA assessments).

2.11.1.26 The benthic subtidal habitats that characterise the Hornsea Four benthic subtidal ecology study area are deemed to be a maximum of medium vulnerability to heavy smothering (5-30 cm), a reasonable worst-case of medium recoverability and of regional to national value. The sensitivity of the receptors is therefore considered to be in the range from **low** to **medium** according to the EIA assessment values, however **Table 2.18** demonstrates that lower levels of sensitivity are recorded for most biotopes.

Table 2.18: MarESA assessment for the benthic subtidal habitats for temporary increase in SSC and sediment deposition (changes in suspended solids, smothering and siltation rate).

Biotope code	Biotope name	MarESA sensitivity assessment	Assessment confidence
SS.SSa.IFiSa.NcirBat / A5.233	*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand	• Low sensitivity to changes in SSC; • Not sensitive to light smothering (< 5 cm); and • Low sensitivity to heavy smothering (5 – 30 cm).	Confidence is low for changes in SSC. Confidence in the quality of the evidence and the agreement of the evidence is high and the applicability of the evidence is medium for smothering.

Biotope code	Biotope name	MarESA sensitivity assessment	Assessment confidence
SS.SSa.CMuSa.AalbNuc / A5.261	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	• Low sensitivity to changes in SSC; • Not sensitive to light smothering (< 5 cm); and • Medium sensitivity to heavy smothering (5 – 30 cm).	Confidence is low for the SSC assessment as assessment is based on expert judgement. Confidence is low to medium for smothering and siltation. 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.
SS.SSa.CFiSa.ApriBatPo / A5.252	*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand	• Low sensitivity to changes in SSC; • Not sensitive to light smothering (< 5 cm); and • Medium sensitivity to heavy smothering (5 – 30 cm).	Confidence is low for the SSC assessment as assessment is based on expert judgement. Confidence is low to medium for smothering and siltation. Confidence in the quality of the evidence is high for the smothering assessments, although the applicability and agreement between the evidence is low.
SS.SSa.CFiSa.EpusOborApri / A5.251	*Echinocyamus pusillus, Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	• Low sensitivity to changes in SSC; • Not sensitive to light smothering (< 5 cm); and • Medium sensitivity to heavy smothering (5 – 30 cm).	Confidence is low for the SSC assessment as assessment is based on expert judgement. Confidence is low to medium for smothering and siltation. 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.
SS.SMx.CMx.MysThyMx / A5.443	*Mysella bidentata* and *Thyasira spp.* in circalittoral muddy mixed sediment	• Not sensitive to changes to SSC; • Not sensitive to light smothering (< 5 cm); and • Low sensitivity to heavy smothering (5 – 30 cm).	Confidence is low for the SSC assessment as assessment 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.
SS.SMu.CFiMu.SpnMeg / A5.361	Seapens and burrowing megafauna in circalittoral fine mud	• Not sensitive to changes to SSC; • Not sensitive to light smothering (< 5 cm); and • Not sensitive to heavy smothering (5 – 30 cm).	Confidence is medium for the SSC assessment as assessment is based on some peer reviewed papers but relies on grey literature and expert judgement. Confidence in the quality of the evidence is low for the smothering assessments.

Biotope code	Biotope name	MarESA sensitivity assessment	Assessment confidence
SS.SMu.CSaMu.AfilMysAnit / A5.351	*Amphiura filiformis*, *Mysella bidentate* and *Abra nitida* in circalittoral sandy mud	• Not sensitive to changes to SSC; • Not sensitive to light smothering (< 5 cm); and • Medium sensitivity to heavy smothering (5 – 30 cm).	Confidence is medium for the SSC assessment as assessment is based on some peer reviewed papers but relies on grey literature and expert judgement. Confidence in the quality of the evidence is low for the smothering assessments.
SS.SCS.CCS.MedLumVen /	*Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel	• Low sensitivity to changes in SSC; • Low sensitivity to light smothering (< 5 cm); and • Medium sensitivity to heavy smothering (5 – 30 cm).	Confidence is high for the SSC assessment as assessment is based on peer reviewed papers or grey literature reports by established agencies on the feature. 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.
SS.SCS.ICS.MoeVen / A5.142	*Moerella* spp. with venerid bivalves in infralittoral gravelly sand	• Low sensitivity to changes in SSC; • Low sensitivity to light smothering (< 5 cm); and • Medium sensitivity to heavy smothering (5 – 30 cm).	Confidence is high for the SSC assessment as assessment is based on peer reviewed papers or grey literature reports by established agencies on the feature. 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.
SS.SSa.IMuSa.FfabMag / A5.133	*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand	• Low sensitivity to changes in SSC; • Low sensitivity to light smothering (< 5 cm); and • Medium sensitivity to heavy smothering (5 – 30 cm).	Confidence is low for the SSC and heavy smothering assessment as assessment is based on expert judgement. Confidence is medium for the light smothering assessment as the assessments is based on some peer reviewed papers but relies on grey literature and expert judgement.
SS.SMX.CMx.FluHyd / A5.444	*Flustra foliacea and Hydrallmania falcata* on tideswept circalittoral mixed sediment	• Not sensitive to changes to SSC; • Not sensitive to light smothering (< 5 cm); and • Low sensitivity to heavy smothering (5 – 30 cm).	Confidence is low for changes in SSC. Confidence in the quality of the evidence and the agreement of the evidence is high and the applicability of the evidence is medium for smothering.
SS.SMx.OMx.PoVen / A5.451	Polychaete-rich deep *Venus*	• Low sensitivity to changes in SSC;	Confidence is high for the SSC assessment as assessment is based

Biotope code	Biotope name	MarESA sensitivity assessment	Assessment confidence
	community in offshore mixed sediments	• Low sensitivity to light smothering (< 5 cm); and • Medium sensitivity to heavy smothering (5 – 30 cm).	on peer reviewed papers or grey literature reports by established agencies on the feature. 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.

2.11.1.27 *A. islandica* is not considered to be sensitive to increases in SSC, which is likely to increase food availability. Similarly, it is not sensitive (**low** sensitivity) to sediment deposition, with individuals known to burrow through any deposited sediment, with no mortality observed (Tyler-Walters and Sabatini 2017).

2.11.1.28 The MarESA sensitivity assessment defines *S. spinulosa* as being 'not sensitive' to a disturbance of this nature. *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, 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 [15].

2.11.1.29 The impact of increased SSC and deposition on biotopes typical of the soft sediment broadscale habitat features of the Holderness Offshore and Inshore MCZs are presented in **Table 2.18** and are considered not to be sensitive to light smothering (<5 cm). Impacts to the broadscale habitat 'moderate to high energy circalittoral rock' are also considered as not sensitive to light smothering, with the moderate to high energy water flow likely to remove sediment rapidly and therefore deposition on characterising rock species such as bryozoans and hydroids.

2.11.1.30 The broadscale habitat features of the Holderness Offshore and Inshore MCZs are deemed to be not vulnerable, with high recoverability and national importance. The sensitivity of these receptors to light smothering is therefore, considered to be **low.**

2.11.1.31 The communities associated with subtidal chalk reef habitat, which is a protected feature of the Flamborough Head SAC are expected to have some tolerance to increases in SSC (De-Bastos and Hill 2016c; Tillin and Hill 2016), particularly as these habitats are near the coast, where background SSC levels are highest. Sensitivity of many animals associated with soft rock habitats to light sediment deposition would also be expected to be limited,

[15] [redacted]

due to the resilience of some characterising species (De-Bastos and Hill 2016c) and the natural sediment mobility in these areas.

2.11.1.32 The subtidal chalk reef habitat exposures of the Flamborough Head SAC is deemed to be of worst-case medium vulnerability, medium to high recoverability and international importance. The sensitivity of these receptors to light smothering is therefore, considered to be worst-case **medium**.

2.11.1.33 A 'not-sensitive' to 'low' MarESA sensitivity is recorded for 'submerged or partially submerged sea caves', which are a protected feature of the Flamborough Head SAC (Tyler-Walters 2018). The upper, vertical walls of caves are unlikely to be subject to any smothering, but the inner reaches of caves with shallow slopes or horizontal ledges may be. In the wave exposed conditions experienced by biotopes typical of this habitat, light smothering of sediment may be removed quickly, depending on the shape of the cave. It is unlikely that the magnitude of this impact would result in any localised anoxia occurring at the base of any flora that might inhabit the cave, and a low vulnerability is therefore recorded. Recovery is likely to be high and the habitat is of international value. The sensitivity of the receptor to light smothering is considered to be **medium**.

Significance of the effect

2.11.1.34 Increases in SSC and associated sediment deposition will represent a temporary and short-term intermittent impact, affecting a relatively small portion of the benthic subtidal habitats in the Hornsea Four benthic subtidal ecology study area. Most receptors are known to have a medium to high degree of tolerance to this impact.

2.11.1.35 Overall, it is predicted that the sensitivity of the benthic subtidal habitats located across the Hornsea Four benthic ecology study area is at worst-case **medium** according to the detailed MarESA assessments and published literature, and the magnitude is **minor.** The **medium** sensitivity and **minor** magnitude of the impact on benthic receptors could result in either a **slight** (not significant) or **moderate** (significant) effect (as per the matrix in **Table 2.15**). However, taking into account the short term and localised nature of this impact and the tolerance and recoverability of benthic ecology receptors identified to increased SSC and deposition, the significance of effect is deemed **slight**, which is not significant in EIA terms.

2.11.1.36 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 for all habitats. For all habitats, the low confidence score for the sensitivity assessment is associated with the resistance assessment rather than the resilience assessment. The significance of effect has been assessed based on the lowest resistance score of medium 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 as **not significant,** is considered to be robust.

Temporary increase in SSC and sediment deposition in the intertidal area (BIE-C-4).

Magnitude of impact

2.11.1.37 Temporary increases in SSC and associated sediment deposition in the intertidal area are expected from the cable installation works. **Volume A2, Chapter 1: Marine Geology, Oceanography and Physical Process** provides an assessment of the impacts on marine processes including the development and fate of suspended sediments and seabed deposition.

2.11.1.38 There is a requirement to use drilling mud, such as bentonite (or another inert mud), in order to undertake HDD activities and make landfall. This in turn may result in the release of drilling mud within the intertidal area at the punch out points. Bentonite is a non-toxic, natural clay mineral (<63 µm particle diameter) and is included in the List of Notified Chemicals approved for use and discharge into the marine environment and is classified as a Group E substance under the Offshore Chemical Notification Scheme. Substances in Group E are defined as the group least likely to cause environmental harm and are "*readily biodegradable and non-bioaccumulative*". This is further supported by bentonite being included on the OSPAR List of Substances Used and Discharged Offshore which are considered to Pose Little or No Risk to the Environment (PLONOR)[16].

2.11.1.39 As bentonite is a clay-based substance, it may persist in suspension for hours to days or longer, becoming diluted to very low concentrations (indistinguishable from natural background levels and variability) within timescales of around one day. The SSC at the point of HDD 'punch out' would decrease notably within one tidal cycle. The MDS sediment volume for the HDD cofferdam excavation area (which is to be below MLWS, outwith the intertidal zone) is a total of up to 20,000 m^3 for up to eight exit pits (six exit pits plus two for contingency). This equates to an average excavation volume of up to 2,500 m^3 per pit and to a maximum depth of 5 m. The total volume of HDD bentonite drilling fluid loss per cable = 265 m^3 x 6 = 1,590 m^3. Any fine material being dispersed from the exit pits during excavation is likely to be widely dispersed and quickly form part of the background concentration of SSC along the nearshore. As detailed within the **Volume A2, Chapter 1: Marine Geology, Oceanography and Physical Processes**, the magnitude of impact resulting from temporarily elevated levels of siltation in the vicinity of the cofferdam would be **negligible**. Irrespective of the sensitivity of the receptor, the significance of the impact is **not significant** as defined in the assessment of significance matrix (**Table 2.15**) and is therefore not considered further in this assessment.

Direct and indirect seabed disturbances leading to the release of sediment contaminants (BIE-C-6).

Magnitude of impact

2.11.1.40 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 ecology receptors.

2.11.1.41 The assessment of contaminants undertaken across the Hornsea Four Order Limits (the full details of which are presented in **Volume 5, Annex 2.1: Benthic and Intertidal Technical Report** and summarised in **paragraph 2.7.1.10** *et seq.*) revealed that hydrocarbon concentrations across most of the Hornsea Four Order Limits were within the expected UKOOA (2001) background concentrations. THC levels above the United Kingdom UKOOA (2001) 95th percentile of 11.39 mg/kg for THC in the Southern North Sea were found at five stations across the offshore ECC. The higher THC levels observed at some of these stations are consistent with the elevated TOC.

2.11.1.42 All metals concentrations across the Hornsea Four Order Limits were generally low, except for arsenic, which was higher that then Cefas AL1 at all stations across the offshore ECC and at four stations across the array area. As discussed in **paragraph 2.7.1.10** *et seq.*, metals were generally present at low concentrations. Therefore, despite the apparent frequent exceedances of the BACs by numerous metal analytes, metal concentrations are generally considered to be at background levels.

2.11.1.43 PAH's across the Hornsea Four Order Limits when compared to OSPAR's BC and BACs (OSPAR 2005), revealed that concentrations were not representative of a 'pristine' environment (as described by OSPAR (2005)), which is expected considering the extent of oil and gas activities within the wider area.

2.11.1.44 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 bio-availability resulting in adverse eco-toxicological effects are not expected.

2.11.1.45 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 **negligible**. Irrespective of the sensitivity of the receptor, the significance of the impact is **not significant** as defined in the assessment of significance matrix (**Table 2.15**) and is therefore not considered further in this assessment.

2.11.2 Operation and Maintenance Phase

2.11.2.1 The potential impacts of the offshore operation and maintenance of Hornsea Four have been assessed on benthic and intertidal ecology. The potential environmental impacts arising from the operation and maintenance of Hornsea Four are listed in **Table 2.12** along with the MDS against which each operation and maintenance phase impact has been assessed.

2.11.2.2 A description of the potential effect on benthic ecology receptors caused by each identified impact is given below.

Permanent habitat loss/ change from the presence of foundations, scour protection and cable protection (BIE-O-8).

Magnitude of impact

2.11.2.3 The presence of the WTG and OSS 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).

2.11.2.4 **Table 2.12** identifies the MDS foundation, scour and cable protection footprint. The total habitat loss arising from these components would be 3.7 km^2, which equates to approximately 0.79% of the Hornsea Four Order Limits.

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

2.11.2.6 No long-term habitat loss will occur in the intertidal area of the Hornsea Four ECC as cable protection will not be used in this area (see Co188 - **Table 2.11** and **Volume A4, Annex 5.2: Commitment Register**).

Sensitivity of the receptor

2.11.2.7 The species and habitats identified during the characterisation study are typical of the wider region. All biotopes identified within the Hornsea Four Order Limits have been assessed according to the MarESA criteria as having no resistance to long-term or permanent habitat loss / change, with recovery assessed as very low as the change at the pressure benchmark is at worst case permanent. The sensitivity of subtidal receptors is therefore considered to be at worst-case **high** according to the EIA assessment values.

Significance of the effect

2.11.2.8 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 long-term or permanent change in seabed habitat within the footprint of the structures and scour and cable protection, the footprint of the area affected 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.

2.11.2.9 Overall, it is predicted that the sensitivity of the benthic subtidal habitats located across the Hornsea Four benthic ecology study area is at worst-case **high** according to the detailed MarESA assessments and the magnitude is **minor**. The **high** sensitivity and **minor** magnitude of the impact on benthic receptors could result in either a **slight** (not significant) or **moderate** (significant) effect (as per the matrix in **Table 2.15**). However, as the habitats and characterising biotopes are common and widespread throughout the wider region the

loss of these habitats is assessed as barely discernible and the effect is considered to be of **slight** significance, which is not significant in EIA terms.

Colonisation of the WTGs and scour/ cable protection may affect benthic ecology and biodiversity (BIE-O-9).

Magnitude of impact

2.11.2.10 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 4.76 km^2, which accounts for approximately 0.1% of the total benthic subtidal ecology study area.

2.11.2.11 Hard substrate habitats are comparatively rare within the Hornsea Four benthic ecology study area which is dominated by sedimentary habitats, although there are numerous sub-surface and surface structures associated with the oil and gas industry within the study area (see **Volume A2, Chapter 11: Infrastructure and Other Users** for further information). 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 Hornsea Four infrastructure and will be permanent, lasting for the duration of the development. Any effects on benthic ecology, arising from the introduction of hard substrates will likely be localised to the Hornsea Four array area and offshore ECC (where cable protection is laid).

2.11.2.12 The impact is therefore predicted to be of local spatial extent, long-term or permanent duration but reversable if the infrastructure is removed, although not all introduced hard substrate is likely to be removed, with cable and scour protection assumed to be remaining in-situ. It is predicted that the impact will affect the receptor directly. As the habitats and characterising biotopes are common and widespread throughout the wider region the loss of these habitats is assessed as barely discernible and the magnitude is therefore, considered to be **minor.**

Sensitivity of the receptor

2.11.2.13 The introduction of new hard substrate will represent a potential shift in the baseline condition within a small proportion of the Hornsea Four benthic subtidal ecology study area. 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.

2.11.2.14 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 the edible crab *Cancer pagurus* (BioConsult 2006).

However, any direct benefits are only likely to occur on a very localised basis (i.e. near the infrastructure).

2.11.2.15 Given the presence of epifaunal species and colonising fauna within discrete parts of the Hornsea Four benthic subtidal ecology study area already (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.

2.11.2.16 The sediment biotopes likely to be affected are deemed to be of low vulnerability and of local to regional value. Recoverability following removal of the infrastructure is expected to be high although not all introduced hard substrate is likely to be removed, with cable and scour protection assumed to be remaining in-situ. The sensitivity of these receptors is therefore, considered to be at worst case **high**, in areas where infrastructure is not removed.

Significance of the effect

2.11.2.17 Any beneficial effects associated with an increase in biodiversity will be highly localised in nature and is not regarded as mitigation for the loss of sedimentary habitat associated with the installation of these structures. The introduction of hard structures such as scour protection can lead to an increase in biomass and biodiversity which may be considered beneficial, but it also represents a change from the baseline environment which may be considered adverse. Overall, it is predicted that the sensitivity of the receptor is **high** and the magnitude is **minor**. According to Table 2.15, the effect could be either **slight** or **moderate** (only a moderate effect is considered to be significant in EIA terms), 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 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 and the effect is considered to be of **slight** significance, which is not significant in EIA terms.

Increased risk of introduction or spread of Marine Invasive Non-Native Species (MINNS) due to presence of infrastructure and vessel movements (e.g. the discharge of ballast water) may affect benthic ecology and biodiversity (BIE-O-10).

Magnitude of impact

2.11.2.18 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 Hornsea Four Order Limits has the potential to impact upon benthic ecology and biodiversity locally and in the broader region.

2.11.2.19 As presented in Table 2.12, up to 4.76 km^2 of new hard substrate habitat will be introduced into the Hornsea Four benthic subtidal ecology study area, which has the potential to provide new habitat for colonisation by MINNS.

2.11.2.20 In addition to this, there will be up to 249,756 round trips to port during the construction phase and up to 1,693 round trips to port by operational and maintenance vessels, which will contribute to the risk of introduction or spread of MINNS through ballast water discharge.

2.11.2.21 Designed-in measures including a CPEMMP with a marine biosecurity plan (see Co111 of **Volume A4, Annex 5.2: Commitment Register**, see **Table 2.11**) will, however, ensure that the risk of potential introduction and spread of MINNS will be minimised.

2.11.2.22 The impacts on biotopes and VER within the Hornsea Four benthic subtidal ecology study area 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), 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.** Irrespective of the sensitivity of the receptor, the significance of the impact is **not significant** as defined in the assessment of significance matrix (**Table 2.15**) and is therefore not considered further in this assessment.

Direct disturbance to seabed from jack-up vessels and cable maintenance activities (BIE-O-11).

Magnitude of impact

2.11.2.23 The total maximum area of 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 repair (including de-burial and re-burial of export and array cables). A total of up to 8.6 km^2 of temporary habitat disturbance is predicted to arise over the 35-year design life of Hornsea Four (equating to approximately 0.2% of the Hornsea Four benthic subtidal ecology study area). Given that the habitats are common and widespread throughout the region impacts from the individual O&M activities will represent a very small footprint compared to their overall extent.

2.11.2.24 With respect to available habitat for *A. islandica*, the total area of temporary habitat loss during the operational phase represents a very small percentage loss (0.001%) of the total area of the OSPAR Region II within which *A. islandica* is listed as under threat and/or decline.

2.11.2.25 The impacts are predicted to be temporary and of short-term duration and only a single event in each location, intermittent and reversable. It is predicted that the impact will affect the receptors directly. The magnitude of this impact is therefore considered to be **negligible.** Irrespective of the sensitivity of the receptor, the significance of the impact is **not significant** as defined in the assessment of significance matrix (**Table 2.15**) and is therefore not considered further in this assessment.

Changes to seabed habitats arising from effects on physical processes, including scour effects and changes in the sediment transport and wave regimes resulting in potential effects on benthic communities (BIE-O-13).

Magnitude of impact

2.11.2.26 The presence of foundations, scour protection and cable protection material may introduce changes to the local hydrodynamic and wave regime (Table 2.12), resulting in changes to the sediment transport pathways and associated effects on benthic ecology. Scour and increases in flow rates can change the characteristics of the sediment potentially making the habitat less suitable for some species.

2.11.2.27 The use of correctly designed scour protection at foundations and sufficiently buried cables (Co82) will prevent scour occurring (**Volume A2, Chapter 1: Marine Geology, Oceanography and Physical Processes**). The impacts of the use of this scour protection has been assessed within this chapter (**paragraph 2.11.2.10** *et seq.*) and found to have no significant effects on the benthic environment.

2.11.2.28 Where rock berms are to be used as cable protection at cable crossings, some scouring is predicted to occur throughout the operational phase at these features. The Marine Geology, Oceanography and Physical Processes assessment has identified that some local scouring may occur around the perimeter of rock berms but that this considered to have a **negligible** magnitude of impact on the seabed and would not have far reaching effects (Section 1.11.2 within **Volume A2, Chapter 1: Marine Geology, Oceanography and Physical Processes**).

2.11.2.29 The Marine Geology, Oceanography and Physical Processes assessment has determined that the impacts on hydrodynamic and wave regimes will be not significant and would therefore not result in any significant changes to sediment transport (Section 1.11.2 within **Volume A2, Chapter 1: Marine Geology, Oceanography and Physical Processes**) and consequently will not have any significant impacts on benthic ecology. The magnitude of this impact is therefore considered to be **negligible.** Irrespective of the sensitivity of the receptor, the significance of the impact is **not significant** as defined in the assessment of significance matrix (Table 2.15) and is therefore not considered further in this assessment.

2.11.3 Decommissioning Phase

2.11.3.1 The impacts of the offshore decommissioning of Hornsea Four have been assessed on benthic and intertidal ecology. The environmental impacts arising from the decommissioning of Hornsea Four are listed in Table 2.12 along with the MDS against which each decommissioning phase impact has been assessed. A description of the significance of effect upon benthic and intertidal receptors caused by each identified impact is provided below.

Temporary habitat disturbance from decommissioning of foundations, cables and rock protection (BIE-D-15).

2.11.3.2 The nature and extent of temporary habitat loss/disturbance during decommissioning is assumed (for the purposes of this assessment) to be similar to that described for the equivalent activities during the construction phase in **paragraphs 2.11.1.1** *et seq.* unless otherwise stated (i.e. activities involved in the decommissioning process that give rise to impacts that are similar to those arising from the construction process such as sandwave clearance, cable installation, anchor placements and jack-up operations).

2.11.3.3 The MDS has assumed the same quantitative requirements for sandwave clearance and boulder clearance activities, prior to decommissioning, as that required during the construction phase, although this is also likely to be over-precautionary.

2.11.3.4 Decommissioning has the potential to cause temporary loss of, or disturbance to, benthic habitats within Hornsea Four, similar to those described during the construction phase. However, as seabed preparation works would not be required, the magnitude of this impact will be lower than during the construction phase.

2.11.3.5 The details of the proposed decommissioning process will be included within the Decommissioning Programme (see Co181 of **Table 2.11** and **Volume A4, Annex 5.2: Commitment Register**) which will be developed and updated throughout the lifetime of Hornsea Four to account for changing best practice.

2.11.3.6 The magnitude of the impact and the sensitivities of the benthic habitats to temporary habitat disturbance are as described for the construction phase (described in detail in **paragraph 2.11.1.2** *et seq.*).

Significance of the effect

2.11.3.7 Based on the assessment undertaken for construction, which represents a MDS, it is predicted that the maximum sensitivity of the receptors is **medium** (**Table 2.16**) and the magnitude is **minor**. The **medium** sensitivity and **minor** magnitude of the impact on benthic receptors could result in either a **slight** (not significant) or **moderate** (significant) effect (as per the matrix in **Table 2.15**). However, taking into account the short-term and localised nature of this impact and the tolerance and recoverability of benthic receptors identified to temporary habitat disturbance of this nature, the significance of effect is deemed **slight**, which is not significant in EIA terms.

Increased SSC and sediment deposition from removal of foundations, cables and rock protection (BIE–D-16).

2.11.3.8 Increases in SSC and sediment deposition from the decommissioning works are expected to be less than that for construction and are therefore of a reduced magnitude. The magnitude of the impact and the sensitivities of the benthic habitats to SSC and sediment deposition are as described for the construction phase (described in detail in **paragraph 2.11.1.19** *et seq.).*

Significance of the effect

2.11.3.9 Based on the assessment undertaken for construction, which would be considered to be a very precautionary MDS for the decommissioning process, it is predicted that the maximum sensitivity of the receptors is **medium** (Table 2.18) and the magnitude is **minor**. The **medium** sensitivity and **minor** magnitude of the impact on benthic receptors could result in either a **slight** (not significant) or **moderate** (significant) effect (as per the matrix in Table 2.15). However, taking into account the short term and localised nature of this impact and the tolerance and recoverability of benthic receptors identified to increased SSC and deposition, the significance of effect is deemed **slight**, which is not significant in EIA terms.

Loss of introduced habitat from the removal of foundations and rock protection (BIE-D-17).

2.11.3.10 As detailed in paragraph 2.11.2.13 *et seq.*, hard substrate introduced into Hornsea Four will become colonised by epifauna. The removal of the foundations and rock protection during decommissioning would therefore remove these species and associated habitats they had created.

Magnitude of impact

2.11.3.11 The removal of the foundations and rock protection will result in a permanent loss of 3.7 km^2 of hard substrate within the Hornsea Four array area (and correspondingly the recovery of sedimentary habitats lost at the time of construction as the infrastructure is removed).

2.11.3.12 The impact is predicted to be of permanent duration (i.e. the colonising species will be permanently lost) and irreversible but it will be of highly localised spatial extent. It is predicted that the impact will affect receptors directly. The magnitude is therefore considered to be **minor**.

Sensitivity of the receptor

2.11.3.13 While the removal of the substrate will result in localised declines in biodiversity, areas of bare habitat, lost during construction, will be exposed and will be open to recolonization by the original soft benthic species. It is expected that the baseline benthic communities will recover in these areas to their pre-construction state based on the recovery rates for disturbed sediment, which would equate to a maximum sensitivity for the baseline habitats of **medium**.

Significance of the effect

2.11.3.14 The loss of species colonising the hard substrate will be highly localised, there will be a typically high recoverability of the subsequently exposed substrate and communities back to their pre-construction state (see paragraphs 2.7.1.17 *et seq.*). Overall, the maximum sensitivity of the receptors is considered to be **medium** and the magnitude of the impact is considered to be **minor**. The **medium** sensitivity and **minor** magnitude of the impact on benthic receptors could result in either a **slight** (not significant) or **moderate** (significant) effect (as per the matrix in Table 2.15). However, taking into account the localised nature of this impact and the recoverability of benthic receptors identified to

disturbed sediment and abrasion/disturbance (Table 2.16), the significance of effect is deemed **slight**, which is not significant in EIA terms.

2.12 Cumulative Effect Assessment (CEA)

2.12.1.1 Cumulative effects can be defined as effects upon a single receptor from Hornsea Four when considered alongside other proposed and reasonably foreseeable projects and developments. This includes all projects that result in a comparative effect that is not intrinsically considered as part of the existing environment and is not limited to offshore wind projects.

2.12.1.2 A screening process has identified a number of reasonably foreseeable projects and developments which may act cumulatively with Hornsea Four. The full list of such projects that have been identified in relation to the offshore environment are set out in **Volume A4, Annex 5.3: Offshore Cumulative Effects** and are presented in a series of maps within **Volume A4, Annex 5.4: Location of Offshore Cumulative Schemes**.

2.12.1.3 In assessing the potential cumulative impacts for Hornsea Four, it is important to bear in mind that some projects, predominantly those 'proposed' or identified in development plans, may not actually be taken forward, or fully built out. There is therefore a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals. For example, those projects under construction are likely to contribute to cumulative impacts (providing effect or spatial pathways exist), whereas those proposals not yet approved are less likely to contribute to such an impact, as some may not achieve approval or may not ultimately be built due to other factors.

2.12.1.4 With this in mind, all projects and plans considered alongside Hornsea Four have been allocated into 'tiers' reflecting their current stage within the planning and development process. This allows the cumulative impact assessment to present several future development scenarios, each with a differing potential for being ultimately built out. This approach also allows appropriate weight to be given to each scenario (tier) when considering the potential cumulative impact. The proposed tier structure that is intended to ensure that there is a clear understanding of the level of confidence in the cumulative assessments provided in the Hornsea Four ES. An explanation of each tier is included in **Table 2.19**.

Table 2.19: Description of tiers of other developments considered for CEA (adapted from PINS Advice Note 17).

Tier 1	Project under construction.
	Permitted applications, whether under the Planning Act 2008 or other regimes, but not yet implemented.
	Submitted applications, whether under the Planning Act 2008 or other regimes, but not yet determined.
Tier 2	Projects on the Planning Inspectorate's Programme of Projects where a Scoping Report has been submitted.
Tier 3	Projects on the Planning Inspectorate's Programme of Projects where a Scoping Report has not been submitted.
	Identified in the relevant Development Plan (and emerging Development Plans with appropriate weight being given as they move closer to adoption) recognising that much information on any relevant proposals will be limited.
	Identified in other plans and programmes (as appropriate) which set the framework for future development consents/approvals, where such development is reasonably likely to come forward.

2.12.1.5 The plans and projects selected as relevant to the CEA of impacts to benthic and intertidal ecology are based on an initial screening exercise undertaken on a long list (see **Volume A4, Annex 5.3: Offshore Cumulative Effects**). Consideration of effect-receptor pathways, data confidence and temporal and spatial scales has allowed the selection of the relevant projects for a topic-specific cumulative short-list. For the majority of potential effects for benthic and intertidal ecology, planned projects were screened into the assessment based on a 10 km screening range surrounding the array, and a 14 km range around the offshore ECC representing the tidal ellipse distance for a single tidal cycle and therefore encompasses the extent of impacts to benthic and intertidal ecology associated with Hornsea Four.

2.12.1.6 The specific projects scoped into the CEA for to benthic and intertidal ecology, as well as the tiers into which they have been allocated are presented in **Table 2.20** below and are illustrated in **Figure 2.9.** The operational projects included within the table are included due to their completion/ commissioning subsequent to the data collection process for Hornsea Four and as such not included within the baseline characterisation. Note that this table only includes the projects screened into the assessment for benthic and intertidal ecology based on the criteria outlined above. For the full list of projects considered, including those screened out, please see the Cumulative Effects Annex (**Volume A4, Annex 5.3: Offshore Cumulative Effects**).

Table 2.20: Projects screened into the benthic subtidal and intertidal ecology cumulative assessment.

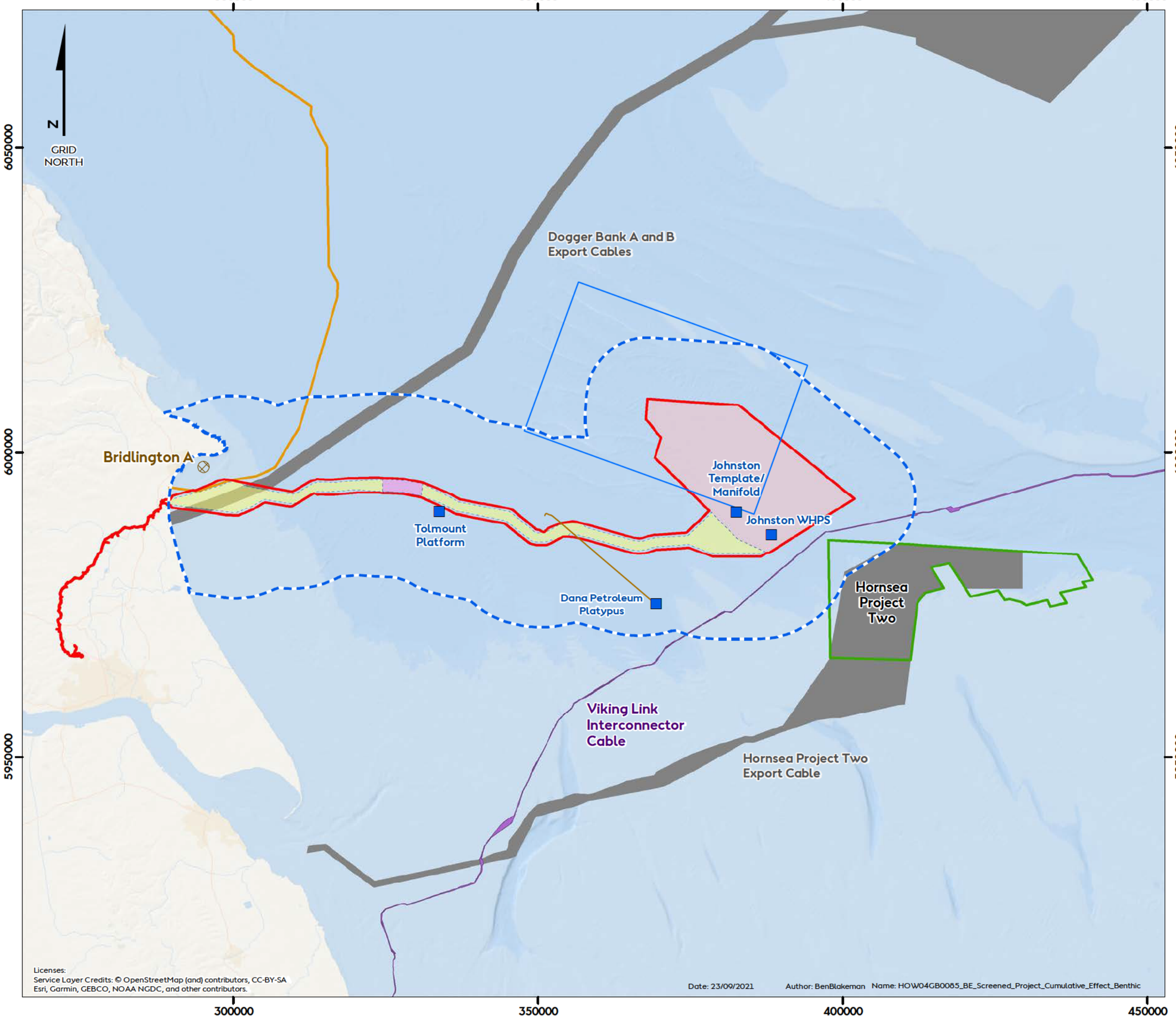
Tier	Project/plan	Details/ relevant dates	Distance to Hornsea Four Array (km)	Distance to Hornsea Four ECC (km)	Distance to Hornsea Four HVAC Booster Area (km)	Reason for inclusion in CEA
1	Hornsea Project Two Offshore Wind Farm	Consented: Will be operational during Hornsea Four construction.	3.46	10.61	67.23	Temporal overlap of operational activity with Hornsea Four construction. Development not included as part of baseline, and therefore to be considered in cumulative assessment.
1	Hornsea Project Two Export Cables	Consented: Will be operational during Hornsea Four construction.	9.30	13.67	54.14	Temporal overlap of operational activity with Hornsea Four construction. Development not included as part of baseline, and therefore to be considered in cumulative assessment.
1	Viking Link Interconnector	Under construction: Will be operational during Hornsea Four construction, with expected completion in 2023.	1.98	4.04	42.23	Temporal overlap of operational activity with Hornsea Four construction. Development not included as part of baseline, and therefore to be considered in cumulative assessment.
1	Dogger Bank A Export Cables	Consented: Will have the final year of construction and will also be operational during Hornsea Four construction	28.88	0.00	9.16	Temporal overlap of construction and operational activity with Hornsea Four construction.
1	Dogger Bank B Export Cables	Consented: Will have the final year of construction and will also be operational during Hornsea Four construction	28.88	0.00	9.16	Temporal overlap of construction and operational activity with Hornsea Four construction. High confidence.
1	Platypus pipeline	Consented 2019, with construction 2020-2022	17.01	0.00	20.56	Potential cumulative impact exists. Development not included as part of

Tier	Project/plan	Details/ relevant dates	Distance to Hornsea Four Array (km)	Distance to Hornsea Four ECC (km)	Distance to Hornsea Four HVAC Booster Area (km)	Reason for inclusion in CEA
						baseline, and therefore to be considered in cumulative assessment.
1	Bridlington A Disposal Site	Site in operational phase	72.14	2.69	28.59	Part of the baseline but has an ongoing impact and is therefore considered relevant to the cumulative impact assessment.
1	Johnston WHPS	Operational with decommissioning expected between 2021 and 2050	0.00	2.83	57.79	Potential temporal overlap of decommissioning activities with Hornsea Four construction.
1	Johnston template/manifold	Oil and gas	0.00	2.86	51.65	Potential temporal overlap of decommissioning activities with Hornsea Four construction.
1	Tolmount Platform	Oil and gas	35.36	1.46	3.98	Temporal overlap of operational activity with Hornsea Four construction. Development not included as part of baseline, and therefore to be considered in cumulative assessment.
3	Endurance Carbon Capture and Storage (CCS)	Not consented: It is expected that construction activities will commence in early 2023 with operations commencing in 2026.	0.00	2.15	18.78	Temporal overlap of operational activity with Hornsea Four construction. Development not included as part of baseline, and therefore to be considered in cumulative assessment.
3	Scotland England Green Link 2 (SEGL2)	Not consented: It is expected that construction activities will commence in 2025 with operations commencing in 2030.	53.53	0.15	16.12	Temporal overlap of operational activity with Hornsea Four construction. Development not included as part of baseline, and therefore to be considered in cumulative assessment.

Hornsea Four

Figure 2.9

Offshore Project/Plans/Activities Screened into the Hornsea Four Cumulative Effect Assessment on Benthic Ecology



- Order Limits
- Array Area
- HVAC Booster Station Works Area
- Offshore Export Cable Corridor
- Study Area (14km from ECC and 10km from Array Area)
- Disposal Site
- Viking Link Interconnector Cable
- Hornsea Project Two OWF (Consented)
- Offshore Wind Farm Export Cable
- Oil and Gas Subsea Structure
- Endurance Carbon Capture and Storage Area
- Dana Petroleum Platypus Pipeline
- Scotland England Green Link 2 (SEGL2)

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:600,000

0 10 20 Kilometres

0 5 10 Nautical Miles

REV	REMARK	DATE
---	First Issue	14/06/2019
A	Updated following PEIR consultations, for DCO	23/09/2021

Cumulative Effect Assessment for Benthic Ecology
Document no: HOW04GB0085
Created by: BPHB
Checked by: AdB
Approved by: LK

GoBe Ørsted

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

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

2.12.1.8 The impacts excluded from the CEA for the above reasons are:

Construction phase:

- Direct and indirect seabed disturbances leading to the release of sediment contaminants: the potential significance of the impact from Hornsea Four alone has been assessed as not significant.

Operation and maintenance phase:

- Increased risk of introduction or spread of MINNS due to presence of subsea infrastructure and vessel movements (e.g. ballast water) may affect benthic ecology and biodiversity: the potential significance of the impact from Hornsea Four alone has been assessed as not significant.

2.12.1.9 The impacts that have been considered in the CEA are as follows:

Construction phase:

- Temporary habitat disturbance; and
- Temporary increase in SSC and sediment deposition.

Operation and maintenance phase:

- Direct disturbance to seabed from jack-up vessels and cable maintenance activities: the impact is highly localised in nature;
- Permanent habitat loss/ change from the presence of foundations, scour protection and cable protection;
- Colonisation of the WTGs and scour/ cable protection may affect benthic ecology and biodiversity; and
- Changes to seabed habitats arising from effects on physical processes, including scour effects and changes in the sediment transport and wave regimes resulting in potential effects on benthic communities.

2.12.1.10 The cumulative MDS described in **Table 2.21** 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 Hornsea Four (summarised for benthic and intertidal ecology in **Table 2.12**), 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 2.21: Cumulative MDS for benthic and intertidal ecology.

Project Phase	Potential Impact	Maximum Design Scenario	Justification
Construction	Temporary habitat disturbance	MDS for the construction of Hornsea Four plus the cumulative impacts associated with the following projects within the Hornsea Four benthic ecology study area: **Tier 1:** -Operation and maintenance of offshore windfarms (Hornsea Project Two); -Cables and pipelines under construction (Dogger Bank A and B export cables); -Maintenance of operational interconnector cables (Viking Link); -Maintenance of oil and gas pipelines (Platypus); -Operational oil and gas platform (Tolmount Platform); and -Decommissioning of oil and gas infrastructure (Johnston WHPS, Johnston template/manifold). **Tier 2:** - No Tier 2 projects identified. **Tier 3:** - Operation and maintenance of carbon capture storage project (Endurance) and; - Cables under construction (Scotland England Green Link 2).	Maximum cumulative temporary habitat disturbance is calculated within the Hornsea Four benthic ecology study area. The cumulative temporary habitat disturbance of these projects has been presented as a percentage of the total project by calculating the area that overlaps with the Hornsea Four benthic ecology study area (further detail is presented in **paragraphs 2.13.1.1** *et seq.*).
Construction	Temporary increase in SSC and sediment deposition	MDS as described for the construction phase of Hornsea Four assessed cumulatively with the following projects, within the Hornsea Four benthic ecology study area: **Tier 1:** -Disposal site (Bridlington A); -Final year construction of Dogger Bank A and B export cables; -Operation and maintenance of offshore windfarms (Hornsea Project Two); -Maintenance of operational export cables (Hornsea Project Two, Dogger Bank A and B); -Maintenance of interconnector cables (Viking Link); -Maintenance of oil and gas pipelines (Platypus); -Operational oil and gas platforms (Tolmount Platform); and -Decommissioning oil and gas infrastructure (Johnston WHPS, Johnston template/manifold).	Maximum cumulative increases in SSC and smothering is calculated within the Hornsea Four benthic ecology study area (further detail is presented in **paragraphs 2.13.1.12** *et seq.*).

Project Phase	Potential Impact	Maximum Design Scenario	Justification
		Tier 2: - No Tier 2 projects identified. **Tier 3:** - Operation and maintenance of carbon capture storage project (Endurance); and - Cables under construction (Scotland England Green Link 2).	
Operation & maintenance	Cumulative direct disturbance to seabed from jack-up vessels and cable maintenance activities	MDS as described for the operation and maintenance phase of Hornsea Four assessed cumulatively with the following projects, within the Hornsea Four benthic ecology study area: **Tier 1:** -Operation and maintenance of offshore windfarms (Hornsea Project Two); -Maintenance of operational export cables (Hornsea Project Two, Dogger Bank A and B); -Maintenance of interconnector cables (Viking Link); **Tier 2:** - No Tier 2 projects identified. **Tier 3:** - Operation and maintenance of carbon capture storage project (Endurance); and - Maintenance of cables (Scotland England Green Link 2).	Maximum cumulative direct disturbance to seabed from jack-up vessels and cable maintenance activities is calculated within the Hornsea Four benthic subtidal ecology study area. There is no exact indication as to where these O&M works will take place, therefore as a very precautionary measure this assessment will assume all occur in the Hornsea Four benthic ecology study area. However, a proportionate value based on the percentage project overlap with Hornsea Four benthic ecology study area, is also presented (further detail is presented in **paragraphs 2.14.1.1** *et seq.*).
Operation & maintenance	Cumulative permanent habitat loss/ change from the presence of foundations, scour protection and cable protection	MDS as described for the operation and maintenance phase of Hornsea Four assessed cumulatively with the following projects, within the Hornsea Four benthic ecology study area: **Tier 1:** -Operation and maintenance of offshore windfarms (Hornsea Project Two); -Maintenance of operational export cables (Hornsea Project Two, Dogger Bank A and B); -Maintenance of interconnector cables (Viking Link); -Maintenance of oil and gas pipelines (Platypus); and -Operational oil and gas platforms (Tolmount Platform); **Tier 2:** - No Tier 2 projects identified. **Tier 3:**	Maximum cumulative permanent habitat loss / change as a result of the presence of foundations, scour protection and cable protection is calculated within the Hornsea Four benthic subtidal ecology study area. There is no exact indication where cable and scour protection will occur, therefore as a very precautionary measure this assessment will assume the total for each project will occur in the Hornsea Four benthic ecology study area. However, a proportionate value based on the percentage project overlap with Hornsea Four

Project Phase	Potential Impact	Maximum Design Scenario	Justification
		- Operation and maintenance of carbon capture storage project (Endurance); and - Maintenance of cables (Scotland England Green Link 2).	benthic ecology study area, is also presented (further detail is presented in **paragraphs 2.14.1.9** *et seq.*).
Operation & maintenance	Cumulative colonisation of the WTGs and scour/ cable protection may affect benthic ecology and biodiversity	MDS as described for the operation and maintenance phase of Hornsea Four assessed cumulatively with the following projects, within the Hornsea Four benthic ecology study area: **Tier 1:** -Operation and maintenance of offshore windfarms (Hornsea Project Two); -Maintenance of operational export cables (Hornsea Project Two, Dogger Bank A and B); -Maintenance of interconnector cables (Viking Link); -Maintenance of oil and gas pipelines (Platypus); and -Operational oil and gas platforms (Tolmount Platform); **Tier 2:** - No Tier 2 projects identified. **Tier 3:** - Operation and maintenance of carbon capture storage project (Endurance).	The MDS of these projects will result in a cumulative colonisation of hard substructures and cable/scour protection, which may impact benthic ecology and biodiversity (further detail is presented in **paragraphs 2.14.1.16** *et seq.*). Note Scotland England Green Link 2 is buried and will therefore not have an effect.
Operation & maintenance	Cumulative changes to seabed habitats arising from effects on physical processes, including scour effects and changes in the sediment transport and wave regimes resulting in potential effects on benthic communities	MDS as described for the operation and maintenance phase of Hornsea Four assessed cumulatively with the following projects, within the Hornsea Four benthic ecology study area: **Tier 1:** -Operation and maintenance of offshore windfarms (Hornsea Project Two); -Maintenance of operational export cables (Hornsea Project Two, Dogger Bank A and B); -Maintenance of interconnector cables (Viking Link); -Maintenance of oil and gas pipelines (Platypus); -Operational oil and gas platforms (Tolmount Platform); and -Decommissioning oil and gas infrastructure (Johnston WHPS, Johnston template/manifold). **Tier 2:** - No Tier 2 projects identified.	The MDS of these projects have the potential to result in cumulative changes to seabed habitats arising from effects on physical processes, which in turn has the potential to impact benthic communities. Further detail is presented in **paragraphs 2.14.1.9** and are also detailed in **Volume A2, Chapter 1: Marine Geology, Oceanography and Physical Processes**. Note Scotland England Green Link 2 is buried and will therefore not have an effect.

Project Phase	Potential Impact	Maximum Design Scenario	Justification
		Tier 3: - Operation and maintenance of carbon capture storage project (Endurance).	

2.12.1.11 A description of the significance of cumulative effects upon benthic and intertidal ecology arising from each identified impact is given below. The cumulative effects assessment has been based on information available in the ESs for the other projects where these are available; it is noted that the project parameters quoted within these ESs are often refined during the determination period and in the post-consent phase such that the final schemes built out may have a reduced impact compared to what has been concluded in the ES.

2.13 Construction Phase

Cumulative temporary habitat disturbance

Tier 1

2.13.1.1 There is potential for cumulative temporary habitat disturbance as a result of construction activities associated with Hornsea Four and other projects (**Table 2.21** and **Figure 2.9**). For the purposes of this assessment, this additive impact has been assessed from projects that fall within a 10 km of the Hornsea Four array area, and 14 km of the offshore ECC (the Hornsea Four benthic subtidal ecology study area). The projects identified in this Tier are Hornsea Project Two, the Dogger Bank A and B export cables, the Viking Link interconnector cable, the Tolmount Platform, the Platypus pipeline the Johnston WHPS and Johnston Template/Manifold oil and gas infrastructure. There are no Tier 2 projects.

2.13.1.2 Hornsea Project Two is located 3.46 km to the southeast of the Hornsea Four array area at its nearest point. The construction of Hornsea Project Two will cease in 2022 and therefore there will be no cumulative impact from construction activities. However, there is the potential for cumulative impacts from maintenance activities within the operational phase of the development. Maintenance works associated with jack-up operations and cable remedial work are predicted to be short-term, intermittent, small scale and localised to the site. Taking this into consideration, there is not predicted to be any cumulative effects from the operational phase of Hornsea Project Two.

2.13.1.3 The Dogger Bank A and B export cables are proposed to cross the Hornsea Four offshore ECC in the nearshore section, running 9.16 km from the Hornsea Four HVAC Booster Station Search Area. The final year of construction, and the operational phase of both export cables will coincide with the construction of Hornsea Four. The construction of the Dogger Bank A and B export cables will result in MDS temporary habitat disturbance of 42.55 km^2 (21.72 km^2 Dogger Bank A and 20.83 km^2 Dogger Bank B) (Forewind 2013). It should be noted that only 4% of the total Dogger Bank A and B export cables cross within the Hornsea Four benthic ecology study area. It can therefore be assumed that worst case 1.7 km^2 temporary habitat disturbance from Dogger Bank A and B export cables falls within the Hornsea Four benthic ecology study area. Any cable maintenance repairs undertaken within the operational phase of the developments will be short term, intermittent and localised to the site and therefore any cumulative impacts are expected to be minimal. Therefore, taking this into consideration, there are not predicted to be any significant cumulative impacts from the construction or operation of the Dogger Bank A and B export cables.

2.13.1.4 The consented Viking Link interconnector cable is proposed pass to the south of the Hornsea Four array area by 1.98 km and the cable is under construction from 2020 to 2023. In addition to this, the consented Platypus pipeline is proposed to cross the Hornsea Four ECC and is under construction from 2020 to 2022. Hornsea Four is not scheduled for construction until at least 2024. Therefore, there will be no temporal overlap of the construction between these consented developments and Hornsea Four, and consequently limited cumulative effects from temporary habitat disturbance. Any maintenance undertaken on the cable and pipeline during the operational phase will be intermittent, with any temporary habitat disturbance expected to be minimal, short term and localised to the site. No significant cumulative effects are predicted from maintenance of the Viking Link Interconnector cable and the Platypus pipeline with the construction of Hornsea Four.

2.13.1.5 The Tolmount Platform (consented) is under construction from 2020 to 2021, with the platform planned to be operational during the construction phase of Hornsea Four. The main impacts from the platform are associated with the construction phase, with any activities association with the operation and maintenance of the platform occurring within a closed system. Therefore, there are not considered to be any cumulative effects from the operational phase of the Tolmount Platform with Hornsea Four.

2.13.1.6 The Johnston WHPS and Johnston template/manifold wellhead structures are proposed to begin decommissioning in 2022, with the process continuing through the proposed six-year construction period for Hornsea Four (2024 -2029). The Tolmount Platform ES and the Platypus pipeline ES (Premier Oil 2017; Dana Petroleum (E&P) Ltd 2018) have been used to inform this assessment on the decommissioning of wellhead structures. Wellhead structures comprise a subsea steel lattice structure, which are typically cut below the level of the seabed and removed during decommissioning, with the remnants of the structure (below the seabed) abandoned. Given the small area of disturbance to the seafloor during this procedure, it is considered unlikely that there will be a cumulative impact to temporary habitat disturbance from the decommissioning of the Johnston WHPS and Johnston template/manifold wellhead structures and the construction of Hornsea Four.

2.13.1.7 As previously described, the construction of the majority of the projects described above won't occur concurrently with Hornsea Four construction. However, cumulative effects can also be considered in terms of duration of exposure from multiple projects which do not overlap but happen consecutively. As the effects from the projects will be short-lived due to the resilience of the sedimentary biotopes to this type of impact (**Section 2.11.1**), concurrent cumulative effects are not expected.

2.13.1.8 The cumulative impacts of temporary habitat disturbance are expected to be of local spatial extent, short-term duration, intermittent and reversible. The magnitude of impacts from the Tier 1 sites identified is therefore considered to be **minor**.

2.13.1.9 Full discussions on the sensitivity of benthic ecology receptors in the Hornsea Four benthic ecology study area are presented in **paragraphs 2.11.1.2** *et seq.* which conclude that most benthic habitats have a maximum of medium (but in most cases low) vulnerability. The maximum sensitivity of receptors in the area is therefore assessed as **medium**, with a **minor** magnitude of impact; this could result in either a **slight** or **moderate** effect (in accordance

to Table 2.15). Taking into consideration the localised and short-term nature of the impacts, it is concluded that the significance of effect from temporary habitat disturbance of Hornsea Four cumulatively, with Hornsea Project Two, the Dogger Bank A and B export cables, the Viking link, the Platypus pipeline the Tolmount Platform and the Johnston WHPS and Johnston template/manifold wellhead structures is **slight**, which is not significant in EIA terms.

Tier 3

2.13.1.10 The Endurance Carbon Capture and Storage project could have the potential to create a cumulative temporary habitat disturbance with Hornsea Four. Construction of pipelines and up to 30 wells and several platform structures are planned to commence in early 2023 with operations commencing in 2026. So, whilst there will be no construction overlap, operation and maintenance activities will overlap with Hornsea Four construction. There is currently limited detail on the Endurance project and therefore it is not possible to make a detailed assessment of the significance of effect, however given that construction activities do not overlap and any temporary habitat disturbance from operational and maintenance of Endurance is predicted to be minimal, short term and localised to the site, it is not anticipated that any effects, once qualified, would result in a significant impact.

2.13.1.11 The Scotland England Green Link 2 (SEGL2) could have the potential to create a cumulative temporary habitat disturbance with Hornsea Four. Construction of the cable is planned to commence in 2025, with the aim of being operational by 2030. As a result, there is the potential for an overlap with the construction of Hornsea Four, with the remainder of the SEGL2 construction phase overlapping with the Hornsea Four operation and maintenance phase. There is currently limited detail on the SEGL2 project and therefore it is not possible to make a detailed assessment of the significance of effect. However, the cumulative impact associated with SEGL2 is predicted to be minimal, short-term and localised to the site. As such, it is not anticipated that any effects, once qualified, would result in a significant impact.

Cumulative temporary increase in SSC and sediment deposition

Tier 1

2.13.1.12 There is potential for cumulative increases in SSC and associated sediment deposition as a result of construction activities associated with Hornsea Four and other projects (Table 2.21 and Figure 2.9). For the purposes of this assessment, this additive impact has been assessed within 10 km of the Hornsea Four array area, and 14 km of the offshore ECC, which is representative of the maximum tidal excursion in the area, and therefore the furthest distance sediments can travel from the site. The projects identified in this Tier are the Bridlington A disposal site, Hornsea Project Two, the Dogger Bank A and B export cables, the Viking Link interconnector cable, the Platypus pipeline, the Tolmount Platform and the Johnston WHPS and Johnston Template/Manifold oil and gas infrastructure. There are no Tier 2 projects.

2.13.1.13 The Bridlington A disposal site (HU015) is located 2.7 km from the Hornsea Four ECC. The disposal site is used for the disposal of maintenance material from the port of Bridlington.

The maximum quantity that is currently authorised for disposal in any one year is 30,000 tonnes, with the use of the site being relatively infrequent and on demand. Material deposited at HU015 varies in composition but is generally a mixture of fine sands and silts and can therefore be expected to move by both wave and tidal currents. In any one day, there can be up to three disposals via the hopper barge, which has a capacity of 400 tonnes. Therefore, a total of 1,200 tonnes (3,398 m^3) could be deposited in one day. If Hornsea Four is discharging overspill of fine silts and sands in the nearshore from cable trenching by CFE on an ebb tide period at the same time as spoil disposal is occurring at HU015 then a larger sediment plume may form, however, this will also quickly disperse given the location of the spoil site in an area of faster flows.

2.13.1.14 The construction of Hornsea Project Two will be completed in 2022 and there will be no cumulative impact from construction activities of that project within the array area and along the export cable corridor. However, there is the potential for cumulative impacts from cable remedial works in the operational phase of the development. Remedial cable works are predicted to be short-term, intermittent, small scale and localised to the site. Taking this into consideration, there is not predicted to be any cumulative effects from the operational phase of Hornsea Project Two.

2.13.1.15 The Dogger Bank A and B export cables final year of construction and the operational phases will coincide with the construction of Hornsea Four. The maximum volume of material displaced from the construction of the Dogger Bank A and B export cable will be approximately 502,000 m^3 (maximum adverse scenario for increased SSC) (Forewind 2013). Cumulatively with Hornsea Four this may result in the disturbance and deposition of up to 13,381,050 m^3 of sediment. However, only a small portion (approximately 4%) of the Dogger Bank A and B export cables intersects with the Hornsea Four benthic subtidal ecology study area, and therefore the maximum amount of sediment released cumulatively with Hornsea Four will be considerably less. It should also be noted that the worst case scenario for the projects (Hornsea Four, Dogger Bank A and B) assumes that the whole volume of sediment from the excavated trenches for the export cables is released for dispersion regardless of the extraction method used and therefore the amount that is actually released is likely to be of a lower volume. Any cable maintenance repairs undertaken within the operational phase of the developments will also be short term, intermittent and localised to the site and therefore cumulative impacts are expected to be minimal. Additionally, due to the naturally dynamic environment of the site, any sediment released from these operations during the construction and operational phases of the development will likely be dispersed in the faster flows. Therefore, taking this into consideration, there are not predicted to be any significant cumulative impacts from the construction or operation of the Dogger Bank A and B export cables.

2.13.1.16 As previously described, the construction of the consented Viking Link interconnector cable and the Platypus pipeline will be not temporally overlapping the construction of Hornsea Four. Consequently, it is expected that there will be limited cumulative effects from increased SSC and deposition. Any maintenance undertaken on the cable and pipeline during the operational phase will be intermittent, with any increases in SSC and deposition expected to be minimal, short term and localised to the site, therefore no significant cumulative effects are predicted from maintenance of the Viking Link Interconnector cable and the Platypus pipeline with the construction of Hornsea Four.

2.13.1.17 The Tolmount Platform (consented) is under construction from 2020 to 2023, with the platform planned to be operational during the construction phase of Hornsea Four. The majority of the impacts from the platform are associated with the construction phase, with any activities association with the operation and maintenance of the platform occurring within a closed system. Therefore, there are not considered to be any cumulative effects from the operational phase of the Tolmount Platform with Hornsea Four.

2.13.1.18 The Johnston WHPS and Johnston template/manifold wellhead structures are proposed to begin decommissioning in 2022, with the process continuing through the proposed six-year construction period for Hornsea Four (2024 -2029). In the absence of an ES for these projects, the Tolmount Platform ES (Premier Oil 2017) has been used to inform this assessment on the decommissioning of wellhead structures. Wellhead structures comprise a subsea steel lattice structure, which are typically cut below the level of the seabed and removed during decommissioning, with the remnants of the structure (below the seabed) abandoned. Given the small area of disturbance to the seafloor during this procedure, it is considered unlikely that there will be a cumulative impact from the increase in SSC and deposition from the decommissioning of the Johnston WHPS and Johnston template/manifold wellhead structures and the construction of Hornsea Four.

2.13.1.19 Cumulative effects can also be considered in terms of duration of exposure from multiple projects which do not overlap but happen consecutively. However, as the effects from the projects will be short-lived, there are likely to be significant temporal gaps between the discrete construction and maintenance events, which will have localised effects. Due to the low to medium sensitivity of benthic receptors in the Hornsea Four benthic ecology study area to increases in SSC and sediment deposition (**Table 2.18**), cumulative effects in terms of duration of exposure are not expected.

2.13.1.20 The cumulative impacts of increased SSC and sediment deposition are expected to be of local spatial extent, short-term duration, intermittent and reversible. The magnitude of impacts from the Tier 1 sites identified is therefore considered to be **minor**.

2.13.1.21 Full discussion of the sensitivity of benthic ecology receptors to increased SSC and sediment deposition is discussed in **paragraphs 2.11.1.25** *et seq.* which conclude that most benthic receptors have a low to medium sensitivity to increased SSC and deposition. The maximum sensitivity of receptors in the area is therefore assessed as **medium**, with a **minor** magnitude of impact; this could result in either a **slight** or **moderate** effect (in accordance to **Table 2.15**). Taking into consideration the localised and short-term nature of the impacts, it is concluded that the significance of effect from temporary habitat disturbance of Hornsea Four cumulatively, with Tier 1 projects is **slight**, which is not significant in EIA terms.

Tier 3

2.13.1.22 The Endurance Carbon Capture and Storage project could have the potential to create a cumulative temporary increase in SSC and sediment deposition with Hornsea Four. Construction of pipelines and up to 30 wells and several platform structures are planned to commence in early 2023 with operations commencing in 2026. So, whilst there will be no construction overlap, operation and maintenance activities will overlap with Hornsea

Four construction. There is currently limited detail on the Endurance project and therefore it is not possible to make a detailed assessment of the significance of effect, however given that construction activities do not overlap and remedial works in the operational phase of the development are predicted to be short-term, intermittent, small scale and localised to the site, there is not expected to be any cumulative effects from the operational phase of Endurance.

2.13.1.23 The SEGL2 cable could have the potential to create a cumulative temporary increase in temporary increase in SSC and sediment deposition with Hornsea Four. Construction of the cable is planned to commence in 2025, with the aim of being operational by 2030. As a result, there is the potential for an overlap with the construction of Hornsea Four, with the remaindered of the SEGL2 construction phase overlapping with the Hornsea Four operation and maintenance phase. There is currently limited detail on the SEGL2 cable and therefore it is not possible to make a detailed assessment of the significance of effect. However, the cumulative impact associated with SEGL2 is predicted to be minimal, short-term and localised to the site. As such, it is not anticipated that any effects, once qualified, would result in a significant impact.

2.14 Operation and Maintenance Phase

Cumulative direct disturbance to seabed from jack-up vessels and cable maintenance activities.

Tier 1

2.14.1.1 There is potential for cumulative direct disturbance to seabed from jack-up vessels and cable maintenance activities associated with Hornsea Four and other projects (**Table 2.21**). For the purposes of this assessment, this additive impact has been assessed within 10 km of the Hornsea Four array area, and 14 km of the offshore ECC, which is representative of the maximum tidal excursion in the area, and therefore the furthest distance sediments disturbed during construction can travel from the site. The projects identified in this Tier are Hornsea Project Two, the Dogger Bank A and B export cable and the Viking Link interconnector cable (**Figure 2.9** and **Table 2.22**). No other projects were identified as adding any cumulative impact under Tier 2.

2.14.1.2 As previously detailed, there will be potential for cumulative effects from maintenance activities associated with Hornsea Project Two to overlap with maintenance activities that are predicted during the operation phase of Hornsea Four. These activities are expected to include temporary habitat disturbance associated with jack-up operations within the array areas associated with turbine and OSS component replacement and access ladder/J-tube repair/replacement and temporary disturbance to habitats along the offshore cable corridor as a result of cable remedial burial and repair. The direct disturbance from jack-up vessels and cable maintenance activities was predicted to be approximately 777,000 m^2 (SMart Wind 2015) for Hornsea Project Two, over a 25-year period. Although, it should be noted that when looking at these sites combined, only a small portion of the sites overlap with Hornsea Four benthic ecology study area (10.5% overlap). It can therefore be assumed that approximately 81,585 m^2 direct disturbance from Hornsea Project Two falls within the Hornsea Four benthic ecology study area (if it is assumed that the operation and maintenance activities are spread evenly across the site).

In addition to this, maintenance repairs will be short term, intermittent and localised to the site and therefore any cumulative impacts are expected to be minimal. Therefore, taking this into consideration, there are not predicted to be any significant cumulative impacts from the operation of Hornsea Project Two.

2.14.1.3 The operational phase of Dogger Bank A and B will overlap with Hornsea Four operation. As previously discussed only 4% of the total Dogger Bank A and B export cables cross within the Hornsea Four benthic ecology study area. Although there are no details within the Dogger Bank ES regarding the predicted direct disturbance from cable maintenance activities, industry often assume that approximately 10% of the cable will require remedial work over the project lifetime, so it can therefore be assumed on a proportion of this will fall in the percentage project overlap with the Hornsea Four benthic ecology study area. In addition to this the impacts associated with maintenance are known to be short term, intermittent, localised to the site and likely not overlapping temporally, any cumulative impacts are therefore expected to be minimal.

2.14.1.4 As with Dogger Bank A and B, the Viking Link interconnector cable crosses the Hornsea Four benthic ecology study area, and its operational phase will also overlap with Hornsea Four operation. No details are presented within the ES regarding the predicted direct disturbance from cable maintenance activities, so again it has been assumed that approximately 10% of the cable will require remedial work over the project lifetime. It should be not that only 4.7% of the Viking Link interconnector cable cross within the Hornsea Four benthic ecology study area, therefore we can apply a proportionate approach and assume not all maintenance activities will occur in the Hornsea Four benthic ecology study area. In addition to this the impacts associated with maintenance are known to be short term, intermittent, localised to the site and potentially not overlapping temporally, any cumulative impacts are therefore expected to be minimal.

2.14.1.5 As previously described, the maintenance activities are unlikely to occur concurrently over the 25-year lifetime of Hornsea Four. However, cumulative effects can also be considered in terms of duration of exposure from multiple projects which do not overlap but happen consecutively. As the maintenance effects from the projects will be short-lived due to the resilience of the sedimentary biotopes to this type of impact (**Section 2.11.2**) concurrent cumulative effects are not expected.

2.14.1.6 The cumulative impacts of direct disturbance are expected to be of local spatial extent, short-term duration, intermittent and reversible. The magnitude of impacts from the Tier 1 sites identified is therefore considered to be **negligible**. Irrespective of the sensitivity of receptors, the significance of the impact is **not significant** as defined in the assessment of significance matrix (**Table 2.15**) and is therefore not considered further in this assessment.

Tier 3

2.14.1.7 The Endurance Carbon Capture and Storage project could have the potential to create a cumulative direct disturbance to seabed from jack-up vessels and maintenance activities with Hornsea Four. Construction of pipelines and up to 30 wells and several platform structures are planned to commence in early 2023 with operations commencing in 2026, so operation and maintenance activities will overlap. There is currently limited detail on the Endurance project and therefore it is not possible to make a detailed assessment of

the significance of effect, however given that direct habitat disturbance from operational and maintenance of Endurance is predicted to be short term and localised to the site, it is not anticipated that any effects, once qualified, would result in a significant impact.

2.14.1.8 The SEGL2 cable could have the potential to create a cumulative direct disturbance to seabed from jack-up vessels and maintenance activities with Hornsea Four. Construction of the cable is planned to commence in 2025, with the aim of being operational by 2030. As a result, there is the potential for an overlap with the construction of Hornsea Four, with remaindered of the SEGL2 construction phase overlapping with the Hornsea Four operation and maintenance phase. There is currently limited detail on the SEGL2 cable and therefore it is not possible to make a detailed assessment of the significance of effect. However, the cumulative impact associated with SEGL2 is predicted to be minimal, short-term and localised to the site. As such, it is not anticipated that any effects, once qualified, would result in a significant impact.

Cumulative permanent habitat loss/ change from the presence of foundations, scour protection and cable protection.

Tier 1

2.14.1.9 Cumulative permanent habitat loss is predicted to occur as a result of the presence of Hornsea Four infrastructure, offshore wind farms which are consented or under construction, cables and pipelines and oil and gas decommissioning activities within a representative 14 km buffer of the Hornsea Four ECC, and 10 km buffer of the array area. Permanent habitat loss may result from the physical presence of foundations, scour protection and cable/pipeline protection, which are assumed to be in place for the lifetime of the relevant offshore wind, cable, or pipeline projects and potentially beyond the lifetime of these projects. The CEA has been based on information available within ESs where available and it is noted that the project parameters quoted in ESs are often refined during the determination period of the application or post consent. The assessments presented within this assessment are therefore considered to be conservative, with the level of impact on benthic ecology expected to be reduced from those presented here.

2.14.1.10 As presented in **Table 2.22**, the predicted cumulative permanent habitat loss from all Tier 1 projects is estimated to be estimated to be 15.36 km^2 which equates to 0.36% of the Hornsea Four benthic ecology study area. As previously discussed, some of these projects don't fully overlap with the Hornsea Four benthic ecology study area, therefore the total permanent habitat loss we should be considering as part of this assessment is likely to be significantly less. Comparable habitats are widely distributed in the Southern North Sea (see **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report**) so this loss is not predicted to diminish regional ecosystem functions.

2.14.1.11 While the cumulative impact of from permanent habitat loss will be locally significant and comprise a permanent change in seabed habitat within the footprint of the structures, the footprint of the area affected is highly localised. It is expected that the impacts are reversible following removal of any of the hard substrate, where this might occur however is less certain. As the habitats and characterising biotopes are common and widespread throughout the wider region the loss of these habitats is assessed as discernible and the magnitude is assessed as **minor**.

2.14.1.12 As previously discussed in **paragraphs 2.11.2.7** *et seq.*, the sensitivity of benthic ecology receptors to permanent habitat loss / change concludes that all benthic receptors have no resistance to 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.

2.14.1.13 The maximum sensitivity of receptors in the area is therefore assessed as **high**, with a **minor** magnitude of impact; this could result in either a **slight** or **moderate** effect (in accordance with **Table 2.15**). Taking into consideration the habitats and characterising biotopes are common and widespread throughout the wider region, the loss of these habitats is assessed as barely discernible and are not predicted to diminish regional ecosystem functions. It is therefore concluded that the significance of effect from permanent habitat loss of Hornsea Four cumulatively, with Tier 1 projects is **slight**, which is not significant in EIA terms.

Table 2.22: Cumulative magnitude of impact for permanent habitat loss/ change from the presence of foundations, scour protection and cable protection.

Project	Total predicted permanent habitat loss (km^2)	Source
Tier 1		
Hornsea Four (array and export cable)	3.7	**Volume A1, Chapter 1: Project Description**
Hornsea Project Two (array and export cable)	5.45	Total habitat loss taken from ES (SMart Wind 2015).
Dogger Bank A (export cable)	1.4	Total habitat loss taken from ES (ForeWind 2013)
Dogger Bank B (export cable)	1.34	Total habitat loss taken from ES (ForeWind 2013)
Tolmount Platform	0.6	Total habitat loss taken from ES (Premier Oil 2017)
Viking Link Interconnector cable	2.86 (within UK sector)	Total habitat loss taken from ES (National Grid Viking Link Limited 2017)
Platypus pipeline	0.007	Total habitat loss taken from ES (Dana Petroleum 2018)
Total Tier 1	15.36 km^2	

Tier 3

2.14.1.14 The Endurance Carbon Capture and Storage project has the potential to create a cumulative permanent habitat loss/change with Hornsea Four. However, there is currently limited detail on the Endurance project and therefore it is not possible to make a detailed assessment of the significance of effect. However, the permanent habitat loss from the Endurance infrastructure is not expected to significantly increase the cumulative impact and although permanent habitat loss will be locally significant and comprise a permanent or permanent change in seabed habitat within the footprint of the structures, the footprint of the area affected is highly localised. It is not anticipated that any effects, once qualified, would result in a significant impact.

2.14.1.15 The SEGL2 cable could have the potential to create a cumulative permanent habitat loss/change with Hornsea Four. There is currently limited detail on the SEGL2 cable and therefore it is not possible to make a detailed assessment of the significance of effect. However, the permanent habitat loss from the SEGL2 cable is not expected to significantly increase the cumulative impact, as the cable is anticipated to be buried, and although permanent habitat loss will be locally significant and comprise a permanent change in seabed habitat within the footprint of the cable corridor, the area affected is highly localised. It is not anticipated that any effects, once qualified, would result in a significant impact

Cumulative colonisation of the WTGs and scour/ cable protection may affect benthic ecology and biodiversity.

Tier 1

2.14.1.16 There is potential for cumulative impacts from colonisation of the WTG foundations and scour / cable protection to affect benthic ecology and biodiversity. For the purposes of this assessment, this additive impact has been assessed within a representative 10 km buffer surrounding the array area, and a 14 km buffer around the offshore ECC. The projects identified in this Tier are Hornsea Project Two, the Dogger Bank A and B export cables, the Viking Link interconnector cable, the Platypus pipeline and the Tolmount Platform (**Figure 2.9** and **Table 2.22**). No other projects were identified as adding any cumulative impact under Tier 2.

2.14.1.17 **Table 2.22** describes the worst-case permanent habitat loss from the presence of foundations, scour protection and cable protection for Tier 1. This demonstrates that the cumulative introduction of hard substrate is estimated to cover approximately 15.36 km^2 of the seabed. It is difficult to accurately quantify the total area of hard substrate that will be introduced within Hornsea Four benthic ecology study area, particularly since this is not quantified in project description for some of the projects. The extent of habitat creation will depend on the exact foundation size, scour and cable protection requirements which will vary for each site. In addition to this, the total area does not consider the proportion of the project that falls within the Hornsea Four benthic ecology study area.

2.14.1.18 Despite this level of uncertainty, the cumulative impact of colonisation of the WTGs and scour/ cable protection on benthic ecology is predicted to be of local spatial extent, permanent duration but reversable once the infrastructure is removed. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **minor**.

2.14.1.19 The sensitivities of the benthic habitats and VERs to the introduction of new hard substrate is described in **paragraphs 2.11.2.14** *et seq.*, which conclude that the soft sediment biotopes likely to be affected by an increase in species diversity are deemed to be of low vulnerability, high recoverability (once the hard substrate is removed) and local to regional value. The sensitivity of these receptors is therefore, considered to be **low**.

2.14.1.20 Any beneficial effects associated with an increase in biodiversity will be highly localised in nature and is not regarded as mitigation for the loss of sedimentary habitat associated with the installation of these structures. The introduction of hard structures such as scour

protection can lead to an increase in biomass and biodiversity which may be considered beneficial, but it also represents a change from the baseline environment which may be considered adverse. Overall, it is predicted that the sensitivity of the receptor is **low** and the magnitude is **minor**. The effect is of **slight** significance, which is not significant in EIA terms.

2.14.1.21 There is little evidence to date from other OWF development within the North Sea of MINNS having any adverse effects on key species and habitats. It is not possible to predict whether such a spread will occur and to what extent and which species, if any, this may involve. However, for most offshore projects the implementation of designed-in measures will ensure that the risk of potential introduction and spread of MINNS is minimised. To adopt a precautionary approach a **high** receptor sensitivity has been attributed to benthic receptors (based on the lack of information on this potential impact) and the magnitude is considered to be **minor** as a result of the local spatial extent; this could result in either a **slight** or **moderate** effect (in accordance with **Table 2.15**). Taking into consideration the designed-in measures including a Construction Project Environmental Management and Monitoring Plan (CPEMMP) with a biosecurity plan (Co111, see **Table 2.11**) and lack of adverse impacts concluded at OWFs to date, the effect from cumulative colonisation from MINNS has been assessed as **slight** significance, which is not significant in EIA terms.

Tier 3

2.14.1.22 The Endurance Carbon Capture and Storage project has the potential for cumulative impacts from colonisation of hard infrastructure. However, there is currently limited detail on the Endurance project and therefore it is not possible to make a detailed assessment of the significance of effect. Despite this level of uncertainty, the colonisation of infrastructure associated with the Endurance project is predicted to be of local spatial extent, long- term duration but reversable once the infrastructure is removed and therefore, it is not anticipated that any effects, once qualified, would result in a significant impact.

Cumulative changes to seabed habitats arising from effects on physical processes, including scour effects and changes in the sediment transport and wave regimes resulting in potential effects on benthic communities.

Tier 1

2.14.1.23 The cumulative presence of offshore structures associated with Hornsea Four and other projects in the region have the potential to introduce changes to the local hydrodynamic and wave regime, resulting in cumulative changes to the sediment transport pathways and associated effects on benthic ecology. For the purposes of this assessment, this additive impact has been assessed within the representative SSC and deposition impact buffer for Hornsea Four (10 km buffer around the array area and 14 km around the ECC). The projects identified for this tier are Hornsea Project Two, Dogger Bank A and B export cable landfall works, Tolmount Platform, Viking Link interconnector cable, Platypus pipeline and the licensed disposal site Bridlington A (HU015). No other projects were identified as adding any cumulative impact under Tier 2.

2.14.1.24 The Marine Geology, Oceanography and Physical Processes assessment (**Volume A2, Chapter 1: Marine Geology, Oceanography and Physical Processes**) has determined that the impacts on hydrodynamic and wave regimes from cumulative impacts would be **not significant** and would therefore not result in any significant changes to sediment transport and consequently will not have any significant adverse impacts on benthic ecology.

Tier 3

2.14.1.25 The Endurance Carbon Capture and Storage project has the potential for cumulative impacts on physical processes, including scour effects and changes in the sediment transport and wave regimes resulting in potential effects on benthic communities. However, there is currently limited detail on the Endurance project and therefore it is not possible to make a detailed assessment of the significance of effect. Despite this level of uncertainty, the construction of pipelines and up to 30 wells and several platform structures have the potential to impact upon physical processes, however the magnitude of these structures upon physical processes is expected to be minor because the influence from them is likely to be small-scale and highly localised. Therefore, it is not anticipated that any effects, once qualified, would result in a significant impact.

2.15 Transboundary Effects

2.15.1.1 Transboundary effects are defined as those effects upon the receiving environment of other European Economic Area (EEA) states, whether occurring from Hornsea Four alone, or cumulatively with other projects in the wider area. A screening of potential transboundary effects was undertaken at Scoping (Annex L of the Scoping Report, (Orsted 2018)), which identified that there was no potential for significant transboundary effects to occur in relation to benthic and intertidal ecology.

2.16 Inter-related Effects

2.16.1.1 Inter-related effects consider impacts from the construction, operation or decommissioning of Hornsea Four on the same receptor (or group). The potential inter-related effects that could arise in relation to benthic and intertidal ecology are presented in **Table 2.23**. 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.

2.16.1.2 A description of the process to identify and assess these effects is presented in **Section 5.8** of **Volume A1 Chapter 5: Environmental Impact Assessment Methodology**.

Table 2.23: Inter-related effects assessment for benthic and intertidal ecology.

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 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 individual phase. There will therefore be no inter-related effects of greater significance compared to the impacts considered alone.
Construction, O&M and decommissioning	Background traffic growth across projects result in cumulative nutrient nitrogen deposition which may impact Saltmarsh in the Humber estuary.	N/A	Air quality modelling (**Volume A3, Chapter 9: Air Quality**) indicated that consideration should be given to a small area of saltmarsh in the Humber estuary, where nutrient nitrogen deposition was above 1% of the Critical Loads. A full assessment will be included within the RIAA (**Volume B2.2 Report to Inform Appropriate Assessment**).
Construction and decommissioning	Indirect impacts to benthic ecology as a result of the temporary increase in SSC and sediment deposition.	As pathways, there is limited potential for inter-related effects to occur upon marine processes. An inter-related effects screening was undertaken at Scoping (Annex J of the Scoping Report), which screened out inter-related effects associated with marine processes.	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 increases 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			

Project phase(s)	Nature of inter-related effect	Assessment alone	Inter-related effects assessment
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, the biotypes affected are widespread across the Southern North Sea, 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.			

2.16.1.3 Overall, the inter-related assessment for Hornsea Four 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.

2.17 Conclusion and Summary

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

2.17.1.2 The benthic habitat types present across the Hornsea Four Order Limits are widespread in the surrounding area and the impacts of the construction of offshore wind farms and associated infrastructure is well studied. 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, alongside any mitigation and residual effects (**Table 2.24**).

2.17.1.3 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 Hornsea Four and other activities in the study area. This includes offshore wind farm operations and disposal sites (**Volume A2, Chapter 12: Cumulative and Transboundary Effects Offshore Summary**).

2.17.1.4 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.

2.17.1.5 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 Hornsea Four (including cumulatively) on intertidal and subtidal benthic ecology receptors will result in a significance of **neutral** or **slight**. The potential effects to intertidal and

subtidal benthic ecology receptors are therefore **not significant** in terms of the EIA Regulations (**Volume A1, Chapter 5: Environmental Impact Assessment Methodology**).

2.17.1.6 **Table 2.24** presents a summary of the significant impacts assessed within this ES, any mitigation and the residual effects.

Table 2.24: Summary of potential impacts assessed for benthic and intertidal ecology.

Impact and Phase	Receptor and value/sensitivity	Magnitude and significance	Mitigation	Residual impact
Construction				
Temporary habitat disturbance in the Hornsea Four array area and offshore ECC from construction activities (BIE-C-1).	SS.SSa.IFiSa.NcirBat, SS.SSa.CMuSa.AalbNuc, SS.SSa.CFiSa.ApriBatPo, SS.SSa.CFiSa.EpusOborApri, SS.SMx.CMx.MysThyMx, SS.SCS.CCS.MedLumVen, SS.SCS.ICS.MoeVen, SS.SSa.IMuSa.FfabMag, SS.SMx.OMx.PoVen: Low SS.SMu.CFiMu.SpnMeg, SS.SMu.CSaMu.AfilMysAnit, SS.SMX.CMx.FluHyd, *Sabellaria spinulosa*: Medium	Minor Negligible (*A. Islandica*) Slight adverse significance	None proposed beyond existing commitments.	Slight significance (not significant in EIA terms)
Temporary increase in SSC and sediment deposition in the Hornsea Four array area and offshore ECC (BIE-C-3).	<u>Sensitivity to heavy smothering (5 – 30 cm)</u> *A. islandica, Sabellaria spinulosa,* SS.SMu.CFiMu.SpnMeg: Not sensitive SS.SSa.IFiSa.NcirBat, SS.SMx.CMx.MysThyMx, SS.SCS.ICS.MoeVen, SS.SMX.CMx.FluHyd: Low SS.SSa.CMuSa.AalbNuc, SS.SSa.CFiSa.ApriBatPo, SS.SSa.CFiSa.EpusOborApri, SS.SMu.CSaMu.AfilMysAnit, SS.SCS.CCS.MedLumVen, SS.SSa.IMuSa.FfabMag, SS.SMx.OMx.PoVen: Medium <u>Sensitivity to light smothering (<5 cm)</u>	Minor Slight adverse significance	None proposed beyond existing commitments.	Slight significance (not significant in EIA terms)

Impact and Phase	Receptor and value/sensitivity	Magnitude and significance	Mitigation	Residual impact
	Chalk reef habitat of Flamborough Head SAC: Medium Submerged or partially submerged sea caves of Flamborough Head SAC: Medium Broadscale habitat features of the Holderness Offshore and Inshore MCZ: Low			
Temporary increase in SSC and sediment deposition in the intertidal area (BIE-C-4).	The magnitude is negligible therefore receptor sensitivity is not considered further in this assessment, as it will not lead to a significant effect based on the matrix used for the assessment of significance and expert judgement.	Negligible Not Significant	None proposed beyond existing commitments.	Not Significant
Direct and indirect seabed disturbances leading to the release of sediment contaminants (BIE-C-6).	The magnitude is negligible therefore receptor sensitivity is not considered further in this assessment, as it will not lead to a significant effect based on the matrix used for the assessment of significance and expert judgement.	Negligible Not Significant	None proposed beyond existing commitments.	Not Significant
Operation & maintenance				
Permanent habitat loss/ change from the presence of foundations, scour protection and cable protection (BIE-O-8).	Maximum sensitivity: High	Minor Slight adverse significance	None proposed beyond existing commitments.	Not Significant
Colonisation of the WTGs and scour/ cable protection may affect benthic ecology and biodiversity (BIE-O-9).	Maximum sensitivity: High	Minor Slight adverse or beneficial significance	None proposed beyond existing commitments.	Slight significance (not significant in EIA terms)
Increased risk of introduction or spread of Marine Invasive Non-Native Species (MINNS) due to presence of infrastructure and	The magnitude is negligible therefore receptor sensitivity is not considered further in this assessment, as it will not lead to a significant effect based on the matrix	Negligible Not Significant	None proposed beyond existing commitments.	Not Significant

Impact and Phase	Receptor and value/sensitivity	Magnitude and significance	Mitigation	Residual impact
vessel movements (e.g. the discharge of ballast water) may affect benthic ecology and biodiversity (BIE-O-10).	used for the assessment of significance and expert judgement.			
Direct disturbance to seabed from jack-up vessels and cable maintenance activities (BIE-O-11).	The magnitude is negligible therefore receptor sensitivity is not considered further in this assessment, as it will not lead to a significant effect based on the matrix used for the assessment of significance and expert judgement.	Negligible Not Significant	None proposed beyond existing commitments.	Not Significant
Changes to seabed habitats arising from effects on physical processes, including scour effects and changes in the sediment transport and wave regimes resulting in potential effects on benthic communities (BIE-O-13).	The magnitude is negligible therefore receptor sensitivity is not considered further in this assessment, as it will not lead to a significant effect based on the matrix used for the assessment of significance and expert judgement.	Negligible Not Significant	None proposed beyond existing commitments.	Not Significant
Decommissioning				
Temporary habitat disturbance from decommissioning of foundation substructures and cables (BIE-D-15).	Maximum sensitivity: Medium	Minor Slight adverse significance	None proposed beyond existing commitments.	Slight significance (not significant in EIA terms)
Increased SSC and sediment deposition from removal of foundations and cables (BIE- D- 16).	Maximum sensitivity: Medium	Minor Slight adverse significance	None proposed beyond existing commitments.	Slight significance (not significant in EIA terms)
Loss of introduced habitat from the removal of foundations (BIE-D-17).	Maximum sensitivity: Medium	Minor Slight adverse or beneficial significance	None proposed beyond existing commitments.	Slight significance (not significant in EIA terms)

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