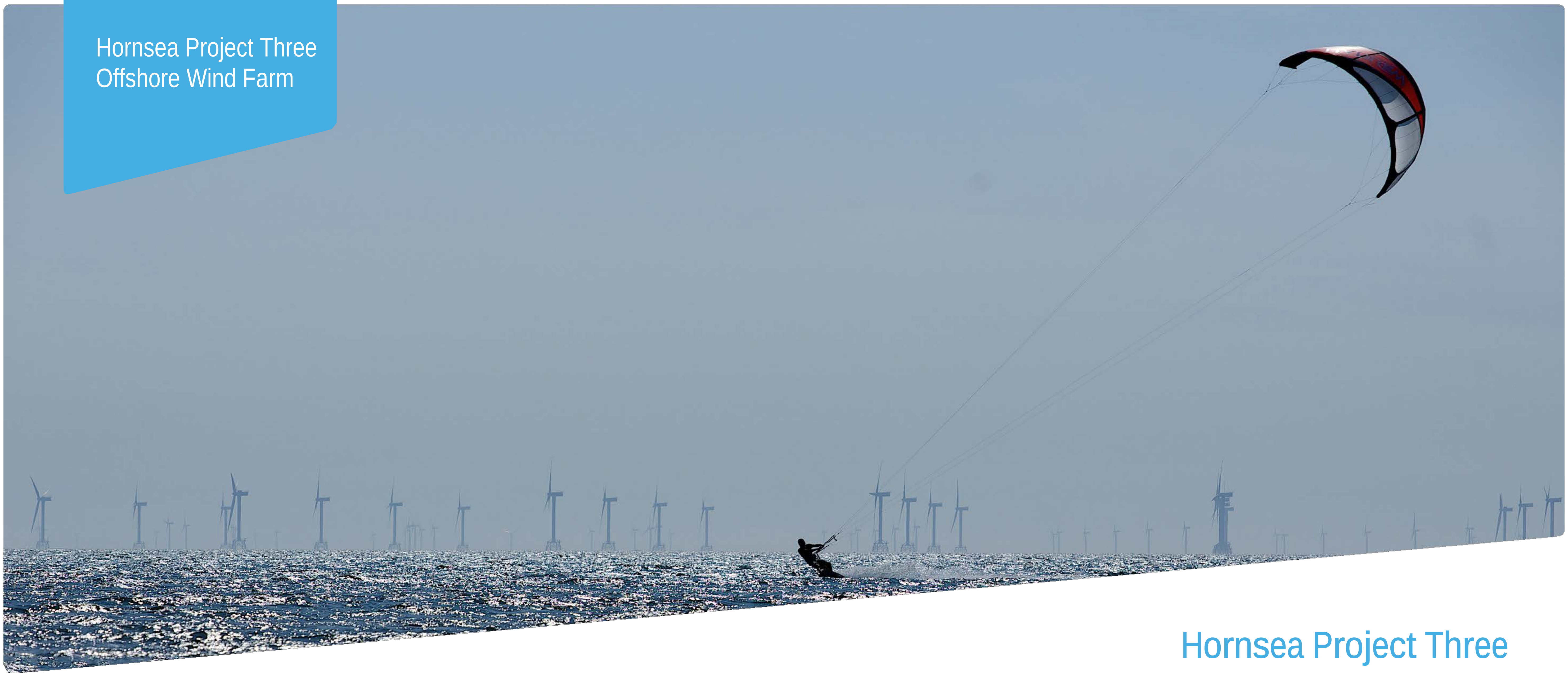
Hornsea Project Three
Offshore Wind Farm



Hornsea Project Three

Offshore Wind Farm

Environmental Statement:
Volume 2, Chapter 2 - Benthic Ecology

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Hornsea 3
Offshore Wind Farm

Ørsted

Environmental Impact Assessment

Environmental Statement

Volume 2

Chapter 2 – Benthic Ecology

Report Number: A6.2.2

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This report is also downloadable from the Hornsea Project Three offshore wind farm website at:

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Glossary

Term	Definition
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.
Biomass	The total quantity of living organisms in a given area, expressed in terms of living or dry weight or energy value per unit area.
Biotope	The combination of physical environment (habitat) and its distinctive assemblage of conspicuous species.
Circalittoral	The subzone of the rocky sublittoral below that dominated by algae (i.e. the infralittoral), and dominated by animals.
Crustacean	An invertebrate belonging to the subphylum of Crustacea, of the phylum Arthropoda. Includes crabs, lobsters, shrimps, barnacles and sand hoppers.
Echinoderm	An invertebrate animal belonging to the phylum Echinodermata that includes sea stars, brittle stars, feather stars, sea urchins and sea cucumbers.
Epibenthic	Organisms living on the surface of the seabed.
Epifauna	Animals living on the surface of the seabed.
European site	A Special Area of Conservation (SAC) or candidate SAC, a Special Protection Area (SPA) or potential SPA, a site listed as a Site of Community importance (SCI) or a Ramsar site.
Hamon grab	A tool for sampling the benthic macro-infauna that is particularly effective for sampling from coarse substrata.
Infauna	The animals living in the sediments of the seabed.
Infralittoral	A subzone of the sublittoral in which upward-facing rocks are dominated by erect algae.
Intertidal	An area of a seashore that is covered at high tide and uncovered at low tide.
Mollusc	Invertebrate animal belonging to the phylum Mollusca that includes the snails, clams, chitons, tooth shells, and octopi.
Polychaete	A class of segmented worms often known as bristleworms.
Spat	The spawn or larvae of shellfish, especially oysters.
Sublittoral	Area extending seaward of low tide to the edge of the continental shelf.
Subtidal	Area extending from below low tide to the edge of the continental shelf.

Acronyms

Acronym	Description
AA	Annual Average
AFDW	Ash-free dry weight
AL1	Action Level 1
AL2	Action Level 2
BAP	Biodiversity Action Plan
cSAC	Candidate Special Area of Conservation
CBD	Convention on Biological Diversity
CBRA	Cable Burial Risk Assessment
CEA	Cumulative Effects Assessment
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CfD	Contract for Difference
COLREGs	The International Regulations for Preventing Collisions at Sea 1972 as amended
CPA	Coast Protection Act 1949
CTV	Crew Transfer Vessel
DCO	Development Consent Order
DDV	Drop Down Video
DECC	Department of Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
DMRB	Design Manual for Roads and Bridges
DTI	Department of Trade and Industry
EA	Environment Agency
EAC	Environmental Assessment Criteria
EcIA	Ecological Impact Assessment
EEA	European Economic Area
EIA	Environmental Impact Assessment
EMF	Electromagnetic Fields
EMODnet	European Marine Observation Data Network
EQS	Environmental Quality Standard
ER-L	Effects Range-Low
EWG	Expert Working Group
FEPA	Food and Environmental Protection Act 1985
FOCI	Feature of Conservation Interest
GBF	Gravity Base Foundations
GES	Good Environmental Status
HADA	Humber Aggregate Dredging Association
HDD	Horizontal Directional Drilling
HRA	Habitats Regulations Assessment
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
ICES	International Council of the Exploration of the Sea
ICGC	Intersessional Correspondence Group on Cumulative Effects
IMO	International Maritime Organization
INNS	Invasive Non-native Species
IPC	Infrastructure Planning Commission
IPMP	In Principle Monitoring Plan
JNCC	Joint Nature Conservation Committee
LDP	Lincolnshire Offshore Gas Gathering Station (LOGGS) Decommissioning Programme
LOGGS	Lincolnshire Offshore Gas Gathering Station
MALSF	Marine Aggregate Levy Sustainability Fund
MarESA	Marine Evidence based Sensitivity Assessment
MCA	Maritime and Coastguard Agency
MCAA	Marine and Coastal Access Act
MCCIP	Marine Climate Change Impacts Partnership
MCZ/rMCZ	Marine Conservation Zone/recommended Marine Conservation Zone
MGN	Marine Guidance Note
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs

Acronym	Description
MMO	Marine Management Organisation
MNA	Marine Natural Area
MPA	Marine Protected Area
MPS	Marine Policy Statement
MSFD	Marine Strategy Framework Directive
NERC	Natural Environment and Rural Communities Act 2006
NPS	National Policy Statement
NSBP	North Sea Benthos Project
NSIP	Nationally Significant Infrastructure Project
OESEA	Offshore Energy Strategic Environmental Assessment
OSPAR	Oslo-Paris Commission
OWEZ	Egmond aan Zee Offshore Wind Farm
PAH	Polyaromatic Hydrocarbons
PEIR	Preliminary Environmental Information Report
PEL	Probable Effect Level
PEMMP	Project Environmental Management and Monitoring Plan
PINS	Planning Inspectorate
PSA	Particle Size Analysis
REC	Regional Environmental Characterisation
RIAA	Report to Inform Appropriate Assessment
SAC	Special Area of Conservation
SCI	Site of Community Importance
SEA	Strategic Environmental Assessment
SPA/pSPA	Special Protection Area/possible Special Protection Area
SPMP	Scour Protection Management Plan
SSC	Suspended Solids Concentrations
SSSI	Site of Special Scientific Interest
TBT	Tributyltin
TEL	Threshold Effect Level

Acronym	Description
TWT	The Wildlife Trust
US EPA	United States Environmental Protection Agency
UK	United Kingdom
UNEP	United Nations Environment Programme
VDP	Viking Decommissioning Programme
VER	Valued Ecological Receptor
WFD	Water Framework Directive
ZoC	Zone of Characterisation
ZoI	Zone of Influence

Units

Unit	Description
%	Percent
cm	Centimetre
km	Kilometre
l	litres
m	Metre
m^2	Metre squared
m^3	Metre Cubed
mg/kg	Milligrams per kilogram
mm	Millimetre
ms-1	Metres per second
ng/kg	Nanograms per kilogram
nm	Nautical mile
µg/l	Microgram per litre

2. Benthic Ecology

2.1 Introduction

2.1.1.1 This chapter of the Environmental Statement presents the findings to date of the Environmental Impact Assessment (EIA) for the potential impacts of the Hornsea Project Three offshore wind farm (hereafter referred to as Hornsea Three) on benthic ecology. Specifically, this chapter considers the potential impact of Hornsea Three seaward of Mean High Water Springs (MHWS) during its construction, operation and maintenance, and decommissioning phases. Those impacts from Hornsea Three landward of MHWS on onshore ecology are assessed in volume 3, chapter 3: Onshore Ecology and Nature Conservation.

2.1.1.2 The detailed baseline information which underpins the impact assessments presented in this chapter is contained within volume 5, annex 2.1: Benthic Ecology Technical Report. The technical report provides a detailed characterisation of the benthic ecology of Hornsea Three and the wider southern North Sea, based on existing literature sources, surveys of the former Hornsea Zone and specifically of Hornsea Three, and includes information on benthic habitats and species of ecological importance and/or of conservation value.

2.2 Purpose of this chapter

2.2.1.1 The primary purpose of the Environmental Statement is to support the Development Consent Order (DCO) application for Hornsea Three under the Planning Act 2008 (the 2008 Act) which accompanies the application to the Secretary of State for Development Consent.

2.2.1.2 The Environmental Statement reports on the likely significant effects that Hornsea Three is expected to have on the environment as required by the EIA Regulations.

2.2.1.3 In particular, this Environmental Chapter:

- Presents the existing environmental baseline established from desk studies, and consultation;
- Presents the potential environmental effects on benthic ecology arising from Hornsea Three (for construction, operation, maintenance and decommissioning), based on the information and data gathered, the analysis and the assessments;
- Identifies any assumptions and limitations encountered in compiling the environmental information; and
- Highlights any necessary monitoring and/or mitigation measures which could prevent, minimise, reduce or offset the possible environmental effects identified in the EIA process.

2.3 Benthic ecology study areas

2.3.1.1 For the purposes of the Hornsea Three benthic ecology characterisation, two study areas were defined (see Figure 2.1):

- The Hornsea Three benthic ecology study area - this area encompasses Hornsea Three, which includes the Hornsea Three array area, offshore cable corridor temporary working area (i.e. encompassing subtidal benthic ecology), and intertidal area (i.e. encompassing intertidal benthic ecology). The subtidal section of the Hornsea Three benthic ecology study area also incorporates the former Hornsea Zone plus a 5 km buffer around the former Hornsea Zone within which previous sampling campaigns were undertaken including those for Hornsea Project One and Hornsea Project Two. Updates in the form of two reroutes have been made to the Hornsea Three offshore cable corridor described in the Preliminary Environmental Information Report (PEIR) as a result of the consultation process, one at the northern end of the Hornsea Three offshore cable corridor and one in the nearshore section, around the west side of the Cromer Shoal Chalk Beds Marine Conservation Zone (MCZ) (see Figure 2.1 and volume 1, chapter 4: Site Selection and Consideration of Alternatives). Both the original and rerouted sections are included in the Hornsea Three benthic ecology study area, though the majority of the site specific sampling had been undertaken prior to the reroutes (see paragraph 2.6.1.4). In the intertidal area, the Hornsea Three benthic ecology study area considers habitats up to the MHWS; and
- The southern North Sea benthic ecology study area - this is the regional benthic ecology study area and was defined by the boundaries of the southern North Sea Marine Natural Area (MNA) (Jones *et al*., 2004). This southern North Sea benthic ecology study area is the area considered through the desktop review, which includes the identification of designated sites (including those within the European Economic Area (EEA) which are within one tidal excursion of Hornsea Three), and provides wider context to the Hornsea Three data.

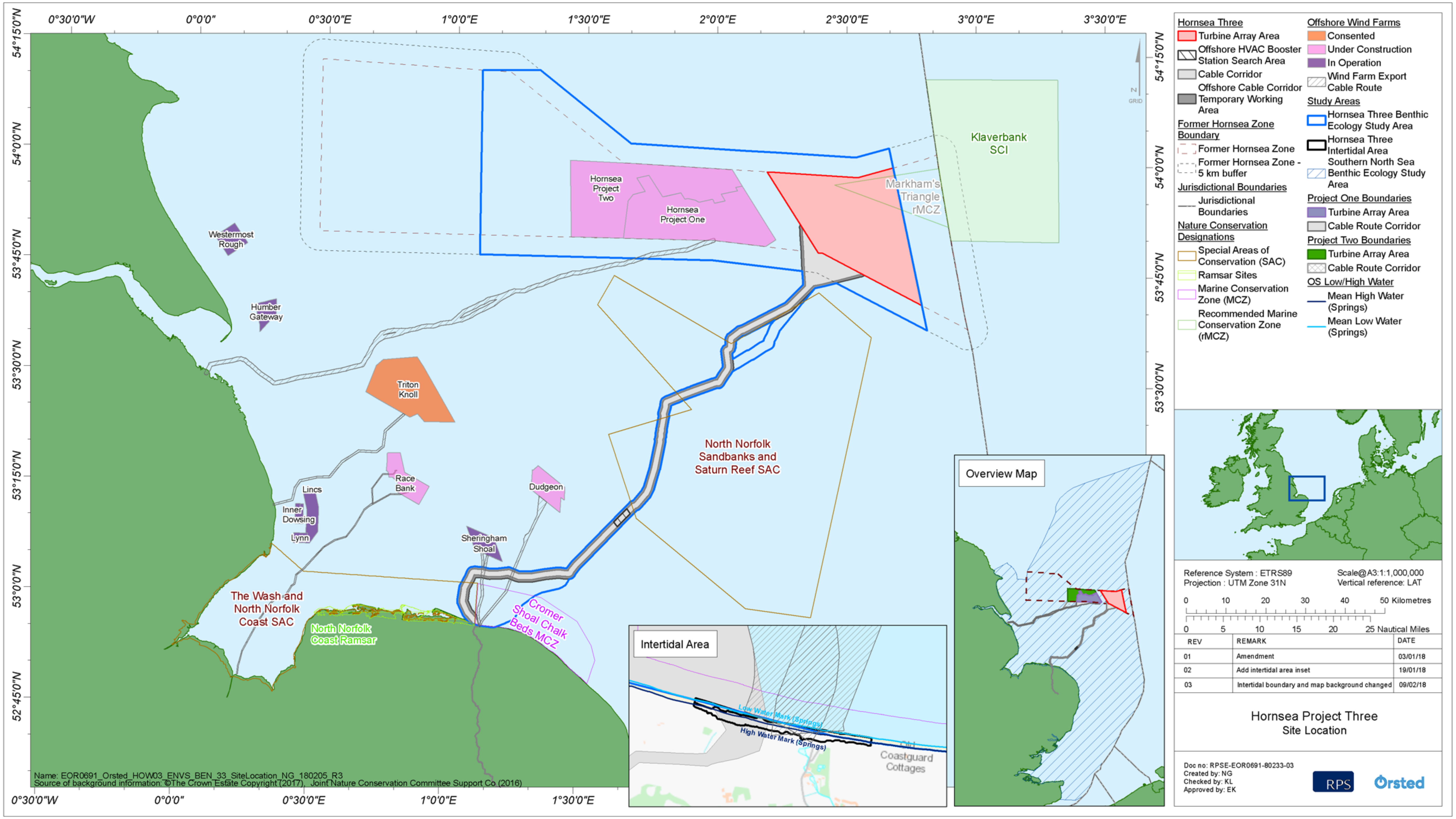

Figure 2.1: The location of Hornsea Three and the former Hornsea Zone, other offshore wind farm sites and nature conservation sites (which have qualifying benthic features and have therefore been screened into the assessment; see volume 5, annex 2.1: Benthic Ecology Technical Report) in the southern North Sea benthic ecology study area (i.e. the southern North Sea MNA).

2.4 Planning policy context

2.4.1 National Policy Statements

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

2.4.1.2 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 and Table 2.2, respectively.

2.4.1.3 NPS EN-3 also highlights factors relating to the determination of an application and in relation to mitigation. These are summarised in Table 2.3 below.

Table 2.1: Summary of NPS EN-3 provisions relevant to this chapter.

Summary of NPS EN-3 provision	How and where considered in the Environmental Statement
Biodiversity	
Applicants should assess the effects on the offshore ecology and biodiversity for all stages of the lifespan of the proposed offshore wind farm (paragraph 2.6.64 of NPS EN-3).	Construction, operation and maintenance, and decommissioning phases of Hornsea Three have been assessed (see section 2.11).
Consultation on the assessment methodologies should be undertaken at early stages 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 Three (see Table 2.6).
Any relevant data that has been collected as part of post-construction ecological monitoring from existing, operational offshore wind farms should be referred to where appropriate (paragraph 2.6.66 of NPS EN-3).	Relevant data collected as part of post-construction monitoring from other offshore wind farm developments has informed the assessment of Hornsea Three (see paragraphs 2.11.1.12, 2.11.1.27, 2.11.1.32, 2.11.1.63, 2.11.1.77, 2.11.1.97 and 2.11.1.100).
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 Three have been assessed (see section 2.11).
Benthic subtidal and intertidal ecology	
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 all phases of development on benthic subtidal and intertidal species and habitats in or near to Hornsea Three. These assessments included likely effects from temporary and long term habitat loss (see paragraphs 2.11.1.3 *et seq.* and 2.11.2.3 *et seq.* respectively) and the effects of changes in physical processes (see paragraph 2.11.2.105 *et seq.*).
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 adverse scenario for cable installation methodologies, on benthic ecology are assessed for all stages of the development (see paragraphs 2.11.1.3 *et seq.* for construction and paragraphs 2.11.3.3 *et seq.* for decommissioning).
Applicants should assess the effects of subtidal habitat disturbance 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 of NPS EN-3).	The Hornsea Three assessment has considered the effects of subtidal and intertidal disturbances throughout all stages of the development (see paragraphs 2.11.1.3 *et seq.* for construction and paragraphs 2.11.3.3 *et seq.* for decommissioning).
Applicants should assess the effects of increased suspended sediment loads during construction on subtidal habitats (paragraph 2.6.113 of NPS EN-3) and intertidal habitats (paragraph 2.6.81 of NPS EN-3).	Specific effects of increased suspended sediment and associated deposition on benthic ecology have been assessed for both subtidal and intertidal habitats/species during the construction phase (see paragraph 2.11.1.100 *et seq.)* and decommissioning phase (see paragraph 2.13.2.28 *et seq.*).
Applicants should assess the predicted rates for subtidal habitat recovery (paragraph 2.6.113 of NPS EN-3) and intertidal zone recovery from temporary disturbance effects (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 (see section 2.11).
If it is proposed to install offshore cables to a depth of at least 1.5 m below the sea bed, the Applicant should not have to assess the effect of the cables on intertidal and subtidal habitat during the operational phase of the offshore wind farm (paragraphs 2.6.82 and 2.6.114 of NPS EN-3).	Typically, the cable will be buried between 1 to 2 m. A Cable Burial Risk Assessment (CBRA) (or similar) will inform cable burial depth which will depend on ground conditions. This assessment will be undertaken post-consent. The potential for adverse effects on benthic ecology to arise from electromagnetic fields (EMF) associated with buried cables, or the discrete areas of cables where burial is not feasible and cable protection measures are employed, is considered to be extremely low. Therefore, the impact from EMF was screened out of the benthic ecology assessment during Scoping.
An assessment of the effects of installing cable across the intertidal zone should include information, where relevant, about any alternative landfall sites that have been considered by the applicant during the design phase and an explanation for the final choice.	Alternative are considered in volume 1, chapter 4: Site Selection and Consideration of Alternatives.

Table 2.2: Summary of NPS EN-1 provisions relevant to this chapter.

Summary of NPS EN-1 provision	How and where considered in the Environmental Statement
Biodiversity (Section 5.3 of NPS EN-1)	
Where the development is subject to EIA the applicant should ensure that the Environmental Statement clearly sets out any effects on internationally, nationally and locally designated sites of ecological or geological conservation importance, on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity.	Effects on benthic features, including habitats and species of conservation importance, including those listed as features of designated sites, are fully considered in sections 2.11.1 (construction phase), 2.11.2 (operation and maintenance phase) and 2.11.3 (decommissioning phase). Baseline information on these receptors is presented in section 2.7, with valuation of these receptors in the context of their conservation importance considered in section 2.7.4.
The applicant should show how the project has taken advantage of opportunities to conserve and enhance biodiversity and geological conservation interests.	Measures designed to conserve benthic biodiversity are outlined in Table 2.18 and include measures for avoiding direct impacts to Annex I reef habitat where possible, a Biodiversity Security Plan and the use of sensitive cable and scour protection measures within the areas of designated sites that coincide with the Hornsea Three offshore cable corridor.
In having regard to the aim of the Government's biodiversity strategy the IPC should take account of the context of the challenge of climate change: failure to address this challenge will result in significant adverse impacts to biodiversity. The policy set out in the following sections recognises the need to protect the most important biodiversity and geological conservation interests. The benefits of nationally significant low carbon energy infrastructure development may include benefits for biodiversity and geological conservation interests and these benefits may outweigh harm to these interests. The IPC may take account of any such net benefit in cases where it can be demonstrated.	The future baseline scenario, including the requirement to take account of potential effects of climate change, are considered in section 2.7.5. The benthic ecology assessment has considered the potential for both adverse and beneficial effects, for example potential beneficial effects on biodiversity associated with the introduction of hard substrates (see paragraph 2.11.2.43 *et seq*.)
As a general principle, and subject to the specific policies below, development should aim to avoid significant harm to biodiversity and geological conservation interests, including through mitigation and consideration of reasonable alternatives; where significant harm cannot be avoided, then appropriate compensation measures should be sought.	Measures designed to avoid significant harm to benthic biodiversity are outlined in Table 2.18. No significant effects, in EIA terms, are predicted on benthic ecology as a result of the construction, operation and maintenance or decommissioning of Hornsea Three (see summary in Table 2.38).
In taking decisions, the IPC should ensure that appropriate weight is attached to designated sites of international, national and local importance; protected species; habitats and other species of principal importance for the conservation of biodiversity; and to biodiversity and geological interests within the wider environment.	As discussed in paragraph 2.7.4.5, the benthic ecology assessment specifically considers the impacts, where relevant, to features of designated sites. Assessments relating to impacts in designated sites in section 2.11 (e.g. temporary habitat loss/disturbance) consider the biotopes rather than just the broader VERs, where appropriate.
The most important sites for biodiversity are those identified through international conventions and European Directives. The Habitats Regulations provide statutory protection for these sites but do not provide statutory protection for potential Special Protection Areas (pSPAs) before they have been classified as a Special Protection Area. For the purposes of considering development proposals affecting them, as a matter of policy the Government wishes pSPAs to be considered in the same way as if they had already been classified. Listed Ramsar sites should, also as a matter of policy, receive the same protection	Effects on benthic features of designated sites are fully considered in sections 2.11.1 (construction phase 2.11.2 (operation and maintenance phase) and 2.11.3 (decommissioning phase). These effects have also been assessed within the Report to Inform Appropriate Assessment (document reference number A5.2) for Natura 2000 sites.
Many Sites of Special Scientific Interest (SSSI) are also designated as sites of international importance; those that are not, should be given a high degree of protection (paragraph 5.3.10 of NPS EN-1). Where a proposed development within or outside an SSSI is likely to have an adverse effect on an SSSI (either individually or together with other developments), development consent should not normally be granted. Where an adverse effect, after mitigation, on the site's notified special interest features is likely, an exception should only be made where the benefits (including need) of the development at this site clearly outweigh both the impacts on site features and on the broader network of SSSIs. The Secretary of State should use requirements and/or planning obligations to mitigate the harmful aspects of the development, and where possible, ensure the conservation and enhancement of the site's biodiversity or geological interest (paragraph 5.3.11 of NPS EN-1).	For SSSIs, where these are within Natura 2000 sites, these have been considered as part of that site in this environmental assessment. Any not included in a Natura 2000 have been considered under their own merit.
MCZs introduced under the Marine and Coastal Access Act (MCAA) 2009 are areas that have been designated to conserve marine flora and fauna, marine habitat, or features of geological or geomorphological interest. The Secretary of State is bound by the duties in relation to MCZs imposed by sections 125 and 126 of the MCAA 2009 (paragraph 5.3.12 in NPS EN-1).	Cromer Shoal Chalk Beds MCZ, which lies within the Hornsea Three benthic ecology study area, has been considered within the assessment (see section 2.11). For the two rMCZs identified within the Hornsea Three benthic ecology study area (Figure 2.1), the habitats and species of conservation priority within these sites have been considered in the assessment of valued ecological receptors (see Table 2.13).
Development proposals provide many opportunities for building-in beneficial biodiversity or geological features as part of good design. When considering proposals, the Infrastructure Planning Commission (IPC) now Planning Inspectorate (PINS) should maximise such opportunities in and around developments, using requirements or planning obligations where appropriate.	Designed-in measures to be adopted as part of the Hornsea Three project are presented in section 2.10.
Other species and habitats have been identified as being of principal importance for the conservation of biodiversity in England and Wales and thereby requiring conservation action. The IPC (now PINS) should ensure that these species and habitats are protected from the adverse effects of development by using requirements or planning obligations.	All species and habitat receptors, including those of principal importance for the conservation of biodiversity in England are considered in section 2.7, with valuation of these receptors in the context of their conservation importance considered in section 2.7.4.

Summary of NPS EN-1 provision	How and where considered in the Environmental Statement
The applicant should include appropriate mitigation measures as an integral part of the proposed development. In particular, the applicant should demonstrate that: • during construction, they will seek to ensure that activities will be confined to the minimum areas required for the works; • during construction and operation best practice will be followed to ensure that risk of disturbance or damage to species or habitats is minimised, including as a consequence of transport access arrangements; • habitats will, where practicable, be restored after construction works have finished; and • opportunities will be taken to enhance existing habitats and, where practicable, to create new habitats of value within the site landscaping proposals.	Mitigation measures proposed for Hornsea Three are presented in section 2.10.
Coastal Change (Section 5.5 of NPS EN-1)[a]	
The Environmental Statement should include an assessment of the effects on the coast. applicants should assess the effects of the proposed project on marine ecology, biodiversity and protected sites (paragraph 5.5.7 of NPS EN-1).	Effects of physical changes on benthic ecology receptors are fully considered in sections 2.11.1 (construction phase), 2.11.2 (operation and maintenance phase) and 2.11.3 (decommissioning phase).
For any projects involving dredging or disposal into the sea, the applicant should consult the Marine Management Organisation (MMO) at an early stage.	As outlined in Table 2.14, there may be dredging and disposal of sediments as a result of seabed preparation works and sandwave clearance activities. The potential effects on benthic ecology as a result of these activities are assessed throughout section 2.11 and a full assessment in presented in volume 4, annex 3.2: Dredging and Disposal: Site Characterisation.
The applicant should be particularly careful to identify any effects of physical changes on the integrity and special features of MCZs, candidate marine Special Areas of Conservation (SACs), coastal SACs and candidate coastal SACs, coastal SPAs and potential coastal SPAs, Ramsar sites, Sites of Community Importance (SCIs) and potential SCIs and SSSIs (paragraph 5.5.9 of NPS EN-1).	Effects of physical changes on benthic features of designated sites are fully considered in sections 2.11.1 (construction phase), 2.11.2 (operation and maintenance phase) and 2.11.3 (decommissioning phase). These effects have also been assessed within the Report to Inform Appropriate Assessment (document reference number A5.2) (for Natura 2000 sites) and within volume 5, annex 2.3: MCZ Assessment (for MCZs and recommended MCZs).
a Section 5.5 of NPS EN-1 only applies to onshore energy infrastructure projects situated on the coast, but given the nature of Hornsea Three (i.e. with offshore, intertidal and onshore aspects) only those provisions of relevance to offshore and intertidal benthic receptors have been considered.	

Table 2.3: Summary of NPS EN-3 policy on decision making relevant to this benthic ecology chapter.

Summary of NPS EN-3 policy on decision making (and mitigation)	How and where considered in the Environmental Statement
Biodiversity	
The Secretary of State should consider the effects of a proposal on marine ecology and biodiversity considering all relevant information made available to it (paragraph 2.6.68 of NPS EN-3).	This has been described and considered within the assessment of Hornsea Three (see section 2.11).
The designation of an area as a European site does not necessarily restrict the construction or operation of offshore wind farms in or near that area (paragraph 2.6.69 of NPS EN-3).	European sites have been considered during the assessment (see section 2.7.3).
Mitigation may be possible in the form of careful design of the development itself and the construction techniques employed (paragraph 2.6.70 of NPS EN-3).	Designed-in measures have been proposed to reduce the potential for impacts on benthic ecology; these are outlined in Table 2.18.
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 enable further useful information to be published which may be relevant to future projects (paragraph 2.6.71 of NPS EN-3).	The requirement for benthic ecology monitoring has been considered within the impact assessment (see Table 2.18, Table 2.25and Table 2.31) and the exact scope of which will be outlined in the In Principle Monitoring Plan (IPMP) (document reference number 8.8). The relevant designed-in measures are considered sufficient (i.e. pre-construction surveys).
Subtidal and Intertidal Ecology	
The conservation status of intertidal habitat (paragraph 2.6.84) and subtidal habitat (paragraph 2.6.115) is of relevance to the Secretary of State.	The conservation status of benthic receptors has been considered throughout the assessment (see Table 2.13).
The Secretary of State should be satisfied that activities have been designed considering sensitive subtidal environmental aspects (paragraph 2.6.116) and intertidal habitat (paragraph 2.6.85).	The assessment has identified potential impacts on sensitive subtidal habitats including biogenic reefs, and intertidal habitats and, where appropriate, designed suitable mitigation (see impact assessment in section 2.11).
Where adverse effects are predicted, in coming to a judgement, the Secretary of State 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 have been considered within the assessment of the significance of effects (see Table 2.14 and 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 Secretary of State to refuse to grant consent for a development (paragraph 2.6.118).	The nature and installation of export cables has been considered in the assessment (see Table 2.14).

2.4.2 Other relevant policies

2.4.2.1 The Marine Policy Statement (MPS) and the East Inshore and East Offshore Coast Marine Plans (MMO, 2014) are also relevant to benthic ecology. Key provisions of these policies are set out in Table 2.4 along with details as to how these have been addressed within the assessment.

Table 2.4: Summary of other policies relevant to benthic ecology.

Policy	Key provisions	How and where considered in the Environmental Statement
MPS		
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. • 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 2.18.
East (Inshore and Offshore) Marine Plan		
East Inshore and East Offshore Marine Plans – ECO1	Cumulative impacts affecting the ecosystem of the East marine plans and adjacent areas (marine, terrestrial) should be addressed in decision-making and plan implementation.	Cumulative effects are considered within section 2.13.
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 Three assessment (volume 5, annex 2.1: Benthic Ecology Technical Report) have been described in section 2.7.3. The predicted changes to benthic ecology have been considered in sections 2.11 and 2.13.

2.4.2.2 Guidance provided within the Marine Strategy Framework Directive (MSFD), adopted in July 2008, has also been considered in the Hornsea Three assessment for benthic ecology. The relevance of the MSFD to Hornsea Three is described in full in volume 1, chapter 2: Policy and Legislation.

2.4.2.3 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. Those descriptors relevant to the benthic ecology assessment for Hornsea Three are listed in Table 2.5, including a brief description of how and where these have been addressed in the Hornsea Three assessment.

2.4.2.4 Further advice specifically in relation to the Hornsea Three development, has been sought through consultation with the statutory authorities and from the PINS scoping opinion (PINS, 2016) (section 2.5 and Table 2.6).

Table 2.5: Summary of the Marine Strategy Framework Directive's (MSFD) high level descriptors of Good Environmental Status (GES) relevant to benthic ecology and consideration in the Hornsea Three assessment.

Summary of MSFD high level descriptors of GES relevant to benthic ecology	How and where considered in the Environmental Statement
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 Three alone and in the cumulative effects assessment (CEA) (see section 2.11 and 2.12, respectively).
Descriptor 2: Non-indigenous species: Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.	The effects of non-indigenous species on ecology within the Hornsea Three benthic ecology study area have been assessed in paragraphs 2.11.2.72 *et seq*.
Descriptor 4: Elements of marine food webs: All elements of the marine food webs, to the extent that 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 ecology has been described and considered within the assessment for Hornsea Three alone and the CEA (see section 2.11 and 2.12, respectively).
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 are not adversely affected.	The effects on benthic ecology has been described and considered within the assessment for Hornsea Three alone and in the CEA (see section 2.11 and 2.12, respectively).
Descriptor 7: Alteration of hydrographical conditions: Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.	The effects of potentially altered hydrographical conditions are assessed in paragraph 2.11.2.105 *et seq*., and chapter 1: Marine Processes.
Descriptor 8: Contaminants: Concentrations of contaminants are at levels not giving rise to pollution effects.	The effects of contaminants on benthic species and habitats have been screened out, see section 2.8.2.
Descriptor 10: Marine litter: Properties and quantities of marine litter do not cause harm to the coastal and marine environment.	A Project Environmental Management and Monitoring Plan (PEMMP) will be developed and implemented to cover the construction and operation and maintenance phases of Hornsea Three. The PEMMP 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 will be developed to cover the decommissioning phase (see Table 2.18).

2.5 Consultation

2.5.1.1 A summary of the key issues raised during consultation specific to benthic ecology is outlined below, together with how these issues have been considered in the production of this Environmental Statement.

2.5.2 Hornsea Project One and Hornsea Project Two consultation

2.5.2.1 Hornsea Three has similarities, both in terms of the nature of the development and its location, to Hornsea Project One and Hornsea Project Two. The matters relevant to Hornsea Three, which were raised by consultees during the pre-application and examination phases of Hornsea Project One and Hornsea Project Two, regarding benthic ecology, are set out in volume 4, annex 1.1: Hornsea Project One and Hornsea Project Two Consultation of Relevance to Hornsea Three.

2.5.3 Hornsea Three consultation

2.5.3.1 Table 2.6 below summarises the issues raised relevant to benthic ecology, which have been identified during consultation activities undertaken to date. Table 2.6 also indicates either how these issues have been addressed within this Environmental Statement or how the Applicant has had regard to them. Further information on the consultation activities undertaken for Hornsea Three can be found in the Consultation Report (document reference number A5.1) that accompanies the application for Development Consent.

2.5.4 Evidence Plan

2.5.4.1 The Evidence Plan process has been set out in the Hornsea Project Three Offshore Wind Farm –Evidence Plan (document reference number A5.1.1), the purpose of which is to agree the information Hornsea Three needs to supply, as part of a DCO application for Hornsea Three. The Evidence Plan seeks to ensure compliance with the Habitat Regulations Assessment (HRA).

2.5.4.2 As part of the Evidence Plan process, the Marine Processes, Benthic Ecology and Fish and Shellfish Ecology Expert Working Group (EWG) was established with representatives from the key regulatory bodies and their advisors and statutory nature conservation bodies, including the Marine Management Organisation (MMO), Centre for Environment, Fisheries and Aquaculture Science (Cefas) and Natural England. Representatives from the Wildlife Trust (TWT), who were not part of the EWG at the start, joined the EWG from February 2017. Between June 2016 and publication of the PEIR, a series of EWG meetings were held that included discussion of key issues regarding the benthic ecology elements of Hornsea Three, including characterisation of the baseline environment, the impacts to be considered within the impact assessment and implications associated with the offshore cable corridor reroutes. Following Section 42 consultation on the PEIR, a further two meetings were held with the EWG, which included discussions on the updated baseline characterisation following collection of site specific survey data, and amendments to the impact assessment considering Section 42 consultation responses. Matters raised during EWG meetings have been included in Table 2.6 below.

Table 2.6: Summary of key consultation issues raised during consultation activities undertaken for Hornsea Three relevant to benthic ecology.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
21 June 2016	Benthic and Fish Ecology and Marine Processes Expert Working Group (EWG) meeting	Agreement with stakeholders that there is no requirement to carry out any additional beam trawls and no requirement to carry out additional sampling of sediment chemistry within the Hornsea Three array.	Sampling strategy of site-specific survey along the Hornsea Three offshore cable corridor and within the Hornsea Three array area, as agreed with the stakeholders, is detailed in volume 5, annex 2.1: Benthic Ecology Technical Report.
6 December 2016	PINS/ Natural England - Scoping Opinion	Point raised on the scoping out of the impact 'remobilisation of contaminated sediments during construction and decommissioning' given the elevated levels of arsenic recorded for Hornsea Project One and Project Two. It was advised that evidence should be included within the Environmental Statement to demonstrate that these elevated levels are due to the presence of natural sources.	Contaminant data is summarised in paragraph 2.7.1.4 and discussed in further detail in volume 5, annex 2.1: Benthic Ecology Technical Report. The impact of seabed disturbance leading to the release of sediment contaminants was scoped out for the Hornsea Three array in the Hornsea Three Scoping Report and was scoped out in November 2017 for the Hornsea Three offshore cable corridor (paragraph 2.8.2) on the basis that the sediment chemistry data from the Hornsea Three offshore cable corridor which showed contaminant concentrations were comparable to those recorded in the Hornsea Three array area (see section 2.8.2).
6 December 2016	PINS - Scoping Opinion	A recommendation to review the Cefas 2012 Southern North Sea Synthesis Hamon grab data, which partly covers both the Hornsea Three array area and offshore cable corridor, to maximise the site characterisation.	Data from selected sampling locations of the North Sea Synthesis Hamon grab survey have been used to inform the characterisation in volume 5, annex 2.1: Benthic Ecology Technical Report and the baseline description presented in this document.
6 December 2016	PINS - Scoping Opinion	Advised to use to most up-to- date, relevant impact assessment methodologies for the Environmental Statement.	Most up-to-date and relevant methodologies used (CIEEM, 2016; IEEM, 2010).
25 November 2016	MMO - Scoping Opinion	Point raised on whether there will be sufficient information for the EIA, including adequate information to characterise the benthic ecology receptors likely to be affected by the proposed development. Concern over possible gaps in the existing survey data for the eastern portion of the Hornsea Three array area, together with potential concerns regarding the sample spacing, and the potential need to have sufficient data to inform any potential impacts on the Markham's Triangle rMCZ.	A geophysical and benthic sampling survey was undertaken at the Hornsea Three array area and further stations were sampled during site-specific surveys along the Hornsea Three offshore cable corridor in 2017, as agreed with the Marine Processes, Benthic Ecology and Fish and Shellfish Ecology EWG (see section 2.6.1 and volume 5, annex 2.1: Benthic Ecology Technical Report).
25 November 2016	MMO - Scoping Opinion	It was recommended that the Environmental Statement include an assessment of smothering effects on sensitive benthic receptors. A need to consider potential impacts associated with the disposal of sediment during construction (arising from drilling for monopile foundations, seabed levelling for gravity-based foundations, and sandwave clearance), which may result in temporary or permanent loss of benthic habitat.	Smothering effects, including disposal of sediment during construction, which may lead to temporary or permanent loss of benthic habitat, have been considered in the assessment. See paragraph 2.11.1.100 *et seq.*
25 November 2016	MMO/Natural England - Scoping Opinion	A need to consider the potential for long-term, permanent impacts on the Cromer Shoal Chalk Beds MCZ, if the chalk within the Cromer Shoal Chalk Beds MCZ is cut during the cable installation.	The potential for direct impacts on subtidal chalk are considered in paragraph 2.11.1.3 *et seq.*
25 November 2016	MMO/Natural England - Scoping Opinion	Advised to assess the potential impact of the spread of non-native species as a separate impact.	Non-native species have been assessed as a separate potential impact; see paragraph 2.11.2.72 *et seq.*
25 November 2016	MMO - Scoping Opinion	Transboundary effects on benthic ecology should be screened into the EIA process given the proximity to Klaverbank SCI.	See paragraph 2.16.1.7.
25 November 2016	MMO - Scoping Opinion	Point raised on whether the potential impacts of re-suspended contaminated sediment in the Hornsea Three offshore cable corridor should be screened out of the EIA process.	The potential impacts of re-suspended contaminated sediment in the Hornsea Three offshore cable corridor has been screened out of the assessment in agreement with the Marine Processes, Benthic Ecology and Fish and Shellfish Ecology EWG; see description of meeting held on 4 December 2017 below and section 2.8.2).
25 November 2016	Natural England - Scoping Opinion	The North Norfolk Coast SPA and the Greater Wash possible SPA should be considered. Impacts on benthic and intertidal ecology may have direct consequences for the North Norfolk Coast SPA and the Greater Wash possible SPA features.	This chapter addresses effects of impacts on the benthic ecology receptors only, impacts on SPAs relate to ornithological receptors which are considered in volume 2, chapter 5: Offshore Ornithology and the Report to Inform Appropriate Assessment (document reference number A5.2). Therefore, impacts on SPA features are not considered as part of the benthic ecology assessment.
25 November 2016	Natural England - Scoping Opinion	Operation and Maintenance Activities: it is advised that thorough consideration is given in the EIA to the likely occurrence, types and duration of operation and maintenance activities and the potential implications for recoverability of the interest features of designated sites.	Likely occurrence, types and duration of operation and maintenance activities and recoverability of habitats have been considered, see section 2.11.
25 November 2016	Natural England - Scoping Opinion	Request to use the available data or any additional modelling and assess any impacts on stratification and in particular the Flamborough Front.	The Flamborough Front has been assessed in volume 2, chapter 1: Marine Processes and volume 2, chapter 3: Fish and Shellfish.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
1 February 2017	Benthic and Fish Ecology and Marine Processes EWG meeting	Agreement with stakeholders that the proposed sampling locations of the Hornsea Three specific survey planned for 2017 are appropriate for characterising the Hornsea Three offshore cable corridor. It was also agreed that extra sampling would be carried out within the vicinity of Markham's Hole in the Hornsea Three array area. The extra sampling will provide a similar level of sampling density within Markham's Hole as the rest of the Hornsea Three array area. With this extra sampling, it was agreed that there would be sufficient data and sampling coverage to characterise the Hornsea Three array area.	The proposed sampling strategy is summarised in section 2.6.4, and further detailed in volume 5, annex 2.1: Benthic Ecology Technical Report.
20 September 2017	Eastern Inshore Fisheries and Conservation Authority - Section 42 consultation response	A small proportion of The Wash and North Norfolk Coast SAC falls within the Hornsea Three offshore cable corridor and so further consideration of protected features within this site is required.	All impacts, where relevant, have been fully assessed against features of The Wash and North Norfolk Coast SAC in section 2.11 and the Report to Inform Appropriate Assessment.
20 September 2017	MMO - Section 42 consultation response	The MMO raised concerns regarding potential trenching through subtidal chalk, peat and clay features and recommended that alternative cable corridor routes which avoid permanent impacts on designated features within the Cromer Shoals Chalk Reef MCZ were further explored.	The Hornsea Three offshore cable corridor has been rerouted in the nearshore section and avoids subtidal chalk, peat and clay features within the Cromer Shoals Chalk Beds MCZ, see volume 5, annex 2.1: Benthic Ecology Technical Report.
20 September 2017	MMO - Section 42 consultation response	Suggestions that the benthic impacts and their significance are reviewed following incorporation of the most recent project data, together with analysis of the Markham's triangle grab samples and samples taken during the Humber Regional Environmental Characterisation (REC) and the southern North Sea Synthesis surveys. Use of the Dudgeon offshore wind farm pre-construction benthic ecology survey carried out in 2014, would provide a more up to date data source than the 2009 characterisation survey used in the PEIR.	The benthic ecology baseline and impact assessment has been updated to include the additional Hornsea Three site specific data collected in 2017 (see section 2.6.4), including Annex I reef (biogenic and stony) assessments for the Hornsea Three offshore cable corridor (see paragraphs 2.7.1.13 *et seq*.). The desktop study also includes analysis of the Markham's Triangle rMCZ grab samples (see paragraph 2.6.4.1) and samples taken during the Humber REC, the southern North Sea Synthesis surveys and the Dudgeon offshore wind farm pre-construction benthic ecology survey (see Table 2.7); full details are presented in volume 5, annex 2.1: Benthic Ecology Technical Report.
20 September 2017	Natural England - Section 42 consultation response	Request to consider disposal of dredged material outside the Hornsea Three cable corridor to ensure that loss of sediment from the North Norfolk Sandbanks and Saturn Reef SAC sandbank system is minimised.	Sandwave material dredged within the North Norfolk Sandbanks and Saturn Reef SAC will be disposed of within the boundaries of the site (to the south east of the dredged location), where possible, to keep the material within the same sandbank system. This is addressed in paragraph 2.11.1.13 and is also considered in volume 1, annex 3.2: Dredging and Disposal: Site Characterisation.
20 September 2017	Natural England - Section 42 consultation response	Concern that the sandbanks feature of the North Norfolk Sandbanks and Saturn Reef SAC was not sufficiently assessed in the PEIR. It was requested that this feature was consistently considered throughout the impact assessment section.	The assessment presented in this Environmental Statement has been substantially revised since PEIR to address Natural England's comments. This has included revisions to the VERs to better align with designated features of the relevant protected areas in proximity to Hornsea Three (e.g. Annex I sandbanks has been included as a VER); see Table 2.13 and volume 5, annex 2.1: Benthic Ecology Technical Report. Each assessment section has also been amended to include separate sections for the consideration of impacts to the features of designated sites and, as requested by Natural England, further information on the sensitivity, recoverability etc. of the component biotopes of the designated features (as mapped during the site-specific surveys) has been provided.
20 September 2017	Natural England - Section 42 consultation response	It was recommended that biotope level information provided in the Hornsea Three Benthic Ecology Technical Report be used to assess the impacts within protected sites to align with the designated features of sites.	
20 September 2017	Natural England - Section 42 consultation response	Request for the following amendments and clarifications in the assessment of 'Construction – Temporary habitat loss/disturbance due to cable laying operations, spud-can leg impacts from jack-up operations and seabed preparation works for gravity base foundations': • A query was raised as to whether there is any difference in particle size analysis (PSA) 6 m underneath the sandwave/sandbank surface, to determine if all the spoil volume would be of similar/same PSA to surface sediments; • Consideration should be given to whether the dredged sediment that will be returned to the system away from trough locations may contain considerably different sediments; and • It was advised that the EIA should consider sensitivity using the Marine Evidence based Sensitivity Assessment (MarESA) pressure benchmarks.	Further consideration of these issues is presented in the assessment of temporary habitat loss/disturbance in paragraphs 2.11.1.13 and 2.11.1.14.
20 September 2017	Natural England - Section 42 consultation response	It was recommended that the *Sabellaria spinulosa* assessment be amended, like that laid out in http://jncc.defra.gov.uk/pdf/Cefas_JNCC_No.7_v2_web.pdf. This would simplify assessment and provide comparable results.	The *Sabellaria spinulosa* assessment has been amended as requested; see methodology in volume 5, annex 2.1: Benthic Ecology Technical Report.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
20 September 2017	Natural England - Section 42 consultation response	Concern raised regarding the maximum design scenario of 25% of each cable running through the Cromer Shoal Chalk Beds MCZ requiring cable protection in addition to that required for cable/pipeline crossings.	The maximum design scenario for cable protection along the Hornsea Three offshore cable corridor, including the Cromer Shoal Chalk Beds MCZ, is presented in Table 2.14 and has been refined since PEIR such that the maximum design scenario is for cable protection for up to only 10% of the length of cables within the Cromer Shoal Chalk Beds MCZ. The Hornsea Three offshore cable corridor has been rerouted in the nearshore section and avoids subtidal chalk, peat and clay features within the Cromer Shoal Chalk Reef MCZ, see volume 5, annex 2.1: Benthic Ecology Technical Report for the location of these features.
20 September 2017	Natural England - Section 42 consultation response	It was advised that cable protection and scour prevention remaining *in situ* should be assessed as a permanent habitat change and should be considered a realistic maximum design scenario, as opposed to long term habitat loss.	The impact 'Permanent habitat loss due to presence of scour/cable protection left *in situ* post decommissioning, and potential effects on benthic ecology' has been assessed, see paragraph 2.11.3.38 *et seq*.
4 December 2017	Benthic and Fish Ecology and Marine Processes EWG meeting	Discussion of project updates since publication of PEIR, including project description changes, updates to baseline characterisation based on site specific survey data and approach to addressing Section 42 consultation responses (as detailed in preceding rows).	Updates to the project description are reflected in the Maximum Design Scenario presented in Table 2.14 and updates to the baseline characterisation based on site specific survey data is discussed in section 2.7.
		Discussions on the benthic ecology baseline characterisation included updates on site specific sampling undertaken since publication of the PEIR and the approach to characterisation of the two offshore cable corridor re-routes. The EWG agreed that sufficient data is available to successfully characterise the potential offshore export cable re-route if this route is taken forward.	The offshore re-route (i.e. in the vicinity of the North Norfolk Sandbanks and Saturn Reef SAC) is characterised, as agreed with the EWG, by site specific survey data (see section 2.7.1) and the nearshore re-route (i.e. in the vicinity of the Cromer Shoal Chalk Beds MCZ) is characterised by a combination of site specific and desktop data sources (see paragraph 2.6.1.4 and 2.7.1.11 *et seq*.). These are fully discussed in volume 5, annex 2.1: Benthic Ecology Technical Report.
		Sediment chemistry data within offshore cable corridor showed low levels of contamination consistent with the patterns observed in the Hornsea Three array area.	Effects of resuspension of sediment bound contaminants were scoped out of the impact assessment (see section 2.8.2)
		Concern raised by Natural England about relocation of boulders and cobbles from cable corridors during cable installation, leading to corridors free from boulders and cobbles where cable installation has occurred.	Effects of boulder clearance are considered under the construction phase impacts (see paragraph 2.11.1.3 *et seq*.)
		Concern raised by Natural England about the effect of jack-up footprints on seabed habitats.	Effects of depressions in seabed from jack-up footprints and cable installation on benthic ecology receptors are considered under the construction phase impacts (see paragraph 2.11.1.3 *et seq.*)
		Concern raised by Natural England and JNCC about the long term and/or permanent effects of placement of cable protection on designated features of the North Norfolk Sandbanks and Saturn Reef SAC, the Wash and North Norfolk Coast SAC, the Cromer Shoal Chalk Beds MCZ.	Long term effects of cable protection on designated features during the operational phase are considered in paragraph 2.11.2.13 *et seq*. Permanent effects on designated features from cable protection left *in situ* following decommissioning are considered in paragraph 2.11.3.44 *et seq*.
11 December 2017	Natural England - Further consultation under Section 42	Seaward re-route: Natural England support the proposed re-route in the seaward part of the corridor (closest to the array). The proposed alternative would reduce the direct impact to the North Norfolk Sandbanks and Saturn Reef SAC due to the cable laying activities. Site-specific benthic sampling was carried out for the proposed re-route as part of the project benthic sampling programme. Natural England considers data to be sufficient to adequately characterise the baseline for that area.	The impacts of temporary habitat loss/disturbance on designated features of the North Norfolk Sandbanks and Saturn Reef SAC are assessed in paragraphs 2.11.1.39 *et seq*.
		Nearshore re-route: while Natural England was pleased to note the alternative route in the near-shore area, which has the potential to avoid most of the Cromer Shoal Chalk Beds MCZ, concerns were raised over the larger footprint of the re-route within The Wash and North Norfolk Coast SAC. The Environmental Statement should include detailed consideration of the potential impacts on the SAC.	Details of the Hornsea Three offshore cable corridor reroute in the nearshore area are outlined in paragraph 2.6.1.4. All impacts, where relevant, on designated features of The Wash and North Norfolk Coast SAC and the Cromer Shoal Chalk Beds MCZ are assessed in section 2.11.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
		Concern raised regarding no site-specific data collection was carried out or proposed for the section of the re-route that deviates from the original cable corridor. Natural England have low confidence in the outputs of Sheringham Shoal and Dudgeon OWFs benthic surveys. Natural England advise Hornsea three to treat these data with caution and recommends that Hornsea Three project specific data is used as the main source of evidence where possible.	As agreed with the EWG at the meeting on 4 December 2017, the nearshore area, including the re-route (i.e. in the vicinity of the Cromer Shoal Chalk Beds MCZ), is characterised by a combination of site specific and desktop data sources (see paragraph 2.6.1.4 *et seq*.). These are fully discussed in volume 5, annex 2.1: Benthic Ecology Technical Report and summarised in paragraphs 2.7.1.11 *et seq*. Natural England's concerns on the use of the Sheringham Shoal and Dudgeon OWFs data are assumed to relate to the design of the surveys and aims of the monitoring, as opposed to sampling technique and laboratory analyses. The data have been used to inform the Hornsea Three characterisation, i.e. identification of biotopes based on grab sample data collected and analyses by a participating member of the NMBACQ, therefore it is considered such concerns should be allayed. The use of these data in combination with a range of other datasets to support the analyses of the Hornsea Three site specific survey data is considered appropriate and the consistency in the reported sediment and community composition across all site specific and desktop data sources provides confidence in the characterisation for the Hornsea Three project.
		Natural England request a 'side by side' comparison of the habitats along each route (original and re-route sections) in the nearshore together with potential impacts, their magnitude, sensitivities of receptors and proposed mitigation for the two near-shore route options.	Provided in a note to Marine Processes, Benthic Ecology and Fish and Shellfish Ecology EWG, titled 'Meeting 6 Follow up - Potential Near Shore Alternative Route Note, December 2017'.
13 December 2017	Norfolk Wildlife Trust and The Wildlife Trust - Further consultation under Section 42	Pleased that the eastern cabling route within Cromer Shoal Chalk Beds MCZ has been removed from the cabling route options, avoiding potential impacts on subtidal chalk reef habitat and that an alternative route has been considered which could avoid impacts on the features of Cromer Shoal Chalk Bed MCZ.	No response required.
18 December 2017	Eastern Inshore Fisheries and Conservation Authority - Further consultation under Section 42	Eastern IFCAs preferred inshore cable route option is the newly proposed re-route which diverts activities further away from the vulnerable chalk features.	No response required.
15 January 2018	TWT - Letter response to Hornsea Three Nearshore Re-route Note (2 January 2018)	TWT are supportive of the nearshore re-route, which will minimise the impacts on the Cromer Shoal Chalk Beds MCZ, including impacts on Subtidal Chalk. A more detailed assessment will be required on The Wash and North Norfolk Coast SAC.	The assessment presented in this Environmental Statement has been substantially revised since PEIR to include separate sections for the consideration of impacts to the features of designated sites including The Wash and North Norfolk Coast SAC. Impacts to The Wash and North Norfolk Coast SAC are discussed further in the RIAA for Hornsea Three (document reference number A5.2).
22 January 2018	Natural England – Discretionary Advice Service on the Potential Near Shore Alternative Route Note provided on 2 January 2018 as a follow up to the EWG meeting on 4 December 2017.	Natural England welcomes Hornsea Three's consideration of the alternative options to that of going through the Cromer Shoal Chalk Beds MCZ as recommended throughout the Evidence Plan process and in response to the Section 42 Consultation. Based on the Alternative Route Note and previous EWG meetings, Natural England believe however that there is insufficient information/evidence for them to support one cable route over the other.	The original Hornsea offshore cable corridor presented in the PEIR considered a number of routes through the MCZ and stakeholders expressed concerns about the effect of cable installation (including cable burial) within features with no recovery potential, i.e. Subtidal Chalk and Peat and Clay Exposures. Following publication of the PEIR, Hornsea Three has investigated the feasibility of a nearshore re-route of the offshore cable corridor, to minimise the length of the offshore cable corridor passing through the Cromer Shoal Chalk Beds MCZ and thereby considerably reducing the direct impacts on MCZ features. The nearshore re-route has been taken forward for inclusion in the final Development Consent application and is therefore considered within this benthic assessment on the basis of the reduced environmental effects to the MCZ. Further details regarding the offshore cable corridor route selection are presented in volume 4, annex 4.1: Offshore Export Cable Route Selection.
		Reiterated preference that no cable protection is placed within the Wash and North Norfolk Coast SAC. This is due to the overall lack of development/infrastructure within the site as a whole and the precedent this would set.	Hornsea Three acknowledge this and while all attempts will be made to bury the cables where possible, in the event that the cables can't be buried in discrete areas, Hornsea Three are committed to minimising the impacts associated with measures which will be required to protect the cable. The designed-in measures are as outlined in Table 2.18 will include sensitive cable protection within designated sites which will consider the local seabed conditions, including sediment/substrate type. These measures will not include concrete mattresses.
		With respect to the baseline characterisation, Natural England agree that the information presented in the Note could be used to characterise the biotopes present for the purposes of the application.	Noted and, as described in paragraph 2.6.1.4, the nearshore area has been characterised by a combination of both site specific data and desktop data.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
		We would also encourage Ørsted to consider potential mitigation measures and whether or not there are potential compensation/measures of equivalent environmental benefit (MEEB) options for the permanent loss of designated habitats. Currently there is not enough evidence to suggest no significant impact on designated features from either of the routes	See volume 5, annex 2.3: MCZ Assessment.
23 February 2018	Benthic and Fish Ecology and Marine Processes EWG – provision of information	Many of the appendices for volume 5, annex 2.1: Benthic Ecology Technical Report, comprise data in spreadsheet form because PDF format (such as is required by the PINS website) is considered inappropriate for the purposes of interrogation or analysis of the data. All raw data and appendices were therefore provided to Cefas and Natural England ahead of the EWG. All appendices are however available on request.	No response required.

2.6 Methodology to inform the baseline

2.6.1 Evidence-based approach

2.6.1.1 The approach proposed by Hornsea Three for the purposes of characterising the benthic ecology within the two benthic ecology study areas defined in paragraph 2.3.1.1, was an evidence based approach to the EIA, which involved utilising existing data and information from sufficiently similar or analogous studies to inform the baseline understanding and/or impact assessments for a new proposed development. In this way, the evidence based approach does not necessarily require new data to be collected, or new modelling studies to be undertaken, to characterise potential impacts with sufficient confidence for the purposes of EIA (see volume 1, chapter 5: Environmental Impact Assessment Methodology).

2.6.1.2 The Hornsea Three array area is located within the former Hornsea Zone, for which extensive data and knowledge regarding benthic ecology is already available. This data/knowledge has been acquired through zonal studies and from the surveys and characterisations undertaken for Hornsea Project One and Hornsea Project Two. It was therefore proposed that the benthic ecology characterisation of the Hornsea Three array area be completed using a combination of desktop data and information sources, and historic survey data collected as part of the characterisations of the Hornsea Project One and Hornsea Project Two offshore wind farms and the former Hornsea Zone. Over a series of EWG meetings undertaken between June 2016 and publication of this Environmental Statement, it was agreed that this approach (further detailed in the sections below) was largely appropriate and sufficient for the purposes of characterising the benthic ecology of Hornsea Three. However, geophysical data were acquired across the whole Hornsea Three array area in 2016 and, as agreed with the Marine Processes, Benthic Ecology and Fish and Shellfish EWG, further sampling was undertaken in 2017 in an area of finer sediment in Markham's Hole, within the Hornsea Three array area, to augment the existing data and ensure sufficient coverage of the eastern extent of the Hornsea Three array area (see section 2.6.4 and Table 2.8).

2.6.1.3 The Hornsea Three offshore cable corridor and intertidal area are unique to Hornsea Three. As such, the existing data and knowledge of the baseline environment along the offshore cable corridor and at the intertidal area for Hornsea Project One and Hornsea Project Two is not relevant and the evidence-based approach described above cannot be applied. Therefore, the baseline characterisation of the Hornsea Three offshore cable corridor and intertidal area within this Environmental Statement has drawn upon several Hornsea Three site-specific surveys completed in 2016 and 2017 together with desktop information from third-party surveys, including surveys targeting areas within and near designated sites. The site-specific surveys of the Hornsea Three offshore cable corridor comprised geophysical data acquisition along the corridor, and in the nearshore area around the Cromer Shoal Chalk Beds MCZ, benthic sampling and drop-down video (DDV) surveys, to establish a robust and up-to-date characterisation of the baseline environment in the Hornsea Three offshore cable corridor. The site-specific Hornsea Three offshore cable corridor surveys were discussed and agreed through the Marine Processes, Benthic Ecology and Fish and Shellfish EWG and the results have been used to update the Hornsea Three benthic ecology baseline characterisation (see section 2.7).

2.6.1.4 Since the EIA baseline surveys and the publication of the PEIR, updates in the form of re-routes have been made to the Hornsea Three offshore cable corridor described in the PEIR, as a result of the EIA consultation process. The Hornsea Three offshore cable corridor in the nearshore area has been rerouted such that it now extends through approximately 1 km of the Cromer Shoal Chalk Beds MCZ rather than the 14 km assumed for the PEIR. This reroute, and a reroute in the vicinity of the North Norfolk Sandbanks and Saturn Reef SAC, are discussed further in volume 1, chapter 4: Site Selection and Consideration of Alternatives. The reroute, and the implications of this on designated features of the Cromer Shoal Chalk Beds MCZ, have been presented to, and discussed with, the Marine Processes, Benthic Ecology and Fish and Shellfish EWG (see Table 2.6). It was agreed with the EWG (see Table 2.6) that a combination of Hornsea Three site specific data and desktop data sources in this area (see paragraph 2.7.6.2 and Table 2.6) would provide a robust characterisation of the nearshore area, including the Hornsea Three offshore cable corridor reroute section (see section 2.7.6).

2.6.2 Desktop study

2.6.2.1 Information on benthic ecology within the southern North Sea study area was collected through a detailed desktop review of existing studies and datasets. The key data sources (not an exhaustive list) are summarised in Table 2.7. Further detail is presented within volume 5, annex 2.1: Benthic Ecology Technical Report.

2.6.3 Identification of designated sites

2.6.3.1 All designated sites, and their relevant qualifying benthic features, within the southern North Sea benthic ecology study area that could be affected by the construction, operation and maintenance, and decommissioning of Hornsea Three for benthic ecology (i.e. that fall within the potential Zone of Influence (ZoI) of Hornsea Three; see section 2.7.3), were identified using the process described below:

- Sites with relevant benthic ecology features which overlap with Hornsea Three and therefore have the potential to be directly affected by Hornsea Three (e.g. by temporary and/or long term habitat loss); and
- Sites with relevant benthic ecology features with the potential to be indirectly affected by Hornsea Three (i.e. by changes in suspended sediment concentrations and/or sediment deposition as determined by the assessment presented in volume 2, chapter 1: Marine Processes).

2.6.3.2 For the PEIR, those designated sites within a precautionary 12 km tidal excursion were screened in to the assessment. However, this approach was refined for the Environmental Statement to use the project specific outputs of the marine processes assessment (see sections 1.7.2 and 1.11.2 of volume 2, chapter 1: Marine Processes).

Table 2.7: Summary of key desktop reports.

Title	Source	Year	Author
Humber REC	Marine Aggregate Levy Sustainability Fund (MALSF)	2011	Tappin *et al.*
Marine Aggregate Regional Environmental Assessment of the Humber and Outer Wash Region	Humber Aggregate Dredging Association (HADA)	2012	Environmental Resources Management
European Marine Observation Data Network (EMODnet) Seabed Habitats Project	EUSeaMap 2016: www.emodnet-seabedhabitats.eu/	2016	EUSeaMap
UK Benthos Database	Oil and Gas UK: http://oilandgasuk.co.uk/product/ukbenthos/	2015	Oil and Gas UK
North Sea Benthos Project (NSBP) 2000	North Sea Benthos Project 2000: www.vliz.be/vmdcdata/nsbp/	2001	International Council of the Exploration of the Sea (ICES)
Technical reports for the Offshore Oil and Gas Strategic Environmental Assessment (SEA) Areas 2 and 3	UK Government, Department of Energy and Climate Change (DECC).	2001	Department of Trade and Industry (DTI)
Southern North Sea Synthesis Benthic Survey	Cefas	2012	Allen *et al.*
Cromer Shoal Chalk Beds rMCZ Post-Survey Site Report.	Department for Environment, Food and Rural Affairs (Defra)	2015	Defra
North Norfolk Sandbanks and Saturn Reef SCI management investigation report.	Joint Nature Conservation Committee (JNCC), Cefas	2015	Jenkins *et al.*
Benthic survey of Inner Dowsing, Race Bank and North Ridge cSAC, and of Haisborough, Hammond and Winterton cSAC.	Cefas	2013	Barrio Froján *et al.*
Sheringham Shoal Offshore Wind Farm Environmental Statement and pre-construction survey data.	Scira Offshore Energy	2006 2014	Scira Offshore Energy. Scira Offshore Energy
Dudgeon Offshore Wind Farm Environmental Statement	Dudgeon Offshore Wind Limited	2009	Dudgeon Offshore Wind Limited
Dudgeon Offshore Wind Farm Pre Construction Baseline Ecology Study	Fugro EMU Ltd	2015	Fugro EMU Ltd

2.6.4 Site specific surveys

2.6.4.1 Data from the following surveys undertaken across the Hornsea Three benthic ecology study area have been used to inform the baseline characterisation. These site specific surveys, together with the desktop data outlined in section 2.6.2, were agreed with the Marine Processes, Benthic Ecology and Fish and Shellfish EWG to be sufficient to establish a robust and up-to-date characterisation of the baseline environment in the Hornsea Three (see section 2.6.1, Figure 2.2 and Figure 2.3):

- Intertidal walkover survey of the Hornsea Three intertidal area in 2016;
- Drop Down Video (DDV) habitat assessment survey in the Cromer Shoal Chalk Beds MCZ in 2017;
- Benthic sampling and DDV habitat assessment survey along the Hornsea Three offshore cable corridor within 60 nautical miles (nm), plus five beam trawls in 2017;
- Benthic sampling and DDV habitat assessment survey beyond 60 nm within the cable fan of the Hornsea Three offshore cable corridor and Markham's Hole in the Hornsea Three array area, plus DDV only throughout Hornsea Three array area in 2017;
- Benthic sampling and DDV habitat assessment survey along the Hornsea Three offshore cable corridor in 2016;
- Faunal and PSA on benthic samples retained during ground-truthing campaigns in 2016 in support of geophysical surveys in the Hornsea Three array area and offshore cable corridor;
- Historic benthic ecology surveys across the former Hornsea Zone between 2010 and 2012; and
- Benthic survey carried out at Markham's Triangle rMCZ by Cefas, commissioned by Defra in 2012.

2.6.4.2 Table 2.8 below provides summary details of each of these site-specific, historic and third party surveys. See volume 5, annex 2.1: Benthic Ecology Technical Report for further information. Note that the temporary working area of the offshore cable corridor has not been directly surveyed (Figure 2.3), however on the basis of proximity and that the habitats recorded within the Hornsea Three offshore cable corridor were typical of the wider area (see section 2.7), there is high confidence that the working area will not differ substantially from the adjacent mapped sections of the corridor.

Table 2.8: Summary of benthic ecology surveys.

Title	Extent of survey	Overview of survey	Survey contractor	Year	Reference to further information
Historic survey data within the Hornsea Three benthic ecology study area					
Zone characterisation (ZoC) benthic sampling survey	Former Hornsea Zone	122 combined DDV and Hamon grab sampling stations, plus 40 epibenthic beam trawl stations	EMU Ltd	2010	Volume 5, annex 2.1: Benthic Ecology Technical Report
Hornsea Project One benthic sampling survey	Former Hornsea Zone	161 combined DDV and Hamon grab sampling stations, of which 40 stations were sampled for sediment chemistry, plus 41 epibenthic beam trawl stations	EMU Ltd	2010 to 2011	Volume 5, annex 2.1: Benthic Ecology Technical Report
Hornsea Project Two benthic infill survey	Former Hornsea Zone	51 combined DDV and Hamon grab sampling stations, of which 8 stations were sampled for sediment chemistry, plus 21 epibenthic beam trawl stations	EMU Ltd	2012	Volume 5, annex 2.1: Benthic Ecology Technical Report
Markham's Triangle rMCZ survey [a]	Markham's Triangle rMCZ	21 combined DDV and Hamon grab sampling stations and 29 stations sampled by Hamon grab only	Cefas	2012	Volume 5, annex 2.1: Benthic Ecology Technical Report
Site specific surveys within Hornsea Three					
Hornsea Three array area geophysical and benthic sampling survey	Hornsea Three array area	Geophysical survey consisting of dual frequency side scan sonar and multibeam echosounder and 20 ground truthing Hamon grab samples for PSA and infaunal analysis	EGS International Ltd (EGSi)	2016	Volume 5, annex 2.1: Benthic Ecology Technical Report
Hornsea Three offshore cable corridor geophysical and benthic sampling survey	Hornsea Three offshore cable corridor	Geophysical survey consisting of dual frequency side scan sonar and multibeam echosounder and 19 combined DDV and Hamon grab sampling stations plus one DDV sampling station	Bibby HydroMap Limited and Benthic Solutions	2016	Volume 5, annex 2.1: Benthic Ecology Technical Report
Hornsea Three intertidal survey	Hornsea Three intertidal area (mean low water spring (MLWS) to MHWS)	Phase I walkover habitat survey habitat with 0.1 m^2 dig-over sampling	RPS Energy	2016	Volume 5, annex 2.1: Benthic Ecology Technical Report
Hornsea Three benthic sampling survey - beyond 60nm	Cable fan section of the Hornsea Three offshore cable corridor and three sampling stations in Markham's Hole within the Hornsea Three array area	6 stations, 3 of which were also sampled for sediment chemistry, and 10 stations for DDV only	Gardline	2017	Volume 5, annex 2.1: Benthic Ecology Technical Report)
Hornsea Three benthic sampling survey - within 60 nm	Hornsea Three offshore cable corridor out to 60 nm	14 combined Hamon grab sampling and DDV stations, 15 stations for DDV only, 5 stations for sediment chemistry only, 5 beam trawls.	Ocean Ecology	2017	Volume 5, annex 2.1: Benthic Ecology Technical Report
Inshore geophysical and DDV survey	Hornsea Three offshore cable corridor coinciding with the Wash and North Norfolk Coast SAC and Cromer Shoal Chalk Beds MCZ	9 DDV transects targeting potential outcropping rock; geophysical data (side scan sonar and bathymetry).	Fugro GB Marine	2017	Volume 5, annex 2.1: Benthic Ecology Technical Report

a PSA data from the Markham's Triangle rMCZ designation survey has been obtained for the purposes of characterising the Hornsea Three array area. This survey was undertaken by Cefas (Defra, 2014) and has no connection with the Hornsea Three development.

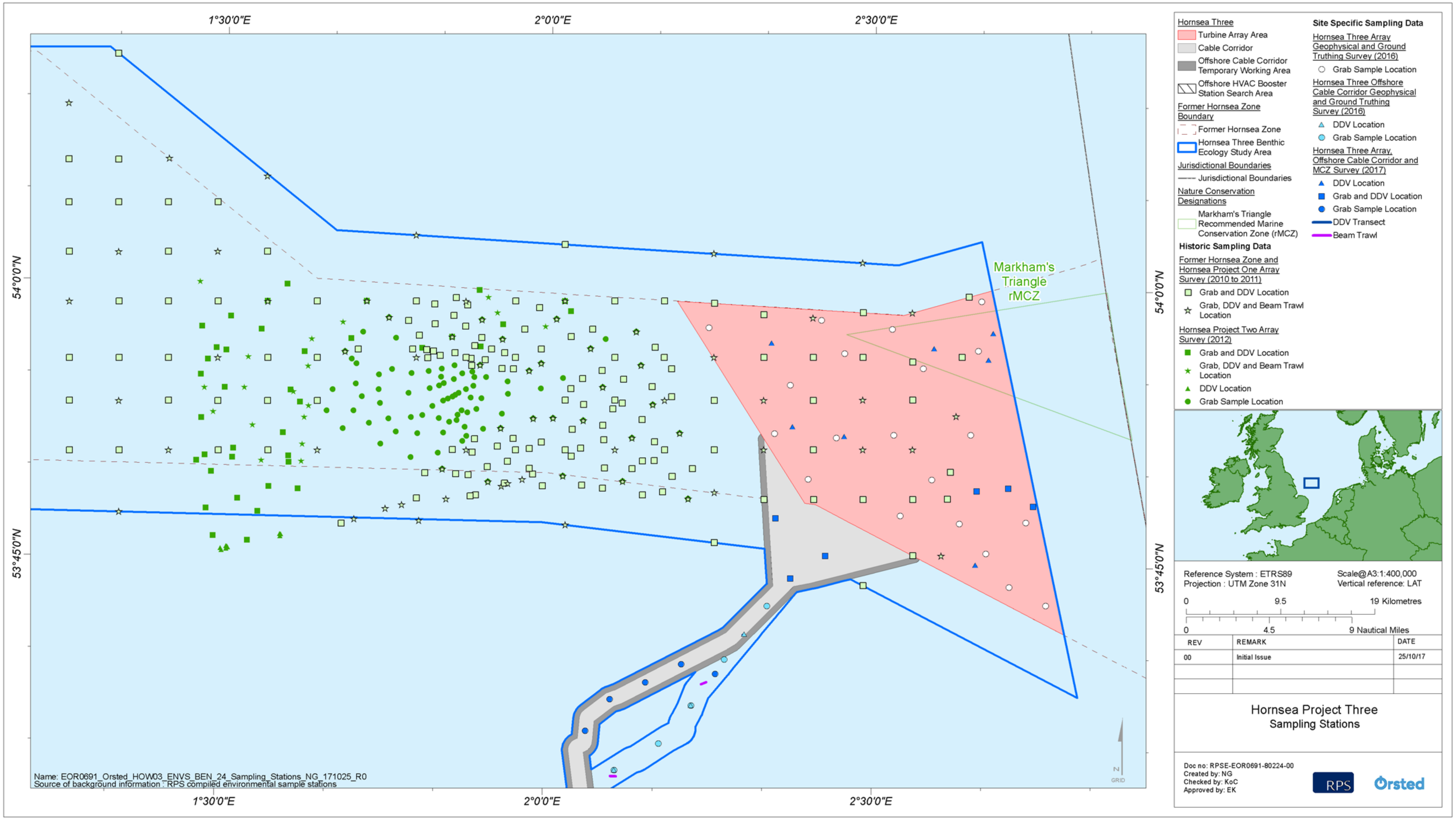

Figure 2.2: Hornsea Three array area with historic (2010-2012) and Hornsea Three site specific (2016 and 2017) benthic ecology sampling locations (benthic grabs/DDV and trawls). Also shown are sampling sites within Markham's Triangle rMCZ (Defra, 2012 (note: third party survey data)).

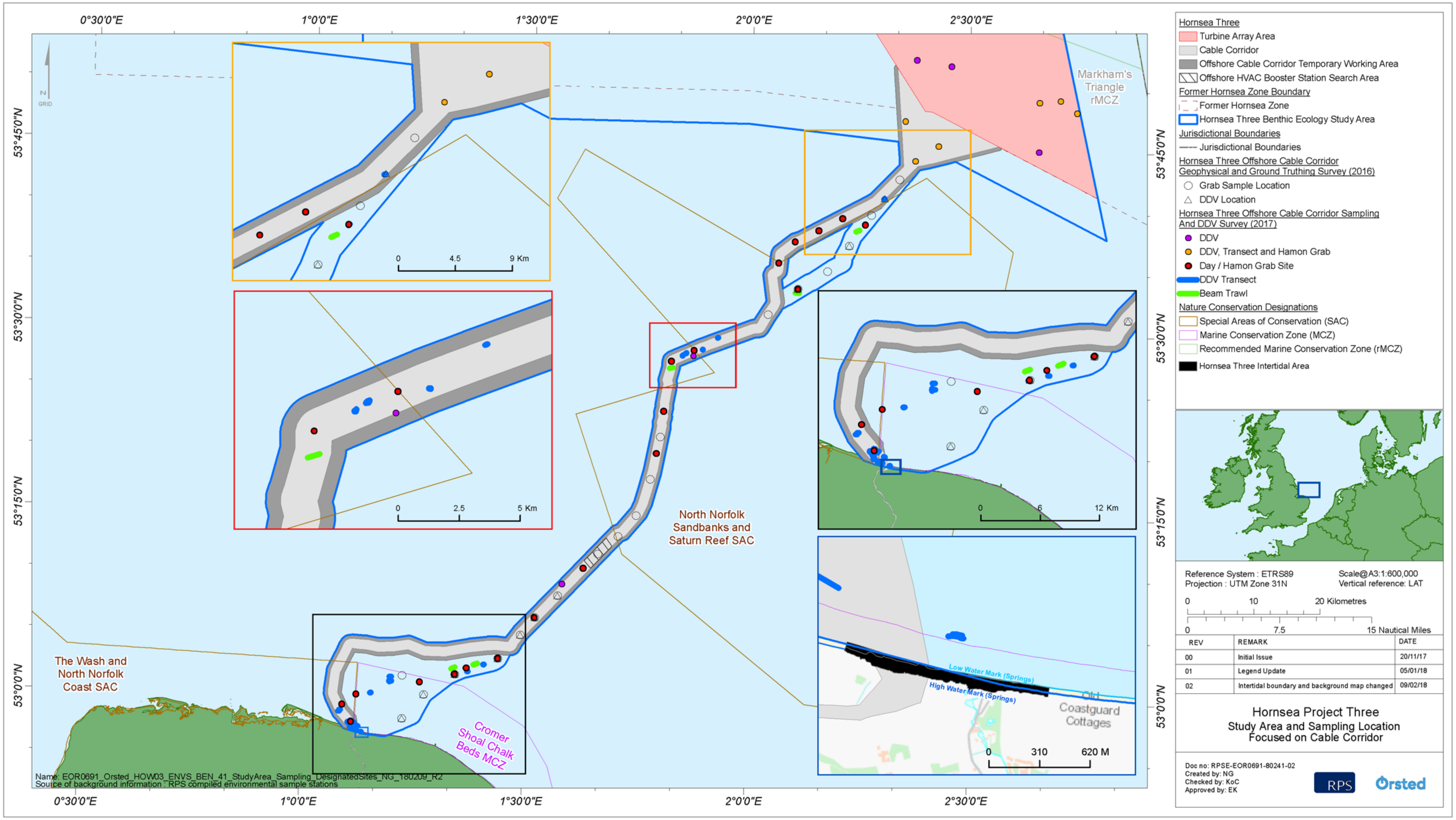

Figure 2.3: Hornsea Three offshore cable corridor with Hornsea Three (2016 and 2017) benthic ecology sampling locations (benthic grabs, DDV and trawls).

2.7 Baseline environment

2.7.1 Subtidal

Sediment composition

2.7.1.1 The benthic subtidal sediments of all samples (site specific samples from the Hornsea Three array area and offshore cable corridor, plus geophysical ground-truthing samples retained for benthic analysis and historic survey data) within the Hornsea Three benthic ecology study area, were classified according to the Simplified Folk Classification (Long, 2006) into three main sediment types: sand and muddy sand (SS.SSA: Sublittoral Sands and Muddy Sands), coarse sediments (SS.SCS: Sublittoral Coarse Sediment) and mixed sediments (SS.SMX: Sublittoral Mixed Sediment). Sand and muddy sands was the most prevalent sediment type throughout the Hornsea Three benthic ecology study area (Figure 2.4).

2.7.1.2 Sand and muddy sand dominated much of the central swathe of the Hornsea Three array area, the central section of the Hornsea Three offshore cable corridor and most of the wider Hornsea Three benthic ecology study area, particularly the area in the west of the former Hornsea Zone (Figure 2.4). Coarse sediments were distributed throughout the southern and northern sections of the Hornsea Three array area, particularly the area corresponding with the Markham's Triangle rMCZ. The areas of coarse material within the Hornsea Three array area were separated by the sand and muddy sand sediments in the centre of the Hornsea Three array area. Patches of coarse material were present in the central former Hornsea Zone, while a large area of coarse sediment dominated the southwestern region of the former Hornsea Zone (Figure 2.4). Isolated patches of mixed sediments were recorded primarily in the centre and in the northeast of the Hornsea Three array area, again where the array and Markham's Triangle rMCZ overlap. Mixed sediments were also found in the area coinciding with the central area of the former Hornsea Zone and to the southeast of this.

2.7.1.3 Sediments along the Hornsea Three offshore cable corridor were dominated by infralittoral/circalittoral coarse and mixed sediments, with some areas comprising circalittoral/infralittoral fine sands, particularly in the central section of the Hornsea Three offshore cable corridor. In the most inshore section of the Hornsea Three offshore cable corridor an area of subcropping rock was present to the northwest of the Hornsea Three intertidal area. The geophysical data indicated that these areas of subcropping rock were covered by a veneer of sandy sediment of between 0.2 and 3 m depth. Much of the seabed surface in this area is characterised by sand ripples of approximately 10 cm elevation and the subcropping rock comes close to the surface (i.e. sediment veneer of <0.2 cm) in discrete areas. DDV transects undertaken across this area showed discrete areas of mixed coarse sediments with scattered gravel, cobbles and boulders, surrounded by rippled sand.

Sediment contamination

2.7.1.4 The results of the heavy metals analyses showed that, except for arsenic, cadmium, mercury and nickel, all metals recorded in subtidal sediments sampled at 63 locations within the Hornsea Three benthic ecology study area were present at concentrations below the Cefas Action Level 1 (AL1) and the Canadian Threshold Effect Levels (TEL), and were therefore at levels below which biological effects in benthic organisms would be expected. In general contaminant levels in dredged material below Action level 1 are not considered to be of concern and are unlikely to influence a dredging disposal licencing decision. The TEL is the minimal effect range within which adverse effects rarely occur.

2.7.1.5 Arsenic was found to exceed the Canadian TEL at all but five sites within the Hornsea Three benthic ecology study area, including at all eight sampling locations along the Hornsea Three offshore cable corridor and at a station on the north western margin of the Hornsea Three array area. Of the sites with elevated levels of arsenic, five recorded concentrations above the Canadian Probable Effect Level (PEL) at levels where a toxicity effect would be evident, though these were not located within Hornsea Three. Levels of arsenic exceeded OSPAR Background Assessment Concentration (BAC) of 25 mg/kg in sediments at 20 sites within the wider Hornsea Three benthic ecology study area, although within the Hornsea Three offshore cable corridor arsenic concentrations were within the BAC at all locations. Any direct comparisons between the site specific data and OSPAR BAC should be made with caution as Hornsea Three data were not normalised to 5% aluminium (aluminium was not part of the heavy metal suite analysed, as agreed with the EWG through consultations on the survey specification for the Hornsea Three offshore cable corridor). Arsenic exceeded the Cefas AL1 of 20 mg/kg at 24 sites including three on the Hornsea Three offshore cable corridor, however all sites were well within the Cefas AL2 of 100 mg/kg.

2.7.1.6 Historically the Humber has been subjected to a large point discharge of arsenic from industrial sources and samples collected during various North Sea surveys between 1991 and 1995 have identified numerous areas with high raw arsenic concentrations, particularly off north Yorkshire and the Humber Estuary (Whalley *et al*., 1999). However, Whalley *et al*. (1999) demonstrated that after normalisation against iron, the levels of arsenic in historical samples were much reduced in significance. Whalley *et al.* (1999) proposed that the low residual values might be explained by dilution into the Humber Estuary's high suspension load, or by particulate transport away from the region. Also, the Humber Estuary receives large amounts of iron waste (Millward and Glegg, 1997) to which arsenic may sorb (Cefas, 2000). The arsenic concentrations within sediments in the Hornsea Three benthic ecology study area are similar to those reported by Whalley *et al.* (1999) and therefore are considered unlikely to represent excessive levels for the region.

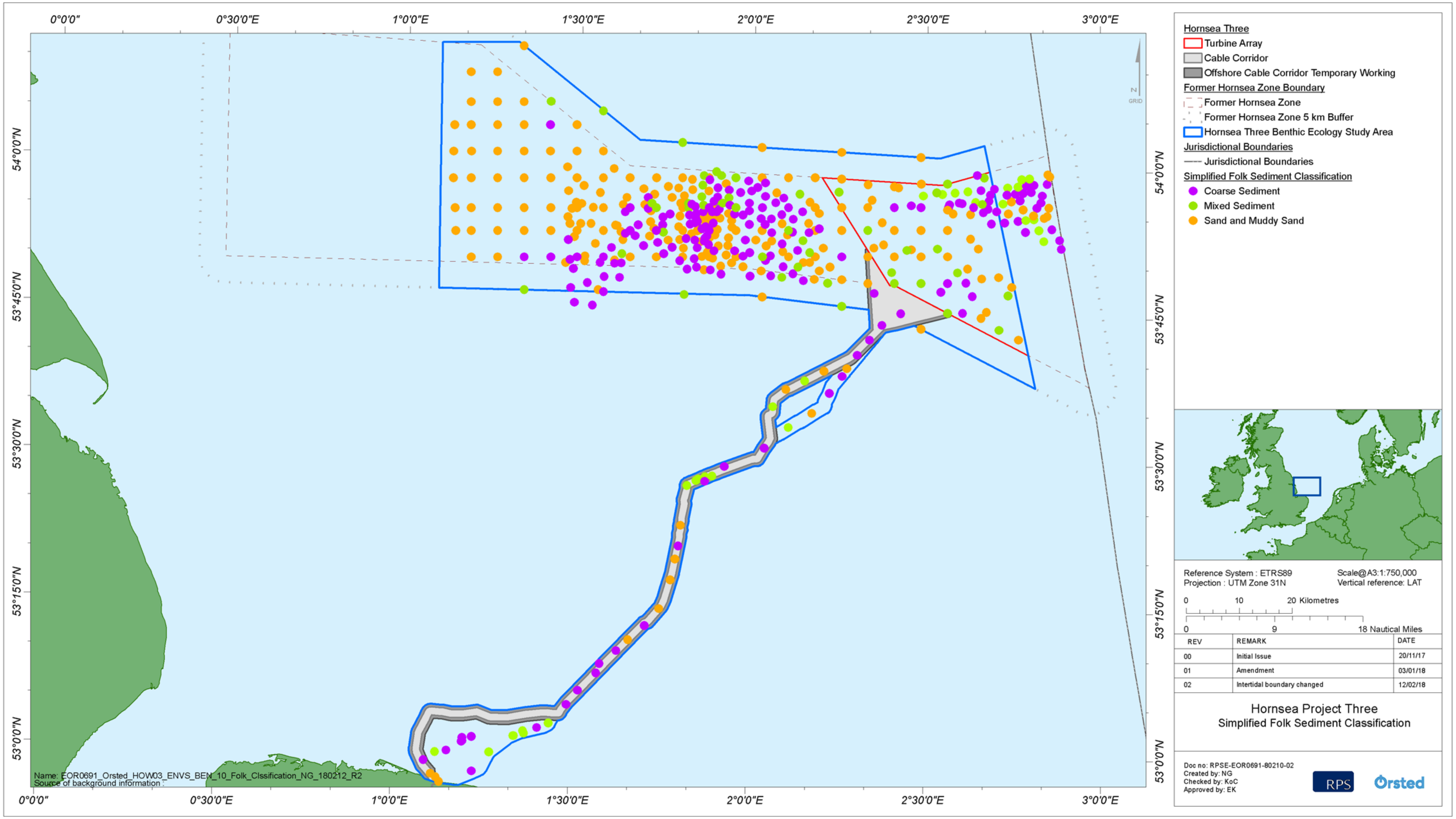

Figure 2.4: Simplified Folk Sediment Classifications for each benthic grab sample location within the Hornsea Three benthic ecology study area.

2.7.1.7 The level of cadmium marginally exceeded the Cefas AL1 at two sites within the Hornsea Three benthic ecology study area (outside Hornsea Three) but were well within the Cefas AL2, the Canadian PEL and the OSPAR BAC (noting concentrations were not normalised to 5% aluminium in the absence of aluminium results; see paragraph 2.7.1.5). The concentration of nickel marginally exceeded the Canadian TEL (15.9 mg/kg) at one site in the central former Hornsea Zone and the concentration of mercury exceeded the Canadian TEL (0.13 mg/kg) at one site in the cable fan of the Hornsea Three offshore cable corridor, though both concentrations were below the respective Cefas AL1 thresholds for those metals.

2.7.1.8 Levels of mercury were within the OSPAR BAC of 0.07 mg/kg at all sampling locations, with the exception of one within the cable fan at the northern end of the Hornsea Three offshore cable corridor where 0.23 mg/kg was recorded (noting that any direct comparisons with the OSPAR BAC should be made with caution as the site specific sediment chemistry data were not normalised to 5% aluminium; see paragraph 2.7.1.5). However, the level of mercury at that sampling location was below the Cefas AL1 threshold and, as outlined in paragraph 2.7.1.4, dredged material with this concentration would typically be considered suitable for disposal at sea.

2.7.1.9 All recorded TPH values in the Hornsea Three benthic study area were well below the Cefas AL1 of 100 mg/kg. Polycyclic aromatic hydrocarbons (PAHs) at most sites were within the range typical for sediments in the North Sea and all single PAH (including United States Environmental Protection Agency (US EPA) 16 listed PAHs) levels at all sites throughout the Hornsea Three benthic ecology study area were well below the Cefas AL1 concentration for individual PAHs and the Canadian TELs. The PAH Dibenzothiophene was recorded at concentrations up to 0.006 mg/kg in Hornsea Three and naphthalene was recorded at up to 0.03 mg/kg, which were both well within the Cefas AL1 concentrations for individual PAHs. Therefore, concentrations of EPA 16 listed PAHs, dibenzothiophene and naphthalene were recorded at levels that would typically be considered suitable for disposal at sea.

Infaunal and epifaunal biotopes

2.7.1.10 The subtidal biotopes identified in the Hornsea Three benthic ecology study area are described in this section, and presented in Figure 2.5 and Table 2.9 (see also volume 5, annex 2.1: Benthic Ecology Technical Report). The broad patterns in the infaunal and epifaunal biotopes identified across the Hornsea Three benthic ecology study area can be summarised as follows:

- Subtidal sandy sediments (biotope codes starting SS.SSa) in the western and central parts of the Hornsea Three benthic ecology study area and much of the Hornsea Three array area were characterised by the FfabMag, NcirBat and EpusOborApri biotopes, with typically extremely sparse epibenthic communities. The FfabMag biotope was widespread in the west of the former Hornsea Zone while the EpusOborApri biotope was prevalent in the northwest and southwest of the former Hornsea Zone, where it was occasionally recorded in association with the ScupHyd epibenthic biotope;
- Muddy sand sediments (biotope codes starting SS.SMu) in deeper waters to the north of the Hornsea Three benthic ecology study area and in the Hornsea Three array area were characterised by the AfilMysAnit biotope with limited associated epifaunal communities, with the exception of brittlestars;
- Coarse sediments (biotope codes starting SS.SCS) with diverse infaunal communities characterised by the PoVen biotope were recorded in large swathes within the Hornsea Three array area, in the southwest of the former Hornsea Zone and patchily distributed in the central section of the former Hornsea Zone. Substantial areas in the southern section of the Hornsea Three offshore cable corridor were also found to represent the PoVen biotope. Most of these sediments had typically sparse epibenthic communities, however, some areas were associated with the FluHyd epibenthic overlay; and
- Several substantial areas of mixed sediments ((biotope codes starting SS.SMx and SS.SBR) along the Hornsea Three offshore cable corridor, largely characterised by the SspiMx infaunal biotope, often exhibited the FluHyd epifauna biotope.

<u>Nearshore biotopes</u>

2.7.1.11 The Hornsea Three site specific surveys identified that the communities across the whole nearshore area (which has been used to characterise the Hornsea Three offshore cable corridor; see paragraph 2.6.1.4) were characterised primarily by the MoeVen and SspiMx biotopes, with the PoVen biotope characterising the areas further offshore (see Table 2.9 and volume 5, annex 2.1: Benthic Ecology Technical Report). Within the Cromer Shoal Chalk Beds MCZ and seaward of it, epifaunal communities were characterised by the FluHyd biotope with discrete areas of FluHyd/Pid biotope, particularly near to clay exposures within the Cromer Shoal Chalk Beds MCZ. The most inshore sampling locations were characterised by sandy sediments with relatively impoverished communities, with the NcirBat characterising this area, and a minimal epifaunal component (represented by the IMoSa biotope).

2.7.1.12 With respect to the inshore part of the Hornsea Three offshore cable corridor that coincides with the Cromer Shoal Chalk Beds MCZ, the surveys indicated that the sediments were characterised by the NcirBat sandy sediment biotope. These patterns are consistent with the available information on The Wash and North Norfolk Coast SAC, which indicated that this part of the SAC was characterised primarily by communities associated with mixed sediments (e.g. SspiMx and FluHyd) and sandy sediments (e.g. NcirBat; volume 5, annex 2.1: Benthic Ecology Technical Report).

Annex I habitats and features of conservation interest

<u>*Sabellaria spinulosa* reef assessment</u>

2.7.1.13 A *Sabellaria* biotope (SspiMx) was identified at ten areas in the Hornsea Three benthic study area with the majority recorded along the Hornsea Three offshore cable corridor. Although *S. spinulosa* reefs are associated with the SspiMx biotope, the occurrence of a *Sabellaria* biotope does not automatically indicate that a reef is present.

2.7.1.14 A full Annex I reef assessment was undertaken for five sites within the Hornsea Three offshore cable corridor, ECR02, ECR04, 26_CPT_ECR, ECR37 and ECR38, as *S. spinulosa* aggregations were visible in the DDV footage at these locations (see Figure 2.6). The density of *S. spinulosa* in the DDV footage at site ECR36, an area previously mapped by JNCC and Cefas in 2013 as Annex I reefs, was not sufficient to warrant a reefiness assessment and therefore this site was considered to be 'not reef'. Stony habitat was, however, recorded at site ECR36 and a stony reef assessment was undertaken (see paragraph 2.7.1.20).

2.7.1.15 At station ECR02, located to the north of the North Norfolk Sandbanks and Saturn Reef SAC (Figure 2.6), the *S. spinulosa* aggregations were estimated to cover an area of approximately 0.084 km^2 ('medium reef'). The mean elevation at station ECR02 achieved a 'low reef' score in the assessment, while patchiness was determined to represent 'high reef', resulting in an overall reef structure score of 'low reef'. However, using expert judgment it was considered appropriate to classify the *S. spinulosa* feature at ECR02 as 'medium reef', given that the patchiness (70.1%) far exceeded the threshold of 30% required to achieve high reef for that category. As such, there is potential for the aggregation at station ECR02 to be considered *S. spinulosa* reef. Grab sampling was avoided at this station after the *S. spinulosa* structure was observed in real-time during DDV operations. Had samples been acquired, a high abundance of *S. spinulosa* worms and a high diversity of associated taxa would have been expected at station ECR02. This *S. spinulosa* reef was recorded outside of the North Norfolk Sandbanks and Saturn Reef SAC boundary (see Figure 2.6).

2.7.1.16 At station ECR04, located within the North Norfolk Sandbanks and Saturn Reef SAC but outside the Hornsea Three offshore cable corridor (see Figure 2.6), it was not possible to delineate the extent of *S. spinulosa* due to the patchiness of the aggregations, therefore the area of the aggregations could not be determined. Both the elevation and patchiness were assessed as being 'low reef' at ECR04 giving an overall reef structure of 'low reef'. As the reef structure at station ECR04 was determined to be 'low reef' this area could only achieve a low reefiness score irrespective of the total area of the aggregations, therefore it is unlikely that this would be considered Annex I *S. spinulosa* reef habitat.

2.7.1.17 *S. spinulosa* aggregations at stations 26_CPT_ECR, ECR37 and ECR38 generally comprised a sparse distribution of tubes across the seafloor and were assessed as 'not reef'. It is unlikely that station 26_CPT_ECR and ECR38 would be considered *S. spinulosa* reef habitat. Station ECR37 was located within the boundary of the North Norfolk Sandbanks and Saturn Reef SAC and in an area previously mapped by JNCC and Cefas in 2013 as Annex I *S. spinulosa* reefs (see Figure 2.6). However, on the basis of the distribution of *S. spinulosa* tubes recorded during the Hornsea Three survey as described above, this area is not considered to be Annex I *S. spinulosa* reef habitat.

2.7.1.18 In summary, *S. spinulosa* reef outside an SAC/SCI was recorded at a single station (ECR02) on the Hornsea Three offshore cable corridor. None of the aggregations investigated at stations within the North Norfolk Sandbanks and Saturn Reef SAC (ECR04 and ECR37) could be considered as Annex I reef; therefore, no Annex I *S. spinulosa* reefs were found within the areas surveyed within the North Norfolk Sandbanks and Saturn Reef SAC including in areas previously mapped by JNCC and Cefas in 2013 as Annex I *S. spinulosa* reefs (see Figure 2.6).

2.7.1.19 The occurrence of *Sabellaria* biotopes throughout the Hornsea Three offshore cable corridor, together with other data such as the Humber REC dataset and the HADA MAREA dataset, indicates a wide distribution throughout this part of the southern North Sea benthic ecology study area, which suggests that *S. spinulosa* reefs in this area are likely to be ephemeral and, although the specific locations may change, the propensity for the presence of reef in these areas and in the Hornsea Three offshore cable corridor is evident. It is therefore concluded that there is potential for ephemeral reefs to occur within discrete parts of the Hornsea Three benthic ecology study area (namely the Hornsea Three offshore cable corridor) if suitable conditions prevail.

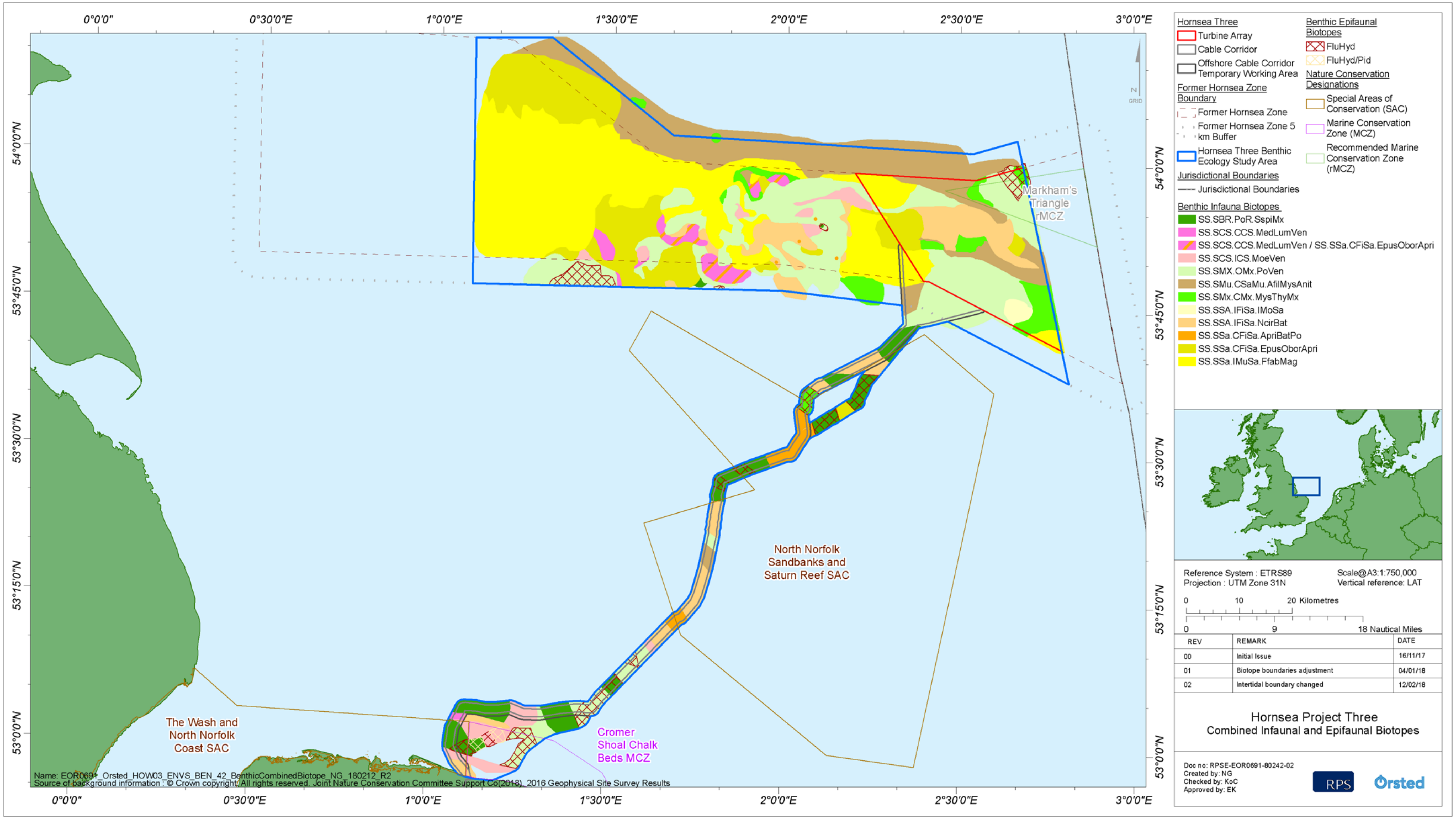

Figure 2.5: Combined infaunal and epifaunal biotope map of the Hornsea Three benthic ecology study area.

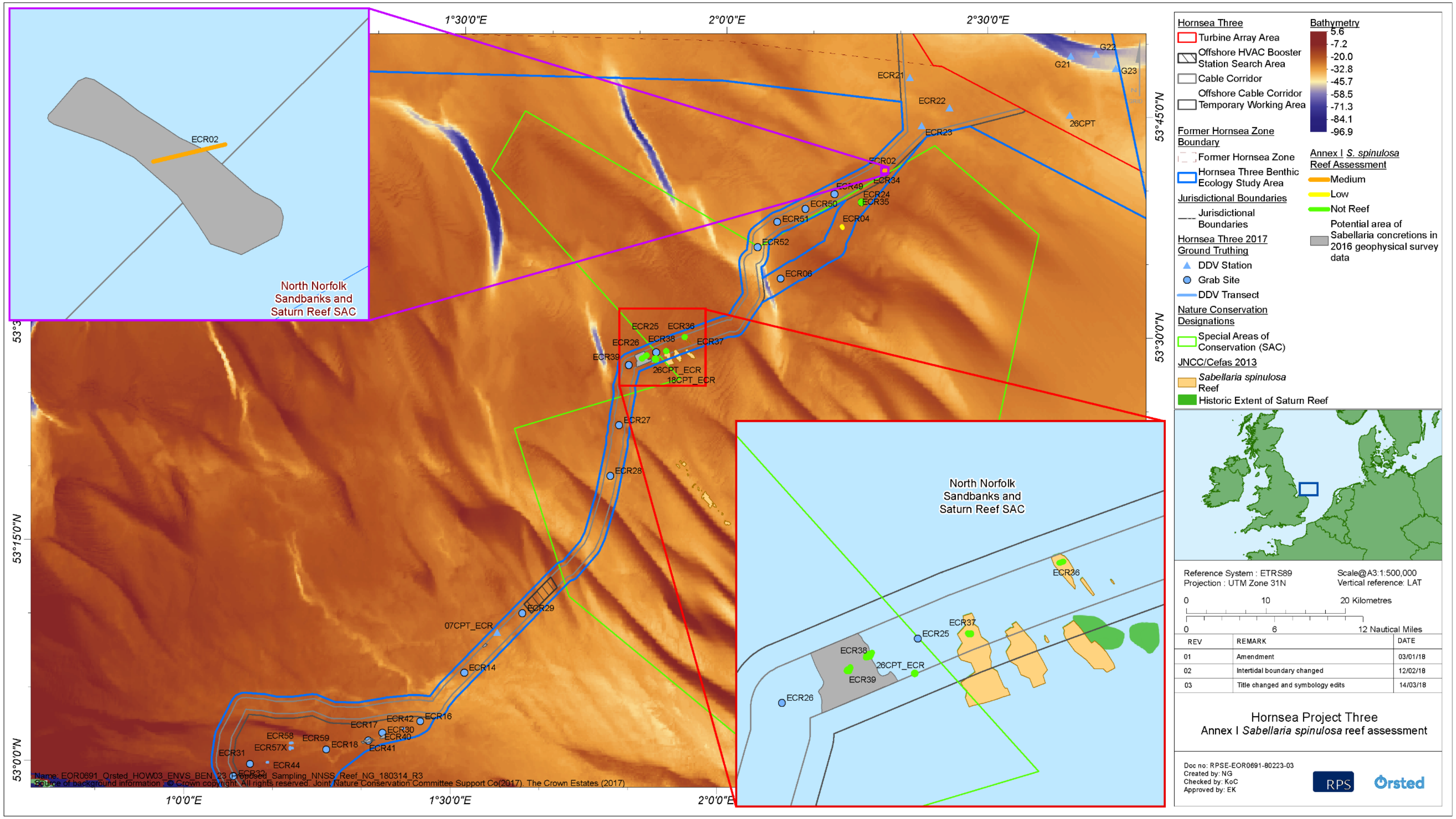

Figure 2.6: The Hornsea Three offshore cable corridor and historic extents of Annex I *S. spinulosa* reefs within the North Norfolk Sandbanks and Saturn Reef SAC, together with the results of the Hornsea Three site specific survey *S. spinulosa* reefiness assessments.

Table 2.9: Benthic infaunal and epifaunal biotopes identified in the Hornsea Three benthic ecology study area, including geographic locations (see Figure 2.5).

Biotope code	Hornsea Three biotope description	Geographic location
Infaunal biotopes		
SS.SSa.IFiSa.NcirBat (NcirBat)	This biotope occurred in well sorted medium and fine sands and was characterised by the polychaetes *Nephtys cirrosa* and *Spiophanes bombyx*, the amphipod *Bathyporeia elegans* and the opossum shrimp *Gastrosaccus spinifer*.	This biotope was located in the central part of the former Hornsea Zone, the central part of the Hornsea Three array area and six discrete areas along the Hornsea Three offshore cable corridor.
SS.SSa.CFiSa.ApriBatPo (ApriBatPo)	Occurring in circalittoral and offshore medium to fine sands with a community characterised by the bivalve *Abra prismatica*, the polychaetes *Scoloplos armiger*, *Nephtys cirrosa*, *Ophelia borealis*, *Spiophanes bombyx* and the amphipods *Bathyporeia elegans* and *Bathyporeia guilliamsoniana*.	This biotope was located at small discrete locations in the former Hornsea Zone and at three locations along the Hornsea Three offshore cable corridor.
SS.SSa.CFiSa.EpusOborApri (EpusOborApri)	Offshore sediments dominated by medium to fine sands and characterised by the polychaetes *Ophelia borealis*, *Spiophanes bombyx* and *Nephtys cirrosa*, high abundances of the pea urchin *Echinocyamus pusillus* and by the venerid bivalve *Abra prismatica*.	This biotope was recorded in the southwest and northwest of the former Hornsea Zone and in the west of the Hornsea Three array area.
SS.SSa.IMuSa.FfabMag (FfabMag)	In stable, fine, compacted and slightly muddy sands in the infralittoral and littoral fringe, this community was characterised by venerid bivalves such as *Fabulina fabula*, *Chamelea striatula* and *Abra prismata*, polychaetes including *Magelona johnstoni* and *Spiophanes bombyx* and the amphipods *Bathyporeia elegans*, *Bathyporeia tenuipes* and *Bathyporeia guilliamsoniana*.	The biotope was the predominant biotope throughout the west of the former Hornsea Zone and in the west of the Hornsea Three array area. It was also recorded in patches throughout the central section of the former Hornsea Zone. There were no records of this biotope along the Hornsea Three offshore cable corridor.
SS.SMu.CSaMu.AfilMysAnit (AfilMysAnit)	Poorly sorted cohesive muddy sands in moderately deep water with an infaunal community dominated by high abundances of the echinoderm *Amphiura filiformis*, the bivalve *Kurtiella (Mysella) bidentata*, polychaetes and nemerteans.	This biotope was assigned to a swathe of sediment stretching the length of the northern former Hornsea Zone. It was also present in the deeper waters of the central part of the Hornsea Three array area, and at one small area in the centre of the Hornsea Three offshore cable corridor.
SS.SCS.CCS.MedLumVen/ SS.SSa.CFiSa.EpusOborApri (MedLumVen/EpusOborApri)	A mosaic biotope with characteristics of both the circalittoral fine sand EpusOborApri biotope and the richer coarser sand MedLumVen biotope dominated by polychaetes and venerid bivalves. This biotope was characterised by the polychaete *Ophelia borealis* and the echinoderm *Echinocyamus pusillus*.	This mosaic biotope was recorded in patches within the central former Hornsea Zone, particularly in the south.
SS.SCS.ICS.MoeVen (MoeVen)	This biotope occurred in infralittoral medium to coarse sand which is subject to moderately strong water movement from tidal streams, with communities characterised by high abundances of the venerid bivalve mollusc *Goodallia triangularis* and to a lesser extent *Timoclea ovata* and a relatively diverse assemblage of polychaetes including *Nephtys cirrosa* and *Ophelia borealis*.	This biotope was found in discrete patches in the central former Hornsea Zone and the shallower water of the nearshore section of the Hornsea Three offshore cable corridor.
SS.SCS.CCS.MedLumVen (MedLumVen)	Circalittoral gravels, coarse to medium sands, and shell gravels, sometimes with a small amount of silt characterised by polychaetes including *Spiophanes bombyx*, *Ophelia borealis*, *Mediomastus fragilis* and *Glycera lapidum* with the pea urchin *Echinocyamus pusillus*. Communities also including *Nemertea* spp. and venerid bivalves such as *Dosinia* sp. which although in low numbers are likely to have been under-sampled in the grab surveys.	This mosaic biotope was mostly recorded in isolated patches of the central former Hornsea Zone.
SS.SMx.OMx.PoVen (PoVen)	In offshore gravelly sands an infaunal community characterised by a particularly rich community of polychaetes including *Notomastus* spp., *Glycera lapidum, Aonides paucibranchiata*, *Mediomastus fragilis*, *Scalibregma inflatum* and *Protodorvillea kefersteini*, *Polycirrus* spp., ribbon worms *Nemertea* spp. and the pea urchin *Echinocyamus pusillus*.	This biotope was distributed extensively throughout the Hornsea Three array area, particularly to the south and northeast of the Hornsea Three array area. It was also found in the southwest and the central section of the former Hornsea Zone and along much of the Hornsea Three offshore cable corridor within approximately 40 km of the shore.
SS.SMx.CMx.MysThyMx (MysThyMx)	Moderately exposed or sheltered, circalittoral muddy sands and gravels characterised by communities of the bivalve *Kurtiella bidentata*, polychaetes such as *Glycera alba*, *Mediomastus fragilis* and *Goniada maculata*. The brittlestar *Amphiura filiformis* was also abundant at some sites.	This biotope was distributed as isolated patches throughout the central northern and eastern sections of the former Hornsea Zone, particularly within the Hornsea Three array area. One isolated area was recorded in the northern section of the Hornsea Three offshore cable corridor.
SS.SBR.PoR.SspiMx (SspiMx)	This biotope occurred on mixed sediments and was characterised by high abundances of the tube-building polychaete *S. spinulosa*, and a diverse community of infaunal polychaetes including *Polycirrus* spp., *Scalibregma inflatum*, *Mediomastus fragilis* and *Pholoe baltica*, together with the bivalve mollusc *Abra alba*.	This biotope was predominantly recorded along the Hornsea Three offshore cable corridor, particularly in the nearshore and most offshore sections.
SS.SSa.IFiSa.IMoSa (IMoSa)	Medium to fine sandy sediment in shallow water, often formed into dunes, on tide swept coasts containing very little fauna due to the mobility of the substratum. Characterised by low numbers of amphipods such as *Bathyporeia* spp., the mysid *Gastrosaccus spinifer* and the venerid bivalve *Ensis siliqua*.	This biotope was found in isolated areas in the central former Hornsea Zone and in the southeast of the Hornsea Three array area.

Biotope code	Hornsea Three biotope description	Geographic location
Epifaunal biotopes		
SS.SSa.IFiSa.IMoSa (IMoSa)	Medium to fine sandy sediment on exposed coasts that often contains very little epifauna due to the mobility of the substratum. Very few epifaunal species were recorded and, except for the echinoderms including *Asterias rubens* and *Astropecten irregularis*, which generally occurred at low abundances including flatfish and sandeels. In areas where localised cobbles and pebbles provided substrate for epifaunal species in an otherwise featureless habitat, hydroid turfs and bryozoan crusts were observed on the pebbles and cobbles.	This biotope was distributed extensively throughout the Hornsea Three benthic ecology study area, particularly the Hornsea Three offshore cable corridor and the central section of the Hornsea Three array area, as well as the area to the west of this.
SS.SSa.IFiSa.ScupHyd (ScupHyd)	Sand sediment with cobbles and pebbles, exposed to strong tidal stream, this biotope is characterised by the echinoderm *Asterias rubens*, conspicuous mixed hydroid and bryozoan turfs and the sand mason *Lanice conchilega* in the surrounding sand.	This biotope was recorded in the central section of the former Hornsea Zone.
SS.SMu (SMu)	Sublittoral mud and cohesive sandy mud found in offshore areas of deeper water. This biotope is characterised by epifaunal communities of brittlestars, echinoderms *Asterias rubens* and burrowing megafauna including *Nephrops norvegicus*.	This biotope was found in the deeper waters to the north, centre and southeast of the Hornsea Three array area.
SS.SCS.ICS.SSh (SSh)	Sublittoral clean shingle and pebbles with a lack of conspicuous fauna. Although most of the sites assigned to this biotope constituted predominantly coarse gravelly sand, rather than pebbles, the distinct lack of epifauna matched this biotope. This biotope was characterised by a lack of epifauna and the presence of similar epifauna to the IMoSa biotope in sandy sediment including the echinoderms *Asterias rubens*, *Astropecten irregularis*, sandeels and locally abundant hydroid turfs and soft coral *Alcyonium digitatum* on cobbles and pebbles.	This biotope was present in large swathes in the north and south of the Hornsea Three array area as well as in the areas of coarser sediments to the west of the Hornsea Three array area. One area of this biotopes was recorded along the Hornsea Three offshore cable corridor, just seaward of the Cromer Shoal Chalk Beds MCZ.
SS.SMx.CMx.FluHyd (FluHyd)	This biotope is best considered as an epifaunal overlay on a substratum of boulder, cobbles or pebbles with gravel and sand. The epifaunal community was characterised by mixed turfs of hydroids and bryozoans including *Flustra foliacea*, barnacles *Balanus crenatus*, the ascidian *Dendrodoa grossularia*, keelworms *Pomatoceros* sp. and anemones including *Urticina* sp. on scattered pebbles and cobbles.	This biotope was found in a discrete location in the northeast of the Hornsea Three array area, in the southwest of the Hornsea Three benthic ecology study area and at several areas along the Hornsea Three offshore cable corridor, particularly the section within approximately 30 km of the shore.
SS.SMx.CMx.FluHyd/ CR.MCR.SfR.Pid (FluHyd/Pid)	This mosaic biotope comprised an epifaunal community on a shallow veneer of coarse and mixed sediments over clay which exhibited a sparse community dominated by the piddock bivalve, typically *Pholas dactylus*, where the clay is exposed through the widespread sediment veneer. Clay is generally too soft for sessile taxa to attach to, resulting in an impoverished community where no other substrates are present. Mobile fauna typically includes the crabs *Necora puber* and *Cancer pagurus*, and common lobster *Homarus gammarus*.	This biotope was recorded in two discrete areas within 10 km of the shore, inside the Cromer Shoal Chalk Beds MCZ.
SS.SBR.PoR.SspiMx	This biotope, also recorded in infaunal sediments, was primarily characterised by high abundances of the tube-building polychaete *S. spinulosa* in the epifaunal datasets, together with *Alcyonium digitatum*, *Flustra* sp. and Actiniaria.	This biotope was predominantly recorded along the Hornsea Three offshore cable corridor, particularly in the nearshore and most offshore sections.

Stony reef assessment

2.7.1.20 Stony substrate was visible in the DDV footage at five locations along, or near to, the Hornsea Three offshore cable corridor (ECR24, ECR35, ECR36, ECR38 and ECR39). A full stony reef assessment was undertaken on data from these five stations. Elevations were observed at between 4.1 cm and 7.6 cm and composition was recorded at between 10.0% and 18.8%. 'Not a reef' was concluded at three locations (ECR24, ECR35 and ECR38), while 'low reef' was determined to be present at the remaining two locations, ECR36 and ECR39.

2.7.1.21 As detailed in Table 2.8, the Hornsea Three 2017 site specific inshore geophysical survey data identified an area of subcropping rock (i.e. covered by <3 m of sediment) in the inshore section of the offshore cable corridor. Sub-bottom profiler data interpretation showed evidence of subcropping rock close to the surface (i.e. sediment veneer of <0.2 cm) in discrete areas and DDV transects were undertaken across this area in October 2017, specifically targeting nine areas where these outcrops were most elevated from the surrounding sediment. The main aim of these DDV transects were to identify areas of potential chalk outcrops which may qualify as chalk reef habitats and/or Annex I stony reef habitats following the criteria identified by Irving (2009; for stony reefs) and qualitative reefiness descriptions for subtidal chalk reef as provided by Natural England, though the EWG (Note: these broadly aligned with the minimum criteria set out by Irving, 2009). As discussed in volume 5, annex 2.1: Benthic Ecology Technical Report, these areas were found to be characterised by discrete areas of mixed coarse sediments, surrounding by rippled sand. Elevation of cobbles and/or other rock (including exposed chalk) was found to be less than 64 mm across the entire survey area and the proportion of the seabed comprising either exposed rock or cobbles/boulders was less than 10%. As such, detailed stony reef assessments were not undertaken on the DDV footage, due to the minimum elevation and patchiness criteria for stony reefs and subtidal chalk reefs not being met.

2.7.1.22 A benthic species of conservation importance, which was recorded within the Hornsea Three benthic ecology study area, was the ocean quahog *Arctica islandica.* This species is listed by Oslo-Paris Commission (OSPAR) as a threatened and/or declining species for the Greater Northern North Sea (OSPAR Region II), and was recorded from nine sites (from six sites as single specimens, and three sites where two individuals were recorded) in the former Hornsea Zone. All records were of juvenile *A. islandica*, except for one which measured less than 10 mm, indicating it was a spat rather than a juvenile (Witbaard and Bergman, 2003). No *A. islandica* individuals were recorded within Hornsea Three.

2.7.2 Intertidal biotopes

2.7.2.1 The Hornsea Three intertidal area at Weybourne was characterised by naturally species-poor intertidal benthic communities, which are typical of dynamic shingle and sandy shore environments. A total of four intertidal biotopes were recorded at the Hornsea Three intertidal area (see Table 2.10 and Figure 2.7). The intertidal zone between Weybourne and Salthouse and the wider intertidal area comprised a shingle beach dominated by barren pebbles and cobbles. The beach profile was steep, as expected for a shingle shore, with distinct ridges or berms across the face of the beach; this profile pattern and the sediment type was largely consistent for the full length of the Hornsea Three intertidal area. Areas of fine sand with reduced shingle content were observed at the MLWS and in isolated patches on the lower shore throughout the Hornsea Three intertidal area.

2.7.2.2 No VERs were identified at the Hornsea Three intertidal area and, while the area in general has been considered in the assessment, the sparse ecological communities at the Hornsea Three intertidal area have not been assessed.

Table 2.10: Intertidal biotopes identified during the intertidal walkover survey of the Hornsea Three intertidal area, within the Hornsea Three benthic ecology study area (Figure 2.7).

Biotope code	Biotope description	Geographic location
LS.LSa.St (St) Strandline	The driftline consisted of decomposing bryozoan colonies, brown seaweed (*Fucus* spp.), reeds, feathers and twigs. A community of sandhoppers (including talitrid amphipods) is often associated with driftline debris as it provides suitable cover and humidity. However, sandhoppers were not observed on the shingle substrate at the Hornsea Three intertidal area.	This biotope was recorded in the upper shore, between 3 and 30 m from the back of the beach.
LS.LCS.Sh.BarSh (BarSh) Barren littoral coarse shingle	This biotope extended over the whole shore at Weybourne, Salthouse and between these locations. Sediment comprised mostly shingle, of pebble or cobble dimension, according to the Wentworth classification system, with some gravel. Gravel was generally limited to the lower shore in association with cusp features and transitions to areas of fine sand. No faunal species were recorded within this biotope.	This biotope, which was present on the upper, mid and lower shore, dominated the Hornsea Three intertidal area between the MHWS and MLWS.
LS.LSa.FiSa (FiSa) Polychaete / amphipod dominated fine sand shores	Sediments comprised clean, fine to medium sand. Fine sand shores usually support a range of species including amphipods and polychaetes; dig-over samples revealed gammarid amphipods with abundances of between 25 and 50 per m^2. No other fauna was recorded.	This biotope was generally located close to the MLWS in the east of the Hornsea Three intertidal area and as a mosaic with BarSh in beach cusp features in the west.
LH.HLR.MusB (MusB) Mussels and/or barnacle communities	Communities of this classification are typically dominated by mussels and/or barnacles comprising *Chthamalus* spp. and/or *Semibalanus balanoides*. This biotope was observed in association with an iron outfall pipe and support structure at Weybourne, in a 1.5 m high band of encrusting barnacle growth, in conjunction with green algae, *Ulva* spp., 1.5 m above the low water mark. No other faunal species were evident.	This minor biotope was associated with the outfall pipe in the mid to lower shore at Weybourne in the east of the Hornsea Three intertidal area.

2.7.3 Designated sites

2.7.3.1 Section 2.6.3 above describes the methods of screening in designated sites and their benthic features. In addition to sites with a physical overlap with Hornsea Three, the potential ZoI from increased suspended sediment concentrations and deposition has been determined using the results of the physical processes assessment as described in volume 2, chapter 1: Marine Processes.

2.7.3.2 Designated sites within the ZoI of Hornsea Three (see section2.6.3), and their relevant benthic ecology features, which have been screened into the benthic assessment, are described here and discussed in full in volume 5, annex 2.1: Benthic Ecology Technical Report.

2.7.3.3 With respect to effects associated with construction within the Hornsea Three array area the assessment predicts that SSC increases of low tens of mg/l may occur out to 7 km as a result of drilling operations and, outside this area, SSC of less than 10 mg/l may occur due to ongoing dispersion and dilution of fine material. For seabed preparation works, elevations in SSC above background levels at distances of hundreds of metres to a few kilometres are predicted to be relatively low (i.e. less than ~20 mg/l) and within the range of natural variability and after 24 hours, elevations in SSC are predicted to typically be less than 5 mg/l. Fine grained material will be dispersed widely within the surrounding region and will not settle with a measurable thickness. Therefore, only the features of those sites within these ranges of potential effect from sediment deposition and/or elevations in SSC have been screened into the assessment.

2.7.3.4 With regards to the Hornsea Three offshore cable corridor works, paragraph 2.11.1.108 describes that the plume of coarse sand and gravels will be spatially limited, only affecting SSC levels at the point of release. Finer material will be rapidly dispersed, to near-background levels (tens of mg/l) within hundreds to a few thousands of metres of the point of release. Irrespective of sediment type, the volumes of sediment being displaced and deposited locally are relatively limited which also limits the combinations of sediment deposition thickness and extent that might realistically occur. Therefore, features of those sites outside these ranges of potential effect from sediment deposition and/or elevations in SSC have been screened into the assessment.

2.7.3.5 The list of designated sites identified in the following sections for inclusion within the benthic assessment were agreed with the statutory consultees.

International designations

Natura 2000 sites

2.7.3.6 Based on the justification outlined above in paragraph 2.7.3.1, the qualifying benthic features of the following Natura 2000 sites (see Figure 2.1) have been included in the benthic assessment:

- North Norfolk Sandbanks and Saturn Reef SAC - this site coincides with Hornsea Three offshore cable route corridor; and
- The Wash and North Norfolk Coast SAC - this site coincides with Hornsea Three offshore cable route corridor.

2.7.3.7 The relevant Annex I habitats for which these sites are designated are outlined in Table 2.11 and have been considered in this benthic assessment for direct and indirect effects.

2.7.3.8 Although Klaverbank SCI site is 11 km from Hornsea Three and has been screened out on the basis that qualifying features are unlikely to be impacted by Hornsea Three, this site is further discussed in section 2.14 in the context of transboundary effects.

National designations

2.7.3.9 Based on the justification outlined above in paragraphs 2.7.3.1 and 2.7.3.4, the qualifying benthic features of the following national designations (see Figure 2.1) have been included in the benthic assessment:

- Cromer Shoal Chalk Beds MCZ – this site coincides with the nearshore section of the Hornsea Three offshore cable route corridor; and
- Markham's Triangle rMCZ – this site coincides with the Hornsea Three array area.

2.7.3.10 The relevant benthic habitats for which these sites are designated are outlined in Table 2.11 and have been considered in this benthic assessment for direct and indirect effects. As also outlined in Table 2.11, the qualifying habitats included in the assessment for Markham's Triangle rMCZ has been extended to include Mixed sediments, in spite of the fact that this habitat is not currently listed as a protected feature proposed for designation within Markham's Triangle rMCZ. It has been included on the basis of advice from Natural England through the Marine Processes, Benthic Ecology and Fish and Shellfish EWG that this broadscale habitat is likely to be included as a feature put forward for designation for Markham's Triangle rMCZ in the future.

Table 2.11: International and national (including proposed) designations considered within the assessment and their associated qualifying habitat features occurring within the Hornsea Three benthic ecology study area.

Site	Qualifying habitats
The Wash and North Norfolk Coast SAC	Sandbanks which are slightly covered by sea water all the time (Subtidal sandbanks) [a]; and Reefs (circalittoral rock, subtidal biogenic reefs (mussel beds and *Sabellaria* spp. reefs) and subtidal stony reef).
North Norfolk Sandbanks and Saturn Reef SAC	Sandbanks which are slightly covered by sea water all the time [b]; and Reefs (including the Saturn *S. spinulosa* biogenic reef).
Cromer Shoal Chalk Beds MCZ	High energy circalittoral rock; Moderate energy circalittoral rock; High energy infralittoral rock; Moderate energy infralittoral rock; Subtidal coarse sediments; Subtidal mixed sediments; Subtidal sand; Peat and clay exposures; and Subtidal chalk.
Markham's Triangle rMCZ	Subtidal coarse sediments; Subtidal sand; and Mixed sediments [c]

a For the purposes of this assessment, the entire SAC is assigned to supporting habitat for Annex I sandbank habitat.

b For the purposes of this assessment, the entire SAC is assigned to the Annex I sandbank habitat, as it is designated and viewed as one integrated sandbank system (JNCC, 2010).

c Not currently proposed for designation but recent advice from Natural England through the EWG has indicated that subtidal mixed sediments are likely to be included as features put forward for designation for Markham's Triangle rMCZ.

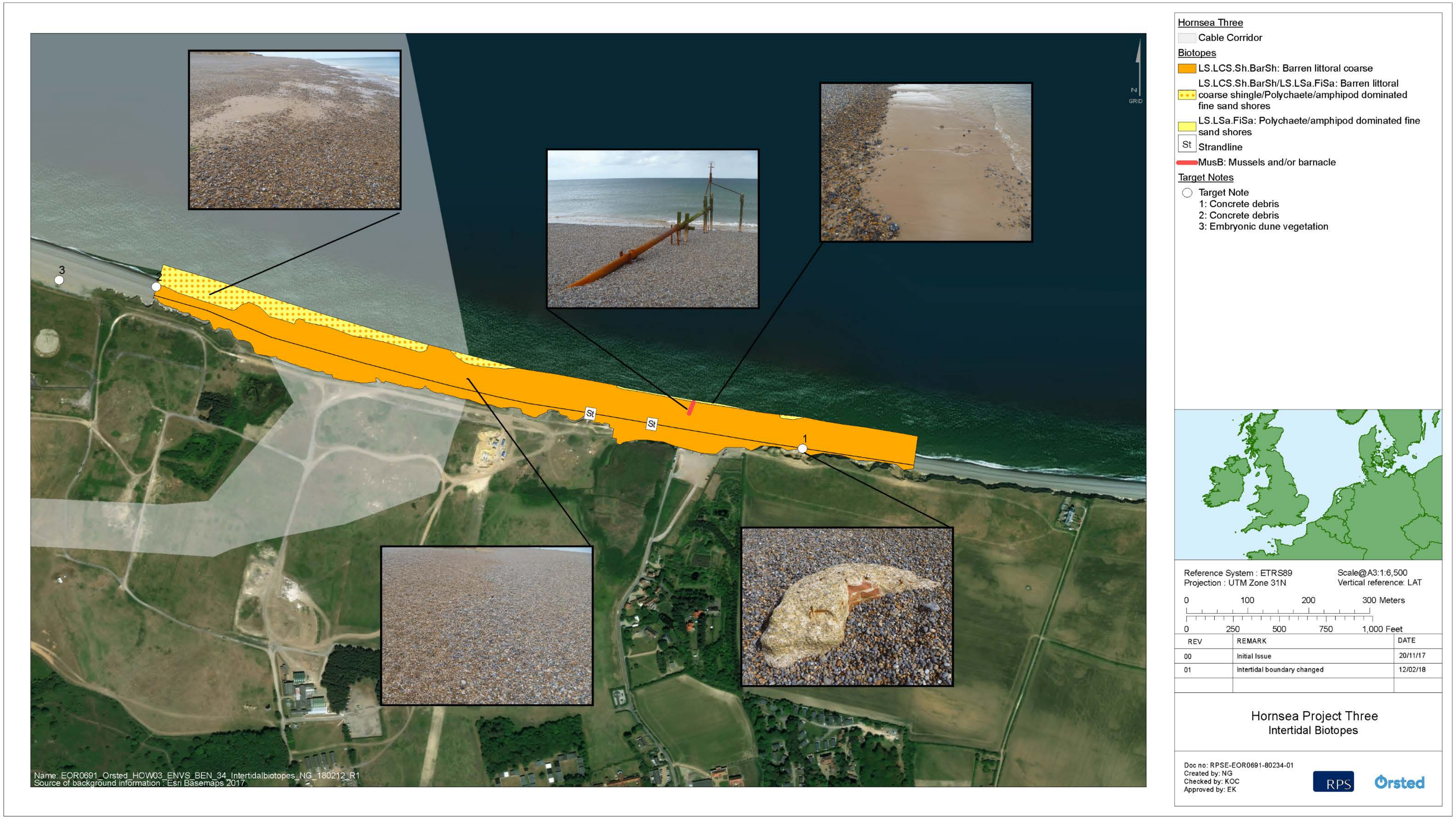

Figure 2.7: Intertidal biotopes at the Hornsea Three intertidal area at Weybourne and Salthouse, within the Hornsea Three benthic ecology study area.

2.7.4 Valued Ecological Receptors

2.7.4.1 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. Annex I habitats under the Habitats Directive, OSPAR, Biodiversity Action Plan (BAP) habitats and species, habitats/species of principal importance listed under the Natural Environment and Rural Communities (NERC) Act 2006 and habitats/species listed as features of MCZs/rMCZs). 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. Table 2.12shows the criteria applied to determining the ecological value of VERs within the geographic frame of reference applicable to the Hornsea Three benthic ecology study area.

2.7.4.2 For the purposes of conducting the EIA, the biotopes present across the Hornsea Three benthic ecology study area have been grouped into five broad habitat/community types. Features of nature conservation designations are also considered as VERs, together with the species of conservation interest, *A. islandica*, which was found within the Hornsea Three benthic ecology study area. These VERs have been used to assess impacts associated with the construction, operation and maintenance and decommissioning of Hornsea Three on benthic ecology within the Hornsea Three and wider southern North Sea benthic ecology study areas. As discussed in paragraph 2.7.2.2, no VERs were identified at the Hornsea Three intertidal area. As such, no intertidal VERs have been considered in the assessment, instead, the Hornsea Three intertidal area has been discussed in general, in relevant impacts within the assessment.

2.7.4.3 The biotopes have been grouped into broad habitat/community types according to the results of the statistical analyses described in volume 5, annex 2.1: Benthic Ecology Technical Report. Habitats with similar physical, biological characteristics (including species complement and richness/diversity) as well as conservation status/interest have been grouped together for the purposes of the EIA. Consideration was also given to the inherent sensitivities of different habitats in assigning the groupings presented in Table 2.13, such that habitats and species with similar vulnerability and recoverability, often because of similar broad sediment types and species complements, were grouped together. The overall value of each VER was then assessed using the criteria presented in Table 2.12.

Table 2.12: Criteria used to inform the valuation of ecological receptors in the Hornsea Three benthic ecology study area.

Value of VER	Criteria to define value
International	Internationally designated sites. Habitats and species protected under international law (i.e. Annex I habitats within an SAC boundary). OSPAR List of Threatened and/or Declining Species and Habitats.
National	Nationally designated sites. Species protected under national law. Annex I habitats not within an SAC boundary. UK BAP priority habitats and species, NERC habitats and species of principal importance in England, and Nationally Important Marine Species that have nationally important populations within Hornsea Three benthic ecology study area, particularly in the context of species/habitat that may be rare or threatened in the UK. Habitats and species that are features of MCZs and rMCZs (i.e. broad-scale habitats and Features of Conservation Importance (FOCI)).
Regional	UK BAP priority habitats, NERC habitats and species of principal importance in England, or Nationally Important Marine Species that have regionally important populations within the Hornsea Three benthic ecology study area (i.e. are locally widespread and/or abundant). Habitats or species that provide important prey items for other species of conservation or commercial value.
Local	Habitats and species which are not protected under conservation legislation which form a key component of the benthic ecology within the Hornsea Three benthic ecology study area.

2.7.4.4 Table 2.13 presents the VERs, their conservation status and importance within the Hornsea Three benthic ecology study area, which are presented geographically in Figure 2.8 for subtidal features. The main habitats identified throughout the benthic ecology study area comprised five broad VERs (Habitats A, B, C, D and E), which are mapped in Figure 2.8. The VER extents are shown for the Hornsea Three benthic ecology study area, rather than just Hornsea Three, as this provides some context to the distribution of these habitats.

2.7.4.5 Whilst the VERs that comprise Annex I habitat features of SACs and features of MCZ/rMCZs are not mapped in Figure 2.8, these VERs have also been assessed. The biotopes identified within the designated conservation sites using the Hornsea Three site specific survey data (as described in Table 2.13 and volume 5, annex 2.1: Benthic Ecology Technical Report) contribute to, or directly represent, these VERs. As such, assessments relating to impacts in designated sites in section 2.11 (e.g. temporary habitat loss/disturbance) consider the biotopes rather than just the broader VERs, where appropriate.

Table 2.13: Valued Ecological Receptors (VERs) within the Hornsea Three benthic ecology study area, their conservation status and importance.

VER	Representative infaunal and/or epifaunal biotopes	Protection status	Conservation interest	Importance within Hornsea Three benthic ecology study area and justification
Habitat A: Sandy sediments with low infaunal diversity and sparse epibenthic communities (Figure 2.8).	IMoSa, IMuSa, NcirBat, FfabMag, EpusOborApri, ApriBatPo and ScupHyd (where present as an epifaunal overlay in small areas of the EpusOborApri biotope).	None	UK BAP priority habitat.	Regional – UK BAP with nationally important populations close to the Hornsea Three benthic ecology study area.
Habitat B: Brittlestar dominated communities in deep muddy sands (Figure 2.8).	AfilMysAnit	None	UK BAP priority habitat.	Regional – although this habitat is representative of a nationally important marine habitat, the southern North Sea is not a key geographic area.
Habitat C: Coarse and mixed sediments with moderate to high infaunal diversity and scour tolerant epibenthic communities (Figure 2.8).	MedLumVen/EpusOborApri, MedLumVen, MoeVen, MysThyMx, PoVen, ScupHyd, FluHyd.	None	UK BAP priority habitat.	Regional – although this habitat is representative of a nationally important marine habitat, the southern North Sea is not a key geographic area.
Habitat D: Mixed sediments with high infaunal and epifaunal diversity (Figure 2.8).	SspiMx	None	Not applicable	Regional - Habitats or species that provide important prey items for other species of conservation or commercial value.
Habitat E: *S. spinulosa* reef outside an SAC/SCI with high infaunal and epifaunal diversity.	SspiMx	Annex I Habitats Directive	OSPAR habitat: *Sabellaria spinulosa* reefs. Qualifying feature of the North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC.	National – although it qualifies as a reef habitat, it does not form part of a European designated site.
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.	National – UK BAP with nationally important populations close to the Hornsea Three benthic ecology study area.
Annex I habitat features SACs				
Sandbanks which are slightly covered by seawater all the time.	N/A	Annex I Habitats Directive	UK BAP priority habitat. Qualifying feature of the North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC.	International – part of European designated sites (i.e. North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC).
Reefs (biogenic reefs, circalittoral rock and stony reefs).	SspiMx	Annex I Habitats Directive	OSPAR habitat: *Sabellaria spinulosa* reefs. UK BAP priority habitat. Qualifying feature of the North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC.	International – part of European designated sites (i.e. North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC).
Broad Scale Habitats: Features of MCZ/rMCZs				
Subtidal coarse sediments.	MedLumVen/EpusOborApri, MedLumVen, MoeVen, MysThyMx, PoVen, ScupHyd, FluHyd.	Annex I Habitats Directive MCZ	Protected feature within the Cromer Shoal Chalk Beds MCZ. Feature proposed for designation within the Markham's Triangle rMCZ.	National –protected feature of the Cromer Shoal Chalk Beds MCZ and proposed feature for designation of Markham's Triangle rMCZ.
Subtidal sand.	IMoSa, IMuSa, NcirBat, FfabMag, EpusOborApri, ApriBatPo and ScupHyd (where present as an epifaunal overlay in small areas of the EpusOborApri biotope).	Annex I Habitats Directive MCZ	Protected feature within the Cromer Shoal Chalk Beds MCZ. Feature proposed for designation within the Markham's Triangle rMCZ.	National – protected feature of the Cromer Shoal Chalk Beds MCZ and proposed feature for designation of Markham's Triangle rMCZ included as a protected feature within the Cromer Shoal Chalk Beds MCZ.

VER	Representative infaunal and/or epifaunal biotopes	Protection status	Conservation interest	Importance within Hornsea Three benthic ecology study area and justification
Subtidal mixed sediments.	SspiMx	Annex I Habitats Directive MCZ	Protected feature within the Cromer Shoal Chalk Beds MCZ. Feature proposed for designation within the Markham's Triangle rMCZ.	National – included as a protected feature within the Cromer Shoal Chalk Beds MCZ.
Subtidal chalk reef (see Figure 3.3 in volume 5, annex 2.1: Benthic Ecology Technical Report).	N/A	Annex I Habitats Directive MCZ	Annex I 'Reefs'. UK BAP priority habitat. Protected feature within the Cromer Shoal Chalk Beds MCZ. 'Subtidal chalk' is a habitat FOCI under the Nature Conservation part (Part 5) of the MCAA 2009.	National –protected feature of the Cromer Shoal Chalk Beds MCZ.
Peat and clay exposures (see Figure 3.3 in volume 5, annex 2.1: Benthic Ecology Technical Report).	FluHyd/Pid	MCZ	UK BAP priority habitat. Protected feature within the Cromer Shoal Chalk Beds MCZ.	National – included as a protected feature within the Cromer Shoal Chalk Beds MCZ.

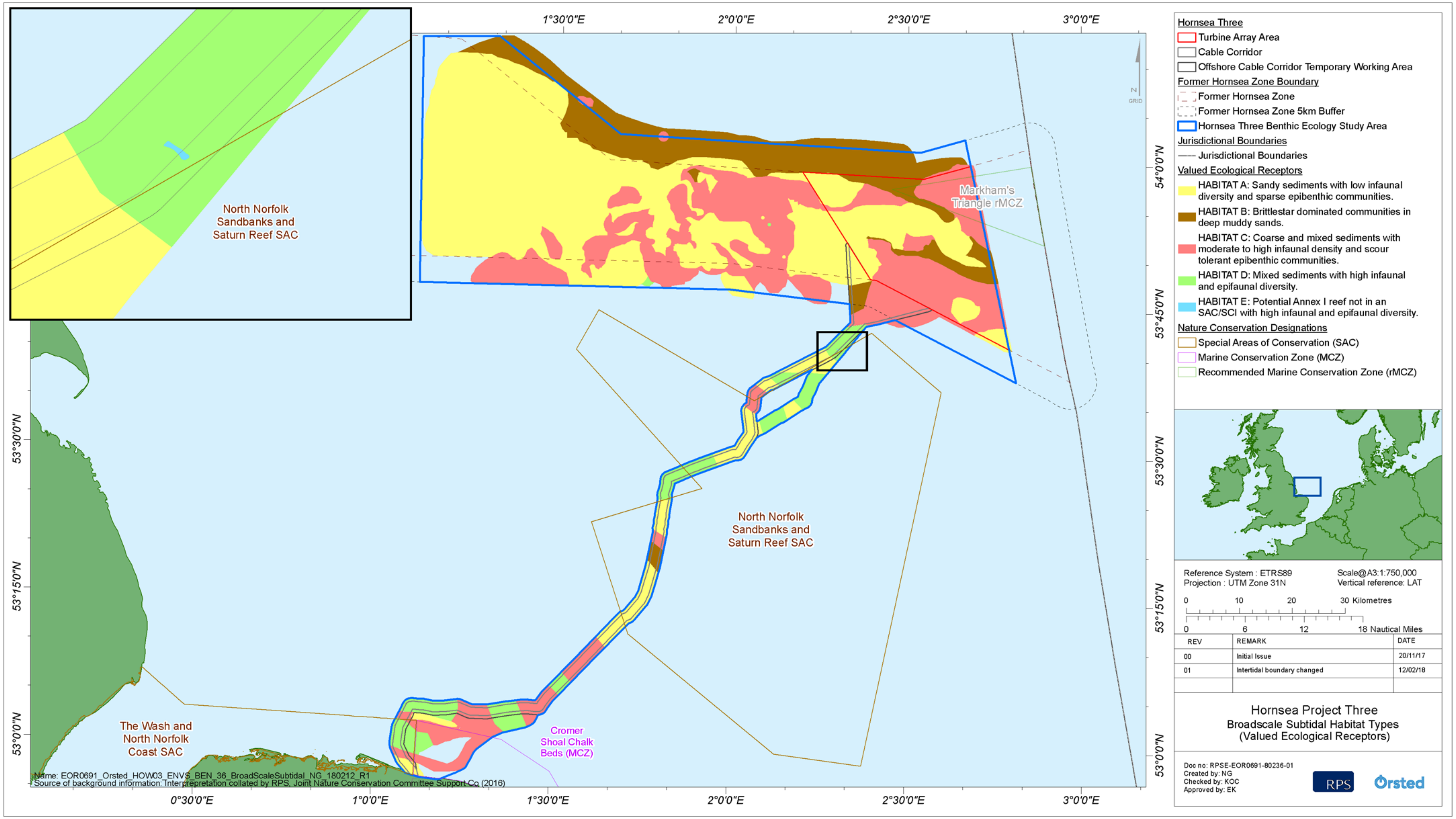

Figure 2.8: Broadscale subtidal VERs in the Hornsea Three benthic ecology study area. Note: as detailed in Table 2.13, where these broadscale VERs occur within a designated site, an assessment on the associated qualifying habitat feature has also been made.

2.7.5 Future baseline scenario

2.7.5.1 The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 requires 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 Environmental Statement.

2.7.5.2 In the event that Hornsea Three does not come forward, an assessment of the future baseline conditions has been carried out 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 Three 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.

2.7.5.3 Further to potential change associated with existing cycles and processes, it is necessary to take account of 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 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 long-living sessile animals have 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). As such, the baseline in the Hornsea Three study area described in paragraphs 2.7.1.1 to 2.7.4.4 is a 'snapshot' of the present benthic ecosystem within a gradual yet continuously changing environment. Any changes that may occur during the 35 year design life span of Hornsea Three should be considered in the context of both greater variability and sustained trends occurring on national and international scales in the marine environment.

2.7.6 Data limitations

2.7.6.1 The Hornsea Three offshore cable corridor reroute avoids the majority of the Cromer Shoal Chalk Beds MCZ (see paragraph 2.6.1.4). This was implemented following feedback from the statutory consultees on the PEIR and, therefore, after the Hornsea Three site specific surveys had been undertaken. Therefore, the nearshore characterisation, including that of the reroute section, has been based on a combination of Hornsea Three site specific data and desktop data sources as agreed with the EWG (see Table 2.6).

2.7.6.2 Specifically, these data sources have been used to extend the nearshore biotope maps generated from the Hornsea Three site specific benthic ecology data, to provide a baseline characterisation for the purposes of the EIA. These data sources include reports relating to The Wash and North Norfolk Coast SAC (APEM, 2013; Meadows and Froján, 2012; McIlwaine, Rance and Froján, 2014; Natural England, 2017), a report relating to the Cromer Shoal Chalk Beds MCZ (Defra, 2015), the Environmental Statements and supporting information for the Dudgeon offshore wind farm (Dudgeon Offshore Wind Limited, 2009) and Sheringham Shoal offshore wind farm (Scira Offshore Energy Ltd., 2006; Scira Offshore Energy Ltd., 2014), and the results of the pre-construction benthic ecology survey of the Dudgeon offshore wind farm and export cable corridor (Fugro EMU Ltd., 2015).

2.7.6.3 Although the sampling design and collection process for the survey data analysed provided robust data on the benthic communities, interpreting these data by classifying and grading biotopes has three main limitations:

- It is often difficult to interpolate data collected from discrete sample locations to cover the whole Hornsea Three benthic ecology study area and to define the precise extent of each biotope, even with site-specific geophysical data;
- Benthic communities generally show a transition from one biotope to another and therefore, boundaries of where one biotope ends and the next begins cannot be defined with absolute precision; and
- The classification of the community data into biotopes is not always straightforward, as some communities do not readily fit the available descriptions in the biotope classification system.

2.7.6.4 Because of the limitations described above, the biotope map should not be interpreted as definitive areas; rather it should be used to describe the main habitats which characterised the Hornsea Three benthic ecology study area that have been used to identify the VERs, described in Table 2.13.

2.7.6.5 As described in paragraph 2.7.4.3 habitats with similar overall general ecology, species assemblages and sensitivities have been grouped together as VERs, where appropriate. Features of nature conservation designations are also considered as VERs. Therefore, any uncertainties in individual biotope codes assigned to certain sites will not affect the certainty of the overall impact assessment.

2.8 Key parameters for assessment

2.8.1 Maximum design scenario

2.8.1.1 The maximum design scenarios identified in Table 2.14 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. These scenarios have been selected from the details provided in the project description (volume 1, chapter 3: Project Description). Effects of greater significance are not predicted to arise should any other development scenario, based on details within the project Design Envelope (e.g. different turbine layout), to that assessed here be taken forward in the final design scheme.

2.8.1.2 The potential impacts associated with Hornsea Three screened into the benthic ecology assessment were identified through Scoping and discussed and agreed with the EWG through the Evidence Plan process. Throughout the assessment presented in section 2.11, where the assessment headings differ from those presented in the Intersessional Correspondence Group on Cumulative Effects (ICGC) pressures list, the corresponding/equivalent pressures, have been outlined for transparency.

2.8.2 Impacts scoped out of the assessment

2.8.2.1 The impact of 'seabed disturbances leading to the release of sediment contaminants and resulting in potential effects on benthic ecology' has been scoped out for both the Hornsea Three array and offshore cable corridor. This impact was scoped out in the Hornsea Three Scoping Report for the array area and more recently for the offshore cable corridor on the basis of the sediment chemistry results from the site specific surveys undertaken on the Hornsea Three offshore cable corridor in 2017. The results showed that metals, organotins, organochlorine pesticides, total hydrocarbons, PAHs and US EPA-listed PAHs were comparable to the concentrations previously recorded in the rest of the Hornsea Three benthic ecology study area and were well below established levels determined to cause significant effects on benthic organisms (see paragraphs 2.7.1.4 to 2.7.1.7).

Table 2.14: Maximum design scenario considered for the assessment of potential impacts on benthic ecology.

Potential impact	Maximum design scenario	Justification
Construction phase		

Temporary habitat loss/disturbance due to cable laying operations (including anchor placements and sandwave clearance), spud-can leg impacts from jack-up operations and seabed preparation works for gravity base foundations (GBFs), may affect benthic ecology.	Total subtidal temporary habitat loss of up to 68,645,736 m^2 (1,301,520 m^2 + 4,235,774 m^2 + 1,560,000 m^2 + 19,920,000 m^2 + 6,300,000 m^2 + 4,704,000 m^2 + 142,300 m^2 + 244,600 m^2 + 27,492,030 m^2 + 2,405,912 m^2 + 339,600 m^2) and total intertidal temporary habitat loss of up to 12,642 m^2. A further breakdown of the habitat loss is provided in the bullet points below.
	Hornsea Three array area construction duration: up to eight years over two phases. A gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction. Pre-construction activities will occur one to two years prior to the start of the eight year construction. The construction activities will occur over the following durations within the eight year construction period:
	• Foundation installation up to 2.5 years;
	• Cable installation up to 2.5 years; and
	• Substations and platforms: up to 38 months (two months per structure).
	Hornsea Three offshore cable corridor construction duration: up to eight years over two phases. A gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction. Pre-construction activities will occur one to two years prior to the start of the eight year construction. The construction activities will occur over the following durations within the eight year construction period:
	• Cable installation: up to three years; and
	• Substations: up to eight months (two months per substation).
	Pre-construction activities including the following would likely be carried out approximately one to two years prior to the start of construction: pre-construction geotechnical surveys; pre-lay grapnel runs of the cable route; sandwave clearance and the deposition of sandwave clearance material; boulder clearance; unexploded ordinance (UXO) clearance; pre-trenching/pre-sweeping; and out of service cable removal.
	Hornsea Three array area - foundations
	Total subtidal temporary habitat loss within the Hornsea Three array area from foundations of up to 7,097,294 m^2 comprising:
	• Up to a total of 1,301,520 m^2 temporary loss due to jack-up barge deployments for up to 319 foundations (up to 300 turbines, up to 12 offshore transformer substations, up to four offshore High Voltage Direct Current (HVDC) converter substations and up to three offshore accommodation platforms) assuming six spud cans per barge, 170 m^2 seabed area affected per spud can and four jack-up operations per turbine (319 foundations x six spud cans x 170 m^2 per spud can x four jack-ups);
	• Up to a total of 4,235,774 m^2 of temporary loss from placement of coarse dredged material to a uniform thickness of 0.5 m (see justification, right) as a result of seabed preparation works prior to the installation of all GBFs. Comprising:
	  • Up to a total of 1,225,800 m^3 of material from seabed clearance due to the installation of up to 300 turbines with GBFs (each with a seabed clearance volume of up to 4,086 m^3) affecting up to 2,451,600 m^2;
	  • Up to a total of 735,000 m^3 of material from seabed clearance due to the installation of up to 12 offshore transformer substations with box GBFs (each with a seabed clearance volume of up to 61,250 m^3) affecting up to 1,470,000 m^2;
	  • Up to a total of 139,552 m^3 of material from seabed clearance for up to four offshore HVDC convertor substations with box GBFs (each with a seabed clearance volume of up to 34,888 m^3) affecting up to 279,104 m^2; and
	  • Up to a total of 17,535 m^3 of material from seabed clearance for up to three offshore accommodation platforms (each with a seabed clearance volume of up to 5,845 m^3) affecting up to 35,070 m^2.
	• Up to a total of 1,560,000 m^2 of temporary loss from the clearance of sandwaves prior to turbine installations.
	Hornsea Three array area - cables
	Total subtidal temporary habitat loss within the Hornsea Three array area from cables of up to 31,310,900 m^2 comprising:
	• Up to a total of 19,920,000 m^2 from burial of up to 830 km of array cables as follows:
	  • Up to a total of 14,940,000 m^2 due to 498 km of the array cable requiring sandwave clearance (up to 30 m wide corridor); and
	  • Up to a total of 4,980,000 m^2 due to boulder clearance and laying (including remedial cable reburial during construction) of up to 332 km of array cables by trenching, mechanical cutting, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development augmented by cable protection installation (up to 15 m wide corridor).
		The maximum design scenario presented is associated with HVDC transmission due to the larger foundation sizes associated with the offshore HVDC converter substations compared to the offshore High Voltage Alternating Current (HVAC) booster stations.
		Seabed preparation works prior to GBF installation represents the maximum design scenario, with respect to spatial extent, for temporary habitat loss, compared to the temporary habitat loss associated with drill arisings resulting from jacket foundation installation.
		The area affected by the placement of material as a result of seabed preparation and sandwave clearance has been calculated based on the maximum volume of sediment placed across the entire Hornsea Three array, assuming all this sediment is coarse material and therefore is placed on the seabed (i.e. is not dispersed through tidal currents; see "Temporary increases in suspended sediment concentrations" impact assessment below). The total area of seabed affected was calculated assuming a mound of uniform thickness of 0.5 m height. As detailed in volume 5, annex 1.1: Marine Processes Technical Report, the area of seabed affected by this scenario broadly aligns with the scenario of a cone shaped mound of 1.7 m maximum height (see Table 4.24 of volume 5, annex 1.1). Temporary loss of benthic habitat is assumed beneath this within the Hornsea Three array area.
		Only temporary habitat loss associated with the deposition of seabed preparation material is included within this assessment. This is because the area of long term habitat loss associated with the footprint of the turbine foundations and associated scour protection, is greater than the area impacted by the seabed preparation activity itself.
		The maximum design scenario for temporary habitat loss has considered the burial of all subtidal cables, except where the necessary burial depth cannot be achieved.
		The maximum design scenario for anchor placements (for cables >20 km offshore) has considered the placement of one anchor per 500 m of all cables. If more anchors are required, this would still fall within the maximum design scenario assessed as they would not be required for the entire cable length.
		The maximum design scenario for temporary habitat loss in the nearshore area from the installation of cables in the Hornsea Three intertidal area has considered the installation of all cables via open cut trenching, as the total potential temporary subtidal habitat loss associated with this method is greater than the temporary subtidal habitat loss associated with either the long HDD option (exit pit located approximately 800 m from MHWS mark) or the short HDD option (exit pit located approximately

Potential impact	Maximum design scenario	Justification

	• Up to a total of 6,300,000 m² from burial of up to 225 km of interconnector cables as follows:
	  ◦ Up to a total of 4,050,000 m² due to 135 km of the interconnector cable requiring sandwave clearance (up to 30 m wide corridor); and
	  ◦ Up to a total of 2,250,000 m² due to boulder clearance and laying (including remedial cable reburial during construction) of up to 90 km of interconnector cables by trenching, mechanical cutting, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development augmented by cable protection installation (up to 25 m wide corridor).
	• Up to a total of 4,704,000 m² from burial of up to 168 km of export cables (up to six trenches of 28 km length) within the array as follows:
	  ◦ Up to a total of 3,024,000 m² due to 100.8 km of the export cables within the array requiring sandwave clearance (up to 30 m wide corridor); and
	  ◦ Up to a total of 1,680,000 m² due to boulder clearance and laying (including remedial cable reburial during construction) of up to 67.2 km of interconnector cables by trenching, mechanical cutting, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development augmented by cable protection installation (up to 25 m wide corridor).
	• Up to a total of 142,300 m² from placement of coarse dredged material to a uniform thickness of 0.5 m as a result of sandwave clearance within the Hornsea Three array, assuming a volume of up to 71,150 m³, placed on the seabed within the Hornsea Three array area.
	• Up to a total of 244,600 m² from cable barge anchor placement associated with array, interconnector and export cable laying within the Hornsea Three array area assuming: one anchor (footprint 100 m²) repositioned every 500 m ((830,000 m + 225,000 m + 168,000 m) x one x 100 m² / 500 m =244,600 m²).
	Hornsea Three offshore cable corridor
	Total subtidal temporary habitat loss within the offshore cable corridor of up to 29,789,810 m² comprising:
	• Up to a total of 27,492,030 m² from burial of up to 978 km of export cable (up to six trenches of 163 km length) as follows:
	  ◦ Up to a total of 18,396,180 m² due to 613.2 km of the export cable requiring sandwave clearance (up to 30 m wide corridor);
	  ◦ Up to a total of 9,095,850 m² due to boulder clearance and cable laying (including remedial cable reburial during construction) of up to 363.8 km of export cable by trenching, mechanical cutting, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development augmented by cable protection installation (up to 25 m wide corridor for boulder clearance and 15 m wide corridor for cable installation).
	• Up to a total of 2,405,912 m² from placement of coarse, dredged material to a uniform thickness of 0.5 m as a result of sandwave clearance on the offshore cable corridor, assuming a volume of up to 1,202,946 m³, placed on the seabed within the Hornsea Three offshore cable corridor.
	• Up to 339,600 m² from cable barge anchor placement associated with cable laying for subtidal export cables within the Hornsea Three offshore cable corridor broken down as follows:
	  ◦ First 20 km of the offshore cable corridor: Up to seven anchors (footprint of 100 m² each) repositioned every 500 m for up to six export cables (20,000 m x seven x 100 m² x six / 500 m = 168,000 m²); and
	  ◦ Export cables beyond 20 km: one anchor (footprint of 100 m²) repositioned every 500 m for up to six export cables ((163,000 m – 20,000 m) x one x 100 m² x six / 500 m = 171,600 m²).
	Hornsea Three intertidal area
	• Up to 12,642 m² from works to bury up to 500 m of cable length (from MHWS to MLWS) with up to six cable circuits (i.e. up to 3 km of export cable in the intertidal) by trenching (assuming habitat loss/disturbance within the entire corridor width) including associated construction activities.
		200 m from MHWS mark), both of which would require the excavation of up to eight horizontal directional drilling (HDD) exits pits below MLWS (each up to 30 m in length and up to 30 m in width) and associated material disposal and jack-up activities in the vicinity of the exit pits (i.e. up to five jack-ups per exit pit equating to a total of 181 m²).
		The purposeful grounding of the cable installation barge (up to eight times) may also be required in the nearshore area affecting up to 600 m² per grounding event. The temporary habitat disturbance arising from this activity is, however, included within the 27,492,030 m² associated with burial of the export cable.
		Temporary habitat loss within the entire offshore cable corridor at the Hornsea Three intertidal area has been considered as the maximum design scenario (including anchor placements), though direct impacts (i.e. excavation) will only occur within a proportion of these areas.

Potential impact	Maximum design scenario	Justification
Temporary increases in suspended sediment concentrations and associated sediment deposition from cable and foundation installation and seabed preparation during the construction phase may affect benthic ecology.	*Drilling operations for foundation installation: Greatest sediment disturbance from a single foundation location* • Largest turbine monopile foundations (up to 160 monopiles), associated diameter 15 m, drilling to 40 m penetration depth, spoil volume per foundation 7,069 m³, up to 10% of foundations may be drilled. • Largest offshore transformer substations piled jacket foundations (up to 12 foundations), 24 piles per foundation (six legs, four piles per leg), 4 m diameter, drilling to 70 m penetration depth, spoil volume per foundation 21,112 m³, up to 100% of foundations may be drilled. • Largest offshore HVDC converter substation piled jacket foundations (up to four foundations), 72 piles per foundation (18 legs, four piles per leg), 3.5 m diameter, drilling to 70 m penetration depth, spoil volume per foundation 48,490 m³, up to 100% of foundations may be drilled. • Largest offshore accommodation platform monopile foundations (up to three monopiles), associated diameter 15 m, drilling to 40 m penetration depth, spoil volume per foundation 7,069 m³, up to 100% of foundations may be drilled. Up to two foundations may be simultaneously drilled with a minimum spacing of 1,000 m. Disposal of drill arisings at the water surface. Hornsea Three array area construction duration: up to eight years over two phases. A gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction. The construction activities will occur over the following durations within the eight year construction period: • Foundation installation up to 2.5 years; and • Substations and platforms: up to 38 months (two months per structure).	Drilling of individual turbine monopile foundations results in the release of relatively larger volumes of relatively fine sediment, at relatively lower rates (e.g. potentially leading to suspended solid concentrations (SSC) effects over a wider area or longer duration), than similar potential impacts for bed preparation via dredging for individual GBFs (which are separately assessed). The greatest volume of sediment disturbance by drilling, for both individual foundations and for the array as a whole, is associated with the largest diameter monopile and piled jacket foundations for substations in the array area. The volume of sediment released through drilling of other turbine and offshore accommodation platform foundation types (e.g. piled jackets) is smaller than for monopiles. The HVDC transmission system option (up to12 offshore transformer substations and up to four offshore HVDC converter substations) results in the largest number of offshore substation foundations and the largest total volume of associated sediment disturbance in the array area compared to the HVAC transmission system option.
	Dredging for seabed preparation for foundation installation: Greatest sediment disturbance from a single foundation location • Largest turbine GBF (up to 160 GBFs), associated base diameter 53 m, associated bed preparation area diameter 61 m, average depth 2 m), spoil volume per foundation 5,845 m³. • Largest offshore transformer substation GBF (up to 12 GBFs), associated base dimensions 75 m, associated bed preparation area dimensions 175 m, average depth 2 m, spoil volume per foundation 61,250 m³. • Largest offshore HVDC converter substation GBFs (up to four GBFs), associated base dimensions 90 x 170 m, associated bed preparation area dimensions 98 x 178 m, average depth 2 m, spoil volume per foundation 34,888 m³. • Largest offshore accommodation platform GBF (up to three GBFs), associated base diameter 53 m, associated bed preparation area diameter 61 m, average depth 2 m), spoil volume per foundation 5,845 m³. Disposal of material on the seabed within Hornsea Three. Dredging carried out using a representative trailer suction hopper dredger (11,000 m³ hopper capacity with split bottom for spoil disposal). Up to two dredgers to be working simultaneously, minimum spacing 1,000 m. Hornsea Three array area construction duration: up to eight years over two phases. A gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction. The construction activities will occur over the following durations within the eight year construction period: • Foundation installation up to 2.5 years; and • Substations and platforms: up to 38 months (two months per structure).	Dredging as part of seabed preparation for individual GBFs results in the release of relatively smaller overall volumes of relatively coarser sediment, at relatively higher rates (e.g. leading to higher concentrations over a more restricted area), than similar potential impacts for drilling of individual monopile or piled jacket foundations (which are separately assessed above). The greatest sediment disturbance from a single GBF location is associated with the largest diameter or dimension GBFs, which results in the greatest volume of spoil from a single foundation. Due to differences in both scale and number, GBFs for turbines, electrical substations and offshore accommodation platforms are separately considered. The HVDC transmission system option (up to12 offshore transformer substations and up to four offshore HVDC converter substations) results in the largest number of offshore substation foundations and the largest total volume of associated sediment disturbance in the array area compared to the HVAC transmission system option. Note: this assessment considers effects on benthic ecology from a passive plume (i.e. sediments transported via tidal currents) during dredging and disposal operations for foundation installation. Placements of coarse dredged materials during dredge disposal are considered in temporary habitat loss.

Potential impact	Maximum design scenario	Justification
	Cable installation • Array cables • Installation method: mass flow excavator; • Total length 830 km; • 4,980,000 m³ total spoil volume from installation of up to 830 km cables in a V-shape trench of width = 6 m and depth =2 m (830 km x 6 m x 2 m x 0.5 (i.e. to account for V-shape of trench) = 4,980,000 m³); and • 71,150 m³ total spoil volume from sand wave clearance by dredging or mass flow excavation within the Hornsea Three array area (based on the Hornsea Three array area geophysical survey data combined with cable installation design specifications). • Interconnector cables • Installation method: mass flow excavator; • 15 interconnector cables, total length 225 km; and • 1,350,000 m³ total spoil volume from installation of up to 225 km cables in a V-shape trench of width = 6 m and depth =2 m (225 km x 6 m x 2 m x 0.5 (i.e. to account for V-shape of trench) = 1,350,000 m³). • Export cables • Up to six cable trenches; each 191 km in length (1,146 km in total); • Installation method: mass flow excavator; • 6,876,000 m³ total spoil volume from installation of up to 1,146 km cables in a V-shape trench of width = 6 m and depth =2 m (6 x 191 km x 6 m x 2 m x 0.5 (i.e. to account for V-shape of trench) = 6,876,000 m³); and • 979,090 m³ total spoil volume from sandwave clearance via either a dredger or mass flow excavator within the Hornsea Three offshore cable corridor (based on the Hornsea Three offshore cable corridor geophysical survey data combined with cable installation design specifications). Hornsea Three array area construction duration: up to eight years over two phases. A gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction. Pre-construction activities will occur one to two years prior to the start of the eight year construction. Cable installation up to 2.5 years within this time. Hornsea Three offshore cable corridor construction duration: up to eight years over two phases. A gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction. Pre-construction activities will occur one to two years prior to the start of the eight year construction. Cable installation up to three years within this time.	Cable installation may involve ploughing, trenching, jetting, rock-cutting, surface laying with post lay burial, and/or surface laying installation techniques. Of these, mass flow excavation will most energetically disturb the greatest volume of sediment in the trench profile and as such is considered to be the maximum design scenario for sediment dispersion. The volume of material to be cleared from individual sandwaves will vary according to the local dimensions of the sandwave (height, length and shape) and the level to which the sandwave must be reduced (also accounting for stable sediment slope angles and the capabilities and requirements of the cable burial tool being used). Based on the available geophysical data, the bedforms requiring clearance are likely to be in the range 1 to 2 height in the array or 1 to 6 m in height in the offshore cable corridor. Sandwave clearance may involve dredging or mass flow excavation tools. Of these, mass flow excavation will most energetically disturb sediment in the clearance profile and as such is considered to be the maximum design scenario for sediment dispersion causing elevated SSC over more than a very short period of time. Dredging will result in a potentially greater instantaneous local effect in terms of SSC and potentially a greater local thickness of sediment deposition, but likely of a shorter duration and smaller extent, respectively. Note: this assessment considers effects on benthic ecology from a passive plume (i.e. sediments transported via tidal currents) during dredging and disposal operations. Placements of coarse dredged materials during dredge disposal are considered in temporary habitat loss.

Potential impact	Maximum design scenario	Justification

Accidental release of pollutants (e.g. from accidental spillage/leakage) may affect benthic ecology.	• Synthetic compound (e.g. from antifouling biocides), heavy metal and hydrocarbon contamination resulting from offshore infrastructure installation and up to 10,774 return trips during the construction phase:
	  ◦ Up to four installation vessels (300 return trips), up to 24 support vessels (1,800 return trips) and up to 12 transport vessels (900 return trips) for wind turbine installation;
	  ◦ Up to three installation vessels (300 return trips), up to 13 support vessels (1,500 return trips), up to 12 dredging vessels (1,200 return trips) and up to four transport vessels (tugs) (1,200 return trips) for wind turbine GBF installation;
	  ◦ Up to two installation vessels (38 return trips), up to 12 support vessels (228 return trips) and up to four transport vessels (38 return trips) for offshore substation foundations installation;
	  ◦ Up to three main cable laying vessels (315 return trips), up to three main cable burial vessels (315 return trips), support vessels comprising up to four crew boats or SOVs, up to two service vessels, up to two diver vessels, up to two PLGR vessels, and up to two dredging vessels (1,890 return trips for support vessels) for array cable installation; and
	  ◦ Up to four main laying vessels comprising up to one barge and three associated tugs (180 return trips), up to four main jointing vessels comprising up to one barge and three associated tugs (120 return trips), up to four main burial vessels comprising up to one barge and three associated tugs (180 return trips) and support vessels comprising up to two crew boats or SOVs, up to one service vessel, up to one diver vessel, up to one PLGR vessel, and up to one dredging vessel (270 return trips for support vessels) for export cable installation.
	• Water-based drilling muds associated with drilling to install foundations, should this be required;
	• A typical wind turbine is likely to contain up to 25,000 litres (l) of lubricants (hydraulic oil, gear oil and grease), up to 80,000 l of nitrogen, up to 7,000 l of transformer silicon/ester oil, up to 13,000 l of coolants, up to 2,000 l of diesel fuel and up to 6 kg of SF_6;
	• A typical offshore accommodation platform is likely to contain up to 10,000 l of coolant, up to 10,000 l of hydraulic oil and up to 3,500 kg of lubricates;
	• Offshore fuel storage tanks:
	  ◦ One tank on each of the up to three offshore accommodation platforms for helicopter fuel and with a total capacity of up to 255,000 l across the entire wind farm; and
	  ◦ One on each of the up to three offshore accommodation platforms for crew transfer vessel (CTV) fuel and each with a capacity of 210,000 l.
	• Potential contamination of nearshore/intertidal habitats from drilling mud (bentonite) used to facilitate the installation of export cables in the intertidal via HDD.
		These parameters are considered to represent the likely maximum design scenario with regards to vessel movements during construction and the offshore storage of fuel.

<table>
<tr><th>Potential impact</th><th>Maximum design scenario</th><th>Justification</th></tr>
<tr><td colspan="3">Operation phase</td></tr>
<tr><td>Long term loss of seabed habitat through presence of foundations, scour protection and cable protection, resulting in potential effects on benthic receptors.</td><td>Long term habitat loss over the lifetime of the project of up to a total of 4,208,028 m^2 (1,623,300 m^2 + 158,700 m^2 + 28,628 m^2 + 109,200 m^2 + 581,000 m^2 + 157,500 m^2 + 117,600 m^2 + 87,500 m^2 + 684,600 m^2 + 660,000 m^2) comprising the following:

Hornsea Three array area – foundations

• Up to a total of 1,623,300 m^2 across the entire Hornsea Three array from GBFs (including scour protection) for up to 300 turbines, each affecting up to 5,411 m^2 of seabed (1,452 m^2 from the foundation and 3,958 m^2 from the scour protection);
• Up to a total of 158,700 m^2 from box GBFs (including scour protection) for up to 12 offshore transformer substations, each affecting up to 13,225 m^2 of seabed (5,625 m^2 from the foundation and 7,600 m^2 from the scour protection);
• Up to a total of 28,628 m^2 from suction caisson jacket foundations (including scour protection) for up to three offshore accommodation platforms, each affecting up to 9,543 m^2 of seabed (2,945 m^2 from the foundation and 6,597 m^2 from the scour protection); and
• Up to 109,200 m^2 from pontoon GBFs (including scour protection) for up to four offshore HVDC converter substations, each affecting up to 27,300 m^2 of seabed (17,850 m^2 from the foundation and 9,450 m^2 from the scour protection).

Hornsea Three array area – cable protection

• Up to a total of 581,000 m^2 based on installation of cable protection for 10% of the up to 830 km of array cables (i.e. 83 km and 7 m wide cable corridor);
• Up to a total of 157,500 m^2 based on the installation of cable protection for 10% of the up to 225 km of interconnector cables (i.e. 22.5 km and 7 m wide cable corridor);
• Up to a total of 117,600 m^2 based on the installation of cable protection for 10% of the up to 168 km of export cables within the Hornsea Three array area (i.e. up to six trenches of 28 km length and 7 m wide corridor);
• Up to a total of 87,500 m^2 for up to 35 cable/pipeline crossings for array cables and interconnector cables within the Hornsea Three array area, each with long term loss of seabed (i.e. through placement of rock berms) of up to 2,500 m^2;
• Cable protection may comprise gravel, concrete mattresses, rock placement, bags filled with gravel, grout or other concrete, artificial fronds or seaweed or bags of grout, concrete, or another substance that cures hard over time; and
• Replenishment of 25% of cable length and cable/pipeline crossings during the operation and maintenance phase.

Hornsea Three offshore cable corridor - cable protection

• Up to a total of 684,600 m^2 based on the installation of cable protection for 10% of the up to 978 km of export cable. Assumes up to six cables, and up to 7 m width of cable protection per cable;
• Up to a total of 660,000 m^2 for cable/pipeline crossings, with up to 44 crossings, assuming up to six cables, with each crossing having a long term loss of seabed (i.e. through placement of rock berms) of up to 2,500 m^2;
• Cable protection may comprise gravel, concrete mattresses, rock placement, bags filled with gravel, grout or other concrete, artificial fronds or seaweed or bags of grout, concrete, or another substance that cures hard over time; and
• Replenishment of 25% of cable length and cable/pipeline crossings during the operation and maintenance phase.

The anticipated design life of Hornsea Three is 35 years. It may be desirable to 'repower' Hornsea Three at or near the end of the design life of Hornsea Three to the end of the 50 year Crown Lease period. If the specifications and designs of the new turbines and/or foundations fell outside of the Maximum design scenario or the impacts of constructing, operation and maintenance, and decommissioning them were to fall outside those considered by this EIA, repowering would require further consent (and EIA) and is therefore outside of the scope of this document.</td><td>The maximum design scenario presented is associated with HVDC transmission due to the larger foundation sizes associated with the offshore HVDC converter substations compared to the HVAC booster stations.

Maximum design scenario is associated with the installation of GBFs for all turbines, box GBFs for offshore transformer substations, suction caisson jacket foundations for offshore accommodation platforms and pontoon GBFs for four offshore HVDC converter substations as these foundations have the largest total surface area in contact with the seabed and therefore result in the greatest long term habitat loss. The maximum design scenario also assumes scour protection is required for all foundations.

The maximum design scenario for long term habitat loss has considered the use of cable protection (i.e. rock placement) along 10% of the subtidal array cables and interconnector power cables. The maximum design scenario assumes that up to 10% of the subtidal export cables within designated sites will require cable protection (i.e. rock placement).

The replenishment of cable protection and cable/pipeline crossings during the operation and maintenance phase will not result in any additional long term habitat loss as it is assumed that replenishment works will be additive in areas in which cable protection was laid during construction.</td></tr>
</table>

Potential impact	Maximum design scenario	Justification

Colonisation of foundations/cable protection/scour protection may affect benthic ecology and biodiversity.	Total introduced hard substrate over the lifetime of the project of up to 5,470,308 m^2 comprising the following:
	Hornsea Three array area – foundations
	• Turbines:
	  • Up to a total of 1,158,303 m^2 from GBFs for 300 turbines, assuming a conical/frustum shape, with a base diameter of 43 m and a sea surface diameter of 15 m and a water depth of 40 m, giving a per foundation surface area of approximately 3,861 m^2; and
	  • Up to a total of 1,187,400 m^2 of scour protection for 300 GBFs for turbines, with a per foundation scour protection of 3,958 m^2.
	• Offshore transformer substations:
	  • Up to a total of 144,000 m^2 from box GBFs for up to 12 offshore transformer substations, each with a length and width of 75 m in a water depth of 40 m, giving a per foundation surface area of approximately 12,000 m^2; and
	  • Up to a total of 91,200 m^2 of scour protection for 12 offshore transformer substations, with a per foundation scour protection of 7,600 m^2.
	• Offshore HVDC converter substations:
	  • Up to a total of 174,400 m^2 from pontoon GBFs (Type 1) for up to four offshore HVDC converter substations, with three pontoons per foundation and each pontoon having a length of up to 170 m and width of up to 35 m in a water depth of 40 m, giving a per foundation surface area of approximately 43,600 m^2; and
	  • Up to a total of 37,800 m^2 of scour protection for four offshore HVDC converter substations, with a per foundation scour protection of 9,450 m^2.
	• Offshore accommodation platforms:
	  • Up to a total of 12,079 m^2 from GBFs for three offshore accommodation platforms, assuming a conical/frustum shape, with a base diameter of 45 m and a sea surface diameter of 15 m and a water depth of 40 m, giving a per foundation surface area of approximately 4,026 m^2; and
	  • Up to a total of 12,252 m^2 of scour protection for three offshore accommodation platforms, with a per foundation scour protection of 4,084 m^2.
	Hornsea Three array area – cable protection
	• Up to a total of 1,058,733 m^2 from the installation of cable protection for 10% of the up to 830 km of array cables, up to 225 km of interconnector cables and up to 168 km of export cables within the array (i.e. up to six trenches of 28 km length). Assumes an up to 7 m wide cable corridor, cable protection to an indicative height of up to 2 m and a berm 3 m wide at the top, giving a per metre surface area of approximately 8.7 m^2; and
	• Up to a total of 87,500 m^2 from installation of cable protection for up to 35 cable/pipeline crossings within the array (2,500 m^2 per crossing for array and interconnector cables).
	Hornsea Three offshore cable corridor - cable protection
	• Up to a total of 846,640 m^2 from the installation of cable protection for 10% of the up to 978 km of export cables. Assumes an up to 7 m wide cable corridor, cable protection to an indicative height of up to 2 m and a berm 3 m wide at the top, giving a per metre surface area of approximately 8.7 m^2; and
	• Up to a total of 660,000 m^2 from installation of cable protection for up to 44 cable/pipeline crossings (2,500 m^2 per crossing) along the offshore cable corridor.
	The anticipated design life of Hornsea Three is 35 years. It may be desirable to 'repower' Hornsea Three at or near the end of the design life of Hornsea Three to the end of the 50 year Crown Lease period. If the specifications and designs of the new turbines and/or foundations fell outside of the Maximum design scenario or the impacts of constructing, operation and maintenance, and decommissioning them were to fall outside those considered by this EIA, repowering would require further consent (and EIA) and is therefore outside of the scope of this document.
		Maximum surface area created by turbines, substation and offshore accommodation platform foundations, scour protection and surface protection for cables where secondary cable protection is required. This assumes that 10% of array and subtidal export cables require secondary protection. It also assumes no rock placement will be used in the intertidal.
		For GBFs, this area includes the surfaces of the foundation shaft, cone and base from the seabed to MHWS (i.e. including intertidal habitat of the turbine).

Increased risk of introduction or spread of invasive and non-native species (INNS) due to presence of subsea infrastructure and vessel movements (e.g. ballast water) may affect benthic ecology and biodiversity.	Introduced hard substrate: • Maximum design scenario as above for "colonisation of foundations/cable protection/scour protection" impact above; and • Increased risk of introduction or spread of INNS from up to 10,774 vessel round trips during the construction phase (see "accidental release of pollutants" impact assessment above for breakdown) and up to 2,885 round trips to port by operational and maintenance vessels (including supply/crew vessels and jack-up vessels).	Maximum surface area created by offshore infrastructure as above for Colonisation of foundations/cable protection/scour protection impact. Maximum design scenario with regards to maximum number of vessel movements during operation and maintenance activities.

Potential impact	Maximum design scenario	Justification
Alteration of 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 ecology.	*Changes in wave and tidal regime* • Largest number of GBFs for turbines (up to 300 of 43 m diameter) and offshore accommodation platforms (up to three of 41 m diameter) and the largest dimensions of GBF for offshore transformer substations (up to 12 of 75 m length scale) and offshore HVDC converter substations (up to four 75 m length scale) in the Hornsea Three array area; • Largest number of offshore HVAC booster station GBFs (up to four foundations, associated base dimensions 75 m) in the Hornsea Three offshore cable corridor; and • Minimum spacing of 1,000 m. *Scour effects* • Local scour around an individual turbine is greatest for a 15 m diameter monopile foundation; • Global scour around an individual turbine foundation is greatest for a piled jacket foundation of 40 m base length; • For the Hornsea Three array area as a whole, local scour footprint was greatest around an array of 160 x 15 m diameter monopile foundations; and • For the Hornsea Three array area as a whole, the global scour footprint was greatest for an array of 300 x piled jacket foundations of 33 m base diameter.	*Changes in wave and tidal regime* The greatest total in-water column blockage to waves and currents is presented by the greatest number of GBFs in the array area, with at least the minimum spacing between turbines. This combination was determined via calculations that quantitatively compare the blockage presented by a range of minimum and maximum sizes of varying foundation types and numbers (see volume 5, annex 1.1: Marine Processes Technical Annex for details). *Scour effects* The maximum design scenario for scour effects was based on the results of the scour assessment presented in volume 5, annex 1.1: Marine Processes Technical Annex. Each foundation type may produce different scour patterns therefore monopiles, GBFs and jacket foundations were all considered. Suction caissons for jackets and monopiles were not explicitly assessed as they fall within the envelope of change of the other three foundation types.

Maintenance operations may result in temporary seabed disturbances and potential effects on benthic ecology.	Temporary habitat loss/disturbance over the lifetime of the project of up to 9,770,400 m^2 comprising:
	• Up to 5,508,000 m^2 as a result of up to 5,400 jack-ups over the 35 year design life for turbine component replacement and access ladder replacement events, assuming six spud cans per jack-up barge and 170 m^2 seabed area affected per spud can (i.e. 5,400 x six x 170);
	• Up to 65,280 m^2 as a result of up to 64 jack-ups in total over the 35 year design life for offshore substation component replacements and J-tube repair/replacement events, assuming six spud cans per jack-up barge and 170 m^2 seabed area affected per spud can (i.e. 64 x six x 170);
	• For array and interconnector cables:
	  ◦ Up to 340,000 m^2 due to up to 17 remedial burial events over the 35 year design life affecting up to 2 km of cable per event and a width of disturbance of up to 10 m (i.e. 17 x 2,000 m x 10 m); and
	  ◦ Up to 910,700 m^2 as a result of up to one cable repair event per year, over the 35 year design life, affecting up to 25,000 m^2 per repair event and requiring one jack-up per repair event assuming six spud cans per jack-up barge and 170 m^2 seabed area affected per spud can (i.e. 35 x 25,000 m^2 + (35 x six x 170 m^2)).
	• For export cables:
	  ◦ Up to 2,400,000 m^2 due to up to 15 remedial burial events over the 35 year design life affecting up to 2 km of cable per event and a width of disturbance of up to twice the water depth (i.e. 15 x 2,000 m x (two x 40 m)); and
	  ◦ Up to 546,420 m^2 as a result of up to 21 cable repair events over the 35 year design life, affecting up to 25,000 m^2 per repair event and requiring one jack-up per repair event assuming six spud cans per jack-up barge and 170 m^2 seabed area affected per spud can (i.e. 21 x 25,000 m^2 + (21 x six x 170 m^2)).
	The anticipated design life of Hornsea Three is 35 years. It may be desirable to 'repower' Hornsea Three at or near the end of the design life of Hornsea Three to the end of the 50 year Crown Lease period. If the specifications and designs of the new turbines and/or foundations fell outside of the Maximum design scenario or the impacts of constructing, operation and maintenance, and decommissioning them were to fall outside those considered by this EIA, repowering would require further consent (and EIA) and is therefore outside of the scope of this document.
		These parameters are considered to represent the likely maximum design scenario for the requirement for jack-up barge operations for all turbines and substations for the lifetime of Hornsea Three.
		No substantive maintenance works on the export cables in the Hornsea Three intertidal area is anticipated, only access will be required periodically as outlined to inspect the cable and for geophysical surveys. Though the burial depth of the cables will be designed so they will remain buried for the full lifetime of Hornsea Three and beyond, it will be necessary to bury the cables if erosion or other natural processes cause them to become exposed. The most appropriate means of reburying any exposed cables will be assessed on an ad-hoc basis but will be no more intrusive than those used during construction.

Potential impact	Maximum design scenario	Justification

Accidental release of pollutants (e.g. from accidental spillage/leakage) may affect benthic ecology.	• Synthetic compound (e.g. from antifouling biocides), heavy metal and hydrocarbon contamination resulting from up to 300 turbines, up to 12 offshore transformer substations, up to four offshore HVDC converter substations (or up to four offshore HVAC booster stations on the offshore cable corridor) and up to three offshore accommodation platforms;
	• Accidental pollution may also result from offshore refuelling for crew vessels and helicopters: i.e. up to 2,885 round trips to port by operational and maintenance vessels (including supply/crew vessels and jack-up vessels) and up to 4,671 round trips by helicopter per year over the 35 year design life;
	• A typical turbine is likely to contain approximately up to 25,000 l of lubricants (hydraulic oil, gear oil and grease), 80,000 l of liquid nitrogen and 7,000 kg of transformer silicon/ester oil, 2,000 l of diesel, 13,000 l of coolant and up to 6 kg of sulphur hexafluoride (SF6);
	• A typical offshore accommodation platform is likely to contain up to 10,000 l of coolant, up to 10,000 l of hydraulic oil and up to 3,500 kg of lubricates.
	• Offshore fuel storage tanks:
	  • One tank on each of the up to three offshore accommodation platforms for helicopter fuel and with a total capacity of up to 255,000 l across the entire wind farm; and
	  • One on each of the up to three offshore accommodation platforms for CTV fuel and each with a capacity of 210,000 l.
	• Potential leachate from zinc or aluminium anodes used to provide cathodic protection to the turbines. Potential contamination in the intertidal resulting from machinery use and vehicle movement.
		These parameters are considered to represent the maximum design scenario with regards to maximum number of turbines, vessel and vehicle movements, and machinery required, and therefore the maximum volumes of potential contaminants carried during operation and maintenance activities.

Decommissioning phase		

Temporary loss of habitat due to operations to remove array cables, interconnector cables and export cables, and jack-up operations to remove foundations, resulting in potential effects on benthic ecology.	Total subtidal temporary habitat loss of up to 57,639,112 m² (1,301,520 m² + 19,920,000 m² + 5,400,000 m² + 4,032,000 m² + 142,300 m² + 244,600 m² + 23,853,180 m² + 2,405,912 m² + 339,600 m²) and total intertidal temporary habitat loss of up to 12,642 m². A further breakdown of the habitat loss is provided in the bullet points below.
	Hornsea Three array area and offshore cable corridor decommissioning durations as outlined above for construction phase.
	Hornsea Three array area - foundations
	• Temporary habitat loss as per construction phase, but excluding seabed preparation works, i.e.:
	  • Up to a total of 1,301,520 m² temporary loss due to jack-up barge deployments for up to 319 foundations (up to 300 turbines, up to 12 offshore transformer substations, up to four offshore High Voltage Direct Current (HVDC) substations and up to three offshore accommodation platforms) assuming six spud cans per barge, 170 m² seabed area affected per spud can and four jack-up operations per turbine (319 foundations x six spud cans x 170 m² per spud can x four jack-ups).
	Hornsea Three array area - cables
	• Up to a total of 19,920,000 m² from removal of up to 830 km of array cables as follows:
	  • Up to a total of 14,940,000 m² due to 498 km of the array cable requiring sandwave clearance (up to 30 m wide corridor) prior to cable removal; and
	  • Up to a total of 4,980,000 m² due to removal of up to 332 km of array cables by trenching, mechanical cutting, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development (up to 15 m wide corridor).
	• Up to a total of 5,400,000 m² from removal of up to 225 km of interconnector cables as follows:
	  • Up to a total of 4,050,000 m² due to 135 km of the interconnector cable requiring sandwave clearance (up to 30 m wide corridor) prior to removal; and
	  • Up to a total of 1,350,000 m² due to removal of up to 90 km of interconnector cables by trenching, mechanical cutting, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development (up to 15 m wide corridor).
	• Up to a total of 4,032,000 m² from removal of up to 168 km of export cables (up to six trenches of 28 km length) within the array as follows:
	  • Up to a total of 3,024,000 m² due to 100.8 km of the export cables within the array requiring sandwave clearance (up to 30 m wide corridor) prior to removal; and
	  • Up to a total of 1,008,000 m² due removal of up to 67.2 km of export cables by trenching, mechanical cutting, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development augmented by cable protection installation (up to 15 m wide corridor).
	• Up to a total of 142,300 m² from placement of coarse dredged material to a uniform thickness of 0.5 m as a result of sandwave clearance within the Hornsea Three array area, assuming a volume of up to 71,150 m³, placed on the seabed within the Hornsea Three array area; and
	• Up to a total of 244,600 m² from cable barge anchor placement associated with array, interconnector and export cable removal within the Hornsea Three array area assuming: one anchor (footprint 100 m²) repositioned every 500 m ((830,000 m + 225,000 m + 168,000 m) x one x 100 m² / 500 m = 244,600 m²).
		Maximum design scenario as per construction phase, excluding seabed preparation works, and assumes the removal of all foundations and all buried subtidal and intertidal cables. Piled foundations would be removed to approximately 2 m below the seabed. The necessity to remove cables will be reviewed at the time, after consideration of the environmental impact of the removal operation and safety of the cables left *in situ* (see volume 1, chapter 3: Project Description). Therefore, the maximum design scenario has assumed the removal of all cables, although this is likely to be over precautionary.
		The maximum design scenario has also assumed the same requirements for sandwave clearance and boulder clearance activities, prior to cable removal, as that during the construction phase, although this is likely to be over precautionary.

<table>
<tr><th>Potential impact</th><th>Maximum design scenario</th><th>Justification</th></tr>
<tr><td></td><td>Hornsea Three offshore cable corridor
• Up to a total of 23,853,180 m² from removal of up to 978 km of export cable (up to six trenches of 163 km length) as follows:
  • Up to a total of 18,396,180 m² due to 613.2 km of the export cable requiring sandwave clearance (up to 30 m wide corridor);
  • Up to a total of 5,457,000 m² due to removal of up to 363.8 km of export cables by trenching, mechanical cutting, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development (up to 15 m wide corridor).
• Up to a total of 2,405,912 m² from placement of coarse, dredged material to a uniform thickness of 0.5 m as a result of sandwave clearance on the offshore cable corridor, assuming a volume of up to 1,202,946 m³, placed on the seabed within the Hornsea Three offshore cable corridor;
• Up to a total of 339,600 m² from cable barge anchor placement associated with cable removal for all subtidal export cables broken down as follows:
  • First 20 km of offshore cable corridor: Up to seven anchors (footprint of 100 m² each) repositioned every 500 m for up to six export cables (20,000 m x seven x 100 m² x six / 500 m = 168,000 m²); and
  • Export cables beyond 20 km: one anchor (footprint of 100 m²) repositioned every 500 m for up to six export cables ((143,000 m – 20,000) x 1 x 100 m² x six / 500 m = 171,600 m²).
Hornsea Three intertidal area
• Up to a total of 12,642 m² from works to remove up to 500 m of cable length (from MHWS to MLWS) with up to six cable circuits (i.e. up to 3 km of export cable in the intertidal) including associated construction activities; assuming habitat loss/disturbance within entire corridor width.</td><td></td></tr>
<tr><td>Temporary increases in suspended sediment concentrations and deposition from removal of array cables, export cables and foundations resulting in potential effects on benthic ecology.</td><td>Increases of suspended sediment concentrations and sediment deposition associated with the removal of up to 319 foundations (i.e. up to 300 turbines, up to 12 offshore transformer substations, up to four offshore HVDC converter substations (or up to four offshore HVAC booster stations on the offshore cable corridor) and up to three offshore accommodation platforms) and up to 2,201 km of array (including interconnector cables) and export cables.
Hornsea Three array area and offshore cable corridor decommissioning durations as outlined above for construction phase.</td><td>Maximum design scenario as per construction phase and assumes the removal of all foundations and all subtidal and intertidal cables.</td></tr>
<tr><td>Removal of foundations leading to loss of species/habitats colonising these structures.</td><td>Total removal of up to 1,488,782 m² of hard substrate comprising the following:
Hornsea Three array area - foundations
  • Up to a total of 1,158,303 m² from GBFs for 300 turbines, assuming a conical/frustum shape, with a base diameter of 43 m and a sea surface diameter of 15 m and a water depth of 40 m, giving a per foundation surface area of approximately 3,861 m²;
  • Up to a total of 144,000 m² from Box GBFs for up to 12 offshore transformer substations, each with a length and width of 75 m in a water depth of 40 m, giving a per foundation surface area of approximately 12,000 m²;
  • Up to a total of 174,400 m² from Pontoon GBFs (Type 1) for up to four offshore HVDC converter substations, with three pontoons per foundation and each pontoon having a length of up to 170 m and width of up to 35 m in a water depth of 40 m, giving a per foundation surface area of approximately 43,600 m²; and
  • Up to a total of 12,079 m² from GBFs for three offshore accommodation platforms, assuming a conical/frustum shape, with a base diameter of 45 m and a sea surface diameter of 15 m and a water depth of 40 m, giving a per foundation surface area of approximately 4,026 m².
Hornsea Three array area and offshore cable corridor decommissioning durations as outlined above for construction phase.</td><td>Maximum design scenario for introduced hard substrate as per operational phase but assuming that scour protection and cable protection will be left in situ.</td></tr>
</table>

Potential impact	Maximum design scenario	Justification
Permanent habitat loss due to presence of scour/cable protection left *in situ* post decommissioning, and potential effects on benthic ecology.	Permanent habitat loss/alteration of up to 3,624,391 m^2 comprising the following: *Hornsea Three array area - foundations* • Up to a total of 1,187,400 m^2 of scour protection for 300 GBFs for turbines, with a per foundation scour protection of 3,958 m^2. • Up to a total of 91,200 m^2 of scour protection for 12 offshore transformer substations, with a per foundation scour protection of 7,600 m^2. • Up to a total of 37,800 m^2 of scour protection for four offshore HVDC converter substations, with a per foundation scour protection of 9,450 m^2. • Up to a total of 19,791 m^2 of scour protection for three offshore accommodation platforms, with a per foundation scour protection of 6,597 m^2. *Hornsea Three array area - cables* • Up to a total of 581,000 m^2 based on the presence of cable protection for 10% of the up to 830 km of array cables (i.e. 83 km and 7 m wide cable corridor); • Up to a total of 157,500 m^2 based on the presence of cable protection for 10% of the up to 225 km of interconnector cables (i.e. 22.5 km and 7 m wide cable corridor). This includes all cable links between HVAC or HVDC converter substations and offshore accommodation platforms; • Up to a total of 117,600 m^2 based on the presence of cable protection for 10% of the up to 168 km of export cables within the array (i.e. up to six trenches of 28 km length and 7 m wide corridor); • Up to a total of 87,500 m^2 for 35 cable/pipeline crossings for array cables and interconnector cables within the Hornsea Three array area, each with long term loss of seabed (i.e. through placement of rock berms) of up to 2,500 m^2; and • Cable protection may comprise gravel, concrete mattresses, rock placement, bags filled with gravel, grout or other concrete, artificial fronds or seaweed or bags of grout, concrete, or another substance that cures hard over time. *Hornsea Three offshore cable corridor* • Up to a total of 684,600 m^2 based on the presence of cable protection for 10% of the up to 978 km of export cable. Assumes up to six cables, and up to 7 m width of cable protection per cable; • Up to a total of 660,000 m^2 for cable/pipeline crossings, with up to 44 crossings along the offshore cable corridor, assuming up to six cables, with each crossing with long term loss of seabed (i.e. through placement of rock berms) of up to 2,500 m^2; and • Cable protection may comprise gravel, concrete mattresses, rock placement, bags filled with gravel, grout or other concrete, artificial fronds or seaweed or bags of grout, concrete, or another substance that cures hard over time.	Maximum design scenario for long term habitat loss as per operational phase but assuming that foundations will be removed but scour and cable protection will be left *in situ*.
Accidental release of pollutants (e.g. from accidental spillage/leakage) may affect benthic ecology.	Maximum design scenario is identical to that of the construction phase.	Maximum design scenario as per construction phase.

2.9 Impact assessment methodology

2.9.1 Overview

2.9.1.1 The benthic ecology assessment has followed the methodology set out in volume 1, chapter 5: Environmental Impact Assessment Methodology. Specific to the benthic ecology EIA, the following guidance documents will also be considered:

- Guidelines for Ecological Impact Assessment (EcIA) in the UK and Ireland. Terrestrial, Freshwater and Coastal (CIEEM, 2016);
- Offshore Wind Farms. Guidance note for EIA in respect of the Food and Environmental Protection Act 1985 (FEPA) and the Coast Protection Act 1949 (CPA) requirements (Cefas *et al*., 2004);
- Guidance on Environmental Considerations for Offshore Wind Farm Development (OSPAR, 2008); and
- Guidelines for the conduct of benthic studies at aggregate dredging sites (DTLR, 2002).

2.9.1.2 In addition, the benthic ecology assessment has followed the legislative framework as defined by the Infrastructure Planning (Environmental Impact Assessment) Regulations 2009, the Wildlife and Countryside Act 1981 (as amended) and the MCAA 2009 (as amended).

2.9.1.3 The assessment has also taken into consideration the requirements of the United Nations Environment Programme (UNEP) Convention on Biological Diversity (CBD), in particular those listed under Article 8 of the Convention. Article 8 of the CBD relates to *in-situ* conservation and includes reference to the need to protect areas for nature conservation. Therefore, where necessary, mitigation measures have been designed-in to Hornsea Three to ensure the *in-situ* conservation of benthic ecology.

2.9.2 Impact assessment criteria

2.9.2.1 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 sensitivity and magnitude are based on those used in the Design Manual for Roads and Bridges (DMRB) methodology, which is described in further detail in volume 1, chapter 5: Environmental Impact Assessment Methodology.

2.9.2.2 The sensitivity of benthic ecology VERs has been defined as a product of the likelihood of damage (termed intolerance or resistance) due to a pressure and the rate of (or time taken for) recovery (termed recoverability or resilience once the pressure has abated or been removed Recoverability is the ability of a habitat to return to the state of the habitat that existed before the activity or event which caused change. It is dependent on its ability to recover or recruit subject to the extent of disturbance/damage incurred. Full recovery does not necessarily mean that every component species has returned to its prior condition, abundance or extent but that the relevant functional components are present and the habitat is structurally and functionally recognisable as the initial habitat of interest. Information on these aspects of sensitivity of the benthic ecology VERs to given impacts has been informed by the best available evidence following environmental impact or experimental manipulation in the field and evidence from analogous activities such as those associated with aggregate extraction and Oil and Gas industries. Where applicable, the MarESA has been drawn upon to support the assessments of sensitivity. For transparency, the benchmarks for the relevant MarESA pressures which have been used to inform each impact assessment have also been referenced under each impact assessment in section 2.11. These assessments have been combined with the assessed status (i.e. the level of designation/importance) of the affected receptor as defined in Table 2.12 and as presented in Table 2.13.

2.9.2.3 For the benthic ecology VERs being considered in this assessment, the overall sensitivity of a receptor to an impact is then identified from a five point scale as presented in Table 2.15 below.

Table 2.15: Definition of terms relating to the sensitivity of the receptor.

Sensitivity	Definition used in this chapter
Very High	Nationally and internationally important receptors with high vulnerability and no ability for recovery.
High	Regionally important receptors with high vulnerability and no ability for recovery. Nationally and internationally important receptors with high vulnerability and low recoverability.
Medium	Locally important receptors with high vulnerability and no ability for recovery. Regionally important receptors with medium to high vulnerability and low recoverability. Nationally and internationally important receptors with medium vulnerability and medium recoverability.
Low	Locally important receptors with medium to high vulnerability and low recoverability. Regionally important receptors with low vulnerability and medium to high recoverability. Nationally and internationally important receptors with low vulnerability and high recoverability.
Negligible	Receptor is not vulnerable to impacts regardless of value/importance. Locally important receptors with low vulnerability and medium to high recoverability.

2.9.2.4 The criteria for defining magnitude in this chapter are outlined in Table 2.16 below.

Table 2.16: Definition of terms relating to the magnitude of an impact.

Magnitude of impact	Definition used in this chapter
Major	Loss of resource and/or quality and integrity of resource; severe damage to key characteristics, features or elements (adverse).
	Large scale or major improvement or resource quality; extensive restoration or enhancement; major improvement of attribute quality (positive).
Moderate	Loss of resource, but not adversely affecting integrity of resource; partial loss of/damage to key characteristics, features or elements (adverse).
	Benefit to, or addition of, key characteristics, features or elements; improvement of attribute quality (positive).
Minor	Some measurable change in attributes, quality or vulnerability, minor loss of, or alteration to, one (maybe more) key characteristics, features or elements (adverse).
	Minor benefit to, or addition of, one (maybe more) key characteristics, features or elements; some beneficial impact on attribute or a reduced risk of adverse impact occurring (positive).
Negligible	Very minor loss or detrimental alteration to one or more characteristics, features or elements (adverse).
	Very minor benefit to, or positive addition of one or more characteristics, features or elements (positive).
No change	No loss or alteration or characteristics, features or elements; no observable impact in either direction.

2.9.2.5 The significance of the effect upon benthic ecology is determined by correlating the magnitude of the impact and the sensitivity of the receptor. The particular method employed for this assessment is presented in Table 2.17. In cases where a range is suggested for the significance of effect, there remains the possibility that this may span the significance threshold (i.e. the range is given as minor to moderate). In such cases the final significance is based upon the expert's professional judgement as to which outcome delineates the most likely effect, with an explanation as to why this is the case.

2.9.2.6 For the purposes of this assessment, any effects with a significance level of minor or less have been concluded to be not significant in terms of the EIA Regulations unless otherwise stated.

Table 2.17: Matrix used for the assessment of the significance of the effect.

		Magnitude of impact				
Sensitivity of receptor		*No change*	*Negligible*	*Minor*	*Moderate*	*Major*
	Negligible	Negligible	Negligible	Negligible or minor	Negligible or minor	Minor
	Low	Negligible	Negligible or minor	Negligible or minor	Minor	Minor or moderate
	Medium	Negligible	Negligible or minor	Minor	Moderate	Moderate or major
	High	Negligible	Minor	Minor or moderate	Moderate or major	Major or substantial
	Very high	Negligible	Minor	Moderate or major	Major or substantial	Substantial

2.9.3 Designated sites

2.9.3.1 Where Natura 2000 sites (i.e. internationally designated sites) are considered, this chapter summarises the assessments made on the interest features of internationally designated sites as described within section 2.6.2 of this chapter (with the assessment on the site itself deferred to the Report to Inform Appropriate Assessment (RIAA) (document reference number A5.2) for Hornsea Three). As outlined in paragraph 2.7.4.5, in addition to the assessment on the broad VERs (i.e. Habitats A, B, C, D and E and ocean quahog *A. islandica*), where relevant, an assessment has also been undertaken separately on the VERs that comprise Annex I habitat features of SACs and features of MCZ/rMCZs. This has been undertaken for all impact assessments except those where the assessment would not differ substantially for designated sites e.g. accidental release of pollutants.

2.9.3.2 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).

2.9.3.3 The RIAA (document reference number A5.2) has been prepared in accordance with Advice Note Ten: Habitats Regulations Assessment Relevant to Nationally Significant Infrastructure Projects (PINS, 2016) and will be submitted as part of the Application for Development Consent.

2.9.3.4 Habitats which constitute protected benthic ecology features for which an MCZ has been designated, or which constitute benthic ecology features for which an rMCZ has been recommended, are considered in this chapter. Each site has been fully assessed in volume 5, annex 2.3: MCZ Assessment.

2.9.3.5 An assessment of potential effects on habitats as Water Framework Directive (WFD) element of the North Norfolk and East Norfolk Coastal water bodies is provided in volume 5, annex 2.2: Water Framework Directive Assessment.

2.10 Measures adopted as part of Hornsea Three

2.10.1.1 As part of the project design process, designed-in measures have been proposed to reduce the potential for impacts on benthic ecology (see Table 2.18). As there is a commitment to implementing these measures, they are considered inherently part of the design of Hornsea Three and have therefore been considered in the assessment presented in section 2.11 below, (i.e. the determination of magnitude and therefore significance assumes implementation of these measures). These measures are considered standard industry practice for this type of development.

Table 2.18: Designed-in measures adopted as part of Hornsea Three.

Measures adopted as part of Hornsea Three	Justification
A pre-construction survey will be undertaken along the Hornsea Three offshore cable corridor to determine the location, extent and composition of any Annex I reefs within SACs and/or biogenic or geogenic reefs outside SACs. Should such reef features be identified during pre-construction surveys of the Hornsea Three offshore cable corridor, appropriate measures will be discussed with statutory consultees to avoid direct impacts to these features, where possible, and on the basis of the extent of these features at the time of construction. This approach is typical for offshore wind farm and cable developments. Should Annex I reefs within SACs and/or biogenic or geogenic reefs outside SACs be identified within the temporary working corridor, appropriate measures will be discussed with statutory consultees to avoid direct impacts to these features (e.g. from disposal of sandwave clearance material).	*S. spinulosa* reefs are known to occur within this part of the southern North Sea benthic ecology study area. Within the Hornsea Three array however, no biogenic or geogenic reefs were identified. Within the Hornsea Three offshore cable corridor, *S. spinulosa* aggregations assessed as being 'low reef' and 'medium reef' were identified. Of these, only the station assessed as 'medium reef' (located just outside the North Norfolk Sandbanks SAC; paragraph 2.7.1.15) was determined to potentially represent *S. spinulosa* reef. Direct impacts (e.g. habitat loss) to ecologically sensitive Annex I reefs within SACs and/or biogenic or geogenic reefs outside SACs are to be avoided where possible. Given the evidence for the propensity for reef to develop in this area, pre-construction surveys will be used to identify the presence of such reefs and ensure that measures can be designed, if necessary, to avoid direct impacts where possible.
In the event that the primary mitigation (i.e. avoiding Annex I reefs within SACs and/or biogenic or geogenic reefs outside SACs within the Hornsea Three offshore cable corridor, where possible) fails and export cables need to be installed through an area of reef(s), the cables would be microsited through areas of lower quality reef, avoiding areas of medium or high quality reef and/or cable installation would be restricted to the periphery of reef features to ensure continuous reef features are not bisected. To facilitate this, as more data on potential future Annex I *S. spinulosa* reefs within the North Norfolk Sandbanks and Saturn Reef SAC becomes available (e.g. JNCC reefs layer based on the results of the 2016 joint JNCC/Cefas survey within the Saturn reef (McIlwaine *et al*., 2017) and Hornsea Three pre-construction surveys data), the Reef Index will be recalculated and used to inform cable routing in the North Norfolk Sandbanks and Saturn Reef SAC.	Where cable installation within Annex I reefs is unavoidable (e.g. due to practical or engineering constraints), further mitigation will be employed to minimise effects on reefs. This will be undertaken on the basis of the extent of these features at the time of construction which will be informed by the most up-to-date Reef Index calculations and core reef assessment prior to construction.
A PEMMP will be developed and implemented to cover the construction and operation and maintenance phases of Hornsea Three. The PEMMP will include planning for accidental spills, contain a biosecurity plan (see below) to limit the spread INNS, address all potential contaminant releases and include key emergency contact details (e.g. the Environment Agency (EA), Natural England and MCA). A Decommissioning Programme will be developed to cover the decommissioning phase.	Measures will be adopted to ensure that the potential for release of pollutants from construction, operation and decommissioning plant is minimised. These will likely include: designated areas for refuelling where spillages can be easily contained; only using chemicals included on the approved Cefas list under the Offshore Chemical Regulations 2002; storage of these in secure designated areas in line with appropriate regulations and guidelines; double skinning of pipes and tanks containing hazardous substances; and storage of these substances in impenetrable bunds. In this manner, the potential for release of contaminants from rigs and supply/service vessels will be strictly controlled, thus providing protection for marine life across all phases of the offshore wind farm development.
A Biosecurity Plan will be produced and agreed in consultation with statutory consultees.	A document detailing how the risk of potential introduction and spread of INNS will be minimised is to be produced. This will include measures for cable/scour protection in the unlikely event that this material is sourced from the marine environment (it is anticipated that this material will originate from non-marine sources). The plan will outline measures to ensure vessels comply with the International Maritime Organization (IMO) ballast water management guidelines, it will consider the origin of vessels and contain standard housekeeping measures for such vessels as well as measures to be adopted in the event that a high alert species is recorded.

Measures adopted as part of Hornsea Three	Justification
Hornsea Three will employ sensitive cable and scour protection within the areas of designated sites that coincide with Hornsea Three. These cable and scour protection measures will not include concrete mattresses. The cable and scour protection will consider the local seabed conditions, including sediment/substrate type. Within the designated sites this may include measures as follows: • Within the North Norfolk Sandbanks and Saturn Reef SAC: this may include measures which may encourage the burial of the scour/cable protection by the surrounding sediment or rock protection which takes into account the typical grain sizes known to occur naturally within the SAC (i.e. coarse gravel, cobbles and boulders); • Within The Wash and North Norfolk Coast SAC: this may include measures which may encourage the burial of the scour/cable protection by the surrounding sediment or rock protection which takes into account the typical grain sizes known to occur naturally within the SAC (i.e. coarse gravel and cobbles); • Within the Cromer Shoal Chalk Beds MCZ: cable protection may comprise gravel and cobbles with a mean grain size of 100 mm, maximum grain size of 250 mm; and • Within the Markham's Triangle rMCZ: cable protection may comprise gravel and cobbles with a mean grain size of 100 mm, maximum grain size of 250 mm, while scour protection for foundations, if required, may have a maximum diameter of 360 mm. Cable protection requirements will be detailed in the Cable Specification and Installation Plan and scour protection requirements will be detailed in the Scour Protection and Management Plan which will be produced prior to construction and agreed in consultation with statutory consultees.	It is anticipated that the use of such material may encourage the burial of the scour/cable protection by the surrounding sediment, which may serve to reduce any potential effect of long term habitat loss. Where such measures can be employed, local communities associated with the habitat features of designated sites (i.e. infaunal communities where sediment accumulation occurs; epifaunal communities in the case of appropriate cable protection) are likely to colonise these areas, potentially providing some limited recovery of communities in areas where cable protection is placed and reducing the extent of long term habitat loss. These measures have been adopted as a result of discussions with the EWG regarding the impacts to designated sites associated with cable protection requirements, rather than as a result of concerns about cable protection requirements for Hornsea Three per se. As such, these measures are discussed further in the RIAA for Hornsea Three (document reference number A5.2) and in volume 5, annex 2.3: Marine Conservation Zone Assessment but have been considered as part of the design of Hornsea Three for the purposes of this benthic ecology assessment.

2.11 Assessment of significance

2.11.1 Construction phase

2.11.1.1 The impacts of the offshore construction of Hornsea Three have been assessed on benthic ecology. The potential environmental impacts arising from the construction of Hornsea Three are listed in Table 2.14 above along with the maximum design scenario against which each construction phase impact has been assessed.

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

Temporary habitat loss/disturbance due to cable laying operations (including anchor placements and sandwave clearance), spud-can leg impacts from jack-up operations and seabed preparation works for gravity base foundations (GBFs), may affect benthic ecology

2.11.1.3 As detailed in Table 2.14, direct temporary loss/disturbance of subtidal habitat within Hornsea Three will occur as a result of jack-up barge operations to install foundations, the deposition of material generated during seabed preparation prior to GBF installation, pre-construction boulder clearance and sandwave clearance, burial of array, interconnector and export cables and the anchor placements associated with these operations. This assessment is considered equivalent to the following pressures identified by the ICGC pressures list under the overarching pressure theme 'Physical damage (reversible change)':

- Habitat structure changes - removal of substratum (extraction);
- Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion; and
- Siltation rate changes, including smothering (depth of vertical sediment overburden).

2.11.1.4 The benchmarks for the relevant MarESA pressures which have been used to inform this impact assessment are as follows:

- Habitat structure changes - removal of substratum (extraction): the benchmark for which is the extraction of substratum to 30 cm. This pressure is considered to be analogous to the impacts associated with sandwave clearance;
- Abrasion/disturbance at the surface of the substratum: the benchmark for which is damage to surface features (e.g. species and physical structures within the habitat). This pressure is analogous to the impacts associated with jack-up vessel operations, anchor placements and boulder clearance;
- Penetration and/or disturbance of the substratum below the surface: the benchmark for which is damage to sub-surface features (e.g. species and physical structures within the habitat). This pressure is analogous to the impacts associated with cable burial, jack-up vessel operations, boulder clearance and anchor placements; and
- Smothering and siltation rate changes (heavy): the benchmark for which is heavy deposition of up to 30 cm of fine material added to the habitat in a single discrete event. This pressure is considered to

be analogous to impacts associated with the deposition of sandwave clearance material and deposition of seabed preparation material dredged prior to foundation installation.

2.11.1.5 As discussed in paragraphs 2.7.4.4 and 2.7.4.5, this assessment has been undertaken on the broad VERs (i.e. Habitats A, B, C, D and E are of relevance for this impact) and separately on the VERs that comprise Annex I habitat features of SACs and features of MCZ/rMCZs. The assessments relating to impacts in designated sites consider the biotopes rather than just the broader VERs.

Magnitude of impact

2.11.1.6 The total maximum area of temporary subtidal habitat loss due to construction activities described in Table 2.14 is predicted to be approximately 68,645,736 m^2 (68.6 km^2). This equates to 1.35% of the Hornsea Three benthic ecology study area. To provide wider context for the Hornsea Three temporary habitat loss numbers, the total area of the Southern North Sea benthic ecology study area is 65,768 km^2, and therefore, temporary disturbance of 68.6 km^2 represents a small proportion of this. Activities resulting in the temporary habitat loss of both subtidal and intertidal habitats will occur intermittently throughout the construction period. Although both the Hornsea Three array area construction duration and the Hornsea Three offshore cable corridor construction durations may be over up to eight years (see Table 2.14), construction activities resulting in temporary habitat loss/disturbance will not occur for the entire duration. Foundation installation will occur over up to 2.5 years (this also includes piling time and therefore seabed preparation will be a small proportion of this time), array cable installation will take place over up to 2.5 years and export cable installation over up to 3 years.

2.11.1.7 There will also be temporary habitat loss arising from pre-construction activities outlined in Table 2.14. These activities would likely be carried out approximately one to two years prior to the start of construction. The following sections, however, only describe sandwave clearance and boulder clearance further as these are the only pre-construction activities that have the potential to lead to disturbance outside the width of disturbance assumed for cable burial (i.e. all other activities including for example, UXO clearance, will be within the 15 m width of disturbance assumed for cable burial).

2.11.1.8 As described in Table 2.14, for the purposes of the current assessment, coarse, granular material disturbed during seabed preparation and pre-construction sandwave clearance activities and disposal within Hornsea Three is assumed to result in sediment deposition to a uniform depth of 0.5 m. Due to the depth of sediment deposition, this has been considered temporary habitat loss as many benthic species will most likely suffer mortality beneath these areas. Any mounds of granular material will, however, erode over time and displaced material will re-join the natural sedimentary environment, gradually reducing the size of the mounds (see section 1.9 in volume 2, chapter 1: Marine Processes). As the sediment type deposited to the seabed will be similar to those in surrounding areas, benthic assemblages would be expected to recolonise these areas (discussed further below).

2.11.1.9 With respect to seabed preparation, only the temporary habitat loss associated with the deposition of seabed preparation material is included within the numbers presented within this section. This is because, the area of long term habitat loss associated with the footprint of the turbine foundations and associated scour protection, considered in paragraph 2.11.2.3 *et seq*., is greater than, and therefore completely encompasses the area impacted by the seabed preparation activity itself.

2.11.1.10 The total maximum area of intertidal temporary direct habitat loss/disturbance is estimated at approximately 12,642 m^2. This includes all cable laying activity, including plant and machinery movements (Table 2.14). As no VERs were recorded at the Hornsea Three intertidal area, due to the barren nature of the sediments (see section 2.7.2), the effect of intertidal habitat loss on benthic ecological receptors is not considered further for this impact.

2.11.1.11 Of the total area of subtidal temporary habitat loss described in Table 2.14, a maximum of 38,408,194 m^2 of this is predicted to be temporarily lost/disturbed within the Hornsea Three array area as a result of pre-construction activities (see paragraph 2.11.1.7), the deposition of seabed preparation material, jack-up barge operations and burial of array, interconnector and export cables within the Hornsea Three array area (including associated anchor placements). The maximum design scenario for each VER affected by temporary habitat loss is estimated based on a scenario of all this loss occurring wholly within Habitat A (Sandy sediments with low infaunal diversity and sparse epibenthic communities), Habitat B (Brittlestar dominated communities in deep muddy sands) or Habitat C (Coarse and mixed sediments with moderate to high infaunal diversity and scour tolerant epibenthic communities, Table 2.13, Figure 2.8). This would equate to approximately 1.81% of Habitat A, approximately 2.75% of Habitat B, and approximately 2.94% of Habitat C within the Hornsea Three benthic ecology study area.

2.11.1.12 Jack-up footprints associated with foundation installation in the Hornsea Three array area may remain on the seabed for a number of years, particularly in cohesive sediments, as described in section 1.11.2 of volume 2, chapter 1: Marine Processes. This has also been demonstrated by monitoring studies of Round 1 offshore wind farms (BOWind, 2008; EGS, 2011). Monitoring at the Barrow offshore wind farm monitoring showed depressions were almost entirely infilled 12 months after construction while Lynn and Inner Dowsing (L&ID) monitoring also showed some infilling of the footprints, although the depressions were still visible a couple of years post construction (BOWind, 2008; EGS, 2011). The presence of such indentation features is not predicted to have implications for sediment transport across Hornsea Three and will infill over time due to local seabed movement under gravity and in proportion to the rate of sediment transport through the area (see section 1.11.2 of volume 2, chapter 1: Marine Processes). The sensitivity and recovery of benthic communities in jack-up footprints is considered in paragraphs 2.11.1.32.

2.11.1.13 Of the total temporary habitat loss/disturbance described in Table 2.14, a maximum of 30,238,142 m^2 will be temporarily lost from the subtidal areas of the Hornsea Three offshore cable corridor as a result of pre-construction activities (see paragraph 2.11.1.7), cable burial and associated anchor placements. The proposed sandwave clearance activities will result in local displacement of the disturbed sediment volume, which will remain the same sediment type as the surrounding seabed (i.e. it is reasonable to assume similarity of sediment particle size with depth based on sediment transport processes) and with no loss of seabed sediments from the local area. In the case of dredging, assuming that any material excavated is disposed of in close proximity to the dredge location, no sediment volume will be removed from the sandbank systems overall. The displaced material will be of the same or similar sediment type (mineralogy and grain size distribution) as the surrounding seabed and, following re-settlement, will be immediately available again for transport at the naturally occurring rate and direction, controlled entirely by natural processes. As such, the sediment will have immediately re-joined the natural sedimentary environment within the local area and so by definition is not 'lost from the system' due to the dredging/spoil disposal process. Due to the dynamic nature of the sandwaves within Hornsea Three, these morphological features are considered to have moderate levels of recoverability (see volume 2, chapter 1: Marine Processes). Should a marine disposal licence for a new disposal site (see volume 4, annex 3.2: Dredging and Disposal: Site Characterisation) not be granted within the vicinity of the dredging areas, material may have to be transported some distance by vessel and therefore potentially 'lost' from the system'. Although this scenario would not be preferable to local disposal, it is still considered unlikely that it would adversely affect the form and function of the sandbanks features (see volume 2, chapter 1: Marine Processes).

2.11.1.14 The patterns of processes governing the overall evolution of the systems (the flow regime, water depths and sediment availability) are at a much larger scale than, and so would not be affected by, the proposed local works. As a result, the proposed clearance is not likely to influence the overall form and function of the system and eventual recovery via natural processes is therefore expected. The rate of recovery would vary in relation to the rate of sediment transport processes, faster infill and recovery rates will be associated with higher local flow speeds and more frequent wave influence (see volume 2, chapter 1: Marine Processes). Pre and repeated post construction monitoring of the Race Bank offshore cable route (DONG Energy, 2017) has demonstrated partial recovery of sandwave crest features, following sandwave clearance, within a four month period for which data are presently available (see volume 2, chapter 1: Marine Processes). Where the sands are deposited into areas of different seabed type (e.g. areas of slightly coarser seabed in some sandwave troughs), the seabed may become locally relatively finer in texture until the body of sand has been winnowed away or reincorporated into a bedform migrating over that location. In all cases, the deposited sediments would be rapidly incorporated into the seabed and local accumulations would be subject to redistribution under the prevailing hydrodynamic conditions. Therefore, the sediment type is anticipated to return to the pre-impacted state over time, providing opportunity for benthic species and communities to recolonise and recover. The recovery of the species and communities associated with these sediments is described in paragraph 2.11.1.24 *et seq*.

2.11.1.15 Pre-construction boulder clearance has been considered here as temporary habitat disturbance (rather than loss) as the process will effectively redistribute boulders and cobbles within discrete areas and potentially concentrating these in the areas either side of the boulder clearance corridor (25 m for the offshore cable corridor and 15 m in the Hornsea Three array). Given the existing patchiness of the distribution of cobbles and boulders in offshore environment (see section 2.7.1) this is considered unlikely to represent a significant shift in the baseline situation and, since no sediment/substrate is being removed, this will not act as a barrier for the recovery of any epifaunal communities impacted during the process. Furthermore, whilst the maximum design scenario assumes that all of the habitat within the boulder clearance corridor will be disturbed, it should be noted that, in reality, only a proportion of this will be via a displacement scour with other parts only requiring clearance via subsea grab which will be far more targeted and will be result in substantially less habitat disturbance.

2.11.1.16 As described in paragraph 2.11.1.12 for jack-up operations, cable trenching also has the potential to leave scars on the seabed, the persistence of which will depend on the local seabed characteristics and ambient hydrodynamic conditions (see section 1.11.2 in volume 2, chapter 1: Marine Processes). In areas where mobile sands and gravels are present, such as are present across the majority of Hornsea Three, these scars are likely to be temporary features which may only persist for a period of weeks to months. However, even if scars persist they are not expected to have implications for sediment transport; they are simply local depressions that will infill over time.

2.11.1.17 The maximum potential losses of each VER affected within the Hornsea Three offshore cable corridor is 23,889,598 m^2 of Habitat A, 291,218 m^2 of Habitat B, 3,145,150 m^2 of Habitat C and 2,912,176 m^2 of Habitat D (Mixed sediments with high infaunal and epifaunal diversity), which equates to 1.12%, 0.02%, 0.24% and 1.37%, respectively, of the total area of each VER within the Hornsea Three benthic ecology study area. The maximum design scenario, for each VER affected by temporary habitat loss along the Hornsea Three offshore cable corridor, is estimated based on a scenario of all loss associated with sandwave clearance occurring wholly within Habitat A. Ephemeral *S. spinulosa* reef was identified at a single location within the Hornsea Three offshore cable corridor outside the North Norfolk Sandbanks and Saturn Reef SAC (i.e. Habitat E). Assuming a maximum adverse scenario that all of the export cables are routed through this habitat (which is highly precautionary), up to approximately 25,000 m^2 of this habitat could be affected. The total area of potential *S. spinulosa* reef mapped during the site specific survey was 84,407 m^2, therefore approximately 70% of this habitat would remain undisturbed. As the Gubbay (2007) guidance states that potential reef should have an area of at least 25 m^2, this impact would not result in a change to the outcome of the *S. spinulosa* reef assessment in this locality (i.e. the reef would still be assessed as 'medium reef'). Appropriate measures will, however, be discussed with statutory consultees to avoid direct impacts to this reef, where possible (see Table 2.18).

2.11.1.18 Following cable installation there may be a requirement for some localised remedial cable reburial works during the construction phase which would be undertaken within approximately one year of the initial works. On the basis of the short timescale following the initial cable laying activities within which these reburial activities may occur, the habitats are not predicted to have substantially recovered within this timeframe and, as such, this is not considered to constitute repeat disturbance but rather an extension of the original disturbance activity within the original footprint. As noted in Table 2.14, Hornsea Three may be constructed over up to two phases, however following completion of cable installation there will be no potential for repeat direct physical disturbance to the footprint of seabed previously impacted by cable burial as this would pose a risk to the integrity of the cable. The potential for repeat habitat disturbance would, therefore, be limited to that associated with the deposition of fine sediments from cable installation works in adjacent areas.

2.11.1.19 Habitat disturbance associated with cable burial following sandwave clearance and boulder clearance will fall within the footprints of effect of these pre-construction activities. Therefore, whilst there will be potential for repeat disturbance to these areas (see paragraph 2.11.1.33 for discussion of this), cable burial activities will not add further to the total area of temporary habitat disturbance.

2.11.1.20 The total maximum potential temporary losses of each VER because of all subtidal operations are therefore as follows (see Figure 2.8):

- Habitat A – 62,297,792 m^2 (2.93% of Habitat A within Hornsea Three benthic ecology study area);
- Habitat B – 38,699,412 m^2 (2.77% of Habitat B within Hornsea Three benthic ecology study area);
- Habitat C – 41,553,344 m^2 (3.18% of Habitat C within Hornsea Three benthic ecology study area);
- Habitat D – 2,912,176 m^2 (1.37% of Habitat D within Hornsea Three benthic ecology study area); and
- Habitat E – 25,000 m^2 (29.63% of Habitat E within Hornsea Three benthic ecology study area although this would not change the outcome of the *S. spinulosa* reef assessment in this locality (i.e. the reef would still be assessed as 'medium reef')).

2.11.1.21 The temporary loss/disturbance will be highly localised to the vicinity of the construction activity (i.e. limited to the immediate footprints). The totals presented for temporary habitat loss/disturbance are over the construction phase of up to eight years for the Hornsea Three array area and up to eight years for the Hornsea Three offshore cable corridor. As discussed in paragraph 2.11.1.6, individual activities resulting in temporary habitat loss/disturbance will occur intermittently throughout this time with only a small proportion of the total area of habitat being impacted at any one time. The predominantly sand and coarse sediment habitats that are most likely to be affected are typical of, and widespread throughout, the southern North Sea and the Hornsea Three benthic ecology study areas.

2.11.1.22 The total area of temporary subtidal habitat loss represents a very small percentage loss (0.009%) of the total area of the OSPAR Region II (Greater North Sea) within which *A. islandica* is listed as under threat and/or decline.

2.11.1.23 The impact of temporary loss/disturbance to Habitats A, B, C, D, E and ocean quahog *A. islandica* is predicted to be localised to Hornsea Three, of medium term duration (i.e. construction phase of up to eight years for the Hornsea Three array area and up to eight years for the Hornsea Three offshore cable corridor, although only a small proportion of the total area will be affected at any one time with individual elements of construction having much smaller durations (see Table 2.14)) and intermittent in nature. It is predicted that the impact will affect the receptors directly. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.11.1.24 The subtidal habitats directly affected by temporary habitat loss and disturbance (Habitats A, B, C, D and E) typically have low sensitivity to disturbance of this nature. Sandy biotopes such as NcirBat and FfabMag and IMoSa, represented by Habitat A, are typical of high energy environments and are therefore naturally subject to, and tolerant of, high levels of physical disturbance. The communities that characterise these biotopes are predominantly infaunal mobile species including polychaetes and venerid bivalves, which can re-enter the substratum following disturbance (Tillin, 2016a). For example, the mollusc *F. fabula* and the polychaetes *M. mirabilis* and *N. cirrosa* are all active burrowers capable of reburying themselves (Tillin and Rayment, 2016). Although while at the sediment surface any displaced infauna may be vulnerable to predation from echinoderms and bottom feeding fish, significant declines in overall species richness are unlikely to be seen and the recoverability of these communities is therefore assessed as high (Tillin, 2016a and 2016b).

2.11.1.25 The recoverability of such communities within Habitat A is likely to occur because of a combination of recruitment from surrounding unaffected areas and larval dispersal, and recovery is likely to occur within five years. This is supported by evidence relating to the recovery of benthic communities following aggregate extraction activities (Newell *et al.,* 1998; Desprez, 2000; Newell *et al*., 2004). Newell *et al*. (1998) reported that following the cessation of dredging activities, the characteristic recovery time for sand communities may be two to three years. Data from a marine aggregate site off the south coast of the UK indicated that following the initial suppression of species' diversity, abundance and biomass recovery of species' diversity to within 70 to 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). Desprez (2000) also reported that the dredging of an industrial site off Dieppe resulted in decreases in species richness, abundance and biomass by 63%, 86% and 83% respectively, resulting in a shift in benthic community. However, within 16 months following cessation of dredging, species richness had been fully restored, abundances had recovered by up to 56%, and after 28 months, biomass had recovered by 75%. It is important to acknowledge however, that the activities associated with aggregate extraction are quite different to those associated with offshore wind farm construction activities. (i.e. they involve the complete removal of sediment). Data collated from more analogous activities such as the burial of telecommunications cables has shown that recovery of sand sediments is likely to occur within one year (Foden *et al*., 2011).

2.11.1.26 With respect to abrasion/physical disturbance resulting from jack-up operations and anchor placements, much of the infauna in Habitat A is likely to have intermediate intolerance to such disturbance at the surface, due to the depths in the sediment in which infauna live. Venerid bivalves including *F. fabula* for example, which have a fragile shell and are shallower burrowers, are more vulnerable. Polychaetes such as *M. mirabilis* which expose their palps at the surface while feeding are similarly vulnerable (Tillin and Rayment, 2016). Although epifaunal communities were typically absent in Habitat A, the larger faunal components of these communities, for example the echinoderms *A. rubens*, are also likely to be vulnerable. However, this species typically exhibits good powers of regeneration and high fecundity, and so recoverability is also likely to be high (Budd, 2008). Overall, as discussed in paragraph 2.11.1.25, the recoverability of Habitat A is likely to occur because of the combination of recruitment from surrounding unaffected areas and larval dispersal, and recovery is likely to occur within five years.

2.11.1.27 Habitat B is represented by the sandy mud biotope AfilMysAnit. Communities associated with this biotope are expected to have low resistance to habitat loss/disturbance including penetration or disturbance of subsurface substratum, abrasion, removal of sediment and heavy smothering (De-Bastos, and Hill, 2016a). Many of the characterising species are likely to be suffer mortality or be severely damaged in the affected areas. Although temporary habitat loss/disturbance will lead to declines in diversity within affected areas, recovery of these communities is likely to occur following installation of offshore wind farm infrastructure. The bivalves *Mysella bidentata* and *Abra nitida* are well adapted for recovery and recolonisation following disturbance. For example, *A. nitida* has a relatively short life span (approximately three years) and high fecundity and larval dispersal, which suggest this genus has high recoverability and can restore biomass within three years following disturbance (Marine Ecological Surveys Limited, 2008). More mobile epifaunal species associated with this biotope also show good recovery potential, including the echinoderm *A. filiformis* which has very low sensitivity to physical disturbance and abrasion (Hill and Wilson 2008; Marine Ecological Surveys Limited, 2008). Associated epifaunal species which include the shrimp *Crangon allmanni*, and a variety of crab species including *L. holsatus*, *L. depurator* and *P. bernhardus* are considered sufficiently mobile to avoid the physical impacts of disturbance. Overall sensitivity of the Habitat B is considered to be medium (De-Bastos, and Hill, 2016a), with recovery of some species occurring rapidly as detailed above, but with full recovery of this biotope expected over a longer period than Habitat A (i.e. potentially greater than five years, but less than ten years).

2.11.1.28 Habitat C includes the MoeVen, PoVen and other coarse and mixed sediment biotopes such as MysThyMx, which have typically low sensitivity to impacts resulting from physical disturbance/abrasion and displacement (Tillin and Rayment 2016; Tillin, 2016c; Tillin, 2016d; De-Bastos and Marshall, 2016a). This habitat, which is characterised by relatively diverse communities of polychaetes and venerid bivalves, is unlikely to experience anything other than minor localised declines in species richness. Most of the infauna will be expected to rebury following displacement with only a small degree of mortality resulting from predation. Although some permanently attached species such as epifaunal hydroids and bryozoans will suffer mortality when removed from the substratum during construction activities, other epifaunal species which remain attached to their substrate will likely survive any physical damage and repair themselves. For example, Silén (1981) demonstrated that damage to the fronds of these species can be repaired within five to ten days. Overall, the high recoverability of the component species of this habitat following removal, displacement and physical disturbance, indicates that damaged or reduced populations will recover numbers and percentage cover within months, with full recovery within five years (Tillin, 2016d). This is also supported by some data from the aggregates industry which has shown that following the cessation of dredging activities, sand and gravel communities typically recover in two to three years (Newell *et al.,* 1998). More recent data has suggested that recovery of gravel communities to dredging activities could take up to nine years (Foden *et al*., 2009); however, as outlined in paragraph 2.11.1.25, the complete removal of sediment associated with aggregate extraction is quite different to that associated with the construction of Hornsea Three. Gravelly sediments (e.g. sandy gravel) have been reported as recovering from cable burial activities within one year (Andrulewicz *et al*., 2003 in Foden *et al*., 2011).

2.11.1.29 Habitat D and Habitat E (*S. spinulosa* reef outside an SAC), both represented by the SspiMx biotope with typically diverse epibenthic communities, were found exclusively along the Hornsea Three offshore cable corridor and could therefore be affected by export cable laying operations and associated anchor placements. Although *S. spinulosa* communities are typically intolerant to temporary disturbance and displacement, recoverability is also high, resulting in overall medium sensitivity to impacts of this nature (Tillin and Marshall, 2015). Following displacement, *S. spinulosa* is not able to rebuild tubes once removed from them and, although associated mobile epifaunal species such as hermit crabs and amphipods may be able to escape unharmed, sessile attached fauna including bryozoans such as *F. foliacea* and *Alcyonidium diaphanum* may be lost resulting in potential declines in overall species richness (Tillin and Marshall, 2015). Although the key characterising species (i.e. *S. spinulosa*) is predicted to recover quickly, the high biodiversity often associated with this habitat may take slightly longer to develop. With respect to anchor placements and jack-up disturbance, intolerance is assessed as intermediate as although abrasion is likely to cause damage to erect epifauna, recovery is likely to be high. *S. spinulosa* is commonly found in disturbed environments and has a typically high rate of reproduction (Holt *et al*., 1998). *S. spinulosa* is often one of the first species to settle on newly exposed surfaces (Ospar Commission, 2010). The presence of any remaining *S. spinulosa* adults will also assist in larval settlement of this species (Jackson and Hiscock, 2008).

2.11.1.30 As the site specific surveys revealed other areas with potential to support *S. spinulosa* reefs within the Hornsea Three offshore cable corridor (see paragraphs 2.7.1.13 *et seq*.), it is likely that suitable conditions will occur to allow *S. spinulosa* reef to re-establish should it be impacted by construction. The recoverability of associated epifauna is also expected to be high, with complete recovery likely within five years (Marshall, 2008; Tillin and Marshall, 2015).

2.11.1.31 The conclusion of recovery of Habitat D and Habitat E within five years is supported by the results of a study funded by Natural England through the MALSF, which investigated the recoverability or colonisation potential of *S. spinulosa* following cessation of aggregate extraction activities at Hastings Shingle Bank (Pearce *et al*., 2007). The study found that dredging had not altered the seabed in a way that was detrimental to colonisation, and initial colonisation and development of a significant *S. spinulosa* aggregation was observed at the site within 18 months and development to a stage equivalent to the oldest aggregations observed in the area was assessed as likely to be complete within three years. It was concluded that a similar pattern could be expected in other extraction areas assuming a supply of larvae in the plankton and that the process would likely be significantly quicker in areas less hampered by trawling (Pearce *et al.*, 2007). The sensitivity of both Habitat D and the reef forming equivalent, Habitat E, is considered to be medium.

2.11.1.32 With respect to recovery from jack-up operations, at the Barrow offshore wind farm, where jack-up footprints were observed around some turbines during scour monitoring undertaken within one year of offshore wind farm construction, although most of these were found to be completely infilled approximately six months later in a subsequent survey (BOWind, 2008). Monitoring at the L&ID offshore wind farm recorded more persistent jack-up barge footprints which were still observed on the seabed three years post construction. Monitoring of footprints adjacent to two turbine locations in the L&ID offshore wind farm showed that the sediments were comprised of mixed sediments, with similar distribution of sediments within and outside the footprints (EGS, 2012). Benthic infaunal analysis from grab samples and DDV sampling within these footprints and in adjacent areas also showed clear signs of recovery, despite the visible footprints on the seabed. Communities were found to have a high degree of similarity, with a diverse infaunal assemblage associated with the SspiMx biotope recorded within and outside the footprints and *S. spinulosa* recorded within both sets of jack-up footprints (EGS, 2012). This supports the conclusion that although these footprints may persist for a number of years, infaunal and epifaunal communities will fully recover into these areas, as the sediment infills the depressions.

2.11.1.33 Effects of temporary habitat loss/disturbance within the construction phase will cease following completion of construction activities. Whilst fauna and flora will be affected, as discussed above, recovery in most cases is likely to be high and typically within five years or less, because of the passive import of larvae and active migration of juveniles and adults from adjacent non-affected areas. The recovery timescales stated are from each individual construction activity (e.g. seabed preparation, cable installation). Whilst there is potential for repeat disturbance during construction to areas impacted by pre-construction activities (e.g. sandwave clearance and boulder clearance; see paragraph 2.11.1.7), following the installation of all infrastructure in any given area, there will be no further disturbance to habitat in that area. Therefore, recovery will not be delayed by further physical disturbance and the recovery timescales described in this section will apply. There is the potential for repeat disturbance to occur during the operation and maintenance phase, this is fully assessed in paragraphs 2.11.2.145 *et seq.*, although it is predicted that the communities will have fully recovered from construction impacts by this time. As outlined previously in paragraphs 2.11.1.12 and 2.11.1.16, although jack-up footprints and cable installation activities may leave indentations in the sediment these are expected to naturally infill over time and as the sediment returns to the area the associated communities are also expected to recover within the timescales stated here.

2.11.1.34 Habitats A and C are deemed to be of low to medium vulnerability, high recoverability and regional value. The sensitivity of these receptors is therefore considered to be low. Habitats B and D are deemed to be of medium to high vulnerability, medium recoverability and regional value; overall the sensitivity is considered to be medium. Habitat E is deemed to be of high vulnerability, medium to high recoverability and national value; overall the sensitivity is considered to be medium. Although *S. spinulosa* itself is likely to recover quickly, the associated high biodiversity may take longer to recover and, as such, the sensitivity of Habitat D and Habitat E is medium. Measures will, however, be discussed with the statutory consultees to avoid direct impacts to *S. spinulosa* reef, where possible.

2.11.1.35 The recovery of Habitats A, B, C, D and E to temporary disturbance is not predicted to be impacted by the potential for a small amount of repeat disturbance from sediment deposition associated with phased construction works as described in paragraph 2.11.1.17. This is because the characterising communities are predominantly infaunal, and as described in paragraph 2.11.1.111 to 2.11.1.112, have low sensitivity to smothering because of deposition.

2.11.1.36 Despite its thick and solid shell, *A. islandica* is intolerant to displacement and abrasion/physical disturbance. In addition, individuals exposed at the surface by the construction activities outlined in Table 2.14 could potentially be subject to a higher risk of predation from starfish and other predators, although they would be expected to bury themselves back into the sediment quickly (Tyler-Walters and Sabatini, 2017). *A islandica* is a slow growing, long lived species with a very low recruitment rate and recoverability to this type of impact is predicted to be low. Therefore *A. islandica* are deemed to be of medium vulnerability, very low recoverability and national value, and the sensitivity of this receptor is considered to be high.

Significance of the effect

2.11.1.37 Overall, the sensitivity of the VERs Habitat A, Habitat B, Habitat C, Habitat D and Habitat E is considered to be low to medium and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

2.11.1.38 Overall, the sensitivity of ocean quahog *A. islandica* is considered to be high and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms. This has been concluded on the basis that only a very small proportion of the habitat for this species in the Southern North Sea is predicted to be affected (0.009%) and, furthermore, as described in paragraph 2.7.1.22, this species was recorded is very low abundances in the former Hornsea Zone and predominately as juveniles, no individuals were recorded within Hornsea Three indicating that Hornsea Three is not an important area for this species.

North Norfolk Sandbanks and Saturn Reef SAC

Magnitude of impact

Annex I sandbanks

2.11.1.39 Of the total predicted temporary habitat loss/disturbance described in paragraph 2.11.1.6, up to maximum of 9,305,800 m^2 of this is predicted to occur within Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC (i.e. from pre-construction sandwave clearance (and sandwave material deposition) and boulder clearance and cable installation including anchor placements; see Table 2.19). This represents 0.26% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC/Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the SAC (i.e. the entire SAC is assigned to the Annex I sandbank habitat, as it is designated and viewed as one integrated sandbank system; JNCC, 2010).

2.11.1.40 Sandwave clearance material from sandwaves cleared within the North Norfolk Sandbanks and Saturn Reef SAC will be deposited within the same sandwave system within the boundary of the North Norfolk Sandbanks and Saturn Reef SAC. The precise disposal location selected within the Hornsea Three disposal sites (see volume 4, annex 3.2: Dredging and Disposal: Site Characterisation) will consider the net direction of sediment transport in the region to ensure that sediment will not be lost from the sandbank system (see paragraphs 2.11.1.13 to 2.11.1.14 and section 1.11 in volume 2, chapter 1: Marine Processes). It is reasonable to assume a similarity of sediment particle size with depth through the sandwave on the basis of sediment transport processes, therefore, in most cases the deposited material is likely to be similar in nature to that present in the area in which it is deposited. Where sands are deposited into areas of different seabed type however (e.g. areas of slightly coarser seabed in some sandwave troughs), the seabed may become locally relatively finer in texture until the body of sand has been winnowed away or reincorporated into a bedform migrating over that location. In all cases, the deposited sediments would be rapidly incorporated into the seabed and local accumulations would be subject to redistribution under the prevailing hydrodynamic conditions.

Table 2.19: Temporary habitat loss of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC (assuming all sediment assigned to this Annex I habitat).

Project element	Temporary habitat loss/disturbance (m^2) of Sandbanks which are slightly covered by seawater all the time	Assumptions
Pre-construction sandwave clearance	2,880,000	Clearance of sandwaves along up to 192 km of cable, with up to six cables, each of up to 32 km length within the North Norfolk Sandbanks and Saturn Reef SAC. Sandwave clearance will affect a corridor of up to 30 m width of seabed (i.e. an additional 15 m width of disturbance on the 15 m associated with cable burial) (192,000 m x 15 m = 2,880,000 m^2).
Pre-construction sandwave clearance disposal activities	1,239,400	Up to 1,239,400 m^2 from placement of coarse, dredged material to a uniform thickness of 0.5 m because of sandwave clearance on the offshore cable corridor, assuming a volume of up to 619,700 m^3 of sandwave clearance material.
Pre-construction boulder clearance	900,000	Clearance of boulders along up to 90 km of cable, with up to six cables, each of up to 15 km length within the North Norfolk Sandbanks and Saturn Reef SAC. Boulder clearance will affect a corridor of up to 25 m width of seabed (i.e. an additional 10 m width of disturbance on the 15 m associated with cable burial) (90,000 m x 10 m = 900,000 m^2).
Cable burial	4,230,000	Burial of up to a total of 282 km cable length, with up to six cables, each of 47 km length within the North Norfolk Sandbanks and Saturn Reef SAC. Cable installation will affect a corridor of up to 15 m width of seabed (282,000 m x 15 m = 4,230,000 m^2).
Anchor placements	56,400	Up to one anchor (footprint of 100 m^2 each) repositioned every 500 m of the 282 km cable length within the North Norfolk Sandbanks and Saturn Reef SAC, with up to six export cables (282,000 m x 100 m^2 x 6 / 500 m = 56,400 m^2).
Total temporary habitat loss/disturbance within the North Norfolk Sandbanks and Saturn Reef SAC	9,305,800	-

2.11.1.41 Should a marine disposal licence for a new disposal site (see volume 4, annex 3.2: Dredging and Disposal: Site Characterisation) not be granted within the vicinity of the dredging areas, material may have to be transported some distance by vessel and therefore be potentially 'lost' from the system. Although local disposal would be preferable to this scenario, it is still considered unlikely that it would adversely affect the form and function of the designated features within the North Norfolk Sandbanks and Saturn Reef SAC. This is because the area impacted is small relative to the overall size of the SAC.

2.11.1.42 The impact of temporary loss/disturbance to Annex I sandbanks within the North Norfolk Sandbanks and Saturn Reef SAC is predicted to be localised to discrete sections of the Hornsea Three offshore cable corridor, of medium term duration (i.e. construction phase of up to eight years for the Hornsea Three offshore cable corridor, although export cable installation will only comprise a small proportion of this (up to three years); see Table 2.14), intermittent in nature and reversible. It is predicted that the impact will affect receptors directly with a small change in the baseline condition. The magnitude is therefore, considered to be minor.

Potential future Annex I S. spinulosa reef

2.11.1.43 As discussed in paragraphs 2.7.1.15 and 2.7.1.16, although the Hornsea Three offshore cable corridor coincides with the JNCC delineated boundary of *S. spinulosa* reef in the North Norfolk Sandbanks and Saturn Reef SAC, no Annex I reefs were identified during the site specific surveys of the Hornsea Three offshore cable corridor coinciding with the North Norfolk Sandbanks and Saturn Reef SAC. This included site specific geophysical and DDV sampling of areas where *S. spinulosa* reef was historically recorded (Jenkins *et al*., 2013; Figure 2.6), the results of which showed that no reef was present within the Hornsea Three offshore cable corridor. Despite this, there is potential for *S. spinulosa* reef to occur within the Hornsea Three offshore cable corridor in the future and to consider the potential for this, the following paragraphs consider the desktop information on the occurrence of these reef features within the SAC and the potential for reef to occur in these areas prior to the Hornsea Three construction phase.

2.11.1.44 In 2003, the Saturn *S. spinulosa* reef covered an area of approximately 1.15 km^2 in the area partially coinciding with the Hornsea Three offshore cable corridor temporary working area (see Figure 2.6). The Saturn reef varied in density over this area and the boundaries of two densely populated regions of reef, each of which were surrounded by less densely populated expanses, were mapped by BMT Cordah (2003; see Figure 2.6). In the two regions densely populated with *S. spinulosa*, consolidation of sediment consisted primarily of upright *Sabellaria* tubes which together covered 80 to 90% of the substratum in those areas. The reef had an elevation of approximately 10 cm above the seabed although some patches of the reef had an elevation of around 25 cm. Subsequent surveys failed to identify the extensive areas of *S. spinulosa* reef previously identified (Limpenny *et al*., 2010), however, the JNCC/Cefas 2013 survey identified Annex I reef to the west of the previously mapped Saturn reef (Jenkins *et al*., 2013; Figure 2.6) highlighting the ephemeral nature of this habitat.

2.11.1.45 High reefiness (as defined by Gubbay, 2007) was, however, infrequently observed in any of the video tows (typically less than 1% of each tow) and, overall, the reef quality in this area was determined as low, although there were a few small patches of medium and high reef quality present (Jenkins *et al.,* 2013). The tow with the most continuous patches of reef was mainly classed as low reefiness. Patch sizes varied between 0.004 km^2 and 1.5 km^2. Although five other areas within the North Norfolk Sandbanks and Saturn Reef SAC (but outside the Hornsea Three offshore cable corridor) were surveyed during the JNCC/Cefas 2013 survey, *S. spinulosa* reef presence was only identified in an area in the centre of the North Norfolk Sandbanks and Saturn Reef SAC (Jenkins *et al*., 2013) and to the south of the Hornsea Three offshore cable corridor. In this area, high reefiness was only observed in a single video tow and, where reef was recorded this was predominantly assigned as low reef and not reef.

2.11.1.46 The previous extent of Saturn reef (BMT Cordah, 2003), in comparison to the more recently collated data (Jenkins *et al*., 2013) highlights the ephemeral nature of this feature, but indicates the favourable conditions for *S. spinulosa* formation within the North Norfolk Sandbanks and Saturn Reef SAC.

2.11.1.47 It is widely acknowledged that *S. spinulosa* reef is a naturally ephemeral habitat and is vulnerable to both natural disturbance (e.g. storms) and anthropogenic activities such as bottom trawling. Therefore, the Hornsea Three site specific survey data showing that the reef recorded by JNCC/Cefas in 2013 is no longer present, is not unusual for this ephemeral reef habitat. It is possible, however, that *S. spinulosa* reefs may form within the Hornsea Three offshore cable corridor, in the intervening time between Hornsea Three characterisation surveys and Hornsea Three pre-construction Annex I reef surveys (Table 2.18). Should Annex I *S. spinulosa* reef be identified in the pre-construction survey within the North Norfolk Sandbanks and Saturn Reef SAC, appropriate measures will be discussed with statutory consultees and the primary objective will be to avoid direct impacts to these Annex I reefs, where possible (see Table 2.18). In order to address uncertainties with regard to the potential for direct impacts on potential future for *S. spinulosa* reefs (i.e. where avoidance is not possible in areas where reef may develop), a precautionary assessment of the effects to potential future Annex I reef has been undertaken. The aims of this assessment are threefold:

- To identify areas where Annex I reef is most likely to occur in the part of the North Norfolk Sandbanks and Saturn Reef SAC coinciding with the Hornsea Three offshore cable corridor, based on historic records of Annex I reef in this area, and to determine the risk of reef being present during the pre-construction survey (noting that *S. spinulosa* reef is ephemeral and was not recorded during the Hornsea Three site specific surveys) - see paragraphs 2.11.1.48 to 2.11.1.53;
- To determine the likelihood of an impact occurring to any potential future reef (should this develop) as a result of export cable installation considering a range of cable installation scenarios (i.e. between zero and six cables installed through potential future reef features; see paragraphs 2.11.1.53 to 2.11.1.59); and
- Based on these precautionary scenarios described in the bullet points above, to describe and assess the effect of cable installation on potential future Annex I *S. spinulosa* reef(s) (see paragraph 2.11.1.68).

2.11.1.48 To determine the risk of Annex I reef being present in the part of the SAC coinciding with the Hornsea Three offshore cable corridor prior to construction, the principles of the core reef approach, which were used to map the distribution of *S. spinulosa* reef in the 2010 and 2014 Wash *S. spinulosa* synthesis (Roberts *et al*., 2016), have been applied. The core reef approach provides a means of predicting areas where reef is most likely to occur (i.e. where conditions are favourable to consistent presence of *S. spinulosa* reef, either continuously or frequently recurring). This approach is currently being incorporated into Natural England's programme to assess the condition of reef within The Wash and North Norfolk Coast SAC and also the Inner Dowsing, Race Bank and North Ridge SAC (Roberts *et al*., 2016).

2.11.1.49 As outlined in Roberts *et al*. (2016), areas of core reef are identified by calculating a Reef Index from the historic data, which consists of a spatial assessment of areas of reef in relation to the survey effort each area has received, as follows:

$$\text{Reef Index} = \frac{\text{Number of times reef found}}{\text{Number of times surveyed}} \times \text{Number of times reef found}$$

2.11.1.50 Jenkins *et al*. (2016) outline that a Reef Index of 1.8 and 2 have both been considered appropriate thresholds for defining core reef (for the Inner Dowsing, Race Bank and North Ridge SCI and The Wash and North Norfolk Coast SAC, respectively). Using this methodology, Reef Index values have been calculated for the area of the Hornsea Three offshore cable corridor coinciding with the North Norfolk Sandbanks and Saturn Reef SAC using all currently available datasets:

- Hornsea Three offshore cable corridor DDV habitat assessment survey in 2017 (see section 2.6.4);
- Dedicated survey of the North Norfolk Sandbanks and Saturn Reef SAC by JNCC and Cefas in 2013 (Jenkins et al., 2015); and
- Original survey of the Saturn Reef in 2003 (BMT Cordah, 2003).

2.11.1.51 The Reef Index values calculated for the area of the Hornsea Three offshore cable corridor coinciding with the North Norfolk Sandbanks and Saturn Reef SAC are presented in Table 2.20 and mapped in Figure 2.9.

Table 2.20: Reef index calculations for areas of potential future Annex I reef in the part of the Hornsea Three offshore cable corridor coinciding with the North Norfolk Sandbanks and Saturn Reef SAC (Figure 2.6). **Reef Index values of ≥2** (purple highlight) are considered as core reef areas.

Potential future Annex I *S. spinulosa* reef area (Figure 2.9)	Number of times surveyed	Number of times reef found	Reef Index	Interpreted risk of Annex I reef occurring in this area prior to construction
Area A [a]	1	1	1	Low
Area B [a]	2	1	0.5	Low
Area C)	1	1	1	Low
Area D	2	2	2	Medium
Area E [a]	1	1	1	Low
Area F [a]	2	1	0.5	Low
Area G [a]	1	1	1	Low
Area H	2	1	0.5	Low
a	Denotes potential future Annex **I** *S. spinulosa* reef area within the Hornsea Three offshore cable corridor.			

2.11.1.52 With the exception of one area, all Reef Index values were <2 which, for the purposes of this assessment, has been interpreted to indicate a low risk of Annex I reef occurring in these areas prior to construction of Hornsea Three. The area identified as having a Reef Index of ≥2 (core reef as per the approach taken for The Wash and North Norfolk Coast SAC (Jenkin *et al*., 2016)) and therefore being considered to have a medium risk of Annex I reef occurring in the future was Area D, the area where Annex I reef was recorded during both the original survey of the Saturn Reef in 2003 (BMT Cordah, 2003) and the JNCC/Cefas survey in 2013 (see Figure 2.9). Although the 2013 survey did not record reef across the entire extent of the original Saturn Reef location, the degree of overlap was considered sufficient to consider this as a single area. It should be noted, however, that this area of core reef (i.e. medium risk) partially coincides with the Hornsea Three offshore cable corridor temporary working area only and, therefore would not be impacted by export cable installation should Annex I reef be recorded in this location during the Hornsea Three pre-construction survey. There is the potential for greater flexibility with the location of activities within the Hornsea Three offshore cable corridor temporary working area than with cable installation (e.g. anchor placements). Therefore, should Annex I reefs be identified within the temporary working corridor, appropriate measures will be discussed with statutory consultees to avoid direct impacts to these features (see Table 2.18).

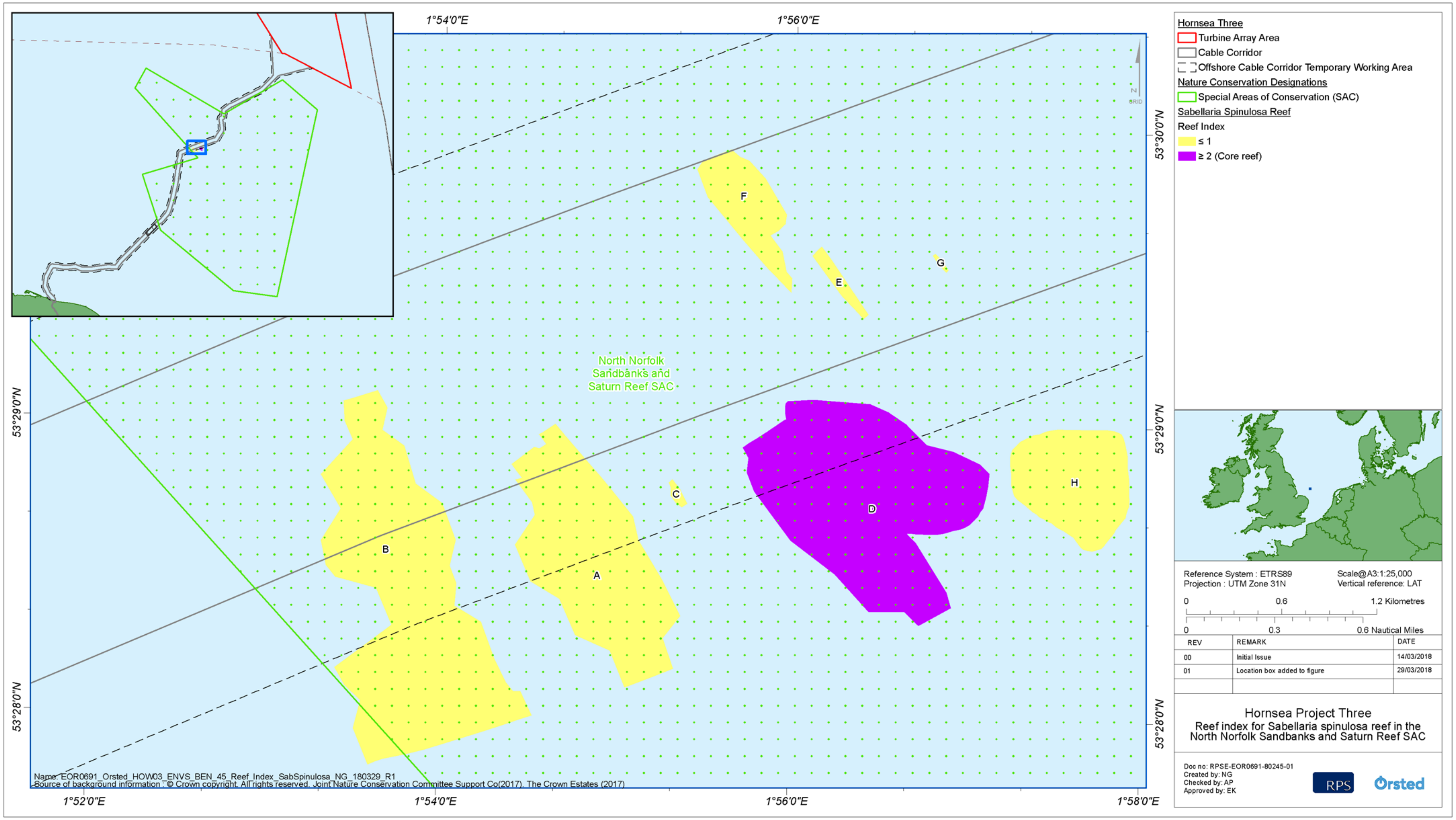

Figure 2.9: Reef Index for *S. spinulosa* reef in the area of the North Norfolk Sandbanks and Saturn Reef SAC coinciding with the Hornsea Three offshore cable corridor using data collected between 2003 and 2017.

2.11.1.53 It is important to note the key limitation associated with the application of this approach to the Hornsea Three assessment, specifically the limited number of datasets available for the area of the North Norfolk Sandbanks and Saturn Reef SAC coinciding with the Hornsea Three offshore cable corridor. In contrast to the three datasets used in this core reef assessment (see paragraph 2.11.1.50), the Wash *S. spinulosa* synthesis, for example, used 16 datasets which had been collected between 1996 and 2012. As more data becomes available (e.g. JNCC reefs layer based on the results of the 2016 joint JNCC/Cefas survey within the Saturn reef (McIlwaine *et al*., 2017) and using Hornsea Three pre-construction survey data), the data layers for the area of the North Norfolk Sandbanks and Saturn Reef SAC coinciding with the Hornsea Three offshore cable corridor will build up and, if necessary, the Reef Index will be recalculated and used to inform cable routing in the North Norfolk Sandbanks and Saturn Reef SAC.

2.11.1.54 To determine the likelihood of an impact occurring to potential future Annex I reef (see paragraph 2.11.1.51) from export cable installation, the risk that 0 to 6 export cables could be installed through each area of potential future Annex I reef has been assessed considering:

- Those areas of potential future reef falling within the Hornsea Three offshore cable corridor (see Table 2.20 and Figure 2.9);
- The minimum spacing distance between export cables (i.e. 20 m between pairs of cables, 100 m or 3x water depth (whichever is greater) between pairs of cables and a 50 m buffer between cables and the Hornsea Three offshore cable corridor boundary; volume 1, chapter 3: Project Description); and
- The proportion/width of the Hornsea Three offshore cable corridor taken up by potential future Annex I reef and those areas where cables could be installed without impacting potential future Annex I reef (Figure 2.9).

2.11.1.55 Although no areas of core reef (i.e. areas identified as having a Reef Index ≥2) were identified within the Hornsea Three offshore cable corridor, a precautionary approach has been adopted to the assessment whereby the assessment has been undertaken for all areas of potential future Annex I reef not qualifying as core reef within the Hornsea Three offshore cable corridor. The assessment is therefore considered to be highly precautionary. Table 2.21 presents the likelihood of each scenario (i.e. 0 to 6 cables installed through each reef feature) in five categories and also presents the magnitude of impact for each of these scenarios. It should be noted that the magnitudes of impact outlined in Table 2.21 have been determined in the absence of mitigation, which is an unrealistic scenario, and the final conclusions for magnitude which take into account the mitigation measures proposed are outlined in paragraph 2.11.1.59. For the purposes of this assessment, Areas E and F have been considered as a single area of potential future reef on the basis of their proximity and the fact that one area of reef could not realistically be avoided without impacting the other. It should be noted, however, that the Reef Index calculations for both of these areas indicate a low risk of Annex I reefs occurring within the Hornsea Three offshore cable corridor in these areas prior to construction (Table 2.20). The areas of potential future Annex I reef falling outside the Hornsea Three offshore cable corridor as shown in Figure 2.9 (i.e. Areas C, D and H) have been excluded from further assessment on the basis that, given the designed in mitigation measures outlined in Table 2.18, they would not be impacted by export cable burial. As shown in Table 2.21, the two areas of potential future Annex I reef most at risk are Areas B and E/F as these have the greatest potential spatial overlap with the Hornsea Three offshore cable corridor (Figure 2.9).

2.11.1.56 Table 2.21 shows that the likelihood of no cables being installed through each of the areas of potential future Annex I reef within the Hornsea Three offshore cable corridor is considered to be high, in which case there would be no impact to areas of potential future Annex I reef from Hornsea Three. This is on the basis that the approach in the first instance will be to avoid Annex I reef where possible. Where this is not possible, further mitigation will be discussed and agreed to minimise effects on reefs. This may include micrositing of cables within the reef feature to ensure direct impacts on areas of lower quality reef only (e.g. avoiding areas of medium and high reefiness) and/or cable installation in the periphery of reef features to ensure continuous reef features are not bisected (see Table 2.18). The results of the Hornsea Three pre-construction Annex I reef surveys will be used to inform such an approach and discussions with the MMO, their advisors and SNCBs.

2.11.1.57 All other assessment scenarios in Table 2.21 are based on the assumption that *S. spinulosa* reefs will return across the areas shown in Figure 2.9, which as discussed in paragraph 2.11.1.51 is a highly conservative assumption. Based on the scenarios considered in Table 2.21, the magnitude of impact ranges from negligible for the 0 cables scenario (high likelihood of this scenario occurring) to moderate for a number of the cable installation scenarios (i.e. six cables in Area B, four to six cables in Area E and F and two cables in Area G). In most scenarios the likelihood for cable installation through reef features is low or very low, based on the proportion of the Hornsea Three offshore cable corridor which was free of potential future Annex I *S. spinulosa* reef and therefore the ability to avoid these features. The exception was for the one to two cable scenario for Area E and F, where there was a high likelihood that up to two cables could be installed within either of these reef features, due to the relatively small distance between these reef features and the boundary of the Hornsea Three offshore cable corridor to the southeast. It should be noted that this high likelihood is based on the assumption that Area E and F are both present in the extents shown in Figure 2.9, which is itself a highly conservative assumption as the risk of each of these reefs occurring in the future was considered to be low (i.e. Area E had a Reef Index of 1, while Area F had a Reef Index of 0.5; see Table 2.20), with Hornsea Three site specific survey data showing that these were not present in 2016/2017. In the absence of one of these reef features (i.e. either Area E or F), the proportion of the total Hornsea Three offshore cable corridor which would be free of potential future Annex I *S. spinulosa* reef would be greater, resulting in a reduction in the likelihood of cable installation in these potential future Annex I reef areas.

2.11.1.58 The maximum design scenario has the potential to result in either the truncation of an area of potential future Annex I *S. spinulosa* reef (i.e. by a cable(s) being installed at the periphery of an area of reef) or in the bisection of an area of potential future Annex I *S. spinulosa* reef resulting in potential increased instability of the resulting smaller areas of reef and the possible loss of integrity of these features. It should be noted however that, even if the primary mitigation of avoiding reefs where possible fails and export cables need to be installed through an area of reef(s), the cables would still be microsited through areas of lower quality reef, avoiding areas of medium or high quality reef (see Table 2.18).

2.11.1.59 The impact of temporary loss/disturbance from cable installation Annex I reef features of the North Norfolk Sandbanks and Saturn Reef SAC is predicted to be localised to discrete sections of the Hornsea Three offshore cable corridor, of medium term duration (i.e. construction phase of up to eight years for the Hornsea Three offshore cable corridor, although export cable installation will only comprise a small proportion of this (up to three years); see Table 2.14), intermittent in nature and reversible. It is predicted that the impact may affect receptors directly with the potential for partial loss of/damage to key characteristics, features or elements of the Annex I reefs. Depending on the cable installation scenario considered, the magnitude of impact may range between negligible and moderate, although the most likely magnitude is considered to be negligible or, at worst, minor for the following reasons:

- The low risk of Annex I reefs occurring within the Hornsea Three offshore cable corridor (Table 2.20);
- The primary mitigation for Annex I reefs is to avoid these entirely, where possible (see Table 2.18);
- The high likelihood that this primary mitigation measure will be effective as the Hornsea Three offshore cable corridor is of sufficient width to allow cables to be microsited around *S. spinulosa* reefs in all but the most unlikely potential future Annex I reef scenarios

Table 2.21: Likelihood of an impact occurring to potential future Annex I *S. spinulosa* reef (should this develop within the Hornsea Three offshore cable corridor) as a result of export cable installation.

Potential future Annex I reef (Figure 2.9)	Extent of reef across Hornsea Three offshore cable corridor (m)	Remaining gap in Hornsea Three offshore cable corridor (m)	Likelihood of number of cables being installed through each potential future Annex I reef area (magnitude of impact in the absence of mitigation in brackets a)							Justification
			0	1	2	3	4	5	6	
Area A (18)	271	1,229	High [b] (Negligible)	None						On the basis that the previously mapped extent of this reef only extends 271 m into the Hornsea Three offshore cable corridor, Hornsea Three are confident that all six export cables could be installed within the remaining 1,229 m so as to avoid this potential future reef area. Therefore, there is no risk of impact to this potential future Annex I reef from export cable installation and this area of potential future Annex I reef has not been considered further in this assessment (negligible magnitude impact).
Area B (19)	878	622	High [b] (Negligible)	Very Low (Minor)	Very Low (Minor)	Very Low (Minor)	Very Low (Minor)	Very Low (Moderate) [a]	Very Low (Moderate) [a]	Based on the minimum cable spacing distance, six export cables would theoretically fit within the gap between the reef edge and the edge of the Hornsea Three offshore cable corridor. There is the possibility, however, that other engineering constraints may mean that this is not feasible and the reef cannot be avoided. The likelihood of any cables being installed in Area B is, therefore, considered to be very low. Installation of two cables within this reef (very low likelihood) would result in a small reduction (i.e. <1%) in the overall extent of the reef as the majority of this reef feature is outside the boundary of the Hornsea Three offshore cable corridor (minor magnitude impact). Up to four cables (very low likelihood) would result in <2% of the reef affected (minor magnitude impact), while up to six cables (very low likelihood) may lead to a reduction of up to 4% of the reef affected. For the six cable scenario, although the individual areas of disturbance associated with each cable are relatively small in the context of the overall extent of this feature, there is greater potential for fragmentation of reef structures which may result in the increased vulnerability of any resulting smaller patches of reef to further natural (e.g. storm events) or anthropogenic (e.g. bottom trawling) disturbance and as such, a moderate magnitude impact is predicted for this scenario. This assessment does not consider the designed-in mitigation measures adopted as part of the project; see paragraph 2.11.1.59 for the final conclusion of magnitude of impact.
Area E (22) and Area F (23)	1,281	219	High [b] (Negligible)	High [c] (Minor)	High [c] (Minor)	Low (Minor)	Low (Moderate) [a]	Very Low (Moderate) [a]	Very Low (Moderate) [a]	Based on the minimum cable spacing distance, four export cables would theoretically fit within the gaps between the reef edge and the edge of the Hornsea Three offshore cable corridor. There is the possibility, however, that other engineering constraints may mean that this is not feasible for all cables and potential future reef cannot be avoided. Therefore the likelihood of up to two cables being installed in this area is considered to be high (noting the low potential for these reefs to return to this exact extent), the likelihood of three to four cables being installed is low, and the likelihood of more than this being installed is deemed to be very low. Should two cables be installed through this reef feature this would result in a small reduction in the overall extent (i.e. up to 1.5 to 3% of the area of this reef), with mitigation to avoid the areas of medium to high "reefiness", should cabling be required in reef habitat (minor magnitude impact). Should four cables be installed, this would result in loss of up to 3 to 5% of the reef feature (moderate magnitude impact), with six cables potentially affecting up to 5 to 8% of the reef feature (moderate magnitude impact). This assessment does not consider the designed-in mitigation measures adopted as part of the project; see paragraph 2.11.1.59 for the final conclusion of magnitude of impact.

Potential future Annex I reef (Figure 2.9)	Extent of reef across Hornsea Three offshore cable corridor (m)	Remaining gap in Hornsea Three offshore cable corridor (m)	Likelihood of number of cables being installed through each potential future Annex I reef area (magnitude of impact in the absence of mitigation in brackets a)							Justification
			0	1	2	3	4	5	6	
Area G (24)	134	1,051 (N) and 314 (S)	High [b] (Negligible)	Very Low (Moderate) [a]	Very Low (Moderate) [a]	None [d]	None [d]	None [d]	None [d]	This small area of potential future Annex I reef is located in the centre of the Hornsea Three offshore cable corridor and extends for only 134 m. Given the large area both to the north and south of this potential future reef within which export cables could be installed it is considered highly unlikely that an export cable would be installed through this feature should Annex I reef be recorded in this area during the Hornsea Three pre-construction survey. Therefore, the likelihood of up to two cables impacting this area of potential future Annex I reef is considered to be very low. Should up to two cables be installed in this reef, it would result in loss of approximately 50% of the extent of this feature (i.e. moderate magnitude impact). This assessment does not consider the designed-in mitigation measures adopted as part of the project; see paragraph 2.11.1.59 for the final conclusion of magnitude of impact.

a The magnitude of impacts presented in this table are in the absence of mitigation measures. The final assessment of magnitude of impact, taking into account the designed-in mitigation measures adopted as part of the project, is presented in paragraph 2.11.1.59.

b The likelihood that no cables are installed through areas of potential future Annex I reef is considered to be high on the basis that the policy in the first instance will be to avoid Annex I reef where possible.

c This high likelihood is based on the assumption that Area E and F are both present in the extents shown in Figure 2.9, a highly conservative assumption due to the low risk of each of these reefs occurring in the future (see Table 2.20). These reefs were not detected at the time of Hornsea Three site specific surveys in 2016/2017.

d This is on the basis that the minimum cable separation requirements would not enable the installation of this number of cables through the potential future Annex I reef feature.

Sensitivity of the receptor

Annex I sandbanks

2.11.1.60 As shown in Figure 2.5, the site specific surveys identified that the sandy sediments of the Hornsea Three offshore cable corridor in the area coinciding with the North Norfolk Sandbanks and Saturn Reef SAC (i.e. the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time'), are predominantly characterised the ApriBatPo, NcirBat and SspiMx biotopes (although it should be noted that *S. spinulosa* reef was not detected in association with the SspiMx biotope). The communities recorded within the SAC during the Hornsea Three site specific surveys were broadly in line with desktop information on this SAC as presented in section 3.1.3 of volume 5, annex 2.1: Benthic Ecology Technical Report.

2.11.1.61 With respect to ApriBatPo and NcirBat, as discussed in paragraphs 2.11.1.24 to 2.11.1.26, these communities are naturally subject to, and tolerant of, high levels of physical disturbance. The predominantly infaunal mobile species are capable of re-burrowing following disturbance (Tillin, 2016b and 2016e) although construction activities that remove sediment (e.g. seabed preparation) are likely to remove animals that are shallowly buried. Although resistance to abrasion/disturbance of the surface is none to low (medium for ApriBatPo; Tillin 2016e), as for example this could collapse burrows and damage species through compression, the resilience of these communities is assessed as high as sediment recovery will be enhanced by wave action and mobility of sand and the characterising species are likely to recover through transport of adults in the water column or migration from adjacent patches. Overall sensitivity to abrasion and disturbance is therefore considered to be low (Tillin, 2016a, 2016b and 2016e; Tillin and Rayment, 2016). The North Norfolk Sandbank is an open shelf ridge sandbank, formed by strong tidal currents, and the Conservation Objectives and Advice on Operations document for the site states that, in response to physical loss, the sandbank could be replenished and recovery relatively rapidly between removal activities and sensitivity to removal and physical damage is assessed as moderate (JNCC, 2012). With regards to the deposition of sandwave clearance material, although the deposition of this material may result in the mortality of characterising amphipods and isopods, and possibly *N. cirrosa*, biotope resistance is assessed as low but resilience is assessed as high. The overall sensitivity is therefore low.

2.11.1.62 With regards to the areas of coarser sediment characterised by the SspiMx biotope, the sensitivity to displacement and abrasion is medium as described in paragraphs 2.11.1.29 to 2.11.1.33. For the impact associated with the deposition of sandwave clearance material, the evidence presented in the MarESA suggests that *S. spinulosa* is sensitive to damage from siltation events but that recovery is likely to be rapid given that larval dispersal is not interrupted and new reefs may be able to establish over old buried ones (Tillin and Marshall, 2015). The overall sensitivity is therefore medium.

2.11.1.63 The biotopes present within the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' are deemed to be of low to medium vulnerability, medium to high recoverability and international value. The sensitivity of the receptor is therefore, considered to be low to medium.

Potential future Annex I S. spinulosa reef

2.11.1.64 The sensitivity of potential future Annex I *S. spinulosa* reef within the North Norfolk Sandbanks and Saturn Reef SAC is as described previously for Habitat E in paragraphs 2.11.1.29 to 2.11.1.31. Although *S. spinulosa* communities are typically intolerant to disturbance and displacement, recoverability is assessed as medium. Larvae of *S. spinulosa* are strongly stimulated to metamorphose by the secretions of their own species, and therefore settle preferentially on sediment used previously by other *S. spinulosa* individuals (Wilson, 1970). Therefore, they may build on the ruins of earlier reefs (e.g. in areas where reefs have been disturbed or removed), and may promote recovery of a reef which had previously deteriorated, providing prevailing environmental conditions are still appropriate (Hendrick and Foster-Smith, 2006). This was demonstrated by monitoring at the Lynn and Inner Dowsing offshore wind farm where *S. spinulosa* was recorded within the jack-up footprints from wind turbine foundation installation (EGS, 2012; see paragraph 2.11.1.32). Similarly, this is reflected in the historic data for the North Norfolk Sandbanks and Saturn Reef SAC which has demonstrated the presence of *S. spinulosa* reef in the same broad area of the SAC over subsequent years (see Area D 'core reef' in Figure 2.9). *S. spinulosa* is commonly found in disturbed environments and has a typically high rate of reproduction (Holt *et al*., 1998). *S. spinulosa* is often one of the first species to settle on newly exposed surfaces (Ospar Commission, 2010). The presence of any remaining *S. spinulosa* adults will also assist in larval settlement of this species (Jackson and Hiscock, 2008). Therefore, there is a high likelihood that even if localised areas of Annex I reef were disturbed during cable installation this would not preclude the recovery of reef in such areas should all other environmental conditions remain favourable for the presence of reef (i.e. assuming successful cable burial and recovery of seabed sediments to the pre-construction baseline).

2.11.1.65 As discussed in paragraph 2.11.1.31, research following aggregate extraction at Hastings Shingle Bank has shown that *S. spinulosa* aggregations can quickly recover from damage or decline. Colonisation and development of a significant *S. spinulosa* aggregation was recorded within 18 months after activity had ceased, and development to a stage equivalent to the oldest aggregations observed in the area was assessed as likely to be complete within three years (Pearce *et al*., 2007).

2.11.1.66 Potential future Annex I *S. spinulosa* reefs are deemed to be of high vulnerability, medium to high recoverability and international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of the effect

Annex I sandbanks

2.11.1.67 Overall, the sensitivity of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC is considered to be low to medium and the magnitude of the impact is deemed to be minor. The effect of temporary habitat loss/disturbance will, therefore, be of **minor** adverse significance, which is not significant in EIA terms. Conclusions on the effects of Hornsea Three on the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

Potential future Annex I S. spinulosa reef

2.11.1.68 Overall, the sensitivity of potential future Annex I *S. spinulosa* reef within the North Norfolk Sandbanks and Saturn Reef SAC is considered to be medium and, as detailed in paragraph 2.11.1.59 the magnitude of impact is considered to be negligible or minor at worst. The effect of temporary habitat loss/disturbance will therefore be of **negligible** to **minor** adverse significance, which is not significant in EIA terms. A significance level of greater than minor adverse is highly unlikely to occur due to the low risk of Annex I reefs extending across a large enough proportion of the Hornsea Three offshore cable corridor as to reduce the effectiveness of the primary mitigation (i.e. avoidance of direct impacts on reef features). Furthermore, in the unlikely event that direct impacts to reef features are unavoidable, further mitigation to minimise any such effects on reef features will ensure any effects are spatially limited and avoid areas of medium to high reefiness to maximise the potential for recovery of *S. spinulosa* into affected areas. Conclusions on the effects of Hornsea Three on the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

The Wash and North Norfolk Coast SAC

<u>Magnitude of impact</u>

2.11.1.69 Of the total predicted temporary habitat loss/disturbance described in paragraph 2.11.1.6, a maximum of 2,356,714 m^2 of this is predicted to affect subtidal habitats within The Wash and North Norfolk Coast SAC (i.e. from pre-construction sandwave clearance (and sandwave material deposition) and boulder clearance and cable installation including anchor placements; see Table 2.22), which represents 0.22% of the total area of The Wash and North Norfolk Coast SAC. For the purposes of this assessment, a precautionary approach has been adopted which assumes that all the subtidal sediment within The Wash and North Norfolk Coast SAC is supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time'. Sandwave clearance material from sandwaves cleared within The Wash and North Norfolk Coast SAC will be deposited within the boundary of The Wash and North Norfolk Coast SAC at a location that considers the net direction of sediment transport in the region to ensure that sediment will not be lost from the sandbank system (see section 1.11.5 in volume 2, chapter 1: Marine Processes).

2.11.1.70 The Wash and North Norfolk Coast SAC is also designated for Annex I reefs (biogenic and geogenic), however, as discussed in paragraphs 2.7.1.15 to 2.7.1.20 and in detail in section 3.1.3 in volume 5, annex 2.1: Benthic Ecology Technical Report, historically, no reefs have been recorded in the area of the Hornsea Three benthic ecology study area that coincides with The Wash and North Norfolk Coast SAC and neither were they recorded during the recent site specific surveys in this area. Should Annex I *S. spinulosa* reef be identified in the pre-construction survey within The Wash and North Norfolk Coast SAC, appropriate measures will be discussed with statutory consultees to avoid direct impacts to these reefs, where possible (see Table 2.18). As such, figures are not presented in this section or Table 2.19 for the temporary loss/disturbance of Annex I reef habitat.

Table 2.22: Temporary habitat loss of Annex I habitat within The Wash and North Norfolk Coast SAC.

Project element	Temporary habitat loss/disturbance (m^2)	Assumptions
Pre-construction sandwave clearance	999,000	Clearance of sandwaves along up to 66.6 km of cable, with up to six cables, each of up to 11.1 km length within The Wash and North Norfolk Coast SAC. Sandwave clearance will affect a corridor of up to 30 m width of seabed (i.e. an additional 15 m width of disturbance on the 15 m associated with cable burial) (66,600 m x 15 m = 999,000 m^2).
Pre-construction sandwave clearance disposal activities	265,474	Up to 265,474 m^2 from placement of coarse, dredged material to a uniform thickness of 0.5 m because of sandwave clearance on the offshore cable corridor, assuming a volume of up to 132,737 m^3 of sandwave clearance material.
Cable burial	999,000	Burial of up to a total of 66.6 km cable length, with up to six cables, each of 11.1 km length within The Wash and North Norfolk Coast SAC. Cable installation will affect a corridor of up to 15 m width of seabed (66,600 m x 15 m = 999,000m^2).
Anchor placements	93,240	Up to seven anchors (each with a footprint of 100 m^2) repositioned every 500 m of the 66.6 km cable length within The Wash and North Norfolk Coast SAC, with up to six export cables (11,100 m x 100 m^2 x 7 x 6 / 500 m = 93,240 m^2).
Total temporary habitat loss/disturbance within The Wash and North Norfolk Coast SAC	2,356,714	-

2.11.1.71 The maximum design scenario for temporary habitat loss/disturbance assumes that pre-construction sandwave clearance would occur along the entire extent of export cables within The Wash and North Norfolk Coast SAC (see Table 2.22). This is, however, a precautionary assumption and there may be discrete areas in which sandwave clearance will not be required but boulder clearance may be required. As discussed in paragraph 2.11.1.15, although this will not contribute to any additional habitat loss, the process will effectively redistribute boulders and cobbles within discrete areas and potentially concentrate these in the areas either side of the 25 m boulder clearance corridor.

2.11.1.72 Therefore, where boulder clearance occurs (i.e. corridors of up to 25 m width within the Hornsea Three offshore cable corridor), this will not represent a significant shift in the baseline situation as any boulders which are present within these areas will be displaced a short distance from their original locations. Since no sediment/substrate is being removed, this will not act as a barrier for the recovery of any epifaunal communities impacted during the process. The mobility of material in the nearshore area is such that under storm conditions, the combined action of currents and waves is expected to remobilise sediments with grain size of up to 100 mm (cobbles) in water depths of up to 8 m and up to 15 mm (pebble gravel) in deeper nearshore areas (up to 14 m). This demonstrates that, over time, there will be a redistribution of the material displaced during boulder clearance and, whilst it is not possible to determine where the sediment will be redistributed to, it is reasonable to assume that some of the material will be moved back in to the areas which were cleared, thus partially restoring to topography of the area.

2.11.1.73 The impact of temporary loss/disturbance within The Wash and North Norfolk Coast SAC is predicted to be localised to discrete sections of the Hornsea Three offshore cable corridor, of medium term (i.e. construction phase of up to eight years for the Hornsea Three offshore cable corridor, although export cable installation will only comprise a small proportion of this (up to three years); see Table 2.14), intermittent in nature and reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.11.1.74 The subtidal biotopes that were mapped within the Hornsea Three offshore cable corridor within The Wash and North Norfolk Coast SAC, as shown in Figure 2.5, were NcirBat at the landward end, merging into MoeVen and then SspiMx extending offshore (although it should be noted that *S. spinulosa* reef was not predicted in association with the SspiMx biotope).

2.11.1.75 The sensitivity of the NcirBat biotope to temporary habitat loss/disturbance is as described in paragraph 2.11.1.61 and is typically low to abrasion, disturbance to the sediment surface and heavy deposition, and medium to habitat extraction (e.g. from sandwave clearance). The sensitivity of the MoeVen biotope communities is as described in paragraph 2.11.1.28 and is considered to be low to abrasion and penetration/disturbance. This is on the basis that jack-up operations, cable burial and anchor placements are likely to damage infauna and epifauna and may damage a proportion of the characterising species although the characterising species are relatively tolerant of penetration and disturbance of the sediments; biotope resistance is therefore assessed as medium (Tillin, 2016c) and in response the disturbance, some species will be displaced and may be predated or injured and killed. Resilience/recoverability is however, assessed as high as opportunistic species are likely to recruit rapidly and some damaged characterising species may recover or recolonise such that the overall sensitivity is low. The biotope is likely to still be classified as MoeVen following disturbance (Tillin, 2016c). With regards to the heavy deposition of material during sandwave clearance disposal activities, small bivalves may be able to migrate through up to 50 cm of sand, although the MarESA highlights that the character of the overburden material is important (Tillin, 2016c). As the material will be deposited within The Wash and North Norfolk Coast SAC and in similar habitats, individuals are more likely to be able to escape from material that is like the material they are commonly found in (Tillin, 2016c). Resistance is assessed as low as few individuals are likely to reposition, resilience is assessed as medium and overall sensitivity is assessed as medium (Tillin, 2016c).

2.11.1.76 The sensitivity of the SspiMx biotope to temporary disturbance is described in paragraph 2.11.1.29 and, overall, is considered to be of medium sensitivity to extraction (e.g. from sandwave clearance) as well as to abrasion and disturbance (e.g. from cable burial and anchor placements). Although this biotope is considered to have none to low intolerance to these pressures, recoverability is likely to be medium, leading to an overall sensitivity of medium (Tillin and Marshall, 2015). As discussed in paragraph 2.11.1.62 for the deposition of material from sandwave clearance activities, this biotope is considered to have no resistance to this impact but recovery will be rapid and recoverability is likely to be medium so that the overall sensitivity to this impact is considered to be medium. Following cable installation, the sediments within the impacted areas are predicted to recover to a condition which will not affect the potential for *S. spinulosa* reef to develop in the future.

2.11.1.77 A post-construction survey at Humber Gateway offshore wind farm examined the effects of export cable and array cable installation on Annex I stony reefs, resulting in corridors of comparatively flat seabed crossing through elevated stony reef features (Precision Marine Survey Ltd (PMSL), 2016). Cable installation in these areas resulted in a reduction in the structural complexity of Annex I stony reefs, particularly along the export cable route, including elevation from the surrounding seabed and coverage of boulders and cobbles within the cable corridors. Outside the areas of Annex I stony reef, the seabed comprised relatively flat seabed with mixed, coarse sediments and post construction monitoring showed considerably less variation in the surface of the seabed or evidence of cable installation (PMSL, 2016). This was supported by DDV sampling in these areas, which showed the presence of pebbles and muddy sandy gravel (i.e. reflecting the pre-construction baseline) in areas where cables had been installed approximately one year previously.

2.11.1.78 It should be noted that the seabed in the nearshore environment off the Holderness coast is different in character to nearshore environment off the North Norfolk coast (i.e. within the Hornsea Three benthic ecology study area). The seabed off the Holderness coast comprises very coarse substrate with a high occurrence of pebbles, cobbles and boulders (including Annex I stony reefs), while the sediments off the North Norfolk coast are largely sandy and mixed in nature, with only patchy distributions of cobbles and boulders, none of which qualified as Annex I stony reef (see paragraph 2.7.1.20 and section 4.1.4 of volume 5, annex 2.1: Benthic Ecology Technical Report 1 for full details). The evidence from post construction monitoring at Humber Gateway offshore wind farm indicates that mixed sediments of sand and gravels would be expected to recover following cable installation, with clear evidence of recovery of sediments to pre-construction baseline conditions approximately one year post-construction (PMSL, 2016).

2.11.1.79 The biotopes present within the supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' are deemed to be of low to medium vulnerability, medium to high recoverability and international value. The sensitivity of the receptor is therefore, considered to be low to medium.

Significance of the effect

2.11.1.80 Overall, the sensitivity of subtidal habitats of The Wash and North Norfolk Coast SAC (i.e. supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time') is considered to be low to medium and the magnitude of the impact is deemed to be minor. The effect of temporary habitat loss/disturbance on benthic habitats within The Wash and North Norfolk Coast SAC will, therefore, be of minor adverse significance, which is not significant in EIA terms.

2.11.1.81 No temporary habitat loss or disturbance to Annex I reef habitat within The Wash and North Norfolk Coast SAC is predicted. Should Annex I reef habitat be identified during pre-construction surveys of the Hornsea Three offshore cable corridor, appropriate measures will be discussed with statutory consultees to avoid direct impacts to these features, where possible (see Table 2.18).

2.11.1.82 Conclusions on the effects of Hornsea Three on the conservation objectives of The Wash and North Norfolk Coast SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

Cromer Shoal Chalk Beds MCZ

Magnitude of impact

2.11.1.83 Of the total predicted temporary habitat loss/disturbance described in paragraph 2.11.1.6, a maximum of 191,200 m^2 of this is predicted to occur within the boundary of the Cromer Shoal Chalk Beds MCZ because of pre-construction activities (e.g. sandwave clearance and associated material deposition), and cable burial and associated anchor placements and jack-ups (see Table 2.23). All the temporary habitat loss/disturbance within the Cromer Shoal Chalk Beds MCZ associated with cable installation will take place only within the broadscale habitat feature Subtidal sand, which equates to approximately 1.04% of the total extent of the Subtidal sand habitat feature within the Cromer Shoal Chalk Beds MCZ (according to the latest estimates of the extent of the broadscale habitats in Defra, 2015). There will be no temporary habitat loss/disturbance to any of the other broadscale habitat features of the Cromer Shoal Chalk Beds MCZ.

2.11.1.84 The maximum design scenario for temporary habitat loss/disturbance assumes that pre-construction sandwave clearance would occur along the entire extent of export cables within Cromer Shoal Chalk Beds MCZ (see Table 2.23). This is, however, a precautionary assumption and there may be discrete areas in which sandwave clearance will not be required but boulder clearance may be required. As discussed in paragraph 2.11.1.71 for The Wash and North Norfolk Coast SAC, although this will not contribute to any additional habitat loss, the process will effectively redistribute boulders and cobbles within discrete areas and potentially concentrate these in the areas either side of the 25 m boulder clearance corridor. As described in paragraph 2.11.1.15 this is considered unlikely to represent a significant shift in the baseline situation and will not act as a barrier for the recovery of epifaunal communities impacted. Furthermore, over time, the action of waves and currents will redistribute the material such that some may be moved back in to the areas which were cleared, thus partially restoring to topography of the area.

2.11.1.85 HDD operations within the Cromer Shoal Chalk Beds MCZ may lead to temporary habitat loss/disturbance of up to 47,381 m^2 of subtidal habitat (i.e. from excavation of up to eight HDD exit pits, disposal of dredged material and up to five jack-up operations per HDD exit pit). This area is not, however, included in the total presented in paragraph 2.11.1.83 and Table 2.23 as an open cut scenario for cable installation leads to a greater total area affected. Jack-up operations (although not included in calculations here) could affect up to approximately 181 m^2 within the Cromer Shoal Chalk Beds MCZ, and as these would occur in sand and gravelly sand sediments recovery of the topography is likely to be as described in paragraph 2.11.1.26. The presence of such indentation features is not predicted to have implications for sediment transport and they will infill over time.

2.11.1.86 As with all designated sites, the material arising from sandwave clearance activities within the Cromer Shoal Chalk Beds MCZ will be deposited within the boundary of the site and at a location that considers the net direction of sediment transport in the region (see section 1.11.5 in volume 2, chapter 1: Marine Processes).

Table 2.23: Temporary habitat loss of the broadscale habitat features of the Cromer Shoal Chalk Beds MCZ.

Project element	Temporary habitat loss/disturbance (m^2)	Assumptions
Pre-construction sandwave clearance	90,000	Clearance of sandwaves along up to 6 km of cable, with up to six cables, each of up to 1 km length within the Cromer Shoal Chalk Beds MCZ. Sandwave clearance will affect a corridor of up to 30 m width of seabed (i.e. an additional 15 m width of disturbance on the 15 m associated with cable burial) (6,000 m x 15 m = 90,000 m^2).
Pre-construction sandwave clearance disposal activities	2,800	Up to 2,800 m^2 from placement of coarse, dredged material to a uniform thickness of 0.5 m as a result of sandwave clearance on the offshore cable corridor, assuming a volume of up to 1,400 m^3 of sandwave clearance material.
Cable burial [a]	90,000	Burial of up to a total of 6 km cable length, with up to six cables, each of 1 km length within the Cromer Shoal Chalk Beds MCZ. Cable installation will affect a corridor of up to 15 m width of seabed (66,000 m x 15 m = 90,000m^2).
Anchor placements	8,400	Up to seven anchors (each with a footprint of 100 m^2) repositioned every 500 m of the 6 km cable length within the Cromer Shoal Chalk Beds MCZ, with up to six export cables (6,000 m x 100 m^2 x 7 / 500 m = 8,400 m^2).
Total temporary habitat loss/disturbance within the Cromer Shoal Chalk Beds SAC.[b]	191,800	-

a Note: the values quoted for temporary disturbance from with cable burial also includes temporary habitat disturbance in the nearshore of up to 4,800 m^2 as a result of the purposeful grounding of the cable installation barge.

b Note: HDD operations within the MCZ, associated with the long HDD option (exit pit located approximately 800 m from MHWS mark), may lead to loss/disturbance of up to 47,381 m^2 of subtidal habitat (i.e. from excavation of up to eight HDD exit pits (up to 900 m^2 per exit pit), disposal of dredged material (up to 5,000 m^2 per exit pit from a maximum excavated volume of 2,500 m^3 per pit) and up to five jack-up operations per HDD exit pit (22.62 m^2 per exit pit)). HDD operations associated with the short HDD option (exit pit located approximately 200 m from MHWS mark), may lead to loss/disturbance of up to 19,781 m^2 of subtidal habitat (i.e. from excavation of up to eight HDD exit pits (up to 450 m^2 per exit pit), disposal of dredged material (up to 2,000 m^2 per exit pit from a maximum excavated volume of 1,000 m^3 per pit) and up to five jack-up operations per HDD exit pit (22.62 m^2 per exit pit)). The area associated with HDD operations is not, however, included in the total presented in this table, as an open cut scenario (presented in the total above) leads to a greater total area affected within the MCZ than the HDD scenario.

2.11.1.87 The impact of temporary loss/disturbance on the broadscale habitat feature Subtidal sand of the Cromer Shoal Chalk Beds MCZ is predicted to be localised to within the Hornsea Three offshore cable corridor, of medium term duration (i.e. construction phase of up to eight years for the Hornsea Three offshore cable corridor, although export cable installation will only comprise a small proportion of this (up to three years); see Table 2.14) and intermittent in nature. It is predicted that the impact will affect the receptors directly resulting in a small change in the baseline condition. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.11.1.88 As shown in Figure 2.5, the baseline characterisation identified that the sandy sediments in the Cromer Shoal Chalk Beds MCZ coinciding with the offshore cable corridor are characterised by the NcirBat biotope. As discussed in paragraphs 2.11.1.24 to 2.11.1.26 and 2.11.1.61, the communities associated with this biotope are adapted to frequent disturbance and their resilience to abrasion, disturbance of the subsurface and heavy smothering (e.g. from the deposition of sandwave clearance material) is considered to be low to medium and recoverability high.

2.11.1.89 The Subtidal sand within the Cromer Shoal Chalk Beds MCZ is deemed to be of low to medium vulnerability, high recoverability and national value. The sensitivity of the receptor is therefore, considered to be low.

Significance of the effect

2.11.1.90 Overall, the sensitivity of the sediment features of the Cromer Shoal Chalk Beds MCZ is considered to be low and the magnitude of the impact is deemed to be minor. The effect of temporary habitat loss/disturbance on the features of Cromer Shoal Chalk Beds MCZ will, therefore, be of minor adverse significance, which is not significant in EIA terms. Discussions on the effects of Hornsea Three on the Cromer Shoal Chalk Beds MCZ are presented in full within volume 5, annex 2.3: MCZ Assessment.

Markham's Triangle rMCZ

Magnitude of impact

2.11.1.91 The maximum temporary habitat loss/disturbance predicted to occur within the boundary of the Markham's Triangle rMCZ assumes that 24% of all array infrastructure could be placed in the part of the Hornsea Three array area which overlaps with the Markham's Triangle rMCZ. This scenario assumes the maximum number of foundations and cables which could possibly be placed within this part of the Hornsea Three array area, based on a minimum spacing of 1 km between offshore structures (i.e. turbines, substations and accommodation platforms), representing the maximum adverse scenario for Markham's Triangle rMCZ (see Table 2.24). Therefore, of the total predicted temporary habitat loss/disturbance described in paragraph 2.11.1.6, a maximum of 5,872,589 m^2 of this is predicted to occur within the Markham's Triangle rMCZ, equating to 2.94% of the total benthic habitat within the site.

2.11.1.92 As is proposed for all designated sites, the material arising from sandwave clearance activities within the Markham's Triangle rMCZ will be deposited within the boundary of the site and at a location that considers the net direction of sediment transport in the region (see section 1.11.5 in volume 2, chapter 1: Marine Processes). As described in paragraph 2.11.1.14, the deposited sediments will be rapidly incorporated into the seabed and local accumulations would be subject to redistribution under the prevailing hydrodynamic conditions.

Table 2.24: Temporary habitat loss of the broadscale habitat features of the Markham's Triangle rMCZ (assuming 24% of all array infrastructure could be placed in the part of the Hornsea Three array which overlaps with the Markham's Triangle rMCZ).

Project element	Temporary habitat loss/disturbance (m²)	Assumptions
Pre-construction sandwave clearance	2,357,400	Assumes maximum of 10% of the total temporary habitat loss from sandwave clearance within the Hornsea Three array (23,574,000 m²) will occur within the Markham's Triangle rMCZ.
Pre-construction sandwave clearance disposal activities	14,926	Habitat loss from placement of coarse dredged material to a uniform thickness of 0.5 m as a result of sandwave clearance within the Markham's Triangle rMCZ, assuming a volume of up to 7,463 m³.
Deposition of material from seabed preparation for GBFs	1,009,150	Assumes maximum of 24% of the total 4,223,330 m² of temporary habitat loss associated with the deposition of material from seabed preparation activities.
Jack-up footprints	310,080	Assumes maximum of 24% of the total 650,760 m² of temporary habitat loss from jack-up placements within the Hornsea Three array area.
Array, interconnector and export (within the Hornsea Three array area) cables (includes boulder clearance)	2,122,759	Assumes maximum of 24% of the total temporary habitat loss associated with the installation of remaining array cables (332 km), interconnector (90 km) and export cables within the array (67.2 km) not requiring sandwave clearance, affecting a corridor up to 15 m for array cables and 25 m for interconnector and export cables.
Anchor placements during cable installation	58,275	Assumes a maximum of 24% of total temporary habitat loss from cable installation vessel anchor placements across the Hornsea three array area.
Total temporary habitat loss within Markham's Triangle rMCZ	5,872,589	-

2.11.1.93 Pre-construction boulder clearance (which is included in the numbers presented for cable burial in Table 2.24 as both have a width of disturbance of 25 m in the Hornsea Three array area) may result in a redistribution of boulders and cobbles within discrete areas and could potentially concentrate these in the areas either side of the cleared corridor. Given the existing patchiness of the distribution of cobbles and boulders in offshore environment (see section 2.7.1) this is considered unlikely to represent a significant shift in the baseline situation and, since no sediment/substrate is being removed, this will not act as a barrier for the recovery of any epifaunal communities impacted during the process.

2.11.1.94 Using the spatial extents of the qualifying habitats (including the broadscale habitat Subtidal mixed sediments which may be proposed for designation) mapped in Defra (2014), the total predicted temporary habitat loss/disturbance to each of the qualifying features of the Markham's Triangle rMCZ is as follows:

- 5,872,589 m² of Subtidal coarse sediments equating to 4.03% of the total extent of this habitat within the Markham's Triangle rMCZ – assuming that, as a maximum design scenario, the temporary habitat loss/disturbance would occur entirely within this broadscale habitat feature of the Markham's Triangle rMCZ;
- 624,016 m² of Subtidal sand sediment equating to 2.37% of the total extent of this habitat within the Markham's Triangle rMCZ – assuming that, as Subtidal sand extends over approximately 10.63% of the area of the Markham's Triangle rMCZ coinciding with the Hornsea Three array area, 10.63% of the maximum temporary habitat loss/disturbance could occur within this habitat; and
- 760,787 m² of Subtidal mixed sediments equating to 2.76% of the total extent of this habitat within the Markham's Triangle rMCZ – assuming that, as Subtidal mixed sediment extends over approximately 12.95% of the area of the Markham's Triangle rMCZ coinciding with the Hornsea Three array area,12.95% of the maximum temporary habitat loss/disturbance could occur within this habitat.

2.11.1.95 The impact of temporary habitat loss/disturbance on qualifying (and proposed qualifying) features of the Markham's Triangle rMCZ (i.e. Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments) is predicted to be localised within the western area of the Markham's Triangle rMCZ, of medium term duration (i.e. construction phase of up to eight years for the Hornsea Three array area, although only a small proportion of the disturbance will occur at any one given time within this time; see Table 2.14) and intermittent in nature. It is predicted that the impact will affect the receptors directly resulting in a small change in the baseline condition. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.11.1.96 As shown in Figure 2.5, the baseline characterisation identified that the coarse sediments in Markham's Triangle rMCZ coinciding with the Hornsea Three array area are characterised predominantly by the PoVen biotope with smaller areas of the MysThyMx biotope in the west and north east of the site. As discussed in paragraph 2.11.1.28, the biological assemblage present in the PoVen biotope is characterised by species that are relatively tolerant of penetration and disturbance of the sediments. Abrasion to the PoVen biotope is likely to damage epifauna and may damage a proportion of the characterising species. Many species are however robust or buried within sediments or are adapted to habitats with frequent disturbance. The resistance of the PoVen biotope to temporary habitat loss/disturbance is therefore assessed as medium. Resilience is assessed as high as most species will recover quickly; opportunistic species are likely to recruit rapidly and some damaged characterising species may recover or recolonise. Biotope sensitivity is assessed as low for abrasion and penetration of the seabed (Tillin, 2016d). With respect to sensitivity to extraction (e.g. such as that associated with seabed preparation and sandwave clearance), this will remove the characterising species and resilience is assessed as medium as some species may require longer than two years to re-establish. The sensitivity of the PoVen biotope to extraction is therefore assessed as medium. For heavy deposition under sand wave clearance material, small bivalves can migrate through up to 50 cm of sand, and as the material will be deposited within similar habitats in the Markham's Triangle rMCZ, individuals are more likely to be able to escape from material that is similar to the material they are commonly found in (Tillin, 2016d). Resistance is assessed as low, resilience is assessed as medium and overall sensitivity is assessed as medium (Tillin, 2016d).

2.11.1.97 With respect to the MysThyMx biotope, some soft-bodied organisms and a proportion of the characterising bivalves are likely to be damaged and removed by abrasion or penetration of the surface. Resistance to abrasion is considered to be medium and to penetration of the surface is considered to be low. Resilience of the biotope is likely to be high and overall the biotope is therefore considered to have low sensitivity to abrasion or disturbance/penetration of the surface of the seabed (De-Bastos and Marshall, 2016). Sensitivity to heavy deposition under sandwave clearance material is also predicted to be low as bivalve and polychaete species have been reported to migrate through depositions of sediment greater that the benchmark outlined in paragraph 2.11.1.4 so resistance is considered to be low as some mortality will occur but recovery is likely to be high. Extraction such as that associated with seabed preparation will remove the characterising biological component of the biotopes so resistance is assessed as none. As resilience is likely to be medium based on sediment and species recovery, sensitivity to extraction (i.e. sandwave clearance) is assessed as medium.

2.11.1.98 The qualifying features of Markham's Triangle rMCZ are deemed to be of low to medium vulnerability, medium to high recoverability and national value. The sensitivity of the receptor is therefore, considered to be low to medium.

Significance of the effect

2.11.1.99 Overall, the sensitivity of features of the Markham's Triangle rMCZ is considered to be low to medium and the magnitude of the impact is deemed to be minor. The effect of temporary habitat loss on the features of Markham's Triangle rMCZ will, therefore, be of **minor** adverse significance, which is not significant in EIA terms. This has been concluded on the basis that although a relatively large total proportion of the rMCZ proposed features may be affected (e.g. up to 4.03% of the Subtidal coarse sediment feature) the area impacted at any one time would only be a small proportion of this. Furthermore, all impacts are fully reversible and recovery of the associated biotope is predicted to occur from surrounding areas on the basis that these sediments and habitats are extensively distributed in the wider area. Discussions on the effects of Hornsea Three on the Markham's Triangle rMCZ are presented in full within volume 5, annex 2.3: MCZ Assessment.

Temporary increases in suspended sediment concentrations and associated sediment deposition from cable and foundation installation and seabed preparation during the construction phase may affect benthic ecology

2.11.1.100 As detailed in Table 2.14 above, increases in SSC and associated sediment deposition are predicted to occur during the construction phase as a result of pre-construction sandwave clearance activities, cable installation and foundation installation (including seabed preparation). Volume 2, chapter 1: Marine Processes and volume 5, annex 1.1: Marine Processes Technical Report provide a full description of the physical assessment, including the numerical modelling used to inform the predictions made with respect to increases in SSC and subsequent sediment deposition, with a summary of maximum design scenarios associated with this impact, as detailed in Table 2.14, provided in this section.

2.11.1.101 This assessment is considered equivalent to the following pressures identified by the ICGC pressures list under the overarching pressure theme 'Physical damage (reversible change)':

- Changes in suspended solids (water clarity); and
- Smothering and siltation rate changes (depth of vertical sediment overburden).

2.11.1.102 The benchmarks for the relevant MarESA pressures which have been used to inform for this impact assessment are follows:

- Changes in suspended solids (water clarity): the benchmark for which is a change in one rank on the WFD scale e.g. from clear to intermediate for one year, caused by activities disturbing sediment and/or organic particulate matter and mobilising it into the water column such as dredging, disposal at sea, cable and pipeline burial. This pressure is analogous to the impacts associated with the passive phase of a plume of increased SSC comprising finer sediments mobilised by drilling, seabed preparation, cable burial and sandwave clearance; and
- Smothering and siltation rate changes (depth of vertical sediment overburden): the benchmark for light deposition is up to 5 cm of fine material added to the habitat in a single discrete event. This pressure is considered to be analogous to impacts associated with the passive phase of a plume of increased SSC comprising finer sediments mobilised by drilling, seabed preparation, cable burial and sandwave clearance.

2.11.1.103 Values of suspended sediment in the southern North Sea in the summer are generally low in offshore areas with typical concentrations of 1 to 10 mg/l. During the winter, background levels in the southern North Sea can reach up to 35 mg/l (Dolphin *et al*., 2011). For both summer and winter months, SSC generally increase with greater proximity to the coast (Dolphin *et al*., 2011; see volume 2, chapter 1: Marine Processes). Background SSC recorded within the Hornsea Three array were typically found to be in the range 10 to 30 mg/l, although SSC in shallow, nearshore areas exposed to larger waves may be in the order of 100's to 1,000's mg/l during storm conditions (see volume 2, chapter 1: Marine Processes), demonstrating the natural variability in SSC values in this part of the southern North Sea.

Magnitude of impact

2.11.1.104 As detailed in Table 2.14, sandwave clearance is expected to be required prior to construction at discrete locations both within the Hornsea Three array area and along the Hornsea Three offshore cable corridor. As described in paragraph 2.11.1.3, deposition of coarse, granular sediments from sandwave clearance is considered temporary habitat loss for the purposes of this assessment. Increases in SSC and subsequent deposition is therefore related to the passive phase of the plume comprised of finer sediments which are likely to stay in suspension and will therefore affect a larger area. Volume 2, chapter 1: Marine Processes predicted that impacts related to increases in SSC were likely to be like those for seabed preparation for GBF installation (see paragraph 2.11.1.106), with elevated SSCs near sandwave clearance activities and lower levels, reflective of natural baseline conditions, at greater distances. It was predicted that increases in depth averaged SSC of 5-10 mg/l would extend less than 13 km upstream and downstream of the source where a trailing suction hopper dredger was used for sandwave clearance and SSC of 5-10 mg/l would extend less than 17.5 km from the source where a mass excavator tool was used (chapter 1: Marine Processes).

2.11.1.105 Table 2.14 presents the maximum design scenario associated with increases in SSC and deposition associated with drilling operations for monopile foundation installation. The Marine Processes assessment (volume 2, chapter 1) concluded that SSC during this activity will be increased by tens to hundreds of thousands of mg/l at the point of sediment release (i.e. near the water surface). Further afield SSC increases of low tens of mg/l will be present in a narrow plume, tens to a few hundreds of metres wide and between 3.5 and 7 km length, aligned with the tidal stream downstream from the source. Outside this area, SSC of less than 10 mg/l may occur due to ongoing dispersion and dilution of fine material. Fine sediment concentrations may persist in suspension for hours to days or longer, but will become diluted to concentrations indistinguishable from the background levels (<5 mg/l) within around one day. Deposition of coarse grained and sandy deposits from drilling of a single monopile foundation will result in sediment accumulation of tens of centimetres to metres and for the purposes of this impact assessment this would be considered habitat loss and is therefore assessed in paragraph 2.11.1.3 *et seq*. Fine grained material from drilling operations will be dispersed widely within the surrounding region and will not settle with a measurable thickness.

2.11.1.106 Table 2.14 presents the maximum design scenario associated with increases in SSC and deposition associated with seabed preparation for installation of GBF. As detailed in Table 2.14, this impact assessment considers increases in SSC and deposition as a result of foundation installation using drilling and seabed preparation as these foundation installation methodologies result in releases of different materials (i.e. drilling operations result in release of relatively larger volumes of fine sediment at low rates, while seabed preparation releases relatively small volumes of coarser material at relatively higher rates). As described in paragraph 2.11.1.3, deposition of coarse, granular sediments from seabed preparation activities is considered temporary habitat loss for the purposes of this assessment. Increases in SSC and subsequent deposition is therefore related to the passive phase of the plume comprised of finer sediments which are likely to stay in suspension and therefore will affect a larger area. Volume 2, chapter 1: Marine Processes predicted that sand sized material could remain in suspension for up to approximately 15 minutes and therefore may be transported up to approximately 0.5 km, with increases in SSC in excess of natural ranges over a short timescale. Finer sediment fractions would remain in suspension for a longer period, affecting a larger area for a longer period, in the order of hours to days. Elevations in SSC above background levels at distances of hundreds of metres to a few kilometres are predicted to be relatively low (i.e. less than ~20 mg/l) and within the range of natural variability and after 24 hours, elevations in SSC are predicted to typically be less than 5 mg/l.

2.11.1.107 The maximum design scenario for increases in SSC associated with array, interconnector and export cable installation are predicted to occur because of installation by mass flow excavator (see Table 2.14 and volume 2, chapter 1: Marine Processes for full details). Disturbance of medium to coarse sand and gravels during cable installation is likely to result in a temporally and spatially limited plume affecting SSC levels (and settling out of suspension) near the point of release. SSC will be locally elevated within the plume close to active cable burial up to tens or hundreds of thousands of mg/l, although the change will only be present for a very short time locally (i.e. seconds to tens of seconds) before the material resettles to the seabed. Depending on the height to which the material is ejected and the current speed at the time of release, changes in SSC and deposition will be spatially limited to within metres downstream of the cable for gravels and within tens of metres for sands. Finer material will be advected away from the release location by the prevailing tidal current. High initial concentrations (similar to sands and gravels) are to be expected but will be subject to rapid dispersion, both laterally and vertically, to near-background levels (tens of mg/l) within hundreds to a few thousands of metres of the point of release. Only a small proportion of the material disturbed is expected to be fines, with a corresponding reduction in the expected levels of SSC.

2.11.1.108 Irrespective of sediment type, the volumes of sediment being displaced and deposited locally are relatively limited (up to 6 m^3 per metre of cable burial) which also limits the combinations of sediment deposition thickness and extent that might realistically occur. The assessment presented in volume 2, chapter 1: Marine Processes suggests that the extent and so the area of deposition will normally be much smaller for sands and gravels, leading to a greater average thickness of deposition in the order of tens of centimetres to a few metres in the immediate vicinity of the cable trench. Fine material, by contrast, will be distributed much more widely, becoming so dispersed that it is unlikely to settle in measurable thickness locally.

2.11.1.109 The installation of cables in nearshore areas of the Hornsea Three offshore cable corridor may occur in areas of seabed where chalk is present at or very close to the surface. In summary, cable burial into chalk will locally give rise to elevated SSC of up to hundreds of thousands of mg/l for several seconds at locations immediately adjacent (i.e. within a few tens of metres) to the cable trench. Any fine chalk arisings may persist in suspension for longer than sand sized materials (order of days) but the plume of increased SSC will be subject to significant dispersion in that time, reducing any change to SSC to tens of mg/l or less in the same timeframe. Because of dispersion, no measurable thickness of accumulation of fine sediment is expected. Further details are provided within volume 5, annex 1.1: Marine Processes Technical Annex and volume 2, chapter 1: Marine Processes.

2.11.1.110 The impact to subtidal benthic receptors from pre-construction sandwave clearance, drilling and seabed preparation for foundation installation and cable installation is predicted to be of regional spatial extent (i.e. within kilometres of Hornsea Three), of medium term (i.e. construction phase of up to eight years for the Hornsea Three array area and up to eight years for the Hornsea Three offshore cable corridor, although at any one time only a small proportion of activities resulting in this impact will occur; see Table 2.14) of intermittent duration, and reversible to baseline conditions following cessation of activities. It is predicted that the impact will affect benthic receptors indirectly. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.11.1.111 Habitats A and B have very low to almost no sensitivity to increased SSC and smothering because of deposition. These conditions are a natural feature of the environment in which these habitats occur and as most of the characterising species are burrowing infaunal polychaetes these species are unlikely to be affected by smothering (De-Bastos and Hill, 2016b; Tillin and Rayment, 2016; Tillin, 2016a). Although high levels of SSC (i.e. over 100 mg/l over one month) may potentially clog the gill filaments of active suspension and filter feeders (Nicholls *et al.,* 2003) such as venerid bivalves, these species are likely to be able to clear these structures with limited effects of mortality on most of the associated species (De-Bastos and Hill, 2016b; Tillin and Rayment, 2016). The increase in SSC may actually increase the food supply for some deposit feeders in these habitats (De-Bastos and Hill, 2016b; Tillin and Rayment, 2016). In comparison, smothering of characteristic species such as venerid bivalves would temporarily halt feeding. However, as these and the associated polychaetes and amphipods are active burrowers this is unlikely to result in any change to overall species richness, as relocation of these species to their preferred depth would be expected (De-Bastos and Hill, 2016b; Tillin and Rayment, 2016; Tillin, 2016a). When SSC return to normal, background concentrations, feeding and respiration should quickly return to normal and as such the recovery of these habitats is expected to be very high to immediate, and overall species richness is likely to be unaffected.

2.11.1.112 Habitats C and D are considered to have medium resilience to and high recoverability from, increased SSC and sediment deposition. The response of characterising species including burrowing infaunal polychaetes and venerid bivalves, are the same as described above in paragraph 2.11.1.111 for sandy sediment communities. Species in these habitats are likely able to relocate to their preferred depth with only minor energetic cost following smothering (Tillin, 2016d; Tillin, 2016f). Larger and more mobile epifauna such as crabs, fish, shrimps and prawns are expected to be able to avoid adverse SSC and areas of deposition. Colonial epifaunal species such the bryozoan *F. foliacea*, where present in these habitats are considered to be tolerant of such impacts due to their tough and flexible form and also because these conditions are typical of the sand scoured environments where these species are usually found (Tyler-Walters and Ballerstedt, 2007). These species are also characteristic of strong to moderate tidal streams and as such deposition would be unlikely to affect these species for long. The soft coral *Alcyonium digitatum* has also been shown to be able to shed settled particles with large amounts of mucous (Hill *et al.,* 1997).

2.11.1.113 Habitat E, *S. spinulosa* reef outside SACs/SCIs, is tolerant of increased SSC and is not considered sensitive to the MarESA smothering benchmark, which is an overburden of 5 cm in a discrete event (Tillin and Marshall, 2015). Experimental evidence relating to the burial tolerance of *S. spinulosa* has demonstrated that short term (i.e. <32 days) burial to depths of up to 7 cm has no effect on survival (Last *et al.,* 2011). Therefore the limited amount of sediment deposition by fine sediment predicted to result from cable installation, including sandwave clearance, as outlined in paragraphs 2.11.1.104 and 2.11.1.107 to 2.11.1.108, is likely to be well within the tolerance of *S. spinulosa*. Recoverability from smothering is considered to be high (Tillin and Marshall, 2015). Pearce *et al.* (2007) found that *S. spinulosa* was present around the periphery of the Hastings Shingle Bank dredge site where sediments were being moved in all directions. This provides supporting evidence that suspended sediments released during dredging, which have been reported at other aggregate extraction sites in the English Channel at levels up to 5.5 g/l within 100 m of the dredger (Hitchcock and Bell, 2004), is not damaging to *S. spinulosa* aggregations, and could in fact enhance them as the worms rely on suspended sediments as a source of both food and building material (Pearce *et al*., 2007).

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

2.11.1.115 The benthic ecology VERs Habitats A to E and ocean quahog *A. islandica* are deemed to be of low vulnerability, high to immediate recoverability and of regional to national importance. The sensitivity of these receptors is therefore, considered to be low.

Significance of the effect

2.11.1.116 Overall, the sensitivity of the benthic VERs Habitats A to E and the ocean quahog *A. islandica* is low and the magnitude of the impact is deemed to be minor. The effects of increases in SSC and associated sediment deposition on these benthic VERs will, therefore, be of minor adverse significance, which is not significant in EIA terms.

North Norfolk Sandbanks and Saturn Reef SAC

Magnitude of impact

2.11.1.117 The construction activities most likely to result in effects on Annex I 'Sandbanks which are slightly covered by seawater all the time' and Annex I reef habitats within the North Norfolk Sandbanks and Saturn Reef SAC from increased SSC and smothering are pre-construction sandwave clearance and export cable installation, as described in paragraphs 2.11.1.104 and 2.11.1.107 to 2.11.1.108. The impact on these habitats is predicted to be of limited spatial extent, medium term duration (i.e. export cables installed over up to three years; Table 2.14), intermittent and reversible. It is predicted that that impact will affect the receptor indirectly. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.11.1.118 Communities associated with 'Sandbanks which are slightly covered by seawater all the time' have low to no sensitivity to increased SSC and smothering because of deposition (Tillin, 2016b). As discussed in paragraph 2.11.1.111 these conditions are a natural feature of the environment in which these habitats occur. The sandy communities recorded in the Hornsea Three offshore cable corridor comprised biotopes that represent communities comprising low infaunal and epifaunal diversity, namely the NcirBat and ApriBatPo biotopes (see Figure 2.5 and volume 5, annex 2.1: Benthic Ecology Technical Report), in addition, the biotope IMoSa has also been recorded at the sandbanks (Jenkins *et al*., 2015). The sandy communities associated with the sandbanks in this designated site are typically sparse and dominated by *Bathyporeia* spp. and *Nephtys cirrosa* (Jenkins *et al*., 2015). These taxa are considered to have a low sensitivity to increased SSC; the main impact being on the decreased light levels to diatoms which are a major food source of *Bathyporeia* spp. (Tillin, 2016b). Sandbank communities are not considered sensitive to light deposition (up to 5 cm of deposition in a single event) as the infauna are likely to be able to burrow through 5 cm of deposited sediment (Tillin, 2016b). The biotope ApriBatPo is determined to have a low sensitivity to both increased SSC and light deposition (Tillin, 2016e), increased SSC could reduce the availability of phytoplankton to the filter-feeding organisms, though the food supply would be quickly replenished from sources outside the ZoI of the impact, therefore moderating such effects (Tillin, 2016e). Light deposition would generally have limited effects on burrowing bivalves and polychaetes, though species adapted to sandy sediments may not be so effective at moving through finer, more cohesive sediments (Tillin, 2016e).

2.11.1.119 As discussed in paragraph 2.11.1.113, *S. spinulosa* is tolerant of increased SSC (Tillin and Marshall, 2015) and a limited amount of sediment deposition by fine sediment is likely to be well within the tolerance of *S. spinulosa*. As such, Annex I *S. spinulosa* reefs are not considered to be sensitive to increases in SSC.

2.11.1.120 'Sandbanks which are slightly covered by seawater all the time' and *S. spinulosa* reefs are considered to be of low vulnerability, high to immediate recoverability and of international importance. The sensitivity of these receptors is therefore, considered to be low.

Significance of the effect

2.11.1.121 Overall, the sensitivity of the 'Sandbanks which are slightly covered by seawater all the time' and Annex I *S. spinulosa reefs* within the North Norfolk Sandbanks and Saturn Reef SAC is considered to be low and the magnitude of the impact is deemed to be minor. The effect of increases in SSC and associated sediment deposition will, therefore, be of minor adverse significance, which is not significant in EIA terms. Conclusions on the effects of Hornsea Three on the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

The Wash and North Norfolk Coast SAC

Magnitude of impact

2.11.1.122 Impacts to supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' in The Wash and North Norfolk Coast SAC from increased SSC and smothering are predicted to arise from export cable installation and associated sandwave clearance only, as described in paragraphs 2.11.1.104 and 2.11.1.107 to 2.11.1.108. The magnitude of the impact on these habitats will be of limited spatial extent, medium term duration (i.e. export cables installed over a period of up to three years; Table 2.14), intermittent and reversible. It is predicted that that impact will affect the receptor indirectly. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.11.1.123 As discussed in paragraphs 2.7.1.15 to 2.7.1.20, no Annex I reef habitat has been recorded along the Hornsea Three offshore cable corridor coinciding with The Wash and North Norfolk Coast SAC. The subtidal biotopes that were recorded within the Hornsea Three offshore cable corridor coinciding with The Wash and North Norfolk Coast SAC, as shown in Figure 2.8, were NcirBat at the landward end, merging into MoeVen and then SspiMx extending offshore. The NcirBat biotope is not sensitive to smothering and has a low sensitivity to SSC, as described in paragraph 2.11.1.111 (Tillin, 2016b). Similarly, the sensitivity of the MoeVen biotope communities to increased SSC is low (Tillin, 2016c). The increase in SSC would inhibit light penetration to the water column and limit availability of phytoplankton as a food source to filter-feeding organisms, however such an impact would be limited in extent and phytoplankton would be expected to be brought into the area from outside the area of impact. An increase in SSC would be expected to be detrimental to feeding and respiration of venerid bivalves, which are active suspension feeders. The infaunal polychaetes characteristic of the MoeVen biotope would not be expected to be directly affected by increases in SSC (Tillin 2016c). MoeVen has low sensitivity to smothering; the bivalves *Donax* spp. and *Tellina* spp. have been found to return to the surface and overlying waters through 20 to 50 cm of deposited sand, respectively, while *Nephtys hombergii* can migrate up to 40 cm of overburden. Also, this biotope occurs in high energy conditions which are likely to quickly remove some of the lighter sediments of any deposited material (Tillin, 2016c).

2.11.1.124 As discussed in paragraph 2.11.1.113, *S. spinulosa* is tolerant of increased SSC (Tillin and Marshall, 2015) and a limited amount of sediment deposition by fine sediment is likely to be well within the tolerance of *S. spinulosa*. As such, Annex I *S. spinulosa* is not considered to be sensitive to increases in SSC.

2.11.1.125 Supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' and *S. spinulosa* reefs are deemed to be of low vulnerability, high to immediate recoverability and of international importance. The sensitivity of these receptors is therefore, considered to be low.

Significance of the effect

2.11.1.126 Overall, the sensitivity of supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' and Annex I *S. spinulosa reefs* within The Wash and North Norfolk Coast SAC is considered to be low and the magnitude if the impact is deemed to be minor. The effect of increases in SSC and associated sediment deposition will, therefore, be of minor adverse significance, which is not significant in EIA terms. Conclusions on the effects of Hornsea Three on the conservation objectives of The Wash and North Norfolk Coast SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

Cromer Shoal Chalk Beds MCZ

Magnitude of impact

2.11.1.127 Impacts to broadscale habitat features of the Cromer Shoal Chalk Beds MCZ from increased SSC and smothering are predicted to arise as a result of export cable installation and associated sandwave clearance only. As outlined in paragraphs 2.11.1.104 to 2.11.1.109, effects of sediment deposition (i.e. of coarse sediments) are likely to be limited primarily to the immediate vicinity of the cable trench, with fine material distributed much more widely and becoming so dispersed that it is unlikely to settle in measurable thickness locally. Furthermore, any effects of individual cable installation operations will be short term (i.e. hours; paragraphs 2.11.1.106 to 2.11.1.109) and intermittent, with SSC returning to baseline levels quickly following cable installation. The impact on subtidal coarse sediments, subtidal sand and subtidal mixed sediments is predicted to be of limited spatial extent, medium term duration (i.e. export cables installed over a period of up to three years; Table 2.14), intermittent and reversible. It is predicted that that impact will affect the receptor indirectly. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.11.1.128 The only subtidal biotope recorded within the Hornsea Three offshore cable corridor in the Cromer Shoal Chalk Beds MCZ, as shown in Figure 2.5 was NcirBat. The NcirBat biotope is not sensitive to smothering and has a low sensitivity to SSC, as described in paragraph 2.11.1.111 (Tillin, 2016b). Subtidal sand is a protected feature of the Cromer Shoal Chalk Beds MCZ, NcirBat was the only sandy sediment biotope recorded within the designated area.

2.11.1.129 Subtidal coarse sediments and subtidal mixed sediments are both protected features of the Cromer Shoal Chalk Beds MCZ. The coarse sediments were found to solely comprise the MoeVen biotope; the sensitivity of the MoeVen biotope communities to both smothering and increased SSC is low, as described in paragraph 2.11.1.112 (Tillin, 2016c). The mixed sediments in the Cromer Shoal Chalk Beds MCZ were characterised by the PoVen and SspiMx biotopes. PoVen was recorded approximately 3 km from the Hornsea Three offshore cable corridor at the closest distance, while the SspiMx biotope in the Cromer Shoal Chalk Beds MCZ was approximately 2 km from the Hornsea Three offshore cable corridor. PoVen is considered to have a low sensitivity to increased SSC and is predicted to be tolerant of short-term increases caused by storms and other sediment mobilising events. The characterising taxa likely to be most susceptible to the effects are venerid bivalves, as, being suspension feeders that trap food particles on their gill filaments, their ability to feed and respire are reduced in waters with higher SSC (Tillin, 2016d) which subsequently affect growth and fecundity. The dog cockle *Glycymeris* is sensitive to increased SSC as its simple palps cannot tolerate fine inorganic particles. The characterising polychaete species including *Glycera* spp. and *Lumbrineris latreilli* are not considered to be sensitive to increased SCC. The biological assemblage of PoVen is considered to have a low sensitivity to smothering by deposition of fine sediments. Similar to the MoeVen biotope the bivalves *Donax* spp. and *Tellina* spp. have been found to return to the surface and overlying waters through 20 to 50 cm of deposited sand, respectively, while *N. hombergii* can migrate up to 40 cm of overburden. The characterising bivalve *Tellina pygmaea* is sensitive to fluctuations in deposition however they have been found to rebound quickly, with substantial increases in in populations having been recorded after a major change in sedimentation. Polychaetes such as *Glycera* spp. and *Lumbrineris latreilli* are less sensitive to smothering however their recovery rates after sedimentation events are lower in comparison (Tillin, 2016d).

2.11.1.130 As described in paragraph 2.11.1.113, *S. spinulosa* is tolerant of increased SSC (Tillin and Marshall, 2015) and a limited amount of sediment deposition by fine sediment is likely to be well within the tolerance of *S. spinulosa*. As such, *S. spinulosa* is not considered to be sensitive to increases in SSC.

2.11.1.131 Communities associated with subtidal chalk reefs and peat and clay exposures, which are protected features of the Cromer Shoal Chalk Beds MCZ, 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 SSC are highest (see chapter 1: Marine Processes). Sensitivity of many animals associated with soft rock habitats to sediment deposition would also be expected to be limited due to the resilience of some characterising species (De-Bastos and Hill, 2016c) and the natural sediment mobility in these areas. Piddocks are known to burrow into soft rock and clay substrates and these have been recorded at clay exposures in the Cromer Shoal Chalk Beds MCZ as part of a FluHyd/Pid biotope mosaic, they may also characterise communities associated with subtidal chalk reefs in the MCZ and (see volume 5, annex 2.1: Benthic Ecology Technical Report). Piddocks have increased sensitivity to sediment deposition as they are essentially sedentary and the short length of their siphons makes them vulnerable to smothering (Tillin and Hill, 2016). However, these species are tolerant to some degree of overburden (i.e. a few centimetres) with observations of siphons protruding through sediments and some species surviving smothering after periods of rough weather. However, where smothering occurs over a longer period, mortality could occur (Tillin and Hill, 2016).

2.11.1.132 Chalk communities can also be dominated by dense tube mats of the burrowing polychaete *Polydora* sp., which can occur in densities such that other epifaunal species are largely excluded (the biotope CR.MCR.SfR.Pol: '*Polydora* sp. tubes on moderately exposed sublittoral soft rock'). These worms generally occur in highly turbid areas and so are not deemed to have a low sensitivity to increased SSC (De-Bastos and Hill, 2016c). Studies have found *Polydora ciliata* to be a pioneering coloniser of newly deposited sediments, though this species is expected to tolerate an overburden of 5 cm and it is possible the worms may have migrated up through the sediment from the old sediment surface (De-Bastos and Hill, 2016c). Therefore, the biotope is considered not sensitive to smothering.

2.11.1.133 The Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediment features of the Cromer Shoal Chalk Beds MCZ are deemed to be of low vulnerability, high to immediate recoverability and regional to national importance. The sensitivity of these receptors is therefore, considered to be low.

2.11.1.134 The subtidal chalk reef habitat and peat and clay exposures habitat of the Cromer Shoal Chalk Beds MCZ are deemed to be of low to medium vulnerability, medium to high recoverability and national importance. The sensitivity of these receptors is therefore, considered to be medium.

<u>Significance of the effect</u>

2.11.1.135 Overall, the sensitivity of the Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments is low and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms.

2.11.1.136 Overall, the sensitivity of the subtidal chalk reef and peat and clay exposures is medium and the magnitude of the impact is deemed to be minor. The effect of increases in SSC and associated sediment deposition will, therefore, be of **minor** adverse significance, which is not significant in EIA terms. Discussions on the effects of Hornsea Three on the Cromer Shoal Chalk Beds MCZ are presented in volume 5, annex 2.3: Marine Conservation Zone Assessment.

Markham's Triangle rMCZ

Magnitude of impact

2.11.1.137 Impacts to broadscale habitat features of Markham's Triangle rMCZ from increased SSC and smothering are predicted to arise as a result of drilling operations for monopile foundation installation, seabed preparation for installation of GBF, cable installation and associated sandwave clearance activities, as described in paragraphs 2.11.1.104 and 2.11.1.107 to 2.11.1.108. The impact on the broadscale habitat features (i.e. Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments) is predicted to be of limited spatial extent, medium term duration (i.e. foundation installation over up to 2.5 years and array cable installation over a period of up to 2.5 years; Table 2.14), intermittent and reversible. It is predicted that that impact will affect the receptor indirectly. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.11.1.138 The section of the Markham's Triangle rMCZ that coincides with the Hornsea Three array area is characterised predominantly by the PoVen biotope with smaller areas of the MysThyMx biotope in the west and north east of the site. As discussed in paragraph 2.11.1.129, the PoVen community is considered to have a low sensitivity to increased SSC and a low sensitivity to smothering by deposition of fine sediments (Tillin 2016d).

2.11.1.139 Studies on some of the characterising species of the MysThyMx biotope have determined that this biotope is not sensitive to increased SSC or deposition (De-Bastos and Marshall, 2016a). *Kurtiella bidentata* is likely to be highly tolerant to increases in SCC as this animal typically inhabits estuarine environments where turbidity is naturally very high. Both *K. bidentata* and *Thyasira flexuosa* are likely to be able to burrow through deposited material, with the latter being able to build channels to the sediment surface. *Thyasira*, which lives within the sediment can suspension feed but it is not particularly reliant on access to the water column as it mostly derives energy from a symbiotic relationship with chemosynthetic bacteria, therefore it is not considered sensitive to increased SSC or sedimentation (De-Bastos and Marshall, 2016a).

2.11.1.140 The subtidal coarse sediments, subtidal sand and subtidal mixed sediments are considered to be of low vulnerability, high to immediate recoverability and of regional to national importance. The sensitivity of these receptors is therefore, considered to be low.

Significance of the effect

2.11.1.141 Overall, the sensitivity of the broadscale habitats within the Markham's Triangle rMCZ is considered to be low and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms. Discussions on the effects of Hornsea Three on the Markham's Triangle rMCZ are presented in volume 5, annex 2.3: Marine Conservation Zone Assessment.

Accidental release of pollutants (e.g. from accidental spillage/leakage) may affect benthic ecology

2.11.1.142 This assessment is considered equivalent to the following pressures identified by the ICGC pressures list under the overarching pressure theme 'Pollution and other chemical changes':

- Transition elements and organo-metal (e.g. tributyltin (TBT)) contamination (Including priority substances listed in Annex II of Directive 2008/105/EC);
- Hydrocarbon and PAH contamination (Including priority substances listed in Annex II of Directive 2008/105/EC);
- Synthetic compound contamination (Including pesticides, antifoulants, pharmaceuticals and priority substances listed in Annex II of Directive 2008/105/EC); and
- Introduction of other substances (solid, liquid or gas).

2.11.1.143 The benchmarks are identical for all the relevant MarESA pressures listed above which have been used to inform this impact assessment, which are compliance with the applicable Annual Average (AA) Environmental Quality Standard (EQS), conformance with PELs, Environmental Assessment Criteria's (EACs) and Effects Range-Low (ER-Ls) (Tillin and Tyler-Walters, 2015).

Magnitude of impact

2.11.1.144 The total additional number of construction-related vessel round trips to port expected because of construction activities over the construction period is up to 10,774. There will also be associated construction activities in the intertidal part of the Hornsea Three benthic ecology study area (e.g. vehicle and machinery movements). The magnitude of the impact of this increase will be dependent on the quantities of potential pollutants carried by construction vessels and intertidal vehicles/machinery. The size of most of these potential sources of pollution in the intertidal will be relatively small, which immediately reduces the potential magnitude of any spill and although a spill in the intertidal at low water would directly affect benthic habitats, it would be easy to contain. In addition, although many of the large construction vessels may contain large quantities of diesel oil, any accidental spill from vessels, vehicles, machinery or from construction activities would be subject to immediate dilution and rapid dispersal in the high energy environment found within the subtidal parts of Hornsea Three.

2.11.1.145 Given the designed-in mitigation (see Table 2.18) the likelihood of accidental release is considered to be extremely low. The measures to be included in the PEMMP will include: designating areas for refuelling; only using chemicals included on the approved Cefas list under the Offshore Chemical Regulations 2002; storage of chemicals in secure designated areas in line with appropriate regulations and guidelines and double skinning of any tanks and pipes containing hazardous substances. Adherence to the mitigation outlined in Table 2.18 (i.e. a PEMMP) and best working practices will significantly reduce the likelihood of an accidental pollution incident occurring. Measures adopted as part of Hornsea Three to reduce the potential for impacts on shipping and navigation (see volume 2, chapter 7: Shipping and Navigation), such as vessels complying with the International Regulations for Preventing Collisions at Sea (COLREGs) will further reduce the likelihood of an accident between vessels resulting in an accidental spill during the construction period.

2.11.1.146 There is a risk to subtidal benthic receptors from water based drilling mud (i.e. bentonite) which is used as a lubricant during the (HDD process, should HDD be used at the Hornsea Three intertidal area to install the export cable. A limited volume of drilling mud will be discharged at the point where the bore punches out of the seabed in the subtidal zone. However, the volume of fluids released will be small and quickly dispersed in the high-energy conditions of the marine environment. As such, impacts to surrounding subtidal receptors will be minimal.

2.11.1.147 The impact on subtidal benthic receptors is predicted to be of a local to regional spatial extent, short term duration (i.e. in the unlikely event that a spillage occurs, the impact would last hours to days), intermittent and reversible. It is predicted that the impact will affect the receptors indirectly. The magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

2.11.1.148 As outlined in paragraph 2.11.1.143, The benchmarks for the MarESA pressures listed assume compliance with all relevant standards (AA EQS, conformance with PELs, EACs and ER-Ls; Tillin and Tyler-Walters, 2015) As such all VERs are not sensitive to pressures associated with pollution and other chemical changes in the MarESA. The following description of sensitivities for the VERs considers the effects of pollutants and chemicals should they be accidently released at concentrations that exceed environmental protection standards.

2.11.1.149 All VERs would be potentially affected by the accidental release of pollutants (i.e. Habitats A, B, C, D, E, sandbanks which are slightly covered by water all the time, Annex I reefs in an SAC, the ocean quahog *A. islandica* and broadscale features of MCZ/rMCZs and SACs (subtidal coarse sediments, subtidal sand, subtidal mixed sediments, subtidal chalk reef and peat and clay exposures)) and are identified as having intermediate to high intolerance to synthetic compound and hydrocarbon contamination, with localised declines in species richness likely as a result.

2.11.1.150 Crustaceans are widely reported to be intolerant to synthetic chemicals (Tillin, 2016b), and there is varying evidence of individual sensitivities of species to impacts such as major oil spills and to TBT (Beaumont *et al*., 1989; Haggera *et al*., 2005; Antizar-Ladislao, 2008). *S. spinulosa* larvae are known to be highly intolerant of some oil dispersants although adult forms have been found to thrive in polluted areas (Jackson and Hiscock, 2008). Gomez Gesteira and Dauvin (2000) found that amphipods are highly sensitive to oil pollution, whereas polychaetes appear to be resistant to high hydrocarbon levels in sediment although both impacts are unlikely in respect to Hornsea Three. The recoverability of these communities to contaminants of this nature is likely to be moderate to high as a result of the life history characteristics of the component species (see paragraphs 2.11.1.24 to 2.11.1.29). These would facilitate rapid recolonisation of affected areas via adult migration and larval settlement following a return to ecological baseline conditions and baseline levels of contaminants. Experimental evidence is limited and the assessments described above have been derived from sources that only cover some aspects of the habitats and species, or from general understanding of the habitats or species (www.marlin.ac.uk). However, subtidal sediments in high energy environments such as those represented by Habitats A to D (except Habitat B) are generally less vulnerable to this type of pollution than low-energy intertidal habitats. The hydrodynamic regime in the offshore parts of Hornsea Three would also lead to high dispersion and breakdown of pollutants, which would be expected to reduce the concentration of contaminants and therefore also the effects on subtidal receptors associated with a severe pollution event (Elliott *et al.,* 1998). The levels of contaminants that subtidal receptors are likely to be exposed to because of accidental pollution is likely to be much lower than the benchmarks used in MarESA to determine sensitivity due to the large dilution and dispersion that would occur offshore. Therefore, the sensitivity of benthic receptors to these levels of pollution is likely to be lower than that described here using the MarESA benchmarks.

2.11.1.151 As no VERs were recorded at the Hornsea Three intertidal area, due to the barren nature of the sediments (see section 2.7.2), no impact assessment has been undertaken for intertidal habitat loss on benthic ecological receptors.

2.11.1.152 The subtidal benthic VERs (i.e. Habitats A to D) are deemed to be of medium vulnerability, high recoverability and regional value. The sensitivity of the subtidal receptors is considered to be low.

2.11.1.153 Habitat E, the ocean quahog *A. islandica,* Annex I sandbanks which are slightly covered by water all the time in an SAC, Annex I reefs in an SAC, and broadscale features of Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ (subtidal coarse sediments, subtidal sand, subtidal mixed sediments, subtidal chalk reef and peat and clay exposures) are deemed to be of medium vulnerability, high recoverability and national to international value. The sensitivity of the receptors is therefore, considered to be medium.

Significance of the effect

2.11.1.154 Provided published guidelines, best working practices and the mitigation measures outlined in Table 2.18 (i.e. implementation of a PEMMP) are adhered to, the likelihood of an accidental spill is extremely low and, in the event of a spill, the volumes of potential contaminants released would be small and rapidly dispersed to concentrations below which deleterious effects would be expected.

2.11.1.155 Overall, subtidal benthic receptors (i.e. Habitats A, B, C, D, E, sandbanks which are slightly covered by water all the time, Annex I reefs in an SAC, the ocean quahog *A. islandica* and broadscale features of MCZ/rMCZs and SACs (subtidal coarse sediments, subtidal sand, subtidal mixed sediments, subtidal chalk reef and peat and clay exposures)) are considered to be of low to medium value and the magnitude of the impact is deemed to be negligible. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

2.11.1.156 Conclusions on the effects of Hornsea Three on the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

2.11.1.157 Conclusions on the effects of Hornsea Three on the Markham's Triangle rMCZ and the Cromer Shoal Chalk Beds MCZ are presented in full within volume 5, annex 2.3: MCZ Assessment.

Future monitoring

2.11.1.158 Table 2.25 below outlines the proposed monitoring commitments for benthic ecology.

Table 2.25: Construction phase monitoring commitments.

Environmental effect	Monitoring commitment
The Hornsea Three assessment assumes that, where possible, there will be no direct impacts (i.e. from temporary, long term and permanent habitat loss) to Annex I reefs within SACs and/or biogenic or geogenic reefs outside SACs within the Hornsea Three offshore cable corridor on the basis of the designed-in mitigation measures outlined in Table 2.18.	As outlined in the IPMP (document reference number 8.8), to ensure where possible no direct impacts to reef habitat, a survey will be undertaken along the Hornsea Three offshore cable corridor prior to construction to determine the location, extent and composition of any Annex I reefs within SACs and/or biogenic or geogenic reefs outside SACs. The exact scope of these surveys will be agreed with the relevant statutory consultees.

2.11.2 Operational and maintenance phase

2.11.2.1 The impacts of the offshore operation and maintenance of Hornsea Three have been assessed on benthic ecology. The potential environmental impacts arising from the operation and maintenance of Hornsea Three are listed in Table 2.14 along with the maximum design scenario 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.

Long term loss of seabed habitat through presence of foundations, scour protection and cable protection, resulting in potential effects on benthic receptors

2.11.2.3 Long term habitat loss will occur directly under all foundation structures and associated scour protection, and all array, interconnector and export cables, where cable protection is required. Long term habitat loss will also result from all cable/pipeline crossings. The values quoted in this section also include operation and maintenance replenishment of cable protection and cable/pipeline crossings (assumed to be 25% of the cables and crossings; see Table 2.14) on the basis that this impact is additive as cable protection will be added to those areas previously impacted by cable protection. This impact considers only the habitat loss occurring during the operational phase of Hornsea Three. Any permanent habitat loss arising from scour and cable protection potentially being left *in situ* following decommissioning is fully assessed in paragraph 2.11.3.38 *et seq*.

2.11.2.4 This assessment is considered to be equivalent to the following pressure identified by the ICGC pressures list under the overarching pressure theme 'Physical loss (permanent change)':

- Physical change (to another seabed type).

2.11.2.5 The benchmark for the relevant MarESA pressure (of the same name) which has been used to inform this impact assessment is the permanent change from sedimentary or soft rock substrata to hard rock or artificial substrata or vice-versa.

Magnitude of impact

2.11.2.6 The maximum total long term habitat loss associated with the installation of foundations and scour protection, and all associated subsea cables requiring cable protection (including cable/pipeline crossings), is estimated at up to 4,208,028 m^2 (Table 2.14) which equates to 0.08% of the area of Hornsea Three benthic ecology study area. Within Hornsea Three, long term habitat loss may affect the VERs Habitats A, B, C, D and E; Habitat D and Habitat E will be affected on the Hornsea Three offshore cable corridor only although it should be noted that appropriate mitigation measures will be discussed with the statutory consultees to avoid direct impacts to Habitat E (*S. spinulosa* reef outside an SAC) where possible and therefore this assessment is highly precautionary. Long term habitat may also affect *A. islandica*.

2.11.2.7 The area of the total long term habitat loss which will occur within the Hornsea Three array area is predicted to be up to 2,863,428 m^2 which equates to a total loss of 0.06% of the total Hornsea Three benthic ecology study area. The maximum total area of each VER potentially lost because of activities within the Hornsea Three array area is based on a Design Envelope of maximum habitat loss for Habitats A, B and C, resulting from the location of all structures within one or other of these habitats which is a highly precautionary approach. The maximum loss of each of the VERs is therefore 2,863,428 m^2 (Table 2.26), assuming all habitat loss occurs within one or other of these habitats which equates to approximately 0.13%, 0.20% and 0.22% of the total area of Habitat A, B and C, respectively within the Hornsea Three benthic ecology study area. The total area of long term habitat loss represents a very small percentage loss (0.0006%) of the total area of the OSPAR Region II (Greater North Sea) within which *A. islandica* is listed as under threat and/or decline. A Scour Protection Management Plan (SPMP) detailing the need, type, sources, quantity, location and installation methods for scour protection will be produced and submitted to the MMO prior to construction.

2.11.2.8 Within the Hornsea Three offshore cable corridor the VERs which would be affected by long term habitat loss due to cable protection where burial is not possible, including cable/pipeline crossings, are Habitats A, B, C, D and E. The total area of impact is predicted to be up to 1,344,600 m^2 and the maximum long term loss of each VER is presented in Table 2.26 together with the proportions of the total area of each within the Hornsea Three benthic ecology study area. This is based on a Design Envelope of maximum habitat loss for each VER which is calculated based on the proportion of each habitat mapped within the offshore cable corridor. As the exact route of the cables is not known at present, a precautionary approach has been adopted for Habitat E (*S. spinulosa* reef outside an SAC) which assumes that all export cables will be routed through this habitat (which is highly precautionary) such that approximately 6,500 m^2 of the total area of reef coinciding with the Hornsea Three offshore cable corridor (84,407 m^2) may be lost as a result of the installation of cable protection, which equates to 7.7% of the area of this habitat that was mapped during the site specific surveys. As discussed in paragraph 2.11.1.17, the impact to the extent of this feature would not result in a change to the outcome of the *S. spinulosa* reef assessment in this locality (i.e. the reef would still be assessed as 'medium reef') and measures will be discussed with the statutory consultees to avoid direct impacts to this habitat, where possible (Table 2.18).

2.11.2.9 The impact is predicted to be of local spatial extent (i.e. restricted to discrete areas within Hornsea Three), long term duration, continuous and irreversible during the lifetime (see Table 2.14) of Hornsea Three. It is predicted that the impact will affect receptors directly. The magnitude is therefore, considered to be minor.

Table 2.26: Maximum long term habitat loss for VERs within Hornsea Three.

VER	Maximum long term habitat loss within Hornsea Three array area (m^2)[a]	Maximum long term habitat loss within Hornsea Three offshore cable corridor (m^2)[b]	Total maximum long term habitat loss	
			Area (m^2)	% of total area of each VER in Hornsea Three benthic ecology study area
Habitat A	2,863,428	438,191	3,301,619	0.16
Habitat B	2,863,428	42,626	2,906,054	0.21
Habitat C	2,863,428	447,560	3,310,988	0.25
Habitat D	0	416,223	416,223	0.20
Habitat E	0	6,500	6,500	7.7

a Based on a Design Envelope of maximum habitat loss for Habitats A, B and C, resulting from the location of all structures within one or other of these habitats.

b Based on a Design Envelope of maximum habitat loss for each VER which is calculated using the proportion of each habitat mapped within the offshore cable corridor.

Sensitivity of the receptor

2.11.2.10 Most species characterising the VERs that will potentially be affected by long term habitat loss during the operational phase are infaunal. These species would be lost along with the substratum underneath the offshore structures and scour/cable protection. All VERs are therefore considered to be highly intolerant of, and vulnerable to, complete habitat loss. However, none of the VERs likely to be affected are rare or geographically restricted. As indicated in the baseline characterisation (section 2.7), comparable habitats are widely distributed in the southern North Sea benthic ecology study area and near Hornsea Three (Tappin *et al*., 2011; see volume 5, annex 2.1: Benthic Ecology Technical Report). Given the small spatial scales of the total long term habitat loss outlined above (i.e. 0.08% of the total Hornsea Three benthic ecology study area) this loss is not expected to undermine regional ecosystem functions or diminish biodiversity. During decommissioning, if the foundations are removed, the impacts will be reversible with the affected habitats likely to recover within similar time scales to those outlined in paragraphs 2.11.1.24 to 2.11.1.31.

2.11.2.11 The VERs likely to be affected by long term habitat loss (i.e. Habitats A, B, C, D, E and ocean quahog *A. islandica*) are deemed to be of high vulnerability and regional to national importance and there is no potential for the recoverability of the affected habitats for the lifetime (see Table 2.14) of Hornsea Three. The sensitivity of the benthic receptors is therefore, considered to be high.

Significance of the effect

2.11.2.12 Overall, the sensitivity of the receptors is considered to be high and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms. This has been concluded on the basis that the impact will be localised to discrete parts of Hornsea Three and that similar habitats are widespread within the southern North Sea.

North Norfolk Sandbanks and Saturn Reef SAC

2.11.2.13 Of the total long term habitat loss predicted for Hornsea Three in paragraph 2.11.2.6, up to 497,400 m^2 of this is predicted to affect the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC (i.e. from cable protection where burial is not possible and pipeline/cable crossings; see Table 2.27). This represents 0.01% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC (i.e. all potential Annex I sandbank habitat). Cable protection requirements along the Hornsea Three offshore cable corridor will be detailed in the Cable Specification and Installation Plan which will be produced prior to construction and agreed in consultation with statutory consultees.

Table 2.27: Maximum long term habitat loss within the North Norfolk Sandbanks and Saturn Reef SAC.

Project element	Total maximum long term habitat loss (m^2)	Assumptions
Cable protection associated with export cables	197,400	Assumes a maximum of 10% of the total length of 282 km of export cables within the North Norfolk Sandbanks and Saturn Reef SAC (up to six cables each of up to 47 km in length) will require cable protection, affecting a corridor of up to 7 m width.
Cable protection associated with cable/pipeline crossings	300,000	Assumes up to 20 crossings per cable within the North Norfolk Sandbanks and Saturn Reef SAC, with long terms habitat loss of up to 2,500 m^2.
Total long term habitat loss	497,400	-

2.11.2.14 As discussed in paragraphs 2.7.1.15 and 2.7.1.16, the Hornsea Three offshore cable corridor coincides with the delineated boundary of *S. spinulosa* reef in the North Norfolk Sandbanks and Saturn Reef SAC, although no reefs were identified within the Hornsea Three benthic ecology study area coinciding with the North Norfolk Sandbanks and Saturn Reef SAC during the site specific surveys. However, should Annex I *S. spinulosa* reef be present in the pre-construction survey within the North Norfolk Sandbanks and Saturn Reef SAC, appropriate measures will be discussed with statutory consultees to avoid direct impacts to these reefs from cable protection, where possible (see Table 2.18). For this reason, figures for long term habitat loss of this Annex I reef habitat are not presented in this section or in Table 2.27.

Magnitude of impact

2.11.2.15 The impact of long term habitat loss within the North Norfolk Sandbanks and Saturn Reef SAC is predicted to be localised to discrete sections of the Hornsea Three offshore cable corridor, affecting a small proportion of the seabed within the North Norfolk Sandbanks and Saturn Reef SAC, with no predicted effects on qualifying Annex I reef habitats. Hornsea Three will employ sensitive cable protection within the areas of designated sites that coincide with Hornsea Three which will consider the local seabed conditions, including sediment/substrate type. These cable protection measures will not include concrete mattresses (see Table 2.18). Hornsea Three will discuss and agree the precise nature of these measures for the North Norfolk Sandbanks and Saturn Reef SAC with the MMO through sign of on the Cable Specification and Installation Plan prior to construction. This may include measures which may encourage the burial of the cable protection by the surrounding sediment or rock protection which takes into account the typical grain sizes (e.g. coarse gravel, cobbles and boulders) known to occur naturally within the SAC. Where such measures can be employed, these may allow local communities associated with the habitat features of the North Norfolk Sandbanks and Saturn Reef SAC (i.e. infaunal communities where sediment accumulation occurs; epifaunal in the case of appropriate rock protection) to colonise these areas, potentially providing some recovery of communities in areas where cable protection is placed and reducing the extent of long term habitat loss in the North Norfolk Sandbanks and Saturn Reef SAC.

2.11.2.16 The impact is predicted to be of local extent, long term, continuous and irreversible during the lifetime (see Table 2.14) of Hornsea Three. It is predicted that the impact will affect the receptors directly. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.11.2.17 As discussed in paragraph2.11.1.61, the site specific surveys identified the biotopes ApriBatPo, NcirBat and SspiMx in association with the sandy and localised areas of coarse sediments within the North Norfolk Sandbanks and Saturn Reef SAC (although the site selection document for the SAC identified that the biological communities present were typical the more species poor IMoSa biotope (JNCC, 2010)). As discussed in paragraph 2.11.2.10, these biotopes are highly intolerant of, and vulnerable to, complete habitat loss with recoverability not applicable for an impact of this nature. The sensitivity of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC, an internationally important receptor, is therefore considered to be high. However, if these structures are removed during decommissioning, the impacts will be reversible with the affected habitats likely to recover within similar time scales to those outlined in paragraphs 2.11.1.24 to 2.11.1.31.

2.11.2.18 It is acknowledged that the presence of the cable protection within the North Norfolk Sandbanks and Saturn Reef SAC may serve as an ongoing barrier to the future establishment of Annex I reefs in those discrete areas. The MarESA for the SspiMx biotope does note, however, that *S. spinulosa* has been recorded colonising bedrock and artificial structures and an increase in the availability of hard substratum may, therefore, be beneficial in areas where sedimentary habitats were previously unsuitable for colonisation, although the resulting biotope would be different (Tillin and Marshall, 2015). This, together with the designed-in mitigation to employ sensitive cable protection in the SAC (see Table 2.18), means that the presence of cable protection within the North Norfolk Sandbanks and Saturn Reef SAC is not considered likely to preclude the establishment of Annex I reefs, or indeed Annex I 'Sandbanks which are slightly covered by seawater all the time' in these areas in the future.

<u>Significance of the effect</u>

2.11.2.19 Overall, the sensitivity of Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC is considered to be high and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms. This conclusion has been made on the basis that the impact will be highly localised within the North Norfolk Sandbanks and Saturn Reef SAC with up to 0.007% of the Annex I habitat within the SAC affected.

2.11.2.20 No long term loss of Annex I reef habitat within the North Norfolk Sandbanks and Saturn Reef SAC is predicted. Should Annex I reef habitat be identified during pre-construction surveys of the Hornsea Three offshore cable corridor, appropriate measures will be discussed with statutory consultees to avoid direct impacts to these features, where possible (see Table 2.18).

2.11.2.21 Conclusions on the effects of Hornsea Three on the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

The Wash and North Norfolk Coast SAC

<u>Magnitude of impact</u>

2.11.2.22 Of the total long term habitat loss predicted for Hornsea Three in paragraph 2.11.2.6, up to 46,200 m^2 of this is predicted to occur within supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' within The Wash and North Norfolk Coast SAC (i.e. from cable protection where burial is not possible). This represents 0.004% of the total area of The Wash and North Norfolk Coast SAC. This will result from the potential requirement for cable protection for up to 10% of the 66 km of export cables within The Wash and North Norfolk Coast SAC (six cables of up to 11 km in length), and up to 7 m width of cable protection per cable (11,000 m x 6 x 0.1 x 7 m = 46,200 m^2). Cable protection requirements along the Hornsea Three offshore cable corridor will be detailed in the Cable Specification and Installation Plan which will be produced prior to construction and agreed in consultation with statutory consultees.

2.11.2.23 Annex I reef is also a qualifying feature of The Wash and North Norfolk Coast SAC, but as discussed in paragraphs 2.7.1.15 to 2.7.1.20, historically, no reefs have been recorded in the area of the Hornsea Three benthic ecology study area coinciding with The Wash and North Norfolk Coast SAC and neither were they recorded during the site specific surveys in this area. Therefore, no direct effects from long term habitat loss are predicted. Should Annex I *S. spinulosa* reef be present in the pre-construction survey within The Wash and North Norfolk Coast SAC, appropriate measures will be discussed with statutory consultees to avoid direct impacts to these reefs from cable protection, where possible (see Table 2.18).

2.11.2.24 The impact of long term habitat loss within The Wash and North Norfolk Coast SAC is predicted to be localised to discrete sections of the Hornsea Three offshore cable corridor, affecting a small proportion of the seabed within the eastern periphery of The Wash and North Norfolk Coast SAC. Hornsea Three will employ sensitive cable protection within the areas of designated sites that coincide with Hornsea Three which will consider the local seabed conditions, including sediment/substrate type. These cable protection measures will not include concrete mattresses and will take into account the local baseline environment (see Table 2.18). Hornsea Three will discuss and agree the precise nature of the cable protection measures for the Wash and North Norfolk Coast SAC with the MMO through sign of on the Cable Specification and Installation Plan prior to construction. This may include the use of rock protection which takes into account the typical grain sizes (e.g. coarse gravel and cobbles) known to occur naturally within the SAC. Where appropriately sized rock protection can be used, such measures may allow some recovery of communities in areas where cable protection is placed and reducing the extent of long term habitat loss in The Wash and North Norfolk Coast SAC.

2.11.2.25 The impact is predicted to be of local spatial extent, long term duration, continuous and irreversible during the lifetime (see Table 2.14) of Hornsea Three. It is predicted that the impact will affect supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' directly. The magnitude is therefore, considered to be minor.

<u>Sensitivity of the receptor</u>

2.11.2.26 As discussed in paragraph 2.11.1.74, the site specific surveys identified that the biotopes NcirBat, MoeVen and SspiMx characterised the Hornsea Three offshore cable route sediments coinciding with The Wash and North Norfolk Coast SAC. As outlined in paragraph 2.11.2.10, these biotopes are deemed to be of high vulnerability and international value (recoverability is not applicable for this impact). The sensitivity of supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' is therefore, considered to be high (Tillin, 2016b and 2016c; Tillin and Marshall, 2015).

2.11.2.27 As discussed in paragraph 2.11.2.23, measures will be implemented to avoid long term loss of Annex I reefs where possible. It is acknowledged however, that the presence of the cable protection material on the seabed has the potential to act as an ongoing barrier to the future establishment of Annex I reefs in those discrete areas. The MarESA for the SspiMx biotope does note, however, that *S. spinulosa* has been recorded colonising bedrock and artificial structures and an increase in the availability of hard substratum may, therefore, be beneficial in areas where sedimentary habitats were previously unsuitable for colonisation, although the resulting biotope would be different (Tillin and Marshall, 2015). Furthermore, as the overall proportion of The Wash and North Norfolk Coast SAC predicted to be affected is very small, 0.004% of the total area of the site, there will remain sufficient similar habitat available for the potential colonisation by *S. spinulosa* and establishment of reefs in the future. The same is also true for available supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time'. Therefore, it is not considered that the presence of cable protection within the North Norfolk Sandbanks and Saturn Reef SAC will preclude the establishment of Annex I reefs, or indeed Annex I 'Sandbanks which are slightly covered by seawater all the time' in these areas in the future.

Significance of the effect

2.11.2.28 Overall, the sensitivity of supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' within The Wash and North Norfolk Coast SAC is considered to be high and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms. This has been concluded on the basis of the very small extent of this habitat within The Wash and North Norfolk Coast SAC which will be impacted. The effect has been assessed as minor, rather than moderate (see Table 2.17), on the basis that the impact will be highly localised within the eastern periphery of The Wash and North Norfolk Coast SAC with up to only 0.004% of potential Annex I habitat within the SAC affected. Furthermore, current evidence does not indicate the presence of either of the Annex I habitats 'Sandbanks which are slightly covered by seawater all the time' or 'Reefs', although there is potential for these protected features to occur in these areas in the future. Also, the sensitive design of the cable protection material (see Table 2.18) may facilitate the recovery of communities in these locations.

2.11.2.29 No long term loss of Annex I reef habitat within The Wash and North Norfolk Coast SAC is predicted. Should Annex I reef habitat be identified during pre-construction surveys of the Hornsea Three offshore cable corridor, appropriate measures will be discussed with statutory consultees to avoid direct impacts to these features, where possible (see Table 2.18).

2.11.2.30 Conclusions on the effects of Hornsea Three on the conservation objectives of The Wash and Norfolk Coast SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

Cromer Shoal Chalk Beds MCZ

2.11.2.31 For the Cromer Shoal Chalk Beds MCZ, the long term habitat loss areas are based on cable protection being placed over up to 10% of the up to 6 km of export cables within the Cromer Shoal Chalk Beds MCZ (i.e. up to six cables each up to 1 km in length). Of the total long term habitat loss predicted for Hornsea Three in paragraph 2.11.2.6, up to 4,200 m^2 of this will occur within the broadscale MCZ habitat feature Subtidal sand. This equates to approximately 0.02% of the total extent of the Subtidal sand habitat feature within the Cromer Shoal Chalk Beds MCZ (according to the latest estimates of the extent of the broadscale habitats in Defra, 2015) and 0.0013% of the total area of the Cromer Shoal Chalk Beds MCZ. There will be no long term habitat loss within any of the other broadscale habitat features of the Cromer Shoal Chalk Beds MCZ. Cable protection requirements will be detailed in the Cable Specification and Installation Plan which will be produced prior to construction and agreed in consultation with statutory consultees.

Magnitude of impact

2.11.2.32 The long term loss of Subtidal sand within the Cromer Shoal Chalk Beds MCZ has been minimised as a result of the Hornsea Three offshore cable corridor reroute (see paragraph 2.6.1.4) and is predicted to be localised within the inshore sections of the Hornsea Three offshore cable corridor and in the western part of the Cromer Shoal Chalk Beds MCZ. The designed-in mitigation measure outlined in Table 2.18, to employ sensitive cable protection within the Cromer Shoal Chalk Beds MCZ which will be designed to consider the local seabed conditions, including substrate type (i.e. cable protection may comprise gravel and cobbles with a mean grain size of 100 mm, maximum grain size of 250 mm within the MCZ), will encourage re-colonisation of these areas by fauna from surrounding areas and may serve to reduce any potential effect of long term habitat loss. In some cases, e.g. in areas characterised by mobile sands, bed load sediment transport and saltation will result in infilling of the interstices in the rock protection, also allowing for some recovery of infaunal communities in these areas. Given that this part of the inshore environment is characterised by mobile sandy sediments with patches of gravel, cobbles and boulders (as recorded during the inshore geophysical and DDV surveys; see paragraph 2.7.1.20 and section 4.1.4 of volume 5, annex 2.1: Benthic Ecology Technical Report 1 for full details), this type of rock protection would not represent a considerable shift in the baseline situation. The habitat loss will be continuous and irreversible during the lifetime (see Table 2.14) of Hornsea Three.

2.11.2.33 The impact is predicted to be of local spatial extent, long term duration, continuous and irreversible for the lifetime of the project (see Table 2.14). It is predicted that the impact will affect the receptors directly. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.11.2.34 The sensitivity of the NcirBat biotope associated with the sediments of the Cromer Shoal Chalk Beds MCZ is as described in paragraph 2.11.2.17 and is considered to be high for a change in sediment type, although it is anticipated that the use of sensitive rock protection described in Table 2.18 will limit the extent of habitat change (e.g. in comparison to the use of concrete mattressing for example).

2.11.2.35 In many areas where cable protection is used, sediments would be expected to recover over part of the area affected, depending on the orientation of the cable protection. As discussed in volume 2, chapter 1: Marine Processes, following installation of cable protection and under favourable conditions, an initial period of sediment accumulation would be expected to occur through bed load sediment transport and saltation, creating a smooth slope against the cable protection. The process of wedge formation may take place over a period of a few months or less, depending on rates of sediment transport. It would be expected that, following accumulation of the sediments from surrounding areas on the cable protection, the biological communities associated with the surrounding sediments would also be expected to colonise these sediments. In addition to this, some of the epifaunal components of the neighbouring biological communities associated with the neighbouring areas of subtidal coarse sediments would be expected to colonise the cable protection measures. This suggests that although long term habitat loss has been assumed across all areas where cable protection is installed, this assumption is likely to overestimate the effect on biological communities, with some recovery of these communities in certain circumstances.

2.11.2.36 The Subtidal sand feature of the Cromer Shoal Chalk Beds MCZ is deemed to be of high vulnerability and national value (recoverability is not applicable for this impact). The sensitivity of the receptor is therefore, considered to be high.

Significance of the effect

2.11.2.37 Overall, the sensitivity of the broadscale habitat Subtidal sand of the Cromer Shoal Chalk Beds MCZ is considered to be high and the magnitude of the impact is deemed to be minor. The effect of temporary habitat loss on the features of Cromer Shoal Chalk Beds MCZ will, therefore, be of minor adverse significance, which is not significant in EIA terms. This has been concluded on the basis that the impact will be localised to the sandy sediments in the south western section of the Cromer Shoal Chalk Beds MCZ only, with up to 0.02% of broadscale habitat affected. The Subtidal sand habitat affected is widespread in the wider geographical area and the sensitive design of the cable protection material may facilitate the recovery of epifaunal communities in these locations. Discussions on the effects of Hornsea Three on the Cromer Shoal Chalk Beds MCZ are presented in full within volume 5, annex 2.3: MCZ Assessment.

Markham's Triangle rMCZ

Magnitude of impact

2.11.2.38 Table 2.28 presents the maximum design scenario for broadscale habitat features within the Markham's Triangle rMCZ. As the exact layout of the Hornsea Three array will depend on technology choice and other decisions made at the procurement stage, maximum design parameters determine that up to 24% of array infrastructure could be located within the boundary of the Markham's Triangle rMCZ, in the context of long term habitat loss within the Markham's Triangle rMCZ (see paragraph 2.11.1.91). This assumes that a maximum of 76 offshore foundations (i.e. turbines, substations and accommodation platforms) could be placed within the part of the Markham's Triangle rMCZ which coincides with the Hornsea Three array, assuming a 1 km separation between foundations, which is considered to be highly precautionary. Of the total long term habitat loss predicted for Hornsea Three in paragraph 2.11.2.6, up to 682,196 m^2 of this will affect broadscale habitats within the Markham's Triangle rMCZ which equates to 0.34% of the total area of the Markham's Triangle rMCZ. Cable protection requirements will be detailed in the Cable Specification and Installation Plan which will be produced prior to construction and agreed in consultation with statutory consultees.

Table 2.28: Maximum long term habitat loss of broadscale habitat features of the Markham's Triangle rMCZ.

Project element	Total maximum long term habitat loss (m^2)	Assumptions
Foundations and scour protection	457,388	Assumes a maximum of 24% of the total long term habitat loss from GBF and associated scour protection within the Hornsea Three array area.
Cable protection associated with inter array, interconnector and export cables (within the array)	203,961	Assumes maximum of 24% of the total habitat loss from cable protection associated with 830 km of array cables, 225 km of interconnector and 168 km of export cables within the array (10% of all cables requiring cable protection, affecting a corridor of up to 7 m width).
Cable protection associated with cable/pipeline crossings	20,846	Assumes a maximum of 24% of the total habitat loss associated with up to seven cable/pipeline crossings within the array.
Total long term habitat loss	682,196	-

2.11.2.39 Long term habitat loss is predicted to affect each broadscale habitat feature of the Markham's Triangle rMCZ as follows:

- Up to 682,196 m^2 of Subtidal coarse sediment, equating to 0.47% of the total area of this habitat within the Markham's Triangle rMCZ if all the habitat loss occurs within this broadscale habitat;
- Up to 72,490 m^2 of Subtidal sands, equating to 0.28% of the total area of this habitat within the Markham's Triangle rMCZ, assuming that; as Subtidal sand extends over approximately 10.63% of the area of the Markham's Triangle rMCZ coinciding with the Hornsea Three array area, 10.63% of the long term habitat loss could occur within this habitat; and
- 88,378 m^2 of Subtidal mixed sediment, equating to 0.32% of the total area of this habitat within the Markham's Triangle rMCZ assuming that, as Subtidal mixed sediment extends over approximately 12.95% of the area of the Markham's Triangle rMCZ coinciding with the Hornsea Three array area,12.95% of the maximum temporary habitat loss/disturbance could occur within this habitat.

2.11.2.40 The designed-in mitigation measure of employing sensitive rock protection material in Markham's Triangle rMCZ (see Table 2.18) which will consider the local seabed conditions, including substrate type (i.e. cable protection to be used within the rMCZ may comprise gravel and cobbles with a mean grain size of 100 mm, maximum grain size of 250 mm and scour protection material (if required) may have a maximum grain size of 360 mm), will encourage re-colonisation of these areas by fauna from surrounding areas and may serve to reduce any potential effect of long term habitat loss. In some cases, bed load sediment transport and saltation will result in infilling of the interstices in the rock protection, also allowing for some recovery of infaunal communities in these areas. Long term loss on features of the Markham's Triangle rMCZ is predicted to be localised within the western area of the Markham's Triangle rMCZ, continuous and irreversible during the lifetime (see Table 2.14) of Hornsea Three although the designed-in mitigation measures for cable and scour protection grain size (see Table 2.18) are intended to reduce the extent of long term habitat loss. The impact will affect the receptors directly resulting in a relatively small change in the baseline condition. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.11.2.41 The site specific surveys identified that the PoVen and MysThyMx biotopes characterised the Hornsea Three offshore cable corridor sediments coinciding with the Markham's Triangle rMCZ (see paragraph 2.11.1.96). The sensitivity of these biotopes to habitat loss is considered to be high (De-Bastos and Marshall, 2016a; Tillin, 2016d), although it is anticipated that the designed-in mitigation measures outlined in Table 2.18 would minimise the extent of long term loss in these biotopes, which are by nature typical of more mixed sediments, by minimising the change in sediment type within these biotopes. Although infaunal species will be affected, the resulting coarser substrate may be suitable for colonisation by epifaunal communities typical of these biotopes.

Significance of the effect

2.11.2.42 Overall, the sensitivity of the features of Markham's Triangle rMCZ is considered to be high and the magnitude of the impact is deemed to be minor. The effect of temporary habitat loss on the features of Markham's Triangle rMCZ will, therefore, be of minor adverse significance, which is not significant in EIA terms. This has been concluded on the basis that the impact will be localised to discrete parts of the Markham's Triangle rMCZ, and only in the western section, with up to 0.34% habitat affected. The habitats present within the rMCZ are widespread in the wider geographical area and it is anticipated that the sensitive design of the cable protection material (see Table 2.18) may facilitate the recovery of epifaunal communities in these locations. Discussions on the effects of Hornsea Three on the Markham's Triangle rMCZ are presented in full within volume 5, annex 2.3: MCZ Assessment.

Colonisation of foundations/cable protection/scour protection may affect benthic ecology and biodiversity

2.11.2.43 Introduction of hard substrates because of installation of foundation structures and associated scour protection, and cable protection for cables will occur within Hornsea Project Three leading to colonisation of these hard substrates. This assessment is considered to be equivalent to the following pressure identified by the ICGC pressures list under the overarching pressure theme 'Physical loss (permanent change)':

- Physical change (to another seabed type).

2.11.2.44 The introduction of hard substrate into a predominantly soft sediment area can also facilitate the spread of INNS. Effects associated with the introduction of INNS are assessed separately in paragraph 2.11.2.72 to paragraph 2.11.2.89.

Magnitude of impact

2.11.2.45 Up to 5,470,308 m^2 of new hard substrate habitat will be created in the Hornsea Three benthic ecology study area as a result of the installation of GBFs and scour protection associated with up to 300 turbines, 12 offshore transformer substations, four HVDC converter substations and three offshore accommodation platforms plus surface protection required for up to 2,201 km of array, interconnector, export cables and cable/pipeline crossings (see Table 2.14). Of this total, up to 3,963,667 m^2 is predicted to be created within the Hornsea Three array area and 1,506,640 m^2 within the Hornsea Three offshore cable route corridor.

2.11.2.46 Hard substrate, except for cobbles and boulders, is rare within the Hornsea Three benthic ecology study area. Any increase in hard substrate, and associated increases in biodiversity, will potentially affect Habitats A, B, C, D and E and will be long term, lasting for the duration of the development (see Table 2.14). Although, ephemeral *S. spinulosa* reef outside an SAC/SCI was identified within the Hornsea Three offshore cable corridor (i.e. Habitat E) appropriate measures will be discussed with statutory consultees to avoid direct impacts to these reefs, where possible (see Table 2.18). Any effects on benthic ecology, if they occur at all, are likely to be localised to the Hornsea Three array area and offshore cable corridor and should not be regarded as mitigation for the loss of soft substrate species associated with the installation of these structures (as described in paragraph 2.11.2.3).

2.11.2.47 The impact on Habitats A, B, C, D and E is predicted to be of local spatial extent, long term duration, continuous and irreversible during the lifetime (see Table 2.14) of Hornsea Three. It is predicted that the impact will affect the receptors indirectly. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.11.2.48 Within Hornsea Three, hard substrate is largely rare and sediments are dominated by sands and coarse sediments. Therefore, the introduction of up to 5,470,308 m² of hard substrate will have a direct effect on benthic ecology by facilitating the establishment of species previously not present in an environment dominated by soft sediment habitats (Kerckhof *et al*., 2011). The introduction of new hard substrate will represent a potential shift in the baseline condition within the Hornsea Three benthic ecology study area and the wider southern North Sea benthic 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 wind farm (OWEZ) (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.

2.11.2.49 Post-construction monitoring of monopiles within the OWEZ recorded colonisation of hard substrate species in two distinct zones. The upper zone (7 to 10 m) was dominated by fast growing mussels *Mytilus edulis* (80-100% surface area coverage) and other fauna including barnacles and starfish. The mussels were estimated to be present in densities of on average 6,725 individuals m^{-2} with a biomass of 1,257 g ash free dry weight (AFDW) m^{-2}. The second, deeper zone (10 m to the seabed) was dominated by a community of anemones together with the small crustacean *Jassa* spp. (Lindeboom *et al*., 2011). The results of the post-construction monitoring surveys at the OWEZ concluded that the colonisation by these species represented an increase in biodiversity and a significant change compared to the situation if no hard substrates were present (Lindeboom *et al*., 2011).

2.11.2.50 An investigation conducted at the research platform Forschungsplattformen in Nord- und Ostsee 1 FINO 1 in the south western German Bight in the North Sea reported similar findings with respect to epifaunal communities colonising offshore foundations (Krone *et al*., 2013) where the blue mussel *M. edulis*, Anthozoa and *Jassa* spp. were found to be the dominant species. The 1 m zone was dominated by a *Mytilus* community, and approximately half of the total biomass (4,300 kg on average) was attached to the 1 m zone (Krone *et al*., 2013). Although *M. edulis* is common in the North Sea, it has generally not been found to settle in significant numbers on entirely submerged shipwrecks; this is in comparison to offshore constructions which have intertidal zones where settlement is much higher. The investigation also found that yearly, 878,000 single shell halves sink onto the seabed from the FINO 1 platform, thereby greatly extending the reef effects created by the construction of the offshore platform structure (Krone *et al*., 2013). In turn, the presence of mussels provides a secondary substrate for the attachment of other epifaunal species (Norling and Kautsky, 2007) and in the long-term the production of shell debris may have indirect effects on benthic ecology by leading to coarser, shell-dominated sediment and enriched structure diversity. However, the extent to which *Mytilus* colonisation and subsequent indirect effects may occur is highly dependent on the nature of the structures installed and site-specific effects. For example, artificial intertidal habitats further offshore and outside the distributional range of *M. edulis* larvae may be colonised less strongly. Although, the higher abundances of the predating *A. rubens* in coastal waters may counteract high larval support and spat fall (i.e. the settling and attachment of bivalves to the substrate) capacity in these areas.

2.11.2.51 The placement of scour material within Hornsea Three may also have beneficial effects as it will increase the structural complexity of the substrata, providing refuge and niche habitats as well as increasing feeding opportunities for a range of larger and more mobile species. For example, lobster have benefitted in the Greater Wash Strategic Environmental Assessment (SEA) (Linley *et al*., 2007).

2.11.2.52 The species potentially introduced through artificial reef structures created by the turbine foundations 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, particularly as post-construction monitoring of offshore wind farm structures has primarily focused on the colonisation and aggregation of species close to the foundations rather than broad scale studies. In turn, the increased biodiversity associated with the structures can have benefits to higher trophic levels as the benthic organisms colonising the structures provide an additional food source for local fish and shellfish species. Studies at the Horns Rev offshore wind farm in Denmark have provided evidence that offshore wind farm 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. to habitats near the foundation structures). The effects of artificial reef structures upon fish and shellfish receptors are discussed in volume 2, chapter 3: Fish and Shellfish Ecology.

2.11.2.53 Given the presence of epifaunal species and colonising fauna within discrete parts of the Hornsea Three benthic 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.

2.11.2.54 The VERs likely to be affected, Habitats A, B, C and D, are deemed to be of low vulnerability and regional value; the sensitivity of these receptors is therefore, considered to be low. With respect to Habitat E, *S. spinulosa* can colonise bedrock and artificial structures and the resulting habitat would be suitable for the development of reefs (however these would be classified as a different biotope type); Tillin and Marshall, 2015. Based on the extent of the predicted loss resistance is deemed to be medium and the habitat is of national value; the sensitivity of this receptor is therefore, considered to be medium.

Significance of the effect

2.11.2.55 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 species associated with the installation of these structures. The species likely to benefit is uncertain. Similarly, whether any negative effects may occur (i.e. from increased competition and predation) is also uncertain.

2.11.2.56 Overall, the sensitivity of Habitats A, B, C and D is considered to be low, the sensitivity of Habitat E is considered to be medium and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of minor adverse or beneficial significance, which is not significant in EIA terms.

North Norfolk Sandbanks and Saturn Reef SAC

Magnitude of impact

2.11.2.57 The introduction of up to 544,123 m^2 of surface area of new hard substrate is predicted to occur because of the protection of export cables and cable/pipeline crossings within the North Norfolk Sandbanks and Saturn Reef SAC (Table 2.29). Associated increases in biodiversity will potentially affect up to 0.015% of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time'. In a habitat where encrusting epifaunal species are rare, this is likely to represent highly localised shifts in the baseline conditions.

2.11.2.58 This impact is not predicted to affect any Annex I reef features of the North Norfolk Sandbanks and Saturn Reef SAC as, as discussed in paragraph 2.11.2.14, no reefs were identified within the Hornsea Three benthic ecology study area coinciding with the North Norfolk Sandbanks and Saturn Reef SAC during the site specific surveys and should Annex I reef be present in the pre-construction survey within the North Norfolk Sandbanks and Saturn Reef SAC, appropriate measures will be discussed with statutory consultees to avoid direct impacts to these reefs from cable protection, where possible (see Table 2.18).

2.11.2.59 The impact is predicted to be of local spatial extent, long term duration, continuous and irreversible for the lifetime of the project (see Table 2.14). It is predicted that the impact will affect the receptors indirectly. The magnitude is therefore, considered to be minor.

Table 2.29: Maximum surface area from introduction of hard substrate within the North Norfolk sandbanks and Saturn Reef SAC during the operational phase.

Project element	Total surface area (m^2)	Assumptions
Cable protection associated with export cables	244,123	Assumes a maximum of 10% of the total length of 282 km of export cables within the North Norfolk Sandbanks and Saturn Reef SAC (up to six cables each of up to 47 km in length) will require cable protection. Assumes an up to 7 m wide cable corridor, cable protection to an indicative height of up to 2 m and a berm 3 m wide at the top, giving a per metre surface area of approximately 8.7 m^2.
Cable protection associated with cable/pipeline crossings	300,000	Assumes up to 20 crossings per export cable within the North Norfolk Sandbanks and Saturn Reef SAC, with habitat creation of up to 2,500 m^2.
Total surface area of introduced habitat	544,123	-

Sensitivity of the receptor

2.11.2.60 The introduction of hard substrate in the predominantly infaunal communities associated with the NcirBat, ApriBatPo and SspiMx biotopes has the potential to introduce species not typically present in these habitats to the area, as discussed in paragraphs 2.11.2.48 *et seq*. The consequences, adverse or beneficial, are difficult to determine but the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' is deemed to be of low vulnerability and international value. The sensitivity of this receptor is therefore, considered to be low.

Significance of the effect

2.11.2.61 Overall, the sensitivity of Annex I Habitats 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC is considered to be low and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of minor adverse or beneficial significance, which is not significant in EIA terms. Conclusions on the effects of Hornsea Three on the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

The Wash and North Norfolk Coast SAC

Magnitude of impact

2.11.2.62 The introduction of up to 57,135 m^2 of surface area of new hard substrate is predicted to occur because of the protection of up to 10% of the 66 km of export cables (six cables of up to 11 km in length) within The Wash and North Norfolk Coast SAC. This is predicted to affect up to 0.005% of the supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' within The Wash and North Norfolk Coast SAC. This impact is not predicted to affect any Annex I reef features of The Wash and North Norfolk Coast SAC as, as discussed in paragraph 2.11.2.23, no reefs were identified within the Hornsea Three benthic ecology study area coinciding with The Wash and North Norfolk Coast SAC during the site specific surveys and should Annex I reef be present in the pre-construction survey within The Wash and North Norfolk Coast SAC, appropriate measures will be agreed with statutory consultees to avoid direct impacts to these reefs from cable protection, where possible (see Table 2.18).

2.11.2.63 The impact is predicted to be of local spatial extent, long term duration, continuous and irreversible during the lifetime of Hornsea Three (see Table 2.14). It is predicted that the impact will affect supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' indirectly. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.11.2.64 The vulnerability of the NcirBat, MoeVen and SspiMx biotopes present within the Hornsea Three offshore cable route within The Wash and North Norfolk Coast SAC to this impact is as described in paragraphs 2.11.2.48 *et seq*. The type of substrate used in cable protection may influence the magnitude of change to the existing communities. Hard substrate from boulders have the potential to support a higher biodiversity and species abundance than soft bottom substrates. In comparison, gravels may result in a lower biodiversity increase and abundance of organisms due to the more unstable environment which they provide (Langhamer 2012 in Pidduck *et al*., 2017). The consequences, adverse or beneficial, are difficult to determine but supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' is deemed to be of low vulnerability and international value. The sensitivity of the receptor is therefore, considered to be low.

Significance of the effect

2.11.2.65 Overall, the sensitivity of supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' within The Wash and North Norfolk Coast SAC is considered to be low and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of minor adverse or beneficial significance, which is not significant in EIA terms. Conclusions on the effects of Hornsea Three on the conservation objectives of The Wash and North Norfolk Coast SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

Cromer Shoal Chalk Beds MCZ

Magnitude of impact

2.11.2.66 The introduction of new hard substrates for the protection of cables within the Cromer Shoal Chalk beds MCZ site is predicted to occur as a result of cable protection for up to 10% of up to 6 km of export cables (six cables of up to 1 km in length). A total of 5,194 m^2 of new hard substrate will be installed within the Cromer Shoal Chalk beds MCZ within the broadscale habitat Subtidal sand. This is predicted to affect up to 0.003% of the total area of the broadscale habitat Subtidal sand within the MCZ. The magnitude of the impact is considered to be negligible due to the highly localised spatial extent of this long term duration (i.e. restricted to the south western part of the Cromer Shoal Chalk Beds MCZ only), continuous and irreversible (during the lifetime of Hornsea Three; see Table 2.14) impact.

Sensitivity of the receptor

2.11.2.67 Given the presence of epifaunal species and colonising fauna within discrete parts of the Cromer Shoal Chalk Beds MCZ already (i.e. associated with coarse and mixed sediment habitats and hard substrates including chalk reefs), it is predicted that colonisation of hard substrates by common species, local to the Cromer Shoal Chalk Beds MCZ will occur, particularly as the new habitat will be sensitive to the local sediment types or geology as described in paragraph 2.11.2.32. The sensitivity of the NcirBat biotope associated with the Subtidal sand broadscale habitat features is as described in paragraph 2.11.2.48 *et seq*., although due to the prevalence of hard substrates in the Cromer Shoal Chalk Beds MCZ, it would be assumed that sensitivity of these habitats within the Cromer Shoal Chalk Beds MCZ would be lower than in offshore areas where hard substrates are less prevalent. These habitat features were deemed to be of low vulnerability and national importance and therefore of low sensitivity to this impact.

Significance of the effect

2.11.2.68 Overall, the sensitivity of the Subtidal sand broadscale habitat feature of the Cromer Shoal Chalk Beds MCZ is considered to be low and the magnitude of the impact is deemed to be negligible. The effect will, therefore, be of minor adverse or beneficial significance, which is not significant in EIA terms.

Markham's Triangle rMCZ

Magnitude of impact

2.11.2.69 A total of up to 944,322 m^2 of new hard substrate surface area will be installed within Markham's Triangle rMCZ area (Table 2.30). Associated increases in biodiversity will potentially affect the broadscale habitats Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments. The impact is predicted to be of local spatial extent, long term duration, continuous and irreversible during the lifetime of Hornsea Three (see Table 2.14). It is predicted that the impact will affect the broadscale habitats indirectly. The magnitude is therefore, considered to be minor.

Table 2.30: Maximum surface area from introduction of hard substrate within Markham's Triangle rMCZ during the operational phase.

Project element	Total surface area (m²)	Assumptions
Foundations and scour protection	671,238	Assumes a maximum of 24% of the total habitat creation associated with the placement of GBF and associated scour protection within the Hornsea Three array area.
Cable protection associated with array, interconnector and export cables within the array	252,237	Assumes maximum of 24% of up to 830 km of array cables, 225 km of interconnector and 168 km of export cables within the array (10% of all cables requiring cable protection) will require cable protection. Assumes an up to 7 m wide cable corridor, cable protection to an indicative height of up to 2 m and a berm 3 m wide at the top, giving a per metre surface area of approximately 8.7 m².
Cable protection associated with cable/pipeline crossings	20,846	Assumes a maximum of 24% of the total habitat creation associated with up to seven cable/pipeline crossings within the array.
Total surface area of introduced habitat	944,322	-

Sensitivity of the receptor

2.11.2.70 Within Markham's Triangle rMCZ, hard substrates are relatively rare with a seabed characterised by sand and coarse sediments and therefore introduction of hard substrates to these soft sediment habitats will represent a change in the communities within the Markham's Triangle rMCZ, enabling establishment of species not usually associated with soft sediment habitats. Sensitivity of the biotopes (i.e. PoVen and MysThyMx) associated with the broadscale habitat features of the Markham's Triangle rMCZ are as described in paragraphs 2.11.2.48 *et seq*. The features of the Markham's Triangle rMCZ are deemed to be of low vulnerability and national value. The sensitivity of the receptors is therefore, considered to be low.

Significance of the effect

2.11.2.71 Overall, the sensitivity of the broadscale habitats within Markham's Triangle rMCZ is predicted to be low and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of minor adverse or beneficial significance, which is not significant in EIA terms. Discussions on the effects of Hornsea Three on the Markham's Triangle rMCZ are presented in full within volume 5, annex 2.3: MCZ Assessment.

Increased risk of introduction or spread of INNS due to presence of subsea infrastructure and vessel movements (e.g. ballast water) may affect benthic ecology and biodiversity

2.11.2.72 The risks of introduction and spread of INNS during both the construction, and operation and maintenance phases have been considered and this assessment is considered to be equivalent to the following pressure identified by the ICGC pressures list under the overarching pressure theme 'Biological pressures':

- Introduction or spread of non-indigenous species.

2.11.2.73 The benchmark for the relevant MarESA pressure (of the same name) which has been used to inform this impact assessment is the direct or indirect introduction of one or more INNS.

2.11.2.74 The impact from construction vessels has been considered together with the impact during the operation and maintenance phase because the majority of this impact will arise as a result of the introduction of hard substrate associated with foundations and cable/scour protection with a smaller potential contribution from vessel movements.

Magnitude of impact

2.11.2.75 As discussed in paragraph 2.11.2.45, up to 5,470,308 m² of new hard substrate habitat (foundations, cable protection, scour protection and cable/pipeline crossings) will be created in the Hornsea Three benthic ecology study area, which will provide new habitat for the potential colonisation by INNS. There will be up to 10,774 round trips to port during the construction phase and up to 2,885 round trips to port by operational and maintenance vessels, which will contribute to the risk of introduction or spread of INNS in ballast water (see Table 2.14). Designed-in measures including a biosecurity plan, a PEMMP and vessels complying with the IMO ballast water management guidelines (Table 2.18) will, however, ensure that the risk of potential introduction and spread of INNS will be minimised.

2.11.2.76 Habitats A, B and C and ocean quahog *A. islandica* within the Hornsea Three array area are more likely to be at greater risk of impact by the introduction of INNS for two reasons. Firstly, much of the new surface area available for colonisation will be associated with the turbines and associated scour protection and cable protection required for array cables within the Hornsea Three array. Secondly, the array will be subjected to a higher risk of introduction of INNS by ballast water or from hulls of vessels, as construction vessels will be focussed on the turbines and the majority of up to 10,774 vessel round trips during the construction phase to port by construction vessels will be to the Hornsea Three array. Similarly, the majority of the 2,885 round trips to port per year, over the project lifetime, by operational and maintenance vessels will be to the Hornsea Three array. On the basis, however, that construction vessels will be arriving on site loaded, there is unlikely to be any requirement for discharge of ballast water within Hornsea Three.

2.11.2.77 Habitats A, B, C, D and E along the Hornsea Three offshore cable corridor, as well as ocean quahog *A. islandica*, are likely to be subjected to a lower risk of INNS introduction from the presence of infrastructure as the export cables will be buried for the most part. A maximum of 10% of the length of the Hornsea Three offshore cable corridor and up to 44 cable/pipeline crossings will have rock protection. The risk of introducing INNS (e.g. vessel fouling) will be considerably lower than at the Hornsea Three array, as only a limited number of round trips by construction and operational and maintenance vessels will be required for the Hornsea Three offshore cable corridor and over a greater geographic area.

2.11.2.78 The impact on Habitats A, B, C, D and E and ocean quahog *A. islandica* is predicted to be of local spatial extent (though the introduction of structures may serve as 'stepping stones' and extend the impact on a regional, national, or international scale, however based on current scientific knowledge it is not possible to predict the extent to which such a spread may occur and which species, if any, this may involve), long term duration, continuous and irreversible. It is predicted that the impact will affect the receptors indirectly. The magnitude is therefore considered to be negligible.

Sensitivity of the receptor

2.11.2.79 The introduction of hard substrate into a predominantly soft sediment area can facilitate the spread of non-native species which may predate on, and compete with, existing native species (Inger *et al*., 2009). Recent studies have demonstrated the potential for offshore renewable energy devices to act as ecological 'stepping stones', facilitating the spread of pelagic larval particles that would otherwise have been lost offshore and allowing the transgression of natural biogeographical boundaries (Adams *et al*., 2014). However, there is little evidence from post construction monitoring undertaken to date to suggest that the hard structures associated with offshore wind farms provide any new or unique opportunities for non-indigenous species which could facilitate their introduction (Linley *et al.,* 2007). A study by Kerckhof *et al*. (2011) of colonisation of Belgian offshore wind farm structures found that creating a new intertidal habitat in an offshore environment resulted in non-indigenous species constituting a major part (approximately one third) of the intertidal colonists. All the non-indigenous species observed, however, were already known to occur in the southern North Sea. These included the barnacles *Elminius modestus* and *Balanus perforatus*, the marine splash midge *Telmatogeton japonicas*, and the amphipod *Jassa marmorata*. Only one non-native species, the invasive American slipper limpet *Crepidula fornicata*, was found subtidally on the turbine columns (Kerckhof *et al*., 2011). *C. fornicata* can be a threat to muddy, mixed and clean sandy biotopes (Blanchard, 1997; De Montaudouin and Sauriau, 1999) though the availability of hard structures and particularly sediments with high gravel or shell content can support high densities of this gastropod (Bohn *et al*., 2015).

2.11.2.80 The carpet sea squirt *Didemnum vexillum*, believed to be native to Japan, was recorded in Holyhead in 2008 and was the first known occurrence of this organism in the UK. The limited evidence of the distribution of this species within the in the UK suggests that *D. vexillum* has predominantly colonised artificial surfaces in the UK, although it is now known to have spread subtidally on the open sea bed in Herne Bay, North Kent (Marine Biological Association, 2016). While mobile sands are unsuitable for growth, *D. vexillum* may have the potential to colonise and dominate offshore gravel habitats and has been recorded as covering over 50% of the seabed in parts on Georges Bank on the US/Canadian border (Valentine *et al*., 2007). A risk assessment undertaken by the Non-native Species Secretariat in 2011 (www.nonnativespecies.org/index.cfm?sectionid=51) on the threat that this organism poses to Great Britain concluded that entry and introduction were very likely, spread would be rapid and the impact would be massive.

2.11.2.81 Non-indigenous species currently co-exist with indigenous species in the region, as demonstrated by the fact that *C. fornicata* was identified within the Hornsea Three benthic ecology study area. Post-construction monitoring of the monopile structures at the OWEZ using video footage and samples collected by divers recorded colonisation by introduced/non-indigenous species including Japanese oyster *Crassostrea gigas*, slipper limpet and the Titan acorn barnacle *Megabalanus coccopoma* (Lindeboom *et al*., 2011).

2.11.2.82 Post construction monitoring of the Barrow offshore wind farm monopiles found no evidence of invasive or non-native species and similarly, studies of the Kentish Flats monopiles identified only *C. fornicata* (Cefas, 2009). The non-indigenous Japanese skeleton shrimp *Caprella mutica* was recorded at the Horns Rev offshore wind farm and despite its ability to rapidly colonise the turbine structures only negligible effects were observed on native communities and these resulted from an increase in local biodiversity and food availability rather than from negative effects (e.g. competition and predation) associated with the non-indigenous species (Bioconsult, 2006). The capacity for introduced hard substrate to facilitate the introduction and spread of non-indigenous species (e.g. via stepping stone effects) could potentially affect all subtidal VERs within the Hornsea Three benthic ecology study area.

2.11.2.83 A Biosecurity Plan has been adopted as a designed-in measure (Table 2.18) to ensure the likelihood of spreading this organism because of Hornsea Three, and all other INNS, is limited.

2.11.2.84 Habitats A, B and C within the Hornsea Three array area are considered more sensitive to impacts from the introduction of INNS as the installation of hard surfaces associated with Hornsea Three will essentially introduce a new type of habitat to the predominantly soft sediments of the Hornsea Three array area. As such, there will only be a limited local epifaunal community which will be able to colonise the new habitat resource, therefore any introduced INNS will face minimal competition and will be more likely to establish local populations. According to the MarESA (De-Bastos and Marshall, 2016a; Tillin, 2016a; Tillin, 2016b; Tillin and Rayment, 2016) some biotopes within these habitats are sensitive to colonisation by INNS, including *Caprella mutica*, *D. vexillum* and in particular *C. fornicata*.

2.11.2.85 With respect to Habitats D and E along the Hornsea Three offshore cable corridor, according to the MarESA, there is currently no evidence that non-indigenous species are currently significantly impacting *S. spinulosa* biotopes. Therefore, based on current evidence, resistance to this impact is assessed as high and recoverability is assessed as high, so that these habitats are generally not considered sensitive to impacts by INNS information (Tillin and Marshall, 2015).

2.11.2.86 Habitats A, B and C and *A. islandica* are deemed to be of medium vulnerability and regional to national value. The sensitivity of these receptors is therefore, considered to be medium.

2.11.2.87 Habitats D and E are deemed to be of low vulnerability and national value. The sensitivity of these receptors is therefore, considered to be low.

Significance of the effect

2.11.2.88 There is little evidence from other offshore wind farm developments within the North Sea of non-indigenous species having any adverse effects on key species and habitats. Overall, the sensitivity of Habitats A, B and C and *A. islandica* is considered to be medium and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

2.11.2.89 Overall, the sensitivity of Habitats D and E is considered to be low and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

North Norfolk Sandbanks and Saturn Reef SAC

Magnitude of impact

2.11.2.90 As discussed in paragraph 2.11.2.57, up to 544,123 m^2 of surface area of new hard substrate is predicted to be installed within the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC as a result of cable protection for up to 10% of 282 km of export cable within the North Norfolk Sandbanks and Saturn Reef SAC (six cables of up to 47 km in length) as well as up to 20 cable/pipeline crossings per cable. As discussed in paragraph 2.11.2.77, the risk of the introduction of INNS is considered to be minimal for the offshore cable route compared to the array as fewer vessels will be required for cable installation and the majority of cables will be buried.

2.11.2.91 The impact on Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC is predicted to be of local spatial extent, long term duration, continuous and irreversible. It is predicted that the impact will affect the receptors indirectly. The magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

2.11.2.92 The sediments characterising the NcirBat biotope are mobile and frequent disturbance limits the establishment of marine and coastal invasive non-indigenous species as the habitat conditions are unsuitable for most species, as exemplified by the low species richness characterising this biotope (Tillin 2016b). This biotope is therefore considered to have low vulnerability and high recoverability, and is assessed as not sensitive to this pressure. The sediment associated with the ApriBatPo biotope are also likely to be too mobile or otherwise unsuitable for most of the recorded invasive non-indigenous species currently recorded in the UK with the exception of *C. fornicata* (Tillin, 2016e). Based on *C. fornicata*, the ApriBatPo biotope sensitivity is assessed as high although this is likely to be over precautionary on the basis of the highly mobile nature of the sandy sediments within the SAC. The sensitivity of the SspiMx biotope also recorded within the North Norfolk Sandbanks and Saturn Reef SAC is as described in paragraph 2.11.2.83; this biotope is not considered to be sensitive to INNS (Tillin and Marshall, 2015).

Significance of the effect

2.11.2.93 Overall, the majority of the communities associated with the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC are not considered to be sensitive and the magnitude of the impact is deemed to be negligible. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms. Conclusions on the effects of Hornsea Three on the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

The Wash and North Norfolk Coast SAC

Magnitude of impact

2.11.2.94 As discussed in paragraph 2.11.2.62, up to 57,135 m^2 of surface area of new hard substrate is predicted to be installed within subtidal habitats within The Wash and North Norfolk Coast SAC because of cable protection for up to 10% of 66 km of export cable within the SAC (six cables of up to 11 km in length). Therefore, the potential available habitat for INNS will be small and the risk posed from cable installation vessels is also predicted to be small on the basis that fewer vessels will be operating in this area compared to the array area for example. The impact on supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' within The Wash and North Norfolk Coast SAC is predicted to be of local spatial extent, long term duration, continuous and irreversible. It is predicted that the impact will affect the receptors indirectly. The magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

2.11.2.95 The sensitivity of the NcirBat and SspiMx biotopes are as described in paragraph 2.11.2.92; they are not predicted to be sensitive to INNS. The sediments characterising the MoeVen biotope, also associated with the part of the offshore cable route coinciding with The Wash and North Norfolk Coast SAC, are also likely to be too mobile or otherwise unsuitable for most of the recorded invasive non-indigenous species currently recorded in the UK, although the MarESA identified *C. fornicata* as a potential for concern resulting in a biotope sensitivity of high, although this is likely to be over precautionary on the basis of the mobile nature of the sediments present in the nearshore area. The sensitivity of the internationally important supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' within The Wash and North Norfolk Coast SAC is, therefore, considered to be up to medium.

Significance of the effect

2.11.2.96 Overall, the sensitivity of communities associated with supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' within The Wash and North Norfolk Coast SAC is considered to be up to medium and the magnitude of impact is deemed to be negligible. The effect will, therefore, be of negligible significance, which is not significant in EIA terms. Conclusions on the effects of Hornsea Three on the conservation objectives of The Wash and North Norfolk Coast SAC are presented within the RIAA for Hornsea Three (document reference number A5.2).

Cromer Shoal Chalk Beds MCZ

Magnitude of impact

2.11.2.97 As discussed in paragraph 2.11.2.66, up to 5,194 m^2 of surface area of new hard substrate is predicted to be installed within the Subtidal sand broadscale habitat feature of the Cromer Shoal Chalk Beds MCZ because of cable protection for up to 10% of the 6 km of export cable within the Cromer Shoal Chalk Beds MCZ (six cables of up to 1 km in length). The small quality, together with the fact that the cable protection will, in parts, be expected to become buried will limit the opportunity for the establishment of INNS should they be introduced. As discussed in paragraph 2.11.2.77, the risk of the introduction of INNS from movements (e.g. from hull fouling) along this part of the Hornsea Three offshore cable corridor is considered to be minimal as fewer vessel round trips will be required and it is likely that each will be of shorter duration (in comparison to those in the array).

2.11.2.98 The impact on the Subtidal sand broadscale habitat feature of the Cromer Shoal Chalk Beds MCZ is predicted to be of local spatial extent, long term duration, continuous and irreversible. It is predicted that the impact will affect the receptors indirectly. The magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

2.11.2.99 The sediments characterising the NcirBat biotope characterising the Subtidal sand broadscale habitat feature of the Cromer Shoal Chalk Beds MCZ are mobile and frequent disturbance is expected to limit the establishment of INNS species as the habitat conditions are unsuitable for most species. The communities are considered to have high resistance, high recoverability to INNS and are of national value. The receptors are therefore, considered to be not sensitive to this pressure (Tillin, 2016b).

Significance of the effect

2.11.2.100 Overall, the broadscale habitats within the Cromer Shoal Chalk Beds MCZ are considered unlikely to be sensitive and the magnitude of the impact is deemed to be negligible. The effect will, therefore, be of negligible significance, which is not significant in EIA terms. Discussions on the effects of Hornsea Three on the Cromer Shoal Chalk Beds MCZ are presented in full within volume 5, annex 2.3: MCZ Assessment.

Markham's Triangle rMCZ

Magnitude of impact

2.11.2.101 Up to 944,322 m^2 of new hard substrate surface area will be installed within Markham's Triangle rMCZ area (see paragraph 2.11.2.69) which will predominantly comprise turbine foundations, scour protection and cable protection for array and interconnector cables. For the reasons outlined in paragraph 2.11.2.76, habitats within the array are at greater risk from INNS due to the greater extent of hard substrate installed, the fact that this substrate in the case of the foundations spans the whole water column, and that a greater number of vessels trips will be required for both construction and operation and maintenance.

2.11.2.102 The impact on the broadscale habitat features within the Markham's Triangle rMCZ (i.e. Subtidal coarse sediment, Subtidal sand and Subtidal mixed sediments) is however predicted to be of local spatial extent, long term duration, continuous and irreversible. It is predicted that the impact will affect the receptors indirectly. The magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

2.11.2.103 The sensitivity of the biotopes (i.e. PoVen and MysThyMx) associated with the broadscale habitat features of the Markham's Triangle rMCZ are as described in paragraphs 2.11.2.83 and 2.11.2.86. The sediments characterising these biotopes are likely to be too mobile for most of the recorded invasive non-indigenous species currently recorded in the UK, however the slipper limpet *C. fornicata* may colonise this habitat resulting in habitat change and potentially classification to the biotope to one dominated by this species. Therefore, resistance of these communities is assessed as none and resilience as very low, so overall sensitivity of these nationally important receptors is assessed as high (Tillin, 2016d; De-Basto and Marshall, 2016a).

Significance of the effect

2.11.2.104 Overall, the sensitivity of the broadscale habitats within Markham's Triangle rMCZ is predicted to be high and the magnitude of the impact is deemed to be negligible. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms. Discussions on the effects of Hornsea Three on the Markham's Triangle rMCZ are presented in full within volume 5, annex 2.3: MCZ Assessment.

Alteration of seabed habitats arising from effects on physical processes, including scour effects and changes in the wave and tidal regimes resulting in potential effects on benthic ecology

2.11.2.105 As detailed in Table 2.14, alteration of seabed habitats arising from effects on physical processes, including scour effects and changes in the wave and tidal regimes are predicted to occur during the operation and maintenance phase because of cable and foundation installation. Volume 2, chapter 1: Marine Processes and volume 5, annex 1.1: Marine Processes Technical Report provide a full description of the physical assessment used to inform the assessments made with respect to scour effects and changes in the wave and tidal regimes, with a summary of maximum design scenarios associated with this impact, as detailed in Table 2.14, provided in this section.

2.11.2.106 This assessment is considered equivalent to the following pressures identified by the ICGC pressures list under the overarching pressure theme 'Hydrological changes (inshore/local)':

- Local water flow (tidal current) changes (including sediment transport considerations); and
- Local wave exposure changes.

2.11.2.107 The benchmarks for the relevant MarESA pressures which have been used to inform this impact assessment are follows:

- Changes in local water flow (tidal current): the benchmark is a change in peak mean spring bed flow velocity of between 0.1 ms^{-1} to 0.2 ms^{-1} for more than 1 year. The pressure is associated with activities that have the potential to modify hydrological energy flows. This pressure is analogous to the impacts associated with the presence of turbine foundations and cable protection; and
- Local wave exposure changes: the benchmark is a change in nearshore significant wave height >3% but <5% for one year. Local changes in wave length, height and frequency can be caused by the change in both the distance of open water over which wind may be allowed to build waves and the strength of the wind. This pressure is typically associated with artificial reefs and wrecks and is considered to be analogous to impacts associated with the presence of turbine foundations and cable protection.

2.11.2.108 It is important to note that the predicted changes in water flow rates because of Hornsea Three (see volume 2, chapter 1: Marine Processes) are much lower than the MarESA benchmark used to inform the assessment below. The benchmark is a change of two categories of water flow rate for one year and, as this is not predicted to occur (see paragraph 2.11.2.110), significant effects on communities are not likely to occur.

Magnitude of impact

2.11.2.109 Volume 2, chapter 1: Marine Processes includes an assessment of the changes to waves (both in isolation and cumulatively), scour and tidal currents. In this assessment, the term 'local scour' refers to the local response to individual structure members. 'Global scour' refers to a region of shallower but potentially more extensive scour associated with a multi-member foundation resulting from the change in flow velocity through the gaps between members of the structure and turbulence shed by the entire structure. Global scour does not imply scour at the scale of the offshore wind farm array (volume 2, chapter 1: Marine Processes).

2.11.2.110 The presence of Hornsea Three would result in near-field current effects only (i.e. primarily within the offshore wind farm footprint), largely spatially limited to within the Hornsea Three array area and a narrow region just outside of the boundary (in the order of 4 km; see volume 2, chapter 1: Marine Processes) with predicted maximum changes in current speeds varying from +0.04 ms^{-1} to -0.1 ms^{-1}. Baseline tidal currents across the former Hornsea Zone vary from approximately 0.6 ms^{-1} (at High Water) to 1 ms^{-1} (at Low Water) for peak mean spring tides and as such the existing tidal strength can be classified as moderately strong (McLeod, 1996). As outlined in volume 1, chapter 3: Project Description, scour protection will be installed around foundations to reduce scour. Cables and cable protection along the Hornsea Three offshore cable corridor and within the Hornsea Three array area will only exert a highly localised influence on the tidal regime.

2.11.2.111 Scour development within the Hornsea Three array area is expected to be dominated by the action of tidal currents, and wave action is considered insufficient for scour around monopiles and jacket foundations. Of all the turbine foundation options, scour effects (vertical and horizontal) are predicted to be greatest for a 15 m diameter monopile structure (without scour protection), with a local scour depth of 19.5 m and local scour extent of 31.2 m in non-cohesive soil (31.2 m; see volume 2, chapter 1: Marine Processes). The maximum depth of scour is calculated using all maximum design assumptions about the development of scour and is the result of applying standard formulae. The scour dimensions described above will therefore not necessarily manifest in real terms.

2.11.2.112 The greatest individual foundation global scour extent is predicted to be 40.0 m, which is associated with the larger (40 m base length) piled jacket structure (see volume 2, chapter 1: Marine Processes).

2.11.2.113 For GBFs, the maximum predicted scour depth under currents alone for 53 m diameter design is 1.6 m. Scour due to waves is likely to result in a scour depth of 2.1 m scour for the same diameter structure, while a combined wave and current scour depth is predicted to be 3.4 m. For the 53 m diameter GBF, the scour hole extent is estimated to be 2.5 m (volume 2, chapter 1: Marine Processes).

2.11.2.114 For the Hornsea Three array area, the greatest total turbine foundation local scour footprint is associated with an array of 160 (15 m diameter) monopile foundations (724,801 m^2, equivalent to approximately 0.1% of the Hornsea Three array area). For the Hornsea Three array area, the greatest total turbine foundation global scour footprint is associated with an array of 300 smaller (33 m base diameter) piled jacket foundations (1,018,432 m^2, equivalent to approximately 0.16% of the Hornsea Three array area).

2.11.2.115 Within the Hornsea Three array area, although the impact from a change in marine processes is predicted to be of long term duration, continuous, and irreversible for the lifetime (see Table 2.14) of Hornsea Three, it is expected to be of local spatial extent (i.e. restricted to Hornsea Three array area and the immediate surrounding area).

2.11.2.116 Predicted impacts within the Hornsea Three array area will be of local extent, long term duration, continuous and irreversible for the lifetime (see Table 2.14) of Hornsea Three. It is predicted that the impact will affect the benthic receptors (Habitats A, B, and C and the ocean quahog *A. islandica*) directly. The magnitude within Hornsea Three array area is therefore, considered to be minor.

2.11.2.117 Predicted impacts along the Hornsea Three offshore cable corridor will be similar of a significantly reduced extent compared to those within the Hornsea Three array area. Again, the impact is predicted to be of long term duration, continuous and irreversible for the lifetime (see Table 2.14) of Hornsea Three, but of highly localised extent. It is predicted that the impact will affect the benthic receptors (Habitats A, B, C, D and E) directly. The magnitude along the Hornsea Three offshore cable corridor is considered to be negligible.

Sensitivity of the receptor

2.11.2.118 All VERs are likely to be affected by changes to flow rate, wave regime and increased scour found within, and immediately adjacent to, the boundary of Hornsea Three array area and to a lesser extent along the Hornsea Three offshore cable corridor (i.e. Habitats A, B, C, D and E and the ocean quahog *A. islandica*).

2.11.2.119 Habitats A and C are characteristic of areas subject to physical disturbance by weak to moderately strong tidal streams or because of wave action and have typically intermediate to high intolerance to large increases and decreases in flow rates. In very strong currents little sediment deposition will take place resulting in coarse sediments that retain little organic matter. The polychaete species characteristic of these habitats are less likely to be affected by increased water flow rate as these species burrow deeper and hunt infaunally (Tillin, 2016b). Burrowing species, such as the amphipod *Bathyporeia pilosa* and key species such as the bivalve *F. fabula* and the polychaetes *Magelon*a sp. are deposit feeders and show a preference for finer sediments. As such, these species may be lost with a shift in the community to one representative of coarser sediments (Tillin and Rayment, 2016). Decrease in water flow, may lead to increased fine sediment deposition, also changing the nature of the substrate to one which favours deposit feeders, therefore resulting in changes to species composition (Tillin, 2016b; Tillin and Rayment, 2016). Recoverability of these habitats is likely to be high to very high on return to prior conditions, but this is not considered relevant for the duration of the operational period. The ocean quahog *A. islandica*, due to the depths in the sediment in which this species lives, has low intolerance and high recoverability to changes in flow rate (Sabatini *et al*., 2008).

2.11.2.120 The brittlestar dominated communities of Habitat B, which was found in deeper waters, are typically associated with areas of weak or very weak tidal streams and so are likely to have high intolerance to changes in water flow. Characterising species such as *A. filiformis* are suspension feeders with no self-produced feeding current, as such; water flow rate is likely to be of primary importance to these species. In increased flow rates *A. filiformis* may be unlikely to maintain their arms vertically in the feeding position and over the long term the nature of the top layers of sediment may become coarser and therefore possibly unsuitable for shallow burrowing species such as brittlestars. Reduced flow rates can impede feeding because it may reduce the transport of organic particles (Hill, 2004). Recoverability of these habitats is likely to be high to very high on return to prior conditions, but this is not considered relevant for the duration of the 35 year design life.

2.11.2.121 Habitats D and E have high intolerance to increases and decreases in flow rate. The tubes of *S. spinulosa* would likely be broken up and redistributed along with much of the infauna and epifaunal species attached to the *S. spinulosa* aggregations in areas of flow increase. As a result, many of the species would be at increased risk of predation at the surface and declines in species richness may be observed (Marshall, 2008). Decreases in flow rate are likely to hinder growth and repair of *S. spinulosa* tubes and reduce food availability for suspension feeders and deposit feeders. However, recovery of this habitat is likely to be high on return to prior conditions, as discussed in paragraph 2.11.1.29, but this is not considered relevant for the duration of the 35 year design life. Changes to the hydrodynamic regime may also affect sediment and/or *S. spinulosa* larval supply, however, this is considered unlikely due to the small predicted changes to current flow across the Hornsea Three array area.

2.11.2.122 Habitats A, B, C and D are deemed to be of low to medium vulnerability and regional value. The sensitivity of the receptors to the magnitude of changes predicted is therefore, considered to be low.

2.11.2.123 Habitat E and the ocean quahog *A. islandica* are deemed to be of low to medium vulnerability and national value. The sensitivity of the receptors to the magnitude of changes predicted is therefore, considered to be medium.

Significance of the effect

2.11.2.124 The predicted changes to flow rate are small and below the MarESA benchmark levels used to assess the sensitivity of the receptors. Although effects may be observed they are likely to be subtler than those described above. Benthic species in the area are tolerant to a certain degree of instability, as well as fluctuating levels of suspended sediments and variable sediment deposition rates, arising from scour and/or small changes in the local wave and tide regime.

2.11.2.125 Overall, the sensitivity of the receptors is considered to be low to medium and the magnitude of the impact is deemed to be negligible for the offshore cable corridor and minor for the Hornsea Three array. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms.

North Norfolk Sandbanks and Saturn Reef SAC

Magnitude of impact

2.11.2.126 The presence of the turbine foundations and associated infrastructure also has the potential to affect the wave regime which could lead to potential impacts on offshore sandbanks including Annex I 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC. The results of the wave modelling predict a general reduction in wave height in the region of the north Norfolk sandbanks when waves are coming from the north, north northeast and north east, which is about 15% of the time. During these conditions, there may be a small reduction in wave height of up to 15% within the vicinity of the Indefatigable Bank system and up to ~2% within the vicinity of sandbanks closer inshore (e.g. Ower Bank; see volume 5, annex 1.1: Marine Processes Technical Annex). Whilst impacts to sandbanks could theoretically occur throughout the operational lifetime (see Table 2.14) of Hornsea Three (i.e. be of long term duration), any impacts would be intermittent in nature. The magnitude of the impact is considered to be minor.

Sensitivity of the receptor

2.11.2.127 Subtidal mobile sandbanks are subject to continued reworking of the sediment by wave action and tidal streams and thus are dominated by species capable of tolerating severe changes in the hydro-physical regime (Elliott *et al*., 1998). The sandy communities recorded along the Hornsea Three offshore cable corridor within the North Norfolk Sandbanks and Saturn Reef SAC comprised biotopes that represent communities comprising low infaunal and epifaunal diversity, namely the NcirBat and ApriBatPo biotopes (see 2.11.1.61 and volume 5, annex 2.1: Benthic Ecology Technical Report), in addition the biotope IMoSa has also been recorded at the sandbanks (Jenkins *et al*., 2015). The sandy communities associated with the sandbanks in this designated site are typically sparse and dominated by *Bathyporeia* spp. and *Nephtys cirrosa* (Jenkins *et al*., 2015). The NcirBat biotope is not sensitive to local changes in tidal current flow or local changes in wave exposure (Tillin, 2016b). Mobile sands characterise this biotope and water movement is therefore an important physical parameter for this biotope, largely as wave action rather than tidal flow, however an increase in flow-related disturbance could shift the community assemblage to one characteristic of the IMoSa biotope, while a decrease can alter NcirBat to the FfabMag biotope (Tillin, 2016b).

2.11.2.128 Similarly, the ApriBatPo biotope is not considered to be sensitive to local changes in tidal current flow or local changes in wave exposure (Tillin, 2016e). Characteristic species may be associated with troughs and crests of rippled bedforms which are created by the tidal flow and wave action, therefore this biotope may emerge following an increase in water flow, or disappear following a reduction in flow (Tillin, 2016e). As discussed in paragraph 2.11.2.110 the tidal currents across the former Hornsea Zone vary from approximately 0.6 ms^{-1} to 1 ms^{-1}. ApriBatPo occurs in flow strengths of between <0.5 ms^{-1} and 1.5 ms^{-1}, therefore the predicted maximum changes in current speeds resulting from Hornsea of +0.04 ms^{-1} to -0.1 ms^{-1} would be unlikely to cause the ApriBatPo biotope to disappear.

2.11.2.129 As discussed in paragraph 2.11.2.121, *S. spinulosa* is tolerant of local changes in tidal current flow and local changes in wave exposure (Tillin and Marshall, 2015). As such, Annex I *S. spinulosa* reefs are not considered to be sensitive to these effects.

2.11.2.130 'Sandbanks which are slightly covered by seawater all the time' and *S. spinulosa* reefs are considered to be of low vulnerability, high to immediate recoverability and of international importance. The sensitivity of the benthic communities associated with 'sandbanks which are slightly covered by water all the time' and Annex I reefs are discussed in paragraphs 2.11.2.119 and 2.11.2.121, respectively, however these features are of international importance and are therefore considered to be of medium sensitivity. This reflects the assessment of the Annex I sandbank features of the North Norfolk Sandbanks and Saturn Reef SAC in volume 2, chapter 1: Marine Processes, for changes to the wave regime impact.

Significance of the effect

2.11.2.131 Overall, the sensitivity of Annex I 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC is considered to be medium and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms. Conclusions on the effects of Hornsea Three on the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

The Wash and North Norfolk Coast SAC

Magnitude of impact

2.11.2.132 The presence of the turbine foundations and associated infrastructure also has the potential to affect the wave regime which could lead to potential impacts on Annex I habitats within The Wash and North Norfolk Coast SAC. However, the results of the wave assessment presented in volume 5, annex 1.1: Marine Processes Technical Report, indicates that although the presence of Hornsea Three will cause a localised reduction in wave heights, under all the wave conditions tested (magnitudes and directions), predicted measurable changes to wave heights due to the operational presence of Hornsea Three do not extend to the adjacent coastlines. Therefore, no effects are predicted on habitats within The Wash and North Norfolk Coast SAC as a result of changes to the wave regime. Impacts associated with cable protection will only exert a highly localised influence on the tidal regime such that the magnitude is considered to be negligible.

Sensitivity of the receptor

2.11.2.133 As discussed in paragraph 2.11.2.130, the sensitivity of the benthic communities associated with the Annex I habitat 'Sandbanks which are slightly covered by water all the time' and Annex I reefs is considered to be medium.

Significance of the effect

2.11.2.134 Overall, the sensitivity of the Annex I habitat 'Sandbanks which are slightly covered by water all the time' and Annex I reefs within The Wash and North Norfolk Coast SAC is considered to be medium and the magnitude of the impact is deemed to be negligible. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms. Conclusions on the effects of Hornsea Three on the conservation objectives of The Wash and North Norfolk Coast SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

Cromer Shoal Chalk Beds MCZ

Magnitude of impact

2.11.2.135 Impacts associated with cable protection within the Cromer Shoal Chalk Beds MCZ will only exert a highly localised influence on the tidal regime such that the magnitude on the broadscale habitats within the Cromer Shoal Chalk Beds MCZ is considered to be negligible.

Sensitivity of the receptor

2.11.2.136 Subtidal chalk reef and peat and clay exposures have low to no sensitivity to flow rates and are not sensitive to wave exposure changes (De-Bastos and Hill, 2016c; Tillin and Hill, 2016). The CR.MCR.SfR.Pid: 'Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay' biotope has been recorded in locations with tidal flow rates ranging from 0.5 to 1.5 ms^{-1} (Connor *et al*., 2004), which is within the baseline tidal current for the Hornsea Three benthic ecology study area (see paragraph 2.11.2.110), and taking into account the maximum changes in current speeds resulting from Hornsea Three. The CR.MCR.SfR.Pol: '*Polydora* sp. tubes on moderately exposed sublittoral soft rock' biotope is known to occur across a range of tidal stream strengths, including strong (3-6 knots), moderately strong (1-3 knots) and weak (<1 knot; Conner *et al*., 2004), though *Polydora ciliata* may be removed by very strong water currents (De-Bastos and Hill, 2016c). A change of up to 0.2 ms^{-1} (the benchmark) is considered to be within normal physical conditions for this biotope as such it is not sensitive to changes in water flow. CR.MCR.SfR.Pol is not considered sensitive to local wave exposure changes, the most damaging change to this biotope is increased wave heights sufficient in power to accelerate erosion of the soft rock with which this biotope is associated (De-Bastos and Hill, 2016c), but a pressure of this nature is not predicted to result from Hornsea Three. Similar to the two previously discussed soft-rock biotopes, the CR.MCR.SfR.Hia: '*Hiatella*-bored vertical sublittoral limestone rock' biotope is not regarded as sensitive to changes in either local tidal current flow or local wave exposure. The wrinkled borer *Hiatella arctica* together with other characterising species of this biotope are considered tolerant of changes at the relevant pressure benchmarks (Tillin, 2016g).

2.11.2.137 Subtidal sand within the designated area was assigned the NcirBat. As discussed in paragraph 2.11.2.127, the NcirBat biotope is not sensitive to local changes in tidal current flow or local changes in wave exposure (Tillin, 2016b). The coarse sediments in the MCZ were found to solely comprise the MoeVen biotope; similar to NcirBat the MoeVen biotope communities are not considered to be sensitive to local changes in tidal current flow or local changes in wave exposure (Tillin, 2016c). The mixed sediments in the MCZ were characterised by the PoVen and SspiMx biotopes. PoVen typically occurs in areas with low tidal flow rates and low wave exposure and in various sediments types. The strong link between sediment composition and hydrodynamic conditions indicates that the associated community is not vulnerable to changes in tidal current flow or wave exposure and this biotope is therefore considered not sensitive (Tillin, 2016d).

2.11.2.138 As discussed in paragraph 2.11.2.121, *S. spinulosa* is tolerant of local changes in tidal current flow and local changes in wave exposure (Tillin and Marshall, 2015). As such, *S. spinulosa* is not considered to be sensitive to these effects.

2.11.2.139 Sensitivity of the broadscale features of MCZ/rMCZs and SACs (subtidal coarse sediments, subtidal sand, subtidal mixed sediments, subtidal chalk reef and peat and clay exposures) which are features of the Cromer Shoal Chalk Beds MCZ, are of national importance and therefore are considered to be of medium sensitivity.

Significance of the effect

2.11.2.140 Overall, the sensitivity of the broadscale habitats within the Cromer Shoal Chalk Beds MCZ is considered to be medium and the magnitude of the impact is deemed to be negligible. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms. Discussions on the effects of Hornsea Three on the Cromer Shoal Chalk Beds MCZ are presented in full within volume 5, annex 2.3: MCZ Assessment.

Markham's Triangle rMCZ

Magnitude of impact

2.11.2.141 The potential impact to the broadscale habitat features of Markham's Triangle rMCZ (i.e. Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments) is as described in paragraph 2.11.2.110 *et seq*. for the Hornsea Three array. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.11.2.142 The section of the Markham's Triangle rMCZ that coincides with the Hornsea Three array area is characterised predominantly by the PoVen biotope with smaller areas of the MysThyMx biotope in the west and north east of the site. The PoVen biotope is not regarded as sensitive to changes in tidal current flow or wave exposure (Tillin 2016d). The MysThyMx biotope is not considered as sensitive to local change in either tidal current flow or wave exposure (De-Bastos and Marshall, 2016a), as it occurs in areas subject to a range of flow conditions, from weak (<0.5 ms^{-1}) to moderately strong (0.5-1.5 ms^{-1}).

2.11.2.143 Sensitivity of the features of the Markham's Triangle rMCZ, i.e. subtidal coarse sediments, subtidal sand and subtidal mixed sediments, are considered to be of medium sensitivity, due to their national importance.

Significance of the effect

2.11.2.144 Overall, the sensitivity of the broadscale habitats within Markham's Triangle rMCZ is considered to be medium and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms. The effects of Hornsea Three on Markham's Triangle rMCZ are presented in full within volume 5, annex 2.3: MCZ Assessment.

Maintenance operations may result in temporary seabed disturbances and potential effects on benthic ecology

2.11.2.145 This assessment is considered equivalent to the following pressure identified by the ICGC pressures list under the overarching pressure theme 'Physical damage (reversible change)':

- Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion.

2.11.2.146 The benchmarks for the relevant MarESA pressures which have been used to inform this impact assessment are follows:

- Abrasion/disturbance at the surface of the substratum: the benchmark for which is damage to surface features (e.g. species and physical structures within the habitat). This pressure is analogous to the impacts associated with jack-up vessel operations and anchor placements; and
- Penetration and/or disturbance of the substratum below the surface: the benchmark for which is damage to sub-surface features (e.g. species and physical structures within the habitat). This pressure is analogous to the impacts associated with cable re-burial, jack-up vessel operations and anchor placements.

Magnitude of impact

2.11.2.147 During the operation and maintenance phase, a total of up to 9,770,400 m^2 of temporary habitat disturbance is predicted to arise over the 35 year design life of Hornsea Three (equating to 0.19% of the Hornsea Three benthic ecology study area). Of this total, up to 5,573,280 m^2 will result from jack-up operations within the Hornsea Three array area associated with turbine and offshore substation component replacement and access ladder/j-tube repair/replacement (Table 2.14). Impacts will be restricted to the immediate area around the turbine foundations, where spud-can legs will encounter benthic habitats. The spatial extent of this impact is very small in relation to the total area of Hornsea Three although there is the potential for repeat disturbance to the habitats in the immediate vicinity of the foundations because of these activities.

2.11.2.148 Similarly, subtidal cable remedial burial and repair works will affect benthic habitats in the immediate vicinity of these operations. As outlined in Table 2.14, within the Hornsea Three array, up to 1,250,700 m^2 of temporary habitat disturbance is predicted to arise from remedial burial and repair works for array and interconnector cables. Temporary habitat disturbance is predicted to affect up to 2,946,420 m^2 of benthic habitats along the Hornsea Three offshore cable corridor because of export cable remedial burial and repair works.

2.11.2.149 The VERs that would be affected by operational jack-up and cable remedial burial and repair works are restricted to those within the boundary of the Hornsea Three array area and along the Hornsea Three offshore cable corridor (i.e. Habitats A, B C, D and E) and *A. islandica*. During the operation and maintenance phase, the maximum design scenario for jack-up operations and cable maintenance within the Hornsea Three array in relation to benthic VERs is that all this temporary habitat loss/disturbance (i.e. 6,823,980 m^2) could occur wholly within each of these habitats equating to the following percentages of the total area of these VERs in the Hornsea Three benthic ecology study area: Habitat A (0.32%), B (0.49%) and C (0.52%).

2.11.2.150 The total temporary disturbance of up to 2,946,420 m^2 to habitats along the Hornsea Three offshore cable corridor as a result of cable remedial burial and repair will be of a smaller magnitude than that within the Hornsea Three array and is estimated to affect the VERs as follows: up to 963,952 m^2 for Habitat A, 90,939 m^2 for Habitat B, 982,140 m^2 for Habitat C and 909,389 m^2 for Habitat D.

2.11.2.151 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 (0.0013%) of the total area of the OSPAR Region II within which *A. islandica* is listed as under threat and/or decline.

2.11.2.152 Temporary seabed disturbance will be avoided where possible to minimise any direct impacts on Habitat E (*S. spinulosa* reef outside an SAC/SCI). Pre-construction surveys are to be undertaken along the Hornsea Three offshore cable corridor to identify these discrete benthic habitats of conservation importance, and appropriate measures will be discussed with statutory consultees to avoid direct impacts on these features, where possible (see Table 2.18). A precautionary maximum adverse scenario considers that up to approximately 2,728 m^2 of Habitat E may be affected by maintenance activities in the event that this habitat cannot be avoided during construction.

2.11.2.153 The impact on Habitats A, B C, D and E and *A. islandica* is predicted to be of local spatial extent, short term duration (i.e. individual maintenance operations would occur over the period of days to weeks, over up to a maximum of three months for cable repairs), intermittent and reversible. It is predicted that the impact will affect the receptors directly. The magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

2.11.2.154 As discussed in paragraphs 2.11.1.26 to 2.11.1.33, Habitats A to E have typically low to intermediate intolerance to physical disturbance as the characterising species are predominantly infaunal. However, recovery is likely to be high as the component species are highly mobile, tolerant of sediment movement and would accompany the influx/re-settlement of disturbed material (Tillin, 2016b; Tillin 2016c, 2016d; Tillin and Rayment, 2016). As such, at most, minor localised declines in species richness are predicted to occur because of maintenance jack-up and cable re-burial operations. In addition, the frequency of maintenance jack-up operations (i.e. approximately six over the lifetime of a turbine) will allow for the recovery of benthic communities between these events. Habitats A, B and C and D are deemed to be of low to medium vulnerability, high recoverability and regional value. The sensitivity of these receptors is therefore, considered to be low. Habitat E is deemed to be of high vulnerability, medium to high recoverability and national value; overall the sensitivity is considered to be medium.

2.11.2.155 As discussed in paragraph 2.11.1.36, *A. islandica* has intermediate intolerance to displacement and abrasion/physical disturbance but recoverability is predicted to be very low (Tyler-Walters and Sabatini, 2017). In addition, the historic benthic ecology surveys did not suggest that Hornsea Three is of particular importance for this species. *A. islandica* is deemed to be of medium vulnerability, very low recoverability and national value. The sensitivity of this receptor is therefore, considered to be high.

Significance of the effect

2.11.2.156 The area of benthic habitat affected by individual operational jack-up operations and cable remedial burial and repair events on Habitats A, B, C, D and E and *A. islandica*, will each be very small and highly localised in nature. However, there is the potential, over the 35 year design life of Hornsea Three, for repeat disturbance to habitats around foundations. Overall, the sensitivity of Habitats A, B, C and D is considered to be low, the sensitivity of Habitat E is considered to be medium and the magnitude of the impact is deemed to be negligible. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms.

2.11.2.157 Overall, the sensitivity of *A. islandica* is considered to be high and the magnitude of the impact is deemed to be negligible. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms.

North Norfolk Sandbanks and Saturn Reef SAC

Magnitude of impact

2.11.2.158 Of the total temporary habitat disturbance loss predicted for Hornsea Three during operation and maintenance in paragraph 2.11.2.147, up to 849,851 m^2 of this is predicted to affect the Annex I 'Sandbanks which are slightly covered by seawater all the time' habitat within the North Norfolk Sandbanks and Saturn Reef SAC over the 35 year design life. This equates to 0.02% of the extent of this Annex I habitat within the North Norfolk Sandbanks and Saturn Reef SAC (i.e. assuming all sediment within the SAC is assigned to Annex I sandbank habitat; JNCC, 2010). It was considered over precautionary and unrealistic to assume that all the temporary habitat disturbance within the Hornsea Three offshore cable corridor would occur entirely within this site, therefore it has been calculated on the assumption that, as approximately 29% of the total export cable length coincides with the North Norfolk Sandbanks and Saturn Reef SAC, 29% of the total operational temporary habitat loss along the Hornsea Three offshore cable corridor could occur within the site. Temporary disturbance to Annex I reef features within this site will be avoided where possible to minimise any direct impacts and, based on the current distribution of habitats within the Hornsea Three offshore cable corridor, impacts to Annex I reef habitat are not predicted.

2.11.2.159 The impact is predicted to be of local spatial extent, short term duration (i.e. individual cable maintenance operations would occur over the period of days to weeks, over up to a maximum of three months for cable repairs), intermittent and reversible. It is predicted that the impact will affect the receptors directly. The magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

2.11.2.160 The sensitivity of the NcirBat and ApriBatPo biotopes associated with the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' is as described in paragraphs 2.11.1.24 to 2.11.1.26. Resistance is considered to be medium, recoverability high and overall sensitivity to temporary disturbance including abrasion is assessed as low.

Significance of the effect

2.11.2.161 It is predicted that the sensitivity of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC is low and the magnitude of the impact is deemed to be negligible. The effect will, therefore, be of negligible significance, which is not significant in EIA terms. The effect has been assessed as negligible, rather than minor adverse (see Table 2.17), on the basis that the impact will be highly localised within the North Norfolk Sandbanks and Saturn Reef SAC with up to only 0.02% of Annex I habitat within the North Norfolk Sandbanks and Saturn Reef SAC affected and that the associated communities are predicted to recover rapidly from disturbance of this nature. Conclusions on the effects of Hornsea Three on the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

The Wash and North Norfolk Coast SAC

Magnitude of impact

2.11.2.162 Of the total temporary habitat disturbance loss predicted for Hornsea Three during operation and maintenance in paragraph 2.11.2.147, up to 198,838 m^2 of this is predicted to affect supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time', within The Wash and North Norfolk Coast SAC over the 35 year design life of Hornsea Three as a result of export cable remedial burial and repair activities. This equates to approximately 0.02% of the total habitat within The Wash and North Norfolk Coast SAC. It was considered over precautionary and unrealistic to assume that all the temporary habitat disturbance within the Hornsea Three offshore cable corridor would occur entirely within this site, therefore it has been calculated on the assumption that, as approximately 7% of the total export cable length coincides with The Wash and North Norfolk Coast SAC, 7% of the total operational temporary habitat loss along the Hornsea Three offshore cable corridor could occur within the site. Temporary disturbance to Annex I reef features within this site will be avoided where possible to minimise any direct impacts.

2.11.2.163 The impact to supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' is predicted to be of local spatial extent, short term duration (i.e. individual cable maintenance operations would occur over the period of days to weeks, over up to a maximum of three months for cable repairs), intermittent and reversible. It is predicted that the impact will affect the receptors directly. The magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

2.11.2.164 The sensitivity of the NcirBat, MoeVen and SspiMx biotopes associated with the part of the Hornsea Three offshore cable corridor coinciding with The Wash and North Norfolk Coast SAC is as described in paragraphs 2.11.1.24 to 2.11.1.33, and is as summarised in paragraphs 2.11.1.75, 2.11.1.76 and 2.11.2.154. Resistance is considered to be medium and recoverability high for NcirBat and MoeVen with overall sensitivity to temporary disturbance including abrasion assessed as low. For the SspiMx biotope recoverability is medium leading to an overall sensitivity of medium.

Significance of the effect

2.11.2.165 Overall, the sensitivity of supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' within The Wash and North Norfolk Coast SAC is considered to be low to medium and the magnitude of the impact is deemed to be negligible. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms. The effect has been assessed as negligible, rather than minor adverse (see Table 2.17), on the basis that the impact will be highly localised within The Wash and North Norfolk Coast SAC with up to only 0.02% of Annex I habitat within The Wash and North Norfolk Coast SAC affected and that the associated communities are predicted to recover rapidly from disturbance of this nature. Conclusions on the effects of Hornsea Three on the conservation objectives of The Wash and North Norfolk Coast SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

Cromer Shoal Chalk Beds MCZ

Magnitude of impact

2.11.2.166 Of the total temporary habitat disturbance loss predicted for Hornsea Three during operation and maintenance in paragraph 2.11.2.147, up to 18,076 m^2 of this is predicted to affect the broadscale habitat Subtidal sand within the Cromer Shoal Chalk Beds MCZ over the 35 year design life of Hornsea Three as a result of export cable remedial burial and repair activities. This equates to approximately 0.10% of the total area of this habitat within the Cromer Shoal Chalk Beds MCZ. It was considered over precautionary and unrealistic to assume that all the temporary habitat disturbance within the Hornsea Three offshore cable corridor would occur entirely within this site, therefore it has been calculated on the assumption that, as approximately 0.6% of the total export cable length coincides with the Cromer Shoal Chalk Beds MCZ, 0.6% of the total operational temporary habitat loss along the Hornsea Three offshore cable corridor could occur within the site. The impact is predicted to be of local spatial extent, short term duration (i.e. individual cable maintenance operations would occur over the period of days to weeks, over up to a maximum of three months for cable repairs), intermittent and reversible. It is predicted that the impact will affect the receptors directly. The magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

2.11.2.167 The sensitivity of the NcirBat biotope associated with the Subtidal sand feature within the Hornsea Three offshore cable corridor is as described in paragraphs 2.11.1.24 to 2.11.1.26 and as summarised in paragraphs 2.11.1.61 and 2.11.2.154. Resistance is considered to be medium, recoverability high and overall sensitivity to temporary disturbance is assessed as low.

Significance of the effect

2.11.2.168 Overall, the sensitivity of the broadscale habitat Subtidal sand within the Cromer Shoal Chalk Beds MCZ is considered to be low and the magnitude of the impact is deemed to be negligible. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms. This has been concluded on the basis that the impact will be highly localised affecting a very small proportion of habitats within the Cromer Shoal Chalk Beds MCZ that have a low sensitivity of disturbance of this nature. Discussions on the effects of Hornsea Three on the Cromer Shoal Chalk Beds MCZ is presented in volume 5, annex 2.3: Marine Conservation Zone Assessment.

Markham's Triangle rMCZ

Magnitude of impact

2.11.2.169 Of the total temporary habitat disturbance loss predicted for Hornsea Three during operation and maintenance in paragraph 2.11.2.147, up to 1,625,776 m^2 of this is predicted to affect broadscale habitat features of Markham's Triangle rMCZ over the 35 year design life of Hornsea Three as a result of jack-up operations and cable remedial burial and repair activities. This equates to 0.81% of the total benthic habitat within the site and assumes that 24% of all operation and maintenance temporary habitat disturbance for the array could occur in the part of the Hornsea Three array which overlaps with the Markham's Triangle rMCZ (see paragraph 2.11.1.91 for a full explanation of this reasoning).

2.11.2.170 Using the spatial extents of the qualifying habitats (including the broadscale habitat Subtidal mixed sediments which may be proposed for designation) mapped in Defra (2014), the total predicted temporary habitat disturbance to each of the qualifying habitat features of the Markham's Triangle rMCZ is as follows:

- 1,625,776 m^2 of Subtidal coarse sediments equating to 1.12% of the total extent of this habitat within the Markham's Triangle rMCZ – assuming that, as a maximum design scenario, the temporary habitat loss/disturbance would occur entirely within this broadscale habitat feature of the Markham's Triangle rMCZ;
- 172,753 m^2 of Subtidal sand sediment equating to 0.66% of the total extent of this habitat within the Markham's Triangle rMCZ – assuming that, as Subtidal sand extends over approximately 10.63% of the area of the Markham's Triangle rMCZ coinciding with the Hornsea Three array area, 10.63% of the maximum temporary habitat loss/disturbance could occur within this habitat; and
- 210,617 m^2 of Subtidal mixed sediments equating to 0.76% of the total extent of this habitat within the Markham's Triangle rMCZ – assuming that, as Subtidal mixed sediment extends over approximately 12.95% of the area of the Markham's Triangle rMCZ coinciding with the Hornsea Three array area,12.95% of the maximum temporary habitat loss/disturbance could occur within this habitat.

2.11.2.171 The impact of temporary habitat disturbance on qualifying (and proposed qualifying) features of the Markham's Triangle rMCZ (i.e. Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments) is predicted to be localised to within the western area of the Markham's Triangle rMCZ, of short term duration and intermittent in nature. It is predicted that the impact will affect the receptors directly and, in the case of jack-up operations, there may be some repeat disturbance to benthic habitats. The magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

2.11.2.172 The sensitivity of the PoVen and MysThyMx biotopes associated with the part of the Markham's Triangle rMCZ coinciding with the Hornsea Three array area is as described in paragraph 2.11.1.28. Resistance is considered to be low medium and recoverability high with overall sensitivity to temporary disturbance including abrasion assessed as low.

Significance of the effect

2.11.2.173 Overall, the sensitivity of the broadscale habitats within Markham's Triangle rMCZ is considered to be low and the magnitude of the impact is deemed to be negligible. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms. This has been concluded on the basis that the impact will be highly localised affecting a very small proportion of habitats within the Markham's Triangle rMCZ that have a low sensitivity of disturbance of this nature. Discussions on the effects of Hornsea Three on the Markham's Triangle rMCZ is presented in volume 5, annex 2.3: Marine Conservation Zone Assessment.

Accidental release of pollutants (e.g. from accidental spillage/leakage) may affect benthic ecology

2.11.2.174 As discussed in paragraph 2.11.1.142, an accidental release of pollutants is considered equivalent to several pressures identified by the ICGC pressures list under the overarching pressure theme 'Pollution and other chemical changes'.

- Transition elements and organo-metal (e.g. TBT) contamination (Including priority substances listed in Annex II of Directive 2008/105/EC);
- Hydrocarbon and PAH contamination (Including priority substances listed in Annex II of Directive 2008/105/EC);
- Synthetic compound contamination (Including pesticides, antifoulants, pharmaceuticals and priority substances listed in Annex II of Directive 2008/105/EC); and
- Introduction of other substances (solid, liquid or gas).

2.11.2.175 The benchmarks are identical for all the relevant MarESA pressures listed above which have been used to inform this impact assessment, and are compliant with the applicable AA EQS, and conform with PELs, EACs and ER-Ls (Tillin and Tyler-Walters, 2015).

Magnitude of impact

2.11.2.176 The magnitude of the impact is entirely dependent on the nature of the pollution incident but the SEA carried out by DECC (2011c) recognised that, "renewable energy developments have a generally limited potential for accidental loss of containment of hydrocarbons and chemicals, due to the relatively small inventories contained on the installations (principally hydraulic, gearbox and other lubricating oils, depending on the type of installation)".

2.11.2.177 A typical turbine is likely to contain approximately up to 25,000 l of lubricants (hydraulic oil, gear oil and grease), 80,000 l of liquid nitrogen, 7,000 kg of transformer silicon/ester oil, 2,000 l of diesel, 13,000 l of coolant and up to 6 kg of SF6. The nacelle, tower, and hub will be designed to retain any leaks, thus reducing the risk to the marine environment. With respect to leachate from anodes, dissolved zinc from anodes is toxic to marine life at low concentrations; the AA EQS is 40 µg/l, but no such EQS currently exists for aluminium. The concentrations of zinc and aluminium released into the marine environment from sacrificial anodes are likely to be minimal and well below the EQS for zinc.

2.11.2.178 A potential for accidental spills will also occur as a result of the 2,885 round trips to port by maintenance and operational vessels and up to 4,671 round trips by helicopter per year over the 35 year design life of Hornsea Three (Table 2.33). However, as most of these vessels will be crew/supply vessels and helicopters, these will be typically small and will therefore be carrying only limited amounts of potential contaminants. Although larger operational and maintenance vessels may contain larger quantities of potential pollutants (e.g. jack-up vessels) such as diesel oil, movements of these vessels will be far fewer in comparison to smaller vessels.

2.11.2.179 Throughout operation there will be the requirement to store fuel offshore for the purposes of refuelling CTVs and/or helicopters, this storage will be on up to three of the offshore accommodation platform barges (Table 2.33). An impact on benthic ecology receptors would only be realised if an incident occurs where the fuel is accidentally released. The historical frequency of pollution events in the southern North Sea benthic ecology study area is low considering the density of existing marine traffic in the area. Given the designed-in mitigation (see Table 2.18) which is proposed (i.e. a PEMMP), it is considered that the likelihood of accidental release is extremely low. Measures adopted as part of Hornsea Three to reduce the potential for impacts on shipping and navigation (see volume 2, chapter 7: Shipping and Navigation), such as vessels complying with COLREGs will further reduce the likelihood of an accident between vessels resulting in an accidental spill during the operation and maintenance period.

2.11.2.180 The risk of an accidental pollution event on subtidal benthic receptors is predicted to be of local to regional spatial extent, short term duration (i.e. in the unlikely event that a spillage occurs, the impact would last hours to days), intermittent and reversible. It is predicted that the impact would affect benthic receptors directly and/or indirectly, but that the likelihood of an accidental pollution incident occurring is small. The magnitude is therefore, considered to be negligible.

2.11.2.181 As no VERs were recorded at the Hornsea Three intertidal area, due to the barren nature of the sediments (see section 2.7.2), no impact assessment has been undertaken for intertidal habitat loss on benthic ecological receptors.

Sensitivity of the receptor

2.11.2.182 The benchmarks for the MarESA pressures listed in paragraph 2.11.2.174 assume compliance with all relevant environmental protection standards. As such all VERs are not sensitive to pressures associated with pollution and other chemical changes in the MarESA. The following description of sensitivities for the VERs considers the effects of pollutants and chemicals should they be accidently released at concentrations that exceed environmental protection standards.

2.11.2.183 All VERs would be potentially affected by the accidental release of pollutants (i.e. Habitats A, B, C, D, E, sandbanks which are slightly covered by water all the time, Annex I reefs in an SAC, the ocean quahog *A. islandica* and broadscale features of MCZ/rMCZs and SACs (subtidal coarse sediments, subtidal sand, subtidal mixed sediments, subtidal chalk reef and peat and clay exposures)) and are identified as having intermediate to high intolerance to synthetic compound and hydrocarbon contamination, with localised declines in species richness likely as a result of this type of contamination, as discussed in paragraph 2.11.1.149. The recoverability of these communities is however likely to be moderate to high due to the life history characteristics of the component species (see paragraphs 2.11.1.24 to 2.11.1.31), although this is based on limited experimental data (see paragraph 2.11.1.150). Recoverability is likely to be assisted by the hydrodynamic regime in the offshore parts of Hornsea Three which would lead to rapid dispersion of pollutants, reducing the probability of a severe pollution event (Elliott *et al*., 1998).

2.11.2.184 Habitats A to D are deemed to be of medium vulnerability, high recoverability and regional value. However, due to the high potential for dilution and dispersal offshore, the sensitivity of the subtidal receptors is considered to be low.

2.11.2.185 Habitat E, the ocean quahog *A. islandica*, sandbanks which are slightly covered by water all the time, Annex I reefs in an SAC, the ocean quahog *A. islandica* and broadscale features of MCZ/rMCZs and SACs (subtidal coarse sediments, subtidal sand, subtidal mixed sediments, subtidal chalk reef and peat and clay exposures) are deemed to be of medium vulnerability, high recoverability and national value to international value. The sensitivity of these receptors is therefore, considered to be medium.

Significance of the effect

2.11.2.186 Provided published guidelines, best working practices and the mitigation measures outlined in Table 1.19 (i.e. implementation of a PEMMP) are adhered to, the likelihood of an accidental spill is extremely low and, in the event of a spill, the volumes of potential contaminants released would be small and rapidly dispersed to concentrations below which deleterious effects would be expected.

2.11.2.187 Overall, the sensitivity on subtidal benthic receptors (i.e. Habitats A, B, C, D, E, sandbanks which are slightly covered by water all the time, Annex I reefs in an SAC, the ocean quahog *A. islandica* and broadscale features of MCZ/rMCZs and SACs (subtidal coarse sediments, subtidal sand, subtidal mixed sediments, subtidal chalk reef and peat and clay exposures)) is considered to be low to medium and the magnitude of the impact is deemed to be negligible. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

2.11.2.188 Conclusions on the effects of Hornsea Three on the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

2.11.2.189 Conclusions on the effects of Hornsea Three on the Markham's Triangle rMCZ and the Cromer Shoal Chalk Beds MCZ are presented in full within volume 5, annex 2.3: Marine Conservation Zone Assessment.

Future monitoring

2.11.2.190 Table 2.31 below outlines the proposed monitoring commitments for benthic ecology.

Table 2.31: Operation and maintenance phase monitoring commitments.

Environmental effect	Monitoring commitment
Monitoring is deemed necessary during the operation and maintenance phase to determine the effectiveness of the designed-in mitigation measures proposed for sensitive cable protection within designated sites.	As outlined in the IPMP (document reference number 8.8), Hornsea Three will undertake monitoring of a representative proportion of the Hornsea Three offshore cable corridor within designated sites (i.e. North Norfolk Sandbanks and Saturn Reef SAC, The Wash and North Norfolk coast SAC and Cromer Shoal Chalk Beds MCZ) in areas where sensitive cable protection material is employed. The aim of the surveys will be to determine the success of sensitive cable protection measures within designated sites by monitoring the behaviour/recovery of the sediments associated with the cable protection over an agreed period of time and by monitoring any recolonisation/recovery of the associated benthic communities. It is likely that the surveys will be undertaken by a combination of geophysical survey and Remote Operated Vehicle (ROV) survey, however, the details of the survey will be agreed with the statutory consultees.

2.11.3 Decommissioning phase

2.11.3.1 The impacts of the offshore decommissioning of Hornsea Three have been assessed on benthic ecology. The environmental effects arising from the decommissioning of Hornsea Three are listed in Table 2.14 along with the maximum design scenario against which each decommissioning phase impact has been assessed.

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

Temporary loss of habitat due to operations to remove array cables, interconnector cables and export cables, and jack-up operations to remove foundations, resulting in potential effects on benthic ecology

2.11.3.3 The nature and extent of temporary habitat loss/disturbance during decommissioning (i.e. from cable removal operations and working areas etc.) is likely to be similar or the same as that described for the same activities during the construction phase in paragraphs 2.11.1.3 to 2.11.1.67 (i.e. sandwave clearance, cable installation, anchor placements and jack-up operations). However, it should be noted that this approach is considered precautionary as there is no statutory requirement for decommissioned cables to be removed. Therefore, cables may be left buried in place or alternatively partially removed by pulling the cables back out of the ducts (see volume 1; chapter 3: Project Description). The maximum design scenario has also assumed the same requirements for sandwave clearance and boulder clearance activities, prior to cable removal, as that required during the construction phase, although this is also likely to be over precautionary. Such details will be included within the Decommissioning Programme which will be developed to minimise environmental disturbance and will be updated throughout the lifetime of Hornsea Three (see Table 2.14) to account for changing best practice.

2.11.3.4 Decommissioning operations to remove array cables, accommodation platform power cables, export cables (subtidal and intertidal), including associated anchor placements, and jack-up operations to remove all foundations have the potential to cause temporary loss of, or disturbance to, benthic habitats within Hornsea Three, 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, as described below in paragraphs 2.11.3.7 to 2.11.3.11.

2.11.3.5 This assessment is considered equivalent to the following pressures identified by the ICGC pressures list under the overarching pressure theme 'Physical damage (reversible change)':

- Habitat structure changes - removal of substratum (extraction);
- Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion; and
- Siltation rate changes, including smothering (depth of vertical sediment overburden).

2.11.3.6 The benchmarks for the relevant MarESA pressures which have been used to inform this impact assessment are as outlined in paragraph 2.11.1.4 for temporary habitat loss during construction.

Magnitude of impact

2.11.3.7 The total maximum area of subtidal temporary habitat loss/disturbance due to the decommissioning activities described above and in Table 2.14 is predicted to be 57,639,112 m^2. This equates to 1.14% of the Hornsea Three benthic ecology study area. The impacts on subtidal habitats will occur intermittently throughout the decommissioning phase.

2.11.3.8 The subtidal benthic VERs likely to be affected by decommissioning activities are the same as described in paragraph 2.11.1.19. The total maximum potential temporary losses of each VER because of decommissioning activities are therefore as follows and have been calculated based on a Design Envelope that all habitat disturbance associated with sandwave clearance occurs within Habitat A, all disturbance within the array occurs within either of the habitats and the disturbance along the cable route is proportional to the length of mapped habitats along the offshore cable corridor:

- Habitat A – 56,502,018 m^2 (2.66% of Habitat A within Hornsea Three benthic ecology study area);
- Habitat B – 32,903,638 m^2 (2.36% of Habitat B within Hornsea Three benthic ecology study area);
- Habitat C – 35,757,570 m^2 (2.74% of Habitat C within Hornsea Three benthic ecology study area);
- Habitat D – 2,912,176 m^2 (1.37% of Habitat D within Hornsea Three benthic ecology study area); and
- Habitat E – 25,000 m^2 (29.62% of Habitat D within Hornsea Three benthic ecology study area).

2.11.3.9 The total area of temporary habitat loss represents a very small percentage loss (0.008%) of the total area of the OSPAR Region II within which *A. islandica* is listed as under threat and/or decline.

2.11.3.10 The impact of temporary loss/disturbance to Habitats A, B, C, D, E and *A. islandica* is predicted to be localised to Hornsea Three, of short to medium term duration (i.e. the duration of the decommissioning phase) and intermittent in nature. It is predicted that the impact will affect the receptors directly, resulting in a very slight change in the baseline condition. The magnitude is therefore, considered to be minor.

2.11.3.11 As discussed in paragraph 2.11.1.10, no VERs were recorded at the Hornsea Three intertidal area and therefore no impact assessment has been undertaken for intertidal habitat loss on benthic ecological receptors.

Sensitivity of the receptor

2.11.3.12 The sensitivity of benthic receptors will be the same as described in paragraphs 2.11.1.24 to 2.11.1.36 for subtidal receptors. The expected sensitivity of Habitats A and C is low, the sensitivity of Habitats B, D and E is considered to be medium and the sensitivity of ocean quahog *A. islandica* is considered to be high.

Significance of the effect

2.11.3.13 Overall, the sensitivity of Habitat A and Habitat C is considered to be low and the magnitude of the impact is deemed to be minor. The effect of temporary habitat loss/disturbance will, therefore, be of minor adverse significance, which is not significant in EIA terms.

2.11.3.14 Overall, the sensitivity of Habitat B, Habitat D, Habitat E and *A. islandica* is considered to be medium and high, respectively, and the magnitude of the impact is considered to be minor. The effect of temporary habitat loss/disturbance will, therefore, be of minor adverse significance, which is not significant in EIA terms. This has been concluded on the basis that only a very small proportion of the habitat for *A. islandica* in the Southern North Sea is predicted to be affected (0.008%) and, furthermore, as described in paragraph 2.7.1.22, this species was recorded is very low abundances in the former Hornsea Zone and predominately as juveniles, no individuals were recorded within Hornsea Three indicating that Hornsea Three is not an important area for this species.

North Norfolk Sandbanks and Saturn Reef SAC

Magnitude of impact

2.11.3.15 Of the total temporary habitat loss/disturbance loss predicted for Hornsea Three during decommissioning in paragraph 2.11.3.7, up to 8,405,800 m^2 of this is predicted to affect the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC (i.e. from export cable removal, including sandwave clearance (and sandwave material deposition) and anchor placements). This is the same as that predicted during construction and represents 0.23% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC (i.e. all potential Annex I sandbank habitat). The magnitude is therefore as described in paragraph 2.11.1.95 and is considered to be minor.

Sensitivity of the receptor

2.11.3.16 On the basis that no Annex I reef was detected within the area of the Hornsea Three offshore cable route coinciding with the North Norfolk Sandbanks and Saturn Reef SAC, no impacts to this habitat feature of the North Norfolk Sandbanks and Saturn Reef SAC are predicted during decommissioning. Should Annex I reef have developed within the Hornsea Three offshore cable corridor prior to decommissioning, in areas likely to be directly impacted by cable removal activities, then an appropriate course of action will be discussed and agreed with the regulators at the time and any measures including mitigation will be detailed in the Offshore Decommissioning Programme.

2.11.3.17 The sensitivity of the NcirBat, ApriBatPo and SspiMx biotopes associated with the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' is as detailed in full in paragraphs 2.11.1.24 to 2.11.1.29 and summarised in paragraphs 2.11.1.61 to 2.11.1.62. The overall sensitivity of the biotopes associated with the internationally important Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' is considered to be low to medium.

Significance of the effect

2.11.3.18 Overall, the sensitivity of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC is considered to be low to medium and the magnitude of the impact is deemed to be minor. The effect of temporary habitat loss/disturbance during decommissioning will, therefore, be of **minor** adverse significance, which is not significant in EIA terms. Conclusions on the effects of Hornsea Three on the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

The Wash and North Norfolk Coast SAC

Magnitude of impact

2.11.3.19 Of the total temporary habitat loss/disturbance loss predicted for Hornsea Three during decommissioning in paragraph 2.11.3.7, up to 2,356,714 m^2 of this is predicted to affect subtidal habitats within The Wash and North Norfolk Coast SAC (i.e. from cable removal, including jack-ups, sandwave clearance including the deposition of material, boulder clearance and anchor placements). This is as described during construction in paragraph 2.11.1.69 and represents 0.22% of the total area of The Wash and North Norfolk Coast SAC. The magnitude of the impact of temporary loss/disturbance during decommissioning is therefore the same as during construction and is considered to be minor.

Sensitivity of the receptor

2.11.3.20 The sensitivity of the NcirBat, MoeVen and SspiMx biotopes associated with the supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' within The Wash and North Norfolk Coast SAC is detailed in full in paragraphs 2.11.1.24 to 2.11.1.29 and as summarised in paragraphs 2.11.1.75 to 2.11.1.76. The overall sensitivity of the biotopes associated with the internationally important supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' is considered to be low to medium.

Significance of the effect

2.11.3.21 Overall, the sensitivity of supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' within The Wash and North Norfolk Coast SAC is considered to be low to medium and the magnitude of the impact is deemed to be minor. The effect of temporary habitat loss/disturbance on will, therefore, be of **minor** adverse significance, which is not significant in EIA terms. Conclusions on the effects of Hornsea Three on the conservation objectives of The Wash and North Norfolk Coast SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

Cromer Shoal Chalk Beds MCZ

Magnitude of impact

2.11.3.22 Of the total temporary habitat loss/disturbance loss predicted for Hornsea Three during decommissioning in paragraph 2.11.3.7, up to 191,200 m^2 is predicted to occur within the boundary of the Cromer Shoal Chalk Beds MCZ. All the temporary habitat loss/disturbance within the Cromer Shoal Chalk Beds MCZ associated with cable removal operations will take place within the broadscale habitat feature Subtidal sand, which equates to approximately 1.04% of the total extent of the Subtidal sand habitat feature within the Cromer Shoal Chalk Beds MCZ (according to the latest estimates of the extent of the broadscale habitats in Defra, 2015). The magnitude is, therefore, as described for construction and is considered to be minor.

Sensitivity of the receptor

2.11.3.23 The sensitivity of the NcirBat biotope associated with the Subtidal sand habitat is as detailed in full in paragraphs 2.11.1.24 to 2.11.1.26 and summarised in paragraphs 2.11.1.61. The overall sensitivity of the biotopes associated with the nationally important 'Subtidal sand habitat' is considered to be low.

Significance of the effect

2.11.3.24 Overall, the sensitivity of the sediment features of the Cromer Shoal Chalk Beds MCZ is considered to be low and the magnitude of the impact is deemed to be minor. The effect of temporary habitat loss/disturbance during decommissioning on the features of Cromer Shoal Chalk Beds MCZ will, therefore, be of **minor** adverse significance, which is not significant in EIA terms. Discussions on the effects of Hornsea Three on the Cromer Shoal Chalk Beds MCZ are presented in full within volume 5, annex 2.3: MCZ Assessment.

Markham's Triangle rMCZ

Magnitude of impact

2.11.3.25 Of the total temporary habitat loss/disturbance loss predicted for Hornsea Three during decommissioning in paragraph 2.11.3.7, up to 4,863,439 m^2 of this is predicted to occur within the boundary of the Markham's Triangle rMCZ. This assumes that 24% of all array infrastructure to be decommissioned is in the part of the Hornsea Three array which overlaps with the Markham's Triangle rMCZ (see paragraph 2.11.1.91 for reasoning). Using the same assumptions for the maximum adverse scenarios for each broadscale habitat features as outlined in paragraph0.0.0, the habitats would be affected as follows (proportions of the total extent of habitats within the rMCZ provided in parentheses): 4,863,439 m^2 of Subtidal coarse sediments (3.34%), 516,785 m^2 of Subtidal sand sediment (1.96%) and 630,053 m^2 of Subtidal mixed sediment (2.29%). The impact of temporary habitat loss/disturbance during decommissioning on qualifying (and proposed qualifying) features of the Markham's Triangle rMCZ is predicted to be localised within the western area of the Markham's Triangle rMCZ, of medium term duration and intermittent in nature. It is predicted that the impact will affect the receptors directly resulting in a small change in the baseline condition. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.11.3.26 The sensitivity of the PoVen and MysThyMx biotopes associated with the broadscale habitat features of the rMCZ is detailed in full in paragraph 2.11.1.28 and as summarised in paragraphs 2.11.1.96 to 2.11.1.97. The overall sensitivity of the biotopes associated with the nationally important habitats within the Markham's Triangle rMCZ is considered to be low to medium.

Significance of the effect

2.11.3.27 Overall, the sensitivity of the features of the Markham's Triangle rMCZ is considered to be low to medium and the magnitude of the impact is deemed to be minor. The effect of temporary habitat loss on the features of Markham's Triangle rMCZ will, therefore, be of **minor** adverse significance, which is not significant in EIA terms. Discussions on the effects of Hornsea Three on the Markham's Triangle rMCZ are presented in full within volume 5, annex 2.3: MCZ Assessment.

Removal of foundations leading to loss of species/habitats colonising these structures

2.11.3.28 This assessment of the removal of colonising communities from the foundations during decommissioning is considered to be equivalent to the following pressure identified by the ICGC pressures list under the overarching pressure theme 'Physical loss (permanent change)':

- Physical change (to another seabed type).

2.11.3.29 The benchmark for the relevant MarESA pressure (of the same name) which has been used to inform this impact assessment is the permanent change from sedimentary or soft rock substrata to hard rock or artificial substrata or vice-versa.

Magnitude of impact

2.11.3.30 The removal of foundations during the decommissioning phase of Hornsea Three would result in the long-term loss of 1,488,782 m² of hard substrate. The VERs which would be affected by these operations are restricted to those within Hornsea Three array (i.e. Habitats A, B and C and *A. islandica*).

2.11.3.31 The impact is predicted to be of long term 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

2.11.3.32 The removal of this substrate would result in localised declines in biodiversity. However, areas of bare sediment will be exposed and it is expected that the soft substrate benthic communities in these areas will recover and revert to their pre-construction state within the time frames outlined in paragraphs 2.11.1.24 to 2.11.1.33. Recovery of the VERs affected is likely to be high and to occur within five years as a result of a combination of recruitment from surrounding unaffected areas, adult migration and larval dispersal.

2.11.3.33 Subtidal benthic receptors (i.e. Habitats A, B and C) are deemed to be of overall high vulnerability to complete removal, however recovery to pre-construction conditions is expected to be high. The sensitivity of receptors is low.

Significance of the effect

2.11.3.34 The loss of species colonising the hard substrate will be highly localised, and given the high recoverability of the subsequently exposed substrate and communities back to their pre-construction state (i.e. within five years). Overall, the sensitivity of receptors is considered to be low and the magnitude of the impact is considered to be minor. The effects on subtidal benthic receptors will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Markham's Triangle rMCZ

Magnitude of impact

2.11.3.35 Of the total loss of hard substrate predicted for Hornsea Three during decommissioning in paragraph 2.11.3.30, up to 354,694 m² of this is predicted to occur within Markham's Triangle rMCZ. The broadscale habitat features that would be affected are as described in paragraph 2.11.2.69 (i.e. Subtidal coarse sediment, Subtidal sands and Subtidal mixed sediments). The impact is predicted to be of long term 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 negligible.

Sensitivity of the receptor

2.11.3.36 Subtidal benthic receptors within the broadscale habitats (i.e. PoVen and MysThyMx biotopes) are deemed to have a low resistance to the removal of epifaunal species from the hard substrate although recoverability of the exposed soft sediment habitats is expected to be medium to high. The expected sensitivity of receptors is low.

Significance of the effect

2.11.3.37 Overall, the sensitivity of features of the Markham's Triangle rMCZ is considered to be low and the magnitude of the impact is deemed to be negligible. The effect of the removal of hard substrate on the features of Markham's Triangle rMCZ will, therefore, be of **negligible** significance, which is not significant in EIA terms. Discussions on the effects of Hornsea Three on the Markham's Triangle rMCZ are presented in full within volume 5, annex 2.3: MCZ Assessment.

Permanent habitat loss due to presence of scour/cable protection left *in situ* post decommissioning, and potential effects on benthic ecology

2.11.3.38 As discussed in Table 2.14, the assessment of impacts during the decommissioning phase assumes that all offshore infrastructure will be removed from the seabed during decommissioning (i.e. all turbines, offshore substations and subsea cables), except for scour protection and cable protection which will be left *in situ*. It should be noted, however, that this approach is considered highly precautionary (i.e. as it assumes the maximum amounts of cable and scour protection left *in situ*) and the precise programme to be followed will use the best available advice and guidance at the time and as per the Offshore Decommissioning Programme to be agreed with the MMO.

Magnitude of impact

2.11.3.39 The removal of all structures during decommissioning, with the exception of cable and scour protection will result in a proportion of the long term habitat loss predicted to occur during the operational phase (see paragraph 2.11.2.6 *et seq*.) continuing post decommissioning. This will result in the permanent loss of up to 3,624,391 m^2 of benthic habitats within Hornsea Three which equates to 0.07% of the Hornsea Three benthic ecology study area.

2.11.3.40 Comparable habitats are widely distributed in the southern North Sea benthic ecology study area and near Hornsea Three (Tappin *et al*., 2011; see volume 5, annex 2.1: Benthic Ecology Technical Report). Given the small spatial scales of the permanent habitat loss, it is not expected that this loss will undermine regional ecosystem functions or diminish the region's biodiversity. The impact is predicted to be permanent (i.e. continuous and irreversible) and will affect benthic receptors directly. The effects will, however, be highly localised to within Hornsea Three. The magnitude of the impact is therefore, considered to be minor.

Sensitivity of the receptor

2.11.3.41 The sensitivities of benthic receptors to permanent habitat loss through leaving scour/cable protection measures *in situ* post decommissioning are highlighted in paragraphs 2.11.2.10 and 2.11.2.11.

2.11.3.42 The VERs likely to be affected by permanent habitat loss (i.e. Habitats A, B, C, D, E and *A. islandica*) are deemed to be of high vulnerability and regional to national value and there is no potential for recovery. However, all the habitats potentially affected are widely distributed in the Hornsea Three benthic ecology study area and wider southern North Sea benthic ecology study area. The sensitivity of the benthic receptors potentially affected is considered to be high.

Significance of the effect

2.11.3.43 There will be a direct permanent negative impact upon Habitats A, B, C, D, E and on habitat available for *A. islandica*. Overall, the sensitivity of the receptors is considered to be high and the magnitude of the impact is deemed to be minor. The effect of permanent habitat loss will, therefore, be of minor adverse significance, which is not significant in EIA terms.

North Norfolk Sandbanks and Saturn Reef SAC

Magnitude of impact

2.11.3.44 All of the long term habitat loss described in paragraph 2.11.2.13 *et seq*. as occurring within the North Norfolk Sandbanks and Saturn Reef SAC is associated with export cable protection and cable/pipeline crossings, so has the potential to persist beyond decommissioning as permanent habitat loss. A total of up to 497,400 m^2 of permanent habitat loss is predicted to occur should cable and scour protection remain *in situ* following decommissioning (see Table 2.27). This equates to 0.01% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC (i.e. all Annex I sandbank habitat).

2.11.3.45 The impact of long term habitat loss within the North Norfolk Sandbanks and Saturn Reef SAC is predicted to be localised to discrete sections of the Hornsea Three offshore cable corridor, affecting a small proportion of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC. The impact will be continuous and irreversible and will affect receptors directly. The magnitude is considered to be minor.

Sensitivity of the receptor

2.11.3.46 The sensitivity of the NcirBat, ApriBatPo and SspiMx biotopes associated with the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC is considered to be high due to their high vulnerability with no potential for recovery although it is anticipated that the sensitive design of the cable protection material, as outlined in Table 2.18, will limit the extent of habitat change (e.g. in comparison to concrete mattressing for example).

2.11.3.47 Although the site specific surveys did not record Annex I reef within the Hornsea Three offshore cable corridor within the North Sandbanks and Saturn Reef SAC, it is acknowledged that these features are ephemeral and therefore there is the potential for the permanent on-going presence of cable protection to serve as an barrier to the future establishment of Annex I reefs in those discrete areas. It is however also possible that the artificial structures may increase the availability of hard substratum for colonisation by *S. spinulosa* in areas where sedimentary habitats were previously unsuitable for colonisation.

Significance of the effect

2.11.3.48 Overall, the sensitivity of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC is considered to be high and the magnitude of the impact is deemed to be minor. The effect on this habitat will, therefore, be of minor adverse significance, which is not significant in EIA terms. This has been concluded using expert judgement, on the basis that the impact will be highly localised within the North Norfolk Sandbanks and Saturn Reef SAC with up to 0.01% of the Annex I habitat within the North Norfolk Sandbanks and Saturn Reef SAC affected. Conclusions on the effects of Hornsea Three on the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

The Wash and North Norfolk Coast SAC

Magnitude of impact

2.11.3.49 All of the long term habitat loss described in paragraph 2.11.2.22 *et seq*. as occurring within The Wash and North Norfolk Coast SAC is associated with export cable protection, so has the potential to persist beyond decommissioning as permanent habitat loss. A total of up to 46,200 m² of permanent habitat loss is predicted to occur should cable protection remain *in situ* following decommissioning. This equates to 0.004% of the total area of The Wash and North Norfolk Coast SAC (i.e. all supporting habitat for Annex I Sandbanks which are slightly covered by seawater all the time'). The impact on supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' will be continuous and irreversible during the lifetime (see Table 2.14) of Hornsea Three and will affect receptors directly although the designed-in measures proposed for the sensitive design of the cable protection material (see Table 2.18), may reduce the extent of permanent habitat loss in The Wash and North Norfolk Coast SAC. The magnitude is, therefore, considered to be minor.

Sensitivity of the receptor

2.11.3.50 The sensitivity of the NcirBat, MoeVen and SspiMx biotopes associated with supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' feature is considered to be high due to the high vulnerability with no potential for recovery. Although the site specific surveys did not record Annex I reef within the Hornsea Three offshore cable corridor within The Wash and North Norfolk Coast SAC, it is acknowledged that these features are ephemeral and therefore there is the potential for the permanent on-going presence of cable protection to serve as an barrier to the future establishment of Annex I reefs in those discrete areas. It is however also possible that the artificial structures may increase the availability of hard substratum for colonisation in areas where sedimentary habitats were previously unsuitable for colonisation.

Significance of the effect

2.11.3.51 Overall, the sensitivity of the supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' within The Wash and North Norfolk Coast SAC is considered to be high and the magnitude of the impact is deemed to be minor. The effect on these habitats will, therefore, be of minor adverse significance, which is not significant in EIA terms.

2.11.3.52 This has been concluded on the basis that the impact will be highly localised within the eastern periphery of The Wash and North Norfolk Coast SAC with up to only 0.004% of supporting habitat for Annex I 'Sandbanks which are slightly covered by seawater all the time' within The Wash and North Norfolk Coast SAC affected. This assumes that all the subtidal sediment within The Wash and North Norfolk Coast SAC has the potential to be the Annex I habitats 'Sandbanks which are slightly covered by seawater all the time' or 'Reefs', despite current evidence indicating that neither of these Annex I habitats occur in the Hornsea Three project area, although there is potential for these protected features to occur in these areas in the future. Also, that the designed-in mitigation measures regarding sensitive design of the cable protection material (Table 2.18) may facilitate the recovery of communities in these locations. Conclusions on the effects of Hornsea Three on the conservation objectives of The Wash and North Norfolk Coast SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

Cromer Shoal Chalk Beds MCZ

Magnitude of impact

2.11.3.53 All of the long term habitat loss described in paragraphs 2.11.2.31 *et seq*. as occurring within the Cromer Shoal Chalk Beds MCZ is associated with export cable protection, so therefore has the potential to persist beyond decommissioning as permanent habitat loss. A total of up to 4,200 m² of permanent habitat loss is predicted to occur should cable protection remain *in situ* following decommissioning. This equates to 0.0013% of the total area of the Cromer Shoal Chalk Beds MCZ and 0.02% of the total area of the Subtidal sand broadscale habitat type that it would occur within. Permanent habitat loss will be restricted to the inshore sections of the Hornsea Three offshore cable corridor and in the western part of the Cromer Shoal Chalk Beds MCZ. It will be continuous and irreversible and will affect the receptors directly. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.11.3.54 The sensitivity of the NcirBat biotope associated with the sediments of the Cromer Shoal Chalk Beds MCZ is as described in paragraph 2.11.2.17 and is considered to be high for a change in sediment type, although it is anticipated that the sensitive design of the cable protection material, as outlined in Table 2.18, will limit the extent of habitat change (e.g. in comparison to concrete mattressing for example).

Significance of the effect

2.11.3.55 Overall, the sensitivity of broadscale habitat Subtidal sand of the Cromer Shoal Chalk Beds MCZ is considered to be high and the magnitude of impact is deemed to be minor. The effect of temporary habitat loss on the features of Cromer Shoal Chalk Beds MCZ will, therefore, be of minor adverse significance, which is not significant in EIA terms. This has been concluded on the basis that the impact will be localised to the sandy sediments in the south western section of the Cromer Shoal Chalk Beds MCZ only, with up to 0.02% of broadscale habitat affected. The Subtidal sand habitat affected is widespread in the wider geographical area and the designed-in mitigation measures for the sensitive design of the cable protection material (Table 2.18) may facilitate the recovery of communities in these locations. Discussions on the effects of Hornsea Three on the Cromer Shoal Chalk Beds MCZ are presented in full within volume 5, annex 2.3: MCZ Assessment.

Markham's Triangle rMCZ

2.11.3.56 The removal of all infrastructure within Markham's Triangle rMCZ during decommissioning, except for cable and scour protection, is predicted to result in the permanent habitat loss of up to 543,148 m^2 within the Markham's Triangle rMCZ on the assumption that 24% of all array infrastructure to be decommissioned is located in the part of the array which overlaps with the Markham's Triangle rMCZ (see paragraph 2.11.1.91 for reasoning). This equates to approximately 0.37% of the Subtidal coarse sediment habitat feature, 0.22% of the Subtidal sand feature and 0.26% of the Subtidal mixed sediment feature of Markham's Triangle rMCZ (based on the assumption that only 10.63% and 12.95% scour and cable protection will be placed in subtidal sand and subtidal mixed sediment, respectively (see paragraph2.11.1.94).

Magnitude of impact

2.11.3.57 As discussed in paragraph 2.11.2.72, the use of sensitive rock protection material which will be designed to take into account the local seabed conditions, including substrate type (i.e. cable protection may comprise gravel and cobbles with a mean grain size of 100 mm and maximum grain size of 250 mm and scour protection (if required) may have a maximum grain size of 360 mm; Table 2.18) will encourage re-colonisation of these areas by fauna from surrounding areas and may lead to recovery of baseline communities (i.e. colonisation of hard substrates by surrounding epifauna and where sediments accumulate in interstices in rock protection, some infaunal recolonization) in these areas. This would reduce any potential effect of long term habitat loss during operation, or permanent habitat loss where rock protection is left *in situ*. Permanent loss of features of the Markham's Triangle rMCZ is predicted to be localised within the western area of the Markham's Triangle rMCZ, continuous and irreversible during the lifetime of Hornsea Three (i.e. Hornsea Three) although the proposed mitigation measures are intended to reduce the extent of long term habitat loss. The impact will affect the receptors directly resulting in a relatively small change in the baseline condition. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.11.3.58 The sensitivity of the communities associated with the broadscale habitats (i.e. PoVen and MysThyMx) is predicted to be high on the basis of no potential for recovery, although the mitigation measures proposed for the grain size of cable protection material, as outlined in paragraph 2.11.3.57, may reduce the extent of permanent habitat loss in the Markham's Triangle rMCZ by allowing for recovery of epifaunal and infaunal into areas affected by cable and scour protection. The sensitivity of these nationally important receptors is considered to be high.

Significance of the effect

2.11.3.59 Overall, the sensitivity of the features of the Markham's Triangle rMCZ is considered to be high and the magnitude of the impact is deemed to be minor. The effect of temporary habitat loss on the features of Markham's Triangle rMCZ will, therefore, be of minor adverse significance, which is not significant in EIA terms. This has been concluded on the basis that the impact will be localised to discrete parts of the Markham's Triangle rMCZ, and only in the western section. The habitats present within the Markham's Triangle rMCZ are widespread in the wider geographical area and the sensitive design of the cable protection material may facilitate the recovery of communities in these locations. Discussions on the effects of Hornsea Three on the Markham's Triangle rMCZ are presented in full within volume 5, annex 2.3: MCZ Assessment.

Temporary increases in suspended sediment concentrations and deposition from removal of array cables, export cables and foundations resulting in potential effects on benthic ecology

2.11.3.60 This assessment is considered equivalent to the following pressures identified by the ICGC pressures list under the overarching pressure theme 'Physical damage (reversible change)':

- Changes in suspended solids (water clarity); and
- Smothering and siltation rate changes (depth of vertical sediment overburden).

2.11.3.61 The benchmarks for the relevant MarESA pressures which have been used to inform this impact assessment are as outlined in paragraph 2.11.1.102 for temporary habitat loss during construction.

Magnitude of impact

2.11.3.62 The magnitude of the impact on subtidal receptors will be substantially less for decommissioning activities when compared to construction activities such as seabed preparation prior to GBF installation (Table 2.14). The impact of increased SSC in the subtidal from cable and foundation removal is predicted to be of local to regional spatial extent, medium term duration (i.e. the duration of the decommissioning phase), intermittent, reversible following cessation of activities and within the natural variability of the area. It is predicted that the impact will affect benthic receptors indirectly. The magnitude is considered to be minor.

Sensitivity of the receptor

2.11.3.63 The sensitivity of benthic receptors to increased SSC and sediment deposition is detailed in paragraphs 2.11.1.111 *et seq*.

2.11.3.64 The benthic ecology VERs Habitats A to E and ocean quahog *A. islandica* are considered to be of low vulnerability, high to immediate recoverability and of regional to national importance. The sensitivity of these receptors is therefore considered to be low.

2.11.3.65 'Sandbanks which are slightly covered by seawater all the time' and *S. spinulosa* reefs in both the North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC are considered to be of low vulnerability, high to immediate recoverability and of international importance. The sensitivity of these receptors is therefore considered to be low.

2.11.3.66 The subtidal chalk reef habitat and peat and clay exposures habitat of the Cromer Shoal Chalk Beds MCZ are considered to be of low to medium vulnerability, medium to high recoverability and of national importance. The sensitivity of these receptors is therefore considered to be medium.

2.11.3.67 The subtidal coarse sediments, subtidal sand and subtidal mixed sediments in the Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ are considered to be of low vulnerability, high to immediate recoverability and of regional to national importance. The sensitivity of these receptors is therefore considered to be low.

Significance of the effect

2.11.3.68 Overall, the sensitivity of benthic VERs Habitats A to E and the ocean quahog *A. islandica* is considered to be low and the magnitude of the impact is deemed to be minor. The effect of increases in SSC and associated sediment deposition on these benthic VERs will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

2.11.3.69 Overall, the sensitivity of 'Sandbanks which are slightly covered by seawater all the time' and Annex I *S. spinulosa reefs* in both the North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC is considered to be low and the magnitude of the impact is deemed to be minor. The effect of increases in SSC and associated sediment deposition on these benthic VERs will, therefore, be of **minor** adverse significance, which is not significant in EIA terms. Conclusions on the effects of Hornsea Three on the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

2.11.3.70 Overall, the sensitivity of the subtidal chalk reef and peat and clay exposures in the Cromer Shoal Chalk Beds MCZ is considered to be medium and the magnitude of the impact is deemed to be minor. The effect of temporary habitat loss/disturbance on all benthic VERs will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

2.11.3.71 Overall, the sensitivity of the subtidal coarse sediments, subtidal sand and subtidal mixed sediments in the Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ is considered is to be low and the magnitude of the impact is deemed to be minor. The effect of increases in SSC and associated sediment deposition on these benthic VERs will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

2.11.3.72 Conclusions on the effects of Hornsea Three on the Markham's Triangle rMCZ and the Cromer Shoal Chalk Beds MCZ are presented in full within volume 5, annex 2.3: Marine Conservation Zone Assessment.

Accidental release of pollutants (e.g. from accidental spillage/leakage) may affect benthic ecology

2.11.3.73 The effects of decommissioning activities are expected to be the same or similar to the effects from construction. The significance of effect is therefore **negligible** (see paragraphs 2.11.1.154 and 2.11.1.155).

Future monitoring

2.11.3.74 No benthic ecology monitoring to test the predictions made within the decommissioning phase impact assessment is considered necessary.

2.12 Cumulative Effect Assessment methodology

2.12.1 Screening of other projects and plans into the Cumulative Effect Assessment

2.12.1.1 The Cumulative Effect Assessment (CEA) considers the impact associated with Hornsea Three together with other projects and plans. The projects and plans selected as relevant to the CEA presented within this chapter are based upon the results of a screening exercise undertaken as part of the 'CEA long list' of projects (see volume 4, annex 5.2: Cumulative Effects Screening Matrix and volume 4, annex 5.3: Location of Schemes). Each project on the CEA long list has been considered on a case by case basis for scoping in or out of this chapter's assessment based upon data confidence, effect-receptor pathways and the spatial/temporal scales involved.

2.12.1.2 In undertaking the CEA for Hornsea Three, it is important to bear in mind that other projects and plans under consideration will have differing potential for proceeding to construction and an operational stage and hence a differing potential to ultimately contribute to a cumulative impact alongside Hornsea Three. For example, relevant projects and plans that are already under construction are likely to contribute to cumulative impact with Hornsea Three (providing effect or spatial pathways exist), whereas projects and plans not yet approved or not yet submitted are less certain to contribute to such an impact, as some may not achieve approval or may not ultimately be built due to other factors. For this reason, all relevant projects and plans considered cumulatively alongside Hornsea Three have been allocated into 'Tiers', reflecting their current stage within the planning and development process. This allows the CEA to present several future development scenarios, each with a differing potential for being ultimately built out. Appropriate weight may therefore be given to each Tier in the decision-making process when considering the potential cumulative impact associated with Hornsea Three (e.g. it may be considered that greater weight can be placed on the Tier 1 assessment relative to Tier 2). An explanation of each tier is included below:

- Tier 1: Hornsea Three considered alongside:
  - Other project/plans currently under construction; and/or
  - Those with consent, and, where applicable (i.e. for low carbon electricity generation projects), that have been awarded a Contract for Difference (CfD) but have not yet been implemented; and/or
  - Those currently operational that were not operational when baseline data was collected, and/or those that are operational but have an on-going impact.
- Tier 2: All projects/plans considered in Tier 1, as well as:
  - Those project/plans that have consent but, where relevant (i.e. for low carbon electricity generation projects) have no CfD; and/or
  - Submitted but not yet determined.
- Tier 3: All projects/plans considered in Tier 2, as well as those on relevant plans and programmes likely to come forward but have not yet submitted an application for consent (the PINS programme of projects and the adopted development plan including supplementary planning documents are the most relevant sources of information, along with information from the relevant planning authorities regarding planned major works being consulted upon, but not yet the subject of a consent application). Specifically, this Tier includes all projects where the developer has advised PINS in writing that they intend to submit an application in the future, those projects where a Scoping Report is available and/or those projects which have published a PEIR.

2.12.1.1 It is noted that offshore wind farms seek consent for a maximum design scenario and the 'as built' offshore wind farm will be selected from the range of consented scenarios. In addition, the maximum design scenario quoted in the application (and the associated Environmental Statement) are often refined during the determination period of the application. For example, it is noted that the Applicant for Hornsea Project One considered a maximum of turbines 332 turbines within the Environmental Statement, but has gained consent for 240 turbines. In addition, it is now known that Hornsea Project One 'as built' will consist of 174 turbines. Similarly, Hornsea Project Two has gained consent for an overall maximum number of turbines of 300, as opposed to 360 considered in the Environmental Statement and the as built number of turbines is likely to be less than this. A similar pattern of reduction in the project envelope from that assessed in the Environmental Statement, to the consented envelope and the 'as built' project is also seen across other offshore wind farms of relevance to this CEA. This process of refinement can result in a reduction to associated project parameters, for example the number and length of cable to be installed and the number of offshore substations. The CEA presented in this benthic ecology chapter has been undertaken on the basis of information presented in the Environmental Statements, for the other projects, plans and activities. Given that this broadly represents a maximum design scenario, the level of cumulative impact on benthic ecology would highly likely be reduced from those presented here.

2.12.1.2 The specific projects scoped into this CEA and the Tiers into which these have been allocated, are outlined in Table 2.32 and shown in Figure 2.10. The projects included as operational in this assessment have been commissioned since the baseline studies for Hornsea Three were undertaken and as such were excluded from the baseline characterisation.

Table 2.32: List of other projects and plans considered within the CEA.

Tier	Phase	Project/Plan	Distance from Hornsea Three array area	Distance from Hornsea Three offshore cable corridor	Details	Date of Construction (if applicable)	Overlap of construction phase with Hornsea Three construction phase	Overlap of operation phase with Hornsea Three operation phase
1	*Offshore wind farms*							
	Operational	Dudgeon Offshore Wind Farm	87 km	11 km	168 turbines consented, of which 67 turbines were constructed.	2015 to 2017	No	Yes
		Race Bank	114 km	28 km	206 turbines consented, of which 91 turbines to be constructed.	2015 to 2017	No	Yes
	Under construction	Hornsea Project One	7 km	14 km	332 turbines assessed in the Environmental Statement (although 240 turbines actually consented), of which 174 turbines to be constructed.	2017 to 2019	No	Yes
		Hornsea Project Two	7 km	20 km	360 turbines assessed in the Environmental Statement (although 300 turbines actually consented).	2020 to 2022	No	Yes
	Consented	Triton Knoll offshore wind farm	100 km	44 km	288 turbines consented, of which 90 to be constructed.	2017 to 2021	Yes	Yes
	Aggregate extraction and disposal sites							
	Operational (with on-going effects)	Humber 3 - 484	43 km	0 km	Application for operation sought up to 31 December 2029	N/A	Yes (operational activity overlapping with Hornsea Three construction)	No
		Inner Dowsing - 481/1-2	126 km	41 km	Operational until end 2023	N/A		No
		Inner Dowsing - 481/1-2	127 km	38 km	Operational until end 2023	N/A		No
		Inner Dowsing - 481/1-2	126 km	41 km	Operational until end 2023	N/A		No
		Inner Dowsing - 481/1-2	127 km	38 km	Operational until end 2023	N/A		No
		Outer Dowsing - 515/1-2	102 km	41 km	Application for operation sought up to 31 December 2029	N/A		No
		Outer Dowsing - 515/1-2	88 km	38 km	Application for operation sought up to 31 December 2029	N/A		No
		Inner Dowsing - 481	125 km	38 km	Operational until end 2023	N/A		No
		Inner Dowsing - 481	125 km	38 km	Operational until end 2023	N/A		No
		Humber 4 and 7 – 506	13 km	8 km	Application for operation sought up to 31 December 2029	N/A		No
		Humber (Disposal)	77 km	32 km	Operational	N/A		Yes
	Cables and pipelines							
	Pre-commission	PL2237 - SATURN TO MIMAS	*33 km*	22 km	3 inch Pre-commission CHEMICAL pipeline operated by CONOCOPHILLIPS	2017 to 2018	No	Yes
	Pre-commission	PLU3122 - JULIET TO PICKERILL A UMBILICAL	89 km	50 km	138 mm Pre-commission MIXED HYDROCARBONS pipeline operated by ENGIE	2017 to 2018	No	Yes
	Pre-commission	PL3088 - CYGNUS TO ETS GAS PIPELINE	48 km	64 km	24 inch Pre-commission GAS pipeline operated by ENGIE	2017 to 2018	No	Yes
	Pre-commission	PL2894 - KATY TO KELVIN GAS EXPORT PIPELINE	39 km	53 km	10 inch Pre-commission GAS pipeline operated by CONOCOPHILLIPS	2019 to 2021	Yes	Yes

Tier	Phase	Project/Plan	Distance from Hornsea Three array area	Distance from Hornsea Three offshore cable corridor	Details	Date of Construction (if applicable)	Overlap of construction phase with Hornsea Three construction phase	Overlap of operation phase with Hornsea Three operation phase
	Pre-commission	PL2895 - KELVIN TO KATY METHANOL PIPELINE	39 km	53 km	2 inch Pre-commission METHANOL pipeline operated by CONOCOPHILLIPS	2019 to 2021	Yes	Yes
	Pre-commission	PL3121 - JULIET TO PICKERILL A GAS PIPELINE	50 km	89 km	12 inch Pre-commission MIXED HYDROCARBONS pipeline operated by ENGIE	2019 to 2021	Yes	Yes
	Under-construction	PL0219_PR K4-Z to K5-A	20 km	35 km	6-inch Under construction Gas pipeline operated by Total E&P Nederland B.V.	2017 to 2018	No	Yes
	Under-construction	PL0219_UM K4-Z to K5-A	20 km	35 km	5-inch Under construction Control pipeline operated by Total E&P Nederland B.V.	2017 to 2018	No	Yes
	Oil and gas decommissioning							
	Decommissioning	Leman BH	79 km	34 km	Gas platform	N/A	Yes (decommissioning activity overlapping with Hornsea Three construction)	No
		Viking Charlie Drilling (CD)	39 km	22 km	Gas platform	N/A		No
		Viking Delta Drilling (DD)	37 km	21 km	Gas platform	N/A		No
		Viking Echo Drilling (ED	45 km	12 km	Gas platform	N/A		No
		Viking Golf Drilling (GD)	40 km	15 km	Gas platform	N/A		No
		Viking Hotel Drilling (HD)	33 km	13 km	Gas platform	N/A		No
		PL89 – Gas Pipeline (Decommissioning)	37.9 km	20.4 km	Pipelines associated with Viking field	N/A		No
		PL90 – Gas Pipeline (Decommissioning)	36.7 km	20.4 km		N/A		No
		PL91 – Gas Pipeline (Decommissioning)	37.9 km	11.5 km		N/A		No
		PL92 – Gas Pipeline (Decommissioning)	37.9 km	16.0 km		N/A		No
		PL93 – Gas Pipeline (Decommissioning)	33.3 km	17.7 km		N/A		No
		PL132 – Gas Pipeline (Decommissioning)	37.9 km	20.4 km		N/A		No
		PL131 – Gas Pipeline (Decommissioning)	36.7 km	20.4 km		N/A		No
		PL133 – Gas Pipeline (Decommissioning)	37.9 km	11.5 km		N/A		No
		PL66 – Gas Pipeline (Decommissioning)	37.9 km	16.0 km		N/A	Yes (decommissioning activity overlapping with Hornsea Three construction)	No
		PL130 – Gas Pipeline (Decommissioning)	33.3 km	17.7 km		N/A		No
		Vulcan UR	67.4 km	12.9 km	Gas platform	N/A		No
		Viscount VO	50 km	15 km	Gas platform	N/A		No
		Vampire/Valkyrie	45 km	4 km	Gas platform	N/A		No
		PL462 - Vulcan UR to Vulcan RD	67.4 km	12.9 km	Pipeline associated with Vulcan platforms	N/A		No
		PL463 - Vulcan RD to Vulcan UR	67.4 km	12.9 km	Pipeline associated with Vulcan platforms	N/A		No

Tier	Phase	Project/Plan	Distance from Hornsea Three array area	Distance from Hornsea Three offshore cable corridor	Details	Date of Construction (if applicable)	Overlap of construction phase with Hornsea Three construction phase	Overlap of operation phase with Hornsea Three operation phase
		PL1962 - Viscount VO to Vampire OD	44.7 km	4.5 km	Pipeline associated with Viscount and Vampire platforms	N/A		No
		PL1963 - Vampire OD to Viscount VO	44.7 km	4.5 km	Pipeline associated with Viscount and Vampire platforms	N/A		No
		PL1692 - Vampire OD to LOGGS PR	44.7 km	4.4 km	Pipeline associated with Vampire platform	N/A		No
		PL1693 - LOGGS PR to Vampire OD	44.7 km	4.4 km	Pipeline associated with Vampire platform	N/A		No
		Audrey A (WD)	39 km	1 km	Gas platform	2019-2023 (decommissioning)		No
		Audrey B (XW)	39 km	6 km	Gas platform			No
		PL496	39.0 km	0 (Crosses route)	Pipelines associated with Audrey field			No
		PL497	39.0 km	0 (Crosses route)				No
		PL723	38.6 km	1.3 km				No
		PL724	38.6 km	1.3 km				No
		PL575	39.0 km	1.3 km				No
		PL576	39.0 km	1.3 km				No
2	*Aggregate extraction*							
	Application	Humber 5 - 483	13 km	8 km	Application for operation sought up to 31 December 2029	N/A	Yes (operational activity overlapping with Hornsea Three construction)	No
		Inner Dowsing - 439	131 km	48 km	Application for operation sought up to 31 December 2029	N/A	Yes (operational activity overlapping with Hornsea Three construction)	No
	Cables and pipelines							
	Proposed	Viking Interconnector	13 km	18 km	High voltage (up to 500 kV) Direct Current (DC) electricity interconnector	2019 to 2022	Yes	Yes
	Proposed	PL0221_HS D18-A to D15-FA-1	19 km	45 km	2-inch Proposed Methanol pipeline operated by GDF SUEZ E&P Nederland B.V.	2019 to 2021	Yes	Yes
	Proposed	PL0221_PR D18-A to D15-FA-1	19 km	45 km	8-inch Proposed Gas pipeline operated by GDF SUEZ E&P Nederland B.V.	2019 to 2021	Yes	Yes
3	*Coastal protection*							
	Concept	Bacton Gas Terminal Coastal Defence Scheme	122.2 km	23.2 km	Measures to protect Bacton Gas Terminal against ongoing cliff erosion.	2019	Yes	Yes

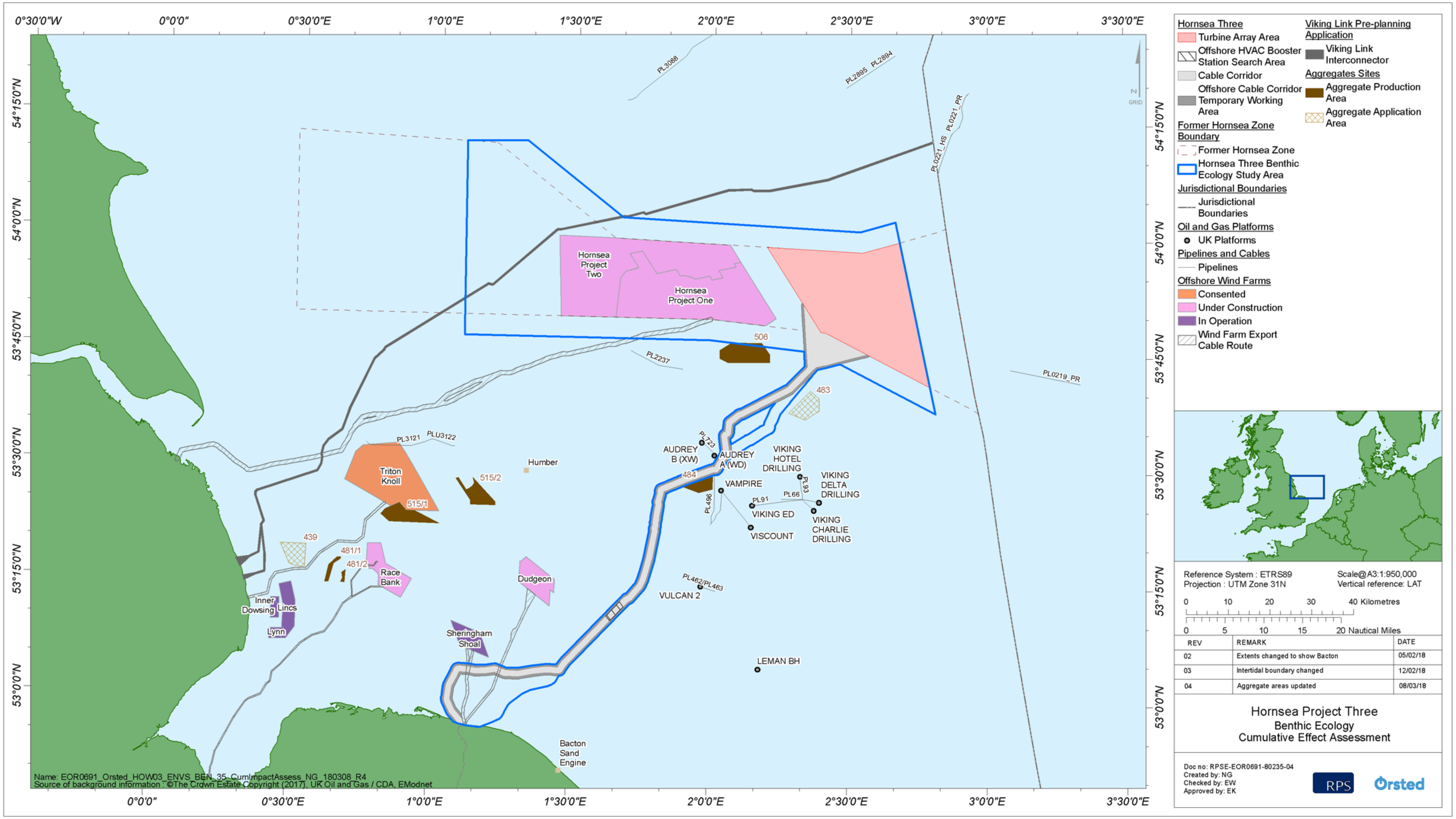

Figure 2.10: Offshore project/plans/activities screened into the Hornsea Three cumulative effect assessment for benthic ecology.

2.12.2 Maximum design scenario

2.12.2.1 The maximum design scenarios identified in Table 2.33 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. The cumulative impact presented and assessed in this section have been selected from the details provided in the Hornsea Three project description (volume 1, chapter 3: Project Description), as well as the information available on other projects and plans, to inform the 'maximum design scenario'. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the project Design Envelope (e.g. different turbine layout), to that assessed here be taken forward in the final design scheme.

2.12.2.2 For the purposes of this Environmental Statement, synergistic/interactive effects (e.g. increased suspended sediment concentrations and sediment deposition) on benthic ecology have been assessed within one spring tidal excursion ellipse of Hornsea Three (see volume 2, chapter 1: Marine Processes). Additive effects (e.g. long term and temporary habitat loss) have been assessed within a 50 km buffer of Hornsea Three as this is deemed to be a fair representation of the habitats present in the wider southern North Sea benthic ecology study area.

2.12.2.3 The range of potential cumulative impacts identified in Table 2.33 is a subset of those considered for the Hornsea Three alone assessment (Table 2.14). This is because many of the potential impacts identified and assessed for Hornsea Three alone are relatively localised and temporary in nature and therefore have limited or no potential to interact with similar changes associated with other projects (e.g. accidental release of pollutants, temporary habitat disturbance associated with maintenance activities). Accordingly, these have been scoped out of the cumulative assessment. Of the impacts set out in Table 2.14, the following have not been considered in the CEA due to the highly localised nature of some of the impacts (i.e. within the Hornsea Three boundary only) and/or because the potential significance of impact has been assessed as negligible for Hornsea Three offshore wind farm alone:

- Construction phase:
  - Accidental release of pollutants (e.g. from accidental spillage/leakage) may affect benthic ecology.
- Operation and maintenance phase:
  - Increased risk of introduction or spread of invasive and non-native species (INNS) due to presence of subsea infrastructure and vessel movements (e.g. ballast water) may affect benthic ecology and biodiversity;
  - Maintenance operations may result in temporary seabed disturbances and potential effects on benthic ecology; and
  - Accidental release of pollutants (e.g. from accidental spillage/leakage) may affect benthic ecology.

2.12.2.4 Similarly, many of the potential impacts considered within the Hornsea Three alone assessment are specific to a particular project phase (e.g. construction/operation/decommissioning). The potential for cumulative effects with other projects only have the potential to occur if the activities causing the change spatially or temporally overlap. This means that whilst a number of potential cumulative impacts have been identified for the construction/operation and maintenance phases, none have been identified for the decommissioning phase as no projects have been identified that have the potential to cumulatively interact during this time period.

Table 2.33: Maximum design scenario considered for the assessment of potential cumulative impacts on benthic ecology.

Potential impact	Maximum design scenario	Justification
Construction phase		
Cumulative temporary habitat loss/disturbance of benthic ecology VERs as a result of offshore wind farm construction, Oil and Gas decommissioning, aggregate extraction activities, and cable and pipeline installation.	228.61 km² total cumulative temporary habitat loss/disturbance of benthic ecology VERs (see Table 2.34). Maximum design scenario as described for construction phase assessed cumulatively with the full development of the following marine projects within a representative 50 km buffer of the Hornsea Three boundary: Tier 1: • All licensed aggregate extraction areas (assuming an average of 8% of the total licensed area is dredged at any one time); • Cables and pipelines (i.e. PL2237 – Saturn to Mimas, PLU3122 and PL3121 – Juliet to Pickerill A gas pipeline and umbilical, PL3088 – Cygnus to ETS gas pipeline, PL2894 – Katy to Kelvin gas export pipeline, PL2895 – Kelvin to Katy methanol pipeline, PL0219_PR and PL0219_UM K4-Z to K5-A pipeline route and umbilical); • Offshore wind farm projects operational and under construction (i.e. Dudgeon, Race Bank Hornsea Project One and Hornsea Project Two); • Consented offshore wind farm projects (i.e. Triton Knoll); and • Oil and Gas decommissioning activities within the Viking field (Viking CD, Viking DD, Viking ED, Viking GD and Viking HD and infield pipelines), Lincolnshire Offshore Gas Gathering Station (LOGGS) area (Vampire/Valkyrie OD, Viscount VO and Vulcan UR and pipelines), Audrey field (Audrey A and B platforms and pipelines) and Leman field (Leman BH). Tier 2: • All application aggregate extraction areas; • Cables and pipelines (i.e. Viking Interconnector, PL0221_HS D18-A to D15-FA-1 and PL0221_PR D18-A to D15-FA-1). Tier 3: • Bacton Gas Terminal Coast Defence Scheme.	Maximum additive temporary habitat loss is calculated within a representative 50 km buffer of Hornsea Three as this area is a fair representation of benthic habitats within the wider southern North Sea benthic ecology study area due to its proximity to Hornsea Three. Areas of temporary habitat loss for other offshore wind farms have been taken from the respective Environmental Statement chapters, were available. An average of 8% of the total licensed aggregate extraction areas is assumed to be dredged at any one time. This is based on the most recent (2016) Annual Report produced by the Crown Estate for the Humber region which reports that in 2016 dredging took place within approximately 8% of the total licensed area (Crown Estate, 2017).
Temporary increases in suspended sediment concentrations and associated sediment deposition from cable and foundation installation and seabed preparation during the construction phase may affect benthic ecology.	Maximum design scenario as described for construction phase of Hornsea Three (for both foundation and cable installation) assessed cumulatively with the following Tier 1 licensed/consented/ aggregate extraction areas: • Humber 3 (484); and • Humber 4 and 7 (506). Tier 2: • Humber 5 (483). Tier 3: • Bacton Gas Terminal Coast Defence Scheme.	Maximum potential for interactive effects from increases in suspended sediment concentrations and consequent deposition (volume 2, chapter 1: Marine Processes).

Potential impact	Maximum design scenario	Justification
Operation and maintenance phase		
Cumulative long term loss of benthic ecology VERs through presence of offshore wind farm foundations and related infrastructure (e.g. cable protection, substations) and Oil and Gas and interconnector installations.	15.58 km² total cumulative long term habitat loss of benthic ecology VERs (see Table 2.36). Maximum design scenario as described for operation and maintenance phase assessed cumulatively with the full development of the following marine projects within a representative 50 km buffer of the Hornsea Three boundary: Tier 1 • Cables and pipelines (i.e. PL2237 – Saturn to Mimas, PLU3122 and PL3121 – Juliet to Pickerill A gas pipeline and umbilical, PL3088 – Cygnus to ETS gas pipeline, PL2894 – Katy to Kelvin gas export pipeline, PL2895 – Kelvin to Katy methanol pipeline, PL0219_PR and PL0219_UM K4-Z to K5-A pipeline route and umbilical); • Operational offshore wind farm projects (i.e. Dudgeon and Race Bank); • Offshore wind farm projects under construction (i.e. Hornsea Project One and Hornsea Project Two); • Consented offshore wind farm projects (i.e. Triton Knoll); and • Oil and Gas decommissioning activities within the Viking field (Viking CD, Viking DD, Viking ED, Viking GD and Viking HD and infield pipelines), Lincolnshire Offshore Gas Gathering Station (LOGGS) area (Vampire/Valkyrie OD, Viscount VO and Vulcan UR and infield pipelines), Audrey field (Audrey A and B platforms and pipelines) and Leman field (Leman BH). Tier 2: • Cables and pipelines (i.e. Viking Interconnector; PL0221_HS D18-A to D15-FA-1 and PL0221_PR D18-A to D15-FA-1). Tier 3: • No Tier 3 projects.	Maximum cumulative long term habitat loss is calculated within a representative 50 km buffer of Hornsea Three as this area is considered to be a fair representation of benthic habitats within the wider southern North Sea benthic ecology study area due to its proximity to Hornsea Three.
Cumulative introduction of subtidal hard substrates (i.e. from offshore wind farm structures) and associated colonisation.	22.14 km² total cumulative introduction of subtidal hard substrates for benthic ecology VERs (see Table 2.37). Maximum design scenario as described for operation and maintenance phase assessed cumulatively with the full development of the following marine projects within a representative 50 km buffer of the Hornsea Three boundary: Tier 1 • Cables and pipelines (i.e. PL2237 – Saturn to Mimas, PLU3122 and PL3121 – Juliet to Pickerill A gas pipeline and umbilical, PL3088 – Cygnus to ETS gas pipeline, PL2894 – Katy to Kelvin gas export pipeline, PL2895 – Kelvin to Katy methanol pipeline, PL0219_PR and PL0219_UM K4-Z to K5-A pipeline route and umbilical); • Operational offshore wind farm projects (i.e. Dudgeon and Race Bank); • Offshore wind farm projects under construction (i.e. Hornsea Project One and Hornsea Project Two); and • Consented offshore wind farm projects (i.e. Triton Knoll); and • Oil and Gas decommissioning activities within the Viking field (Viking CD, Viking DD, Viking ED, Viking GD and Viking HD and pipelines), Lincolnshire Offshore Gas Gathering Station (LOGGS) area (Vampire/Valkyrie OD, Viscount VO and Vulcan UR and pipelines), Audrey field (Audrey A and B platforms and pipelines) and Leman field (Leman BH). Tier 2: • Cables and pipelines (i.e. Viking Interconnector; PL0221_HS D18-A to D15-FA-1 and PL0221_PR D18-A to D15-FA-1). Tier 3: • No Tier 3 projects.	Maximum cumulative habitat creation is calculated within a representative 50 km buffer of Hornsea Three as this area is considered to be a fair representation of benthic habitats within the wider southern North Sea benthic ecology study area due to its proximity to Hornsea Three.

Potential impact	Maximum design scenario	Justification
Alteration of seabed habitats arising from effects on physical processes, wave and tidal regimes resulting in potential effects on benthic ecology.	Maximum design scenario as described for the operation and maintenance phase of Hornsea Three assessed cumulatively with the following Tier 1 offshore wind farms: • Lincs; • Sheringham Shoal; • Humber Gateway; • Westermost Rough; • Lynn and Inner Dowsing; • Triton Knoll; • Dudgeon; • Race Bank; • Hornsea Project One; and • Hornsea Project Two. Tier 2 and Tier 3: • No Tier 2 or Tier 3 projects.	Maximum potential cumulative effects on the tidal and wave regimes (see volume 2, chapter 1: Marine Processes).

2.13 Cumulative Effect Assessment

2.13.1.1 A description of the significance of cumulative effects upon benthic ecology receptors arising from each identified impact is given below.

2.13.2 Construction phase

Cumulative temporary habitat loss/disturbance of benthic ecology VERs as a result of offshore wind farm construction, Oil and Gas decommissioning, aggregate extraction activities, and cable and pipeline installation

2.13.2.1 There is the potential for cumulative temporary habitat loss as a result of construction activities associated with Hornsea Three and other Round 2 and Round 3 offshore wind farms (i.e. from cable/pipeline burial, anchor placements and seabed preparation for the installation of GBFs), aggregate extraction activities and Oil and Gas decommissioning activities (see Figure 2.10). For the purposes of this Environmental Statement, this additive impact has been assessed within a representative 50 km buffer of Hornsea Three using the tiered approach outlined above in paragraph 2.12.1.2 and in Table 2.33. The 50 km buffer area is considered to be a fair representation of benthic habitats within the wider southern North Sea benthic ecology study area in proximity to Hornsea Three.

2.13.2.2 Almost all plans/projects/activities screened into the assessment for cumulative effects from temporary habitat loss/disturbance are either on-going activities (i.e. licensed and application aggregate extraction areas) or other offshore wind farms which are consented, submitted or under construction (i.e. Tier 1). Three Tier 2 projects and one Tier 3 project have been identified within the representative 50 km buffer.

Tier 1

Magnitude of impact

2.13.2.3 Predicted cumulative temporary habitat loss/disturbance from each of the Tier 1 plans/projects/activities is presented in Table 2.34 together with a breakdown of the sources of this data from the relevant Environmental Statements and any assumptions made where necessary information was not presented in these Environmental Statements. Table 2.34 shows that for all projects/plans/activities in the Tier 1 assessment, the cumulative temporary habitat loss/disturbance is estimated at 196.26 km^2. However, as discussed in paragraph 2.12.1.1, these areas are likely to be highly precautionary.

2.13.2.4 The maximum total temporary habitat loss/disturbance associated with all offshore wind farms within a representative 50 km buffer is 147.40 km^2. The values of temporary habitat loss for Hornsea Three are comparably larger than for many of the other offshore wind farms presented in Table 2.34, as the Hornsea Three assessment includes habitat affected as a result of seabed preparation and also considers the installation of up to six export cable trenches for the HVAC maximum design scenario.

2.13.2.5 For licensed aggregate extraction areas (assuming an average of 8% of the total licensed areas is dredged at any one time; see Table 2.33 for justification) the maximum total temporary habitat loss/disturbance is approximately 16.88 km^2. The estimate of temporary habitat loss resulting from aggregate extraction activities is also likely to be an over-estimation as only the most recent Crown Estate report (TCE, 2017) states that 90% of regional dredging effort in the Humber region took place within only 8.49 km^2. Furthermore, as only a proportion of the active licence areas are dredged at any one time this allows for recovery between dredging events.

2.13.2.6 Temporary habitat loss associated with Oil and Gas decommissioning activities for the first Viking Decommissioning Programme 1 (VDP1) and the first Lincolnshire Offshore Gas Gathering Station (LOGGS) Decommissioning Programme (LDP1) is predicted as 17.28 km^2, and of this total, an estimated 17.2 km^2 will result from over-trawlability surveys following completion of the decommissioning activities, to identify any snagging risk and to recover debris (BEIS, 2017). All pipelines associated with the VDP1 and LDP1 are to be left *in situ*, with no consequent temporary habitat loss/disturbance effects (Conoco Phillips, 2017a and 2017b). For decommissioning activities associated with the Audrey Field (i.e. decommissioning of Audrey A and B platforms and removal of pipelines; some pipelines to be left *in situ*), temporary habitat loss is predicted to affect up to 11.68 km^2 of seabed habitat, with the majority of this (i.e. 11.27 km^2) coming from over-trawlability surveys (Centrica, 2017). Numbers for habitat disturbance associated with the Leman BH decommissioning were not provided in the Decommissioning Programme (Shell UK Ltd., 2017) and have therefore not been incorporated into the numbers presented in this assessment. The area of physical impact from decommissioning will, however, be very localised to the Oil and Gas infrastructure. For cable and pipeline installation projects the total temporary habitat loss is estimated at 3.02 km^2 (Table 2.34).

2.13.2.7 The benthic subtidal habitats most likely to be affected by cumulative temporary habitat loss are those within the Hornsea Three array as described in paragraph 2.11.1.8 for Hornsea Three (i.e. Habitats A, B and C and habitat for ocean quahog *A. islandica*). These habitats are typical of, and widespread throughout, the southern North Sea benthic ecology study area (see volume 5, annex 2.1: Benthic Ecology Technical Report). These habitats, in addition to Habitat D, along the Hornsea Three offshore cable corridor are also likely to be affected by cumulative temporary habitat loss but to a lesser degree than within the array.

2.13.2.8 The cumulative impact of temporary habitat loss is predicted to be of regional spatial extent, medium term duration (i.e. Hornsea Three array area construction phase of up to eight years and Hornsea Three offshore cable corridor construction phase of up to eight years; see Table 2.14), intermittent and reversible but with a relatively small amount of the loss described occurring at any one time. It is predicted that the impact will affect the receptors directly. The magnitude is therefore, considered to be minor.

Table 2.34: Cumulative temporary habitat loss for Hornsea Three and other plans/projects/activities in the CEA within a representative 50 km buffer of Hornsea Three.

Project	Total predicted temporary habitat loss (km^2)	Source
Tier 1		
Offshore wind farms		
Hornsea Three	68.65	See Table 2.14.
Dudgeon Offshore Wind Farm	1.23	Values taken from Environmental Statement (Dudgeon Offshore Wind Limited, 2009): 1.2 km^2 from cable installation and 0.0315 km^2 from jack-up barges.
Race Bank Offshore Wind Farm	1.02	Values taken from Environmental Statement (Centrica Energy, 2009): 0.01236 km^2 from jack-up barges, 0.8641 km^2 from export cable installation and 139 km of array cables (1 m width disturbance).
Triton Knoll Offshore Wind Farm	2.45	Values taken from Environmental Statement (TKOWFL, 2012): 0.53 km^2 from array and inter-substation cable installation, 0.60 km^2 from jack-up barges and 1.319 km^2 from seabed preparation.
Hornsea Project One Offshore Wind Farm	28.52	Values taken from Environmental Statement (SMart Wind, 2013): 0.143 km^2 from jack-up barges, 5.3 km^2 from array and inter-connector cable burial, 6 km^2 from export cable burial, 16.8 km^2 from seabed preparation and 0.279 km^2 from anchor placements. Note: *It is noted that the Applicant for Hornsea Project One gained consent for an overall maximum number of turbines of 240, as opposed to 332 considered in the Environmental Statement. Furthermore, the as built design for Hornsea Project One will be for 174 turbines and a HVAC transmission option (rather than the HVDC considered as the maximum adverse scenario within the Environmental Statement).*
Hornsea Project Two Offshore Wind Farm	45.53	Values taken from Environmental Statement (SMart Wind, 2015): 0.466 km^2 from jack-up barges, 8.47 km^2 from array and inter-connector cable burial, 17.498 km^2 from export cable burial, 18.162 km^2 from seabed preparation and 0.930 km^2 from anchor placements. Note: *It is noted that the Applicant for Hornsea Project Two gained consent for an overall maximum number of turbines of 300, as opposed to 360 considered in the Environmental Statement.*
Total Offshore Wind Farms	147.40	-
Cables and pipelines		
PL2237 - Saturn to Mimas	0.28	Assumptions made for the cumulative assessment: trench width of 21 m along the entire 13.4 km pipeline length.
PLU3122 and PL3121 Juliet to Pickerill A Gas Pipeline and Umbilical	0.46	Values taken from Environmental Statement (GDF Suez, 2012).
PL3088 - Cygnus to ETS Gas Pipeline	1.33	Values taken from Environmental Statement (GDF Suez, 2011).
PL2894 - Katy to Kelvin Gas Export Pipeline	0.29	Assumptions made for the cumulative assessment: trench width of 21 m along the entire 14 km pipeline length.
PL2895 - Kelvin to Katy Methanol Pipeline	0.29	Assumptions made for the cumulative assessment: trench width of 21 m along the entire 14 km pipeline length.
PL0219_PR and PL0219_UM K4-Z to K5-A pipeline route and umbilical	0.36	Assumptions made for the cumulative assessment: trench width of 21 m along the entire 17.2 km pipeline and umbilical length.
Total Cables and Pipelines	3.02	
Aggregate extraction and disposal areas		
Licensed areas	16.88	8% of total licensed areas of 211 km^2.
Total aggregate extraction/disposal	16.88	-
Oil and gas decommissioning		
Viking CD, DD, ED, GD, HD; Vulcan UR; Viscount VO; Vampire/Valkyrie	17.28 km^2	Value taken from the Habitats Regulations Assessment undertaken for the first Viking Decommissioning Programme (VDP1) and the first Lincolnshire Offshore Gas Gathering Station (LOGGS) Decommissioning Programme (LDP1) (Department for Business, Energy and Industrial Strategy (BEIS), 2017). All pipelines to remain *in situ* (Conoco Phillips, 2017a and 2017b).
Audrey A and B platforms and associated pipelines	11.68 km^2	Values taken from Centrica (2017).
Total Oil and Gas	28.96 km^2	-
Total Tier 1	196.26	-
Tier 2		
Application aggregate extraction areas		
Application areas	4.36	8% of total application areas of 28.2 km^2.
Cables and pipelines		
Viking Link Interconnector	2.86	Assumptions made for the cumulative assessment: trench width of 20 m for up to 2 cable circuits along the 93 km interconnector length in UK waters within a 50 km buffer of Hornsea Three.
PL0221_HS D18-A to D15-FA-1	0.45	Assumptions made for the cumulative assessment: trench width of 21 m along the entire 17.2 km pipeline length.
PL0221_PR D18-A to D15-FA-1	0.45	Assumptions made for the cumulative assessment: trench width of 21 m along the entire 17.2 km pipeline length.

Project	Total predicted temporary habitat loss (km²)	Source
Total cables and pipelines	3.77	-
Total Tier 2	204.38	-
Tier 3		
Coastal protection		
Bacton Gas Terminal Coastal Defence Scheme	Not quantified	Scoping Report (Royal Haskoning, 2016).
Total Tier 3	204.38	-

Sensitivity of the receptor

2.13.2.9 The sensitivity of benthic subtidal habitats to offshore wind farm related impacts, as well as the likely impacts associated with the decommissioning of Oil and Gas infrastructure and installation of cables and pipelines will be as described for the construction phase impacts of Hornsea Three in paragraphs 2.11.1.24 to 2.11.1.36. With respect to marine aggregate dredging, research has shown that the recovery of marine benthic communities to such activities appears to be largely site specific, reflecting complex interactions between the intensity of dredging and the level of screening, the composition of sediments at the site and the extent to which the resident organisms are adapted to environmental disturbance (Hill *et al*., 2011). A relevant study in Licence Area 408 in the central North Sea has provided evidence that restoration of species composition and population density is accomplished rapidly by recolonisation of small individuals, even within the boundaries of the dredged area (Newell *et al*., 2002). A study investigating the effects of sustained dredging at the Cross Sands dredge site (5 to 25 km off the east coast of Great Yarmouth and Lowestoft), similarly demonstrated that even though variables such as abundance and species richness were found to depart significantly from an equitable state during the eight year study period, the effect did not persist from one year to the next and the potential for short term partial recovery of the assemblage was not compromised (at least in terms of abundance and species richness) (Barrio Froján *et al*., 2008). The rapid restoration of community structure by active recolonisation of mobile, opportunistic species is characteristic of shallow marine environments. These environments are subject to the influences of tide and wave action, such as those associated with Habitats A and C within the Hornsea Three benthic ecology study area, and the species typically inhabiting them, such as polychaetes. As such, the vulnerability of habitats is considered to be low to high, but with high recoverability with most recovery occurring within months and full recovery within five years.

2.13.2.10 Habitats A to C are deemed to be of low to medium vulnerability, high recoverability and regional value. The sensitivity of the receptor is therefore, considered to be **low**. Habitat D is deemed to be of medium to high vulnerability, medium recoverability and regional value. Although *S. spinulosa* is likely to recover quickly, the associated high biodiversity may take longer to recover and, as such, the sensitivity of Habitat D is considered to be medium. Ocean quahog *A. islandica* is deemed to be of medium vulnerability, very low recoverability and national value, and the sensitivity of this receptor is considered to be high.

Significance of the effect

2.13.2.11 Overall, the sensitivity of the receptors is considered to be low to medium (high for ocean quahog *A. islandica*) and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Tier 2

Magnitude of impact

2.13.2.12 The Tier 2 assessment includes all Tier 1 projects, aggregate extraction application areas and the construction of the three proposed cable and pipeline projects (Table 2.33).

2.13.2.13 For aggregate extraction application areas (assuming an average of 8% of the total application areas may be dredged at any one time; see Table 2.33 for justification) the maximum total temporary habitat loss/disturbance is approximately 4.36 km². As discussed in paragraph 2.13.2.5, this is likely to be an over-estimation and, as only a proportion of the areas will be dredged at any one time, this will allow for recovery between dredging events. For cable and pipeline installation projects the total temporary habitat loss is estimated at 3.77 km² (Table 2.34). The cumulative temporary habitat loss associated with the Tier 2 projects is predicted at up to 8.13 km² which when combined with the Tier 1 projects gives a total estimated temporary habitat loss for the Tier 2 assessment of 204.38 km².

2.13.2.14 The cumulative impact of temporary habitat loss from Tier 2 projects is predicted to be of regional spatial extent, medium term duration (i.e. Hornsea Three array area construction phase of up to eight years and Hornsea Three offshore cable corridor construction phase of up to eight years; see Table 2.14), intermittent and reversible but with a relatively small amount of the loss described occurring at any one time. It is predicted that the impact will affect the receptors directly. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.13.2.15 As detailed in paragraph 2.13.2.10, the habitats characterising this part of the southern North Sea are expected to have low, medium and high vulnerabilities, medium to high recoverability and regional to national value. The sensitivity of the receptor is therefore, considered to be low to medium.

Significance of the effect

2.13.2.16 Overall, it is predicted that the sensitivity of the receptors is considered to be low to medium and the magnitude of the impact is deemed to be minor. The effect of Tier 2 projects will, therefore, be of minor adverse significance, which is not significant in EIA terms.

Tier 3

2.13.2.17 The only Tier 3 project which has been identified in the CEA with the potential to result in cumulative temporary habitat loss with Hornsea Three is the Bacton Gas Terminal Coastal Defence Scheme. There is, however, currently no information on the impact the Bacton Gas Terminal Coastal Defence Scheme will have on benthic subtidal ecology receptors, although the Scoping Report (Royal Haskoning, 2016) for this project has identified that smothering due to placement of sediment on the nourishment zone (i.e. considered for the purposes of the Hornsea Three assessment as temporary habitat loss; see Table 2.33) will be an impact to be assessed in the EIA. Therefore, no quantification of Tier 3 cumulative impacts is possible at this stage.

North Norfolk Sandbanks and Saturn Reef SAC

2.13.2.18 With respect to cumulative temporary habitat loss/disturbance within the North Norfolk Sandbanks and Saturn Reef SAC, only those cumulative projects that are located within the site boundary are considered relevant for this impact. These include:

- Tier 1 projects:
  - Oil and Gas decommissioning associated with VDP1, LDP and the Leman field; and
  - Licenced aggregate extraction areas: Area 484.
- Tier 2 projects:
  - Aggregation and extraction Application Area 483.

Magnitude of impact

2.13.2.19 Using the numbers presented in Table 2.19 for temporary habitat loss/disturbance within the North Norfolk Sandbanks and Saturn Reef SAC during the construction phase of Hornsea Three (9.31 km^2) together with the values for Tier 1 and Tier 2 projects in Table 2.35, the total Tier 1 temporary habitat loss of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the SAC is predicted to be 39.64 km^2. This equates to 1.1% of the total area of this habitat within the site (i.e. the total area of the SAC). As measures will be implemented for Hornsea Three to ensure no direct impacts to Annex I reefs within the SAC, where possible, (see Table 2.18 and paragraph 2.11.1.43), no cumulative temporary loss of this habitat is predicted. The majority of the Tier 1 cumulative temporary habitat loss will arise from the Oil and Gas decommissioning activities (28.96 km^2), with the majority of this associated with over-trawlability surveys (see paragraph 2.13.2.6). The Tier 1 projects which have the potential to physically overlap with construction activities within the Hornsea Three offshore cable corridor, and therefore potentially result in localised repeat disturbance, are aggregate extraction within licensed Area 484 and pipelines PL496 and PL497 (pipelines within the Audrey field which cross the Hornsea Three offshore cable corridor and which may temporally overlap with the first two years of Hornsea Three offshore construction) although according Centrica (2017), these pipelines are to remain *in situ* following decommissioning of this field.

2.13.2.20 The Tier 2 assessment, which also includes application Area 483, is predicated to result in up to 41.90 km^2 of temporary habitat loss. This application aggregate extraction area does not physically overlap with the offshore cable route corridor and therefore there is no potential for repeat disturbance to the same areas of seabed.

2.13.2.21 Both the Tier 1 and Tier 2 cumulative impacts are predicted to be of localised to discrete areas of the North Norfolk Sandbanks and Saturn Reef SAC, medium term duration (i.e. Hornsea Three offshore cable corridor construction phase of up to eight years; see Table 2.14), intermittent and reversible but with a relatively small amount of the loss described occurring at any one time. It is predicted that the impact will affect the receptors directly. The magnitude of the Tier 1 and Tier 2 assessments is therefore, considered to be minor.

Sensitivity of the receptor

2.13.2.22 The sensitivity of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' to temporary habitat loss/disturbance is as described in paragraphs 2.11.1.60 to 2.11.1.63 and overall is low to medium.

Table 2.35: Cumulative temporary habitat loss for Hornsea Three and other plans/projects/activities in the CEA within the North Norfolk Sandbanks and Saturn Reef SAC.

Project	Total predicted temporary habitat loss within the North Norfolk Sandbanks and Saturn Reef SAC (km^2)	Source
Tier 1		
Hornsea Three	9.31	See Table 2.33.
VDP1 (Viking CD, DD, ED, GD and HD platforms) / LDP1 (Vampire VO/Valkyrie, Viscount VO and Vulcan VR platforms)	17.28	Value taken from the Habitats Regulations Assessment undertaken for the VDP1 and the LDP1 (BEIS, 2017).
Audrey A and B platforms and associated pipelines	11.68	Values taken from Centrica (2017).
Leman BH	Not quantified	Values for predicted temporary habitat loss are not presented in the Decommissioning Programme for this project (Shell UK Ltd., 2017).
Aggregate Area 484	1.38	8% of total licenced areas of 17.2 km^2.
Total Tier 1	39.64	-
Tier 2		
Application Area 483.	2.26	8% of total licenced areas of 28.2 km^2.
Total Tier 2	41.90	-

Significance of the effect

2.13.2.23 Overall, the sensitivity of the North Norfolk Sandbanks and Saturn Reef SAC is considered to be low to medium and the magnitude of the impact is deemed to be minor. The effect of cumulative temporary habitat loss/disturbance on this habitat feature will, therefore, be of minor adverse significance, which is not significant in EIA terms. Conclusions on the effects of Hornsea Three on the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

The Wash and North Norfolk Coast SAC

2.13.2.24 There are no Tier 1, Tier 2 or Tier 3 plans or projects that have been identified within The Wash and North Norfolk Coast SAC that may contribute to cumulative temporary habitat loss with Hornsea Three. Therefore, there is no cumulative assessment of temporary habitat loss for this site.

Markham's Triangle rMCZ

2.13.2.25 There are no Tier 1, Tier 2 or Tier 3 plans or projects that have been identified within the boundary of Markham's Triangle rMCZ that may contribute to cumulative temporary habitat loss of any of the broadscale habitat features. Therefore, there is no cumulative assessment of temporary habitat loss for this site.

Cromer Shoal Chalk Beds MCZ

2.13.2.26 There are no Tier 1 or Tier 2 plans or projects that have been identified within the boundary of the Cromer Shoal Chalk Beds MCZ that may contribute to cumulative temporary habitat loss of any of the broadscale habitat features.

2.13.2.27 The only Tier 3 project which has been identified within the Cromer Shoal Chalk Beds MCZ which has the potential to result in cumulative temporary habitat loss is the Bacton Gas Terminal Coastal Defence Scheme. There is, however, currently no information on the impact the Bacton Gas Terminal Coastal Defence Scheme on benthic subtidal ecology receptors, although the Scoping Report (Royal Haskoning, 2016) for this project has identified that smothering due to placement of sediment on the nourishment zone (i.e. considered for the purposes of the Hornsea Three assessment as temporary habitat loss; see Table 2.33) will be an impact to be assessed in the EIA. Therefore, no quantification of cumulative impacts is possible at this stage.

Temporary increases in suspended sediment concentrations and associated sediment deposition from cable and foundation installation and seabed preparation during the construction phase may affect benthic ecology

2.13.2.28 There is potential for cumulative impacts from increased SSC and associated sediment deposition to occur during the construction of Hornsea Three and similar from aggregate extraction activities and the construction of other offshore wind farms within one tidal excursion (see volume 2, chapter 1: Marine Processes).

2.13.2.29 All plans/projects/activities screened into the assessment for cumulative effects from temporary increases in SSC and associated sediment deposition are either on-going activities (i.e. licensed aggregate extraction areas), other offshore wind farms which are consented, submitted or under construction (i.e. Tier 1). Two Tier 2 projects and one Tier 3 project have been identified within the representative 50 km buffer.

Tier 1

Magnitude of impact

2.13.2.30 The Tier 1 assessment includes Hornsea Three together with licensed aggregate extraction areas within one tidal excursion, which have been considered in volume 2, chapter 1: Marine Processes. The licensed aggregate extraction area Humber 3 - 484 is located 43 km from the Hornsea Three array area and overlaps with the Hornsea Three offshore cable corridor (see Figure 2.10). The aggregate extraction area Humber 4 and 7 - 506 is located 13 km from the Hornsea Three array area and 8 km from the Hornsea Three offshore cable corridor (see Figure 2.10).

2.13.2.31 The target material at the marine aggregate area 484 is sands and gravels. The aggregate deposits in this region are generally understood to contain less than 5% fines (silt and clay) and therefore the concentrations of this fraction in the overflow from the dredging vessels are anticipated to be relatively low. Aggregate extraction operations in area 484 may release sediment into the water column through overspill and/or screening. The spatial extent of this plume will largely be determined by the sediments being extracted and the local hydrodynamic regime: heavier gravel-sized particles will settle rapidly at the discharge point, whilst sand-sized particles typically settle within about 250 m to 500 m, and within 5 km where tidal currents are strong (volume 2, chapter 1: Marine Processes).

2.13.2.32 Plume dispersion modelling results for area 484 showed that the maximum extent of a turbid plume resulting from dredging activity would be 15.5 km (ABPmer, 2013b). Maximum increases in near-seabed concentrations could exceed 600 mg/l near to the dredger within the area for a period of 1 hour, before reducing to approximately 50 to 150 mg/l for the remainder of the dredging period. It is expected that a return to near background concentrations would take approximately four days during spring tides or slightly longer during neap tides. The maximum sedimentation thickness resulting from the dredge plumes is expected to be approximately 1 mm in very close proximity to the dredge location, though the settled material will be transitory with the changing flood/ebb and spring/neap variations in the tidal currents (ABPmer, 2013b). Deposition of dispersed sediment resulting from cable laying activities in Hornsea Three at these aggregate dredging areas is considered to be low, as levels of deposition resulting from cable laying is predicted to be approximately 0.06 m within 100 m from the Hornsea Three offshore cable corridor (volume 2, chapter 1: Marine Processes).

2.13.2.33 The turbid plume arising from the dredging activities at Application Area 506 (see Figure 2.10) is predicted to extend between 2.5 to 4 km to the north-northwest and between 2 to 3 km to the south-southwest of the area (ABPmer, 2010). Depth averaged increases in SSC of between 50 and 70 mg/l above background levels would be likely to occur within the dredging area and down current of a dredger at Area 506 (ABPmer, 2010). Outside of the dredging area SSC of 50 mg/l above background levels would be likely to occur. The plume was predicted to extend no further than 4 km north-northwest or 3 km south-southwest and at this point the predicted increase in SSC was less than 10 mg/l. In terms of deposition the dredging footprint based on the maximum design scenario was predicted to extend up to 2 km (ABPmer, 2010).

2.13.2.34 The plumes arising from both the aggregate extraction-related dredging activity and the Hornsea Three extraction activity are generally predicted to coalesce together, creating a larger plume with concentrations similar to the alone activities, as opposed to an additive plume with a higher concentration (volume 2, chapter 1: Marine Processes). It is considered that activities would mostly likely cause an additive plume of higher concentrations only if cable installation for Hornsea Three took place at the same time and in the vicinity of the eastern margin of the 506 aggregate extraction area, though this is predicted to cause a maximum additive plume of a few 10's mg/l over the construction of Hornsea Three alone, as described in volume 2, chapter 1: Marine Processes.

2.13.2.35 The cumulative impact of increased SSC and sediment deposition on subtidal benthic receptors (i.e. Habitats A, B, C, D, E and the ocean quahog *A. islandica*) from dredging at aggregation extraction areas 484 and 506 and activities relating to the development of Hornsea Three, is predicted to be of regional spatial extent (i.e. within kilometres of Hornsea Three), of medium term (i.e. construction phase of up to eight years for the Hornsea Three array area and up to eight years for the Hornsea Three offshore cable corridor; Table 2.14) and intermittent duration, and reversible to baseline conditions following cessation of activities. It is also predicted that the impact will affect benthic receptors indirectly and therefore, the magnitude is considered to be minor.

Sensitivity of the receptor

2.13.2.36 The sensitivities of the benthic ecology VERs to temporary increases in suspended sediments and associated deposition from construction activities are discussed in paragraphs 2.11.1.111 to 2.11.1.115.

2.13.2.37 The benthic ecology VERs Habitats A to E and ocean quahog *A. islandica* are considered to be of low vulnerability, high to immediate recoverability and of regional to national importance. The sensitivity of these receptors is therefore considered to be low.

Significance of the effect

2.13.2.38 Overall, the sensitivity of the benthic VERs Habitats A to E and the ocean quahog *A. islandica* is considered to be low and the magnitude of the impact is deemed to be minor. The effect of increases in SSC and associated sediment deposition on these benthic VERs will, therefore, be of minor adverse significance, which is not significant in EIA terms.

Tier 2

Magnitude of impact

2.13.2.39 The Tier 2 assessment includes Hornsea Three together with application aggregate extraction areas within one tidal excursion, which have been considered in volume 2, chapter 1: Marine Processes.

2.13.2.40 The application aggregate extraction area 483 is located 14 km from the Hornsea Three array area and 2 km from the Hornsea Three offshore cable corridor, respectively (see Figure 2.10).

2.13.2.41 As discussed in 2.13.2.31, the concentrations of fines in the overflow from the dredging vessels are anticipated to be relatively low. The spatial extent of the plume will largely be determined by the sediments being extracted and the local hydrodynamic regime: heavier gravel-sized particles will settle rapidly at the discharge point, whilst sand-sized particles typically settle within about 250 m to 500 m, and within 5 km where tidal currents are strong (volume 2, chapter 1: Marine Processes).

2.13.2.42 Plume dispersion modelling results for application area 483 showed that the maximum extent of a turbid plume resulting from dredging activity would be 17.0 km (ABPmer, 2013b). Maximum increases in near-seabed concentrations could exceed 600 mg/l near to the dredger for a period of 1 hour, before reducing to approximately 50 to 150 mg/l for the remainder of the dredging period. It is expected that a return to near background concentrations would take approximately four days during spring tides or slightly longer during neap tides. The maximum sedimentation thickness resulting from the dredge plumes is expected to be approximately 1 mm in very close proximity to the dredge location, though the settled material will be transitory with the changing flood/ebb and spring/neap variations in the tidal currents (ABPmer, 2013b). Deposition of dispersed sediment resulting from cable laying activities in Hornsea Three at aggregate dredging areas is considered to be low, as levels of deposition resulting from cable laying is predicted to be approximately 0.06 m within 100 m from the Hornsea Three offshore cable corridor (volume 2, chapter 1: Marine Processes).

2.13.2.43 The plumes arising from both the aggregate extraction-related dredging activity and the Hornsea Three extraction activity are generally predicted to coalesce together, creating a larger plume with concentrations similar to the alone activities, as opposed to an additive plume with a higher concentration (volume 2, chapter 1: Marine Processes). It is considered that activities would mostly likely cause an additive plume of higher concentrations only if cable installation for Hornsea Three took place at the same time and in the vicinity of the western margin of 483 application aggregate extraction area, though this is predicted to cause a maximum additive plume of a few 10's mg/l over the construction of Hornsea Three alone, as described in volume 2, chapter 1: Marine Processes.

2.13.2.44 The cumulative impact of increased SSC and sediment deposition on subtidal benthic receptors (i.e. Habitats A, B, C, D, E and the ocean quahog *A. islandica*) from dredging at application areas 483 and 506, and activities relating to the development of Hornsea Three, is predicted to be of regional spatial extent (i.e. within kilometres of Hornsea Three), of medium term (i.e. construction phase of up to eight years for the Hornsea Three array area and up to eight years for the Hornsea Three offshore cable corridor; Table 2.14) and intermittent duration, and reversible to baseline conditions following cessation of activities. It is also predicted that the impact will affect benthic receptors indirectly and therefore, the magnitude is considered to be minor.

Sensitivity of the receptor

2.13.2.45 The sensitivities of the benthic ecology VERs to temporary increases in SSC and associated deposition from construction activities are discussed in paragraphs 2.11.1.111 to 2.11.1.115.

2.13.2.46 The benthic ecology VERs Habitats A to E and ocean quahog *A. islandica* are considered to be of low vulnerability, high to immediate recoverability and of regional to national importance. The sensitivity of these receptors is therefore considered to be low.

Significance of the effect

2.13.2.47 Overall, the sensitivity of benthic VERs Habitats A to E and the ocean quahog *A. islandica* is considered to be low and the magnitude of the impact is deemed to be minor. The effect of increases in SSC and associated sediment deposition on these benthic VERs will, therefore, be of minor adverse significance, which is not significant in EIA terms.

Tier 3

2.13.2.48 The only Tier 3 project which has been identified in the CEA which has the potential to result in cumulative increased SSC and deposition with Hornsea Three is the Bacton Gas Terminal Coastal Defence Scheme.

2.13.2.49 The Scoping Report (Royal Haskoning, 2016) for this project has identified that the following potential impacts will be assessed in the EIA (i.e. considered for the purposes of the Hornsea Three assessment as increased SSC and deposition; see Table 2.33):

- Smothering due to placement of sediment on the nourishment zone;
- Changes to suspended sediment causing increased suspended sediment concentrations which could affect benthic species;
- Changes to rates of sedimentation following placement of sediment and subsequent settlement; and
- Changes to down drift coastal communities resulting from sand input from alternative sources

2.13.2.50 There is, however, currently no information on the impact the Bacton Gas Terminal Coastal Defence Scheme on benthic subtidal ecology receptors, therefore no quantification of Tier 3 cumulative impacts is possible at this stage.

North Norfolk Sandbanks and Saturn Reef SAC

2.13.2.51 With respect to cumulative increased SSC and deposition within the North Norfolk Sandbanks and Saturn Reef SAC, only those cumulative projects with ZoIs that overlap the site boundary are considered relevant for this impact. These include:

- Tier 1 projects:
  - Licenced aggregate extraction areas: Area 484; and
  - Aggregation and extraction Application Area 506
- Tier 2 projects:
  - Aggregation and extraction Application Area 483.

Magnitude of impact

2.13.2.52 The cumulative impact of increased SSC and sediment deposition on subtidal benthic receptors (i.e. sandbanks which are slightly covered by water all the time and Annex I reefs) from dredging at aggregation extraction areas 484 and 506 and potential dredging at application area 483 together with activities relating to the development of Hornsea Three, is predicted to be of regional spatial extent (i.e. within kilometres of Hornsea Three), of medium term (i.e. construction phase of up to eight years for the Hornsea Three array area and up to eight years for the Hornsea Three offshore cable corridor; Table 2.14) and intermittent duration, and reversible to baseline conditions following cessation of activities. It is also predicted that the impact will affect benthic receptors indirectly and therefore, the magnitude is considered to be minor.

Sensitivity of the receptor

2.13.2.53 The sensitivities of the benthic ecology VERs in North Norfolk Sandbanks and Saturn Reef SAC to temporary increases in suspended sediments and associated deposition from construction activities are discussed in paragraphs 2.11.1.118 to 2.11.1.120.

2.13.2.54 'Sandbanks which are slightly covered by seawater all the time' and *S. spinulosa* reefs in the North Norfolk Sands and Saturn Reef SAC are considered to be of low vulnerability, high to immediate recoverability and of international importance. The sensitivity of these receptors is therefore considered to be low.

Significance of the effect

2.13.2.55 Overall, the sensitivity of 'Sandbanks which are slightly covered by seawater all the time' and Annex I *S. spinulosa reefs* in the North Norfolk Sands and Saturn Reef SAC is considered to be low and the magnitude of the impact is deemed to be minor. The effect of increases in SSC and associated sediment deposition on these benthic VERs will, therefore, be of minor adverse significance, which is not significant in EIA terms. Conclusions on the effects of Hornsea Three on the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

The Wash and North Norfolk Coast SAC

2.13.2.56 The maximum extent of a turbid plume resulting from dredging activity at area 484 would be 15.5 km (as discussed in paragraph 2.13.2.32) and for area 506 would be 4.0 km (as discussed in paragraph 2.13.2.33). The maximum extent of turbid plumes resulting from dredging activity at application area 483 would be 17.0 km (as discussed in paragraph 2.13.2.42). Therefore, there are no Tier 1 or Tier 2 plans or projects that have been identified with a ZoI that overlaps The Wash and North Norfolk Coast SAC that may contribute to cumulative increased SSC and deposition at any of the VERs.

Cromer Shoal Chalk Beds MCZ

2.13.2.57 The maximum extent of a turbid plume resulting from dredging activity at area 484 would be 15.5 km (as discussed in paragraph 2.13.2.32) and for area 506 would be 4.0 km (as discussed in paragraph 2.13.2.33). The maximum extent of turbid plumes resulting from dredging activity at application area 483 would be 17.0 km (as discussed in paragraph 2.13.2.42). Therefore, there are no Tier 1 or Tier 2 plans or projects that have been identified with a ZoI that overlaps the Cromer Shoal Chalk Beds MCZ that may contribute to cumulative increased SSC and deposition at any of the VERs.

2.13.2.58 The only Tier 3 project which has been identified in the CEA which has the potential to result in cumulative increased SSC and deposition with Hornsea Three is the Bacton Gas Terminal Coastal Defence Scheme. There is, however, currently no information on the impact the Bacton Gas Terminal Coastal Defence Scheme on benthic subtidal ecology receptors, therefore no quantification of Tier 3 cumulative impacts on the VERs within Cromer Shoal Chalk Beds MCZ is possible at this stage.

Markham's Triangle rMCZ

2.13.2.59 The maximum extent of a turbid plume resulting from dredging activity at area 484 would be 15.5 km (as discussed in paragraph 2.13.2.32) and for area 506 would be 4.0 km (as discussed in paragraph 2.13.2.33). The maximum extent of turbid plumes resulting from dredging activity at application area 483 would be 17.0 km (as discussed in paragraph 2.13.2.42). Therefore, there are no Tier 1, Tier 2 or Tier 3 plans or projects that have been identified with a ZoI that overlaps Markham's Triangle MCZ that may contribute to cumulative increased SSC and deposition at any of the VERs.

2.13.3 Operation and maintenance phase

Cumulative long term loss of benthic ecology VERs through presence of offshore wind farm foundations and related infrastructure (e.g. cable protection, substations) and Oil and Gas and interconnector installations

2.13.3.1 Tier 1 cumulative long term habitat loss is predicted to occur as a result of the presence of Hornsea Three, all other offshore wind farms which are consented, submitted or under construction within a representative 50 km buffer of Hornsea Three, cable and pipeline projects and decommissioning activities for VDP1 and LDP 1 (see Table 2.33 and Figure 2.10). Long term habitat loss may result from the physical presence of foundations, scour protection and cable protection. Three Tier 2 cable/pipeline projects have been identified within the representative 50 km buffer (Viking Interconnector, PL0221_HS D18-A to D15-FA-1 and PL0221_PR D18-A to D15-FA-1) while no Tier 3 projects have been identified.

Tier 1

Magnitude of impact

2.13.3.2 The predicted cumulative long term habitat loss from each of the Tier 1 offshore wind farm projects, cable/pipeline projects and Oil and Gas decommissioning programmes is presented in Table 2.36 with values taken from Environmental Statements, where available. Where such information is not available (i.e. PL2237 – Saturn to Mimas, PL2894 – Katy to Kelvin gas export pipeline, PL2895 – Kelvin to Katy methanol pipeline, PL0219_PR and PL0219_UM K4-Z to K5-A pipeline route and umbilical), it has not been possible to estimate the cable/pipeline protection that might be left on the seabed after decommissioning as the proportion of cable protection is site specific and depends on local ground conditions for each project. Therefore, it is not possible to estimate the percentage of a cable that might require cable protection (e.g. 10% or 90% of a cable length). As such, areas of long term habitat loss have not been included in the Tier 1 assessment for many of the cable and pipelines within 50 km of Hornsea Three. See Table 2.36 for the data available. On the basis of the information that is available for other cable/pipelines it is likely that the quantities will be lower than that estimated for offshore wind farm projects.

2.13.3.3 Table 2.36 shows that for all projects/plans/activities in the Tier 1 assessment (for which long term habitat is quantified, the cumulative long term habitat loss within a 50 km buffer of Hornsea Three is estimated to be 15.44 km^2. This equates to 0.06% of the total area of subtidal habitat within a 50 km buffer of Hornsea Three. It should be noted that for the Oil and Gas decommissioning works associated with VDP1, LDP1 and the Audrey field the long term habitat loss of 0.13 km^2 will effectively be permanent habitat as this is associated with rock placement as part of the decommissioning works. Comparable habitats are however, widely distributed in the southern North Sea benthic ecology study area (see volume 5, annex 2.1: Benthic Ecology Technical Report) so this loss is not predicted to diminish regional ecosystem functions.

Table 2.36: Cumulative long term habitat loss for Hornsea Three and other plans/projects in the Tier 1 assessment within a representative 50 km buffer of Hornsea Three.

Project	Total predicted long term habitat loss (km^2)	Source
Tier 1		
Offshore wind farms		
Hornsea Three	4.21	See Table 2.14
Dudgeon Offshore Wind Farm	0.42	Values taken from Environmental Statement (Dudgeon Offshore Wind Limited, 2009).
Race Bank Offshore Wind Farm	0.10	Values taken from Environmental Statement (Centrica Energy, 2009).
Triton Knoll Offshore Wind Farm	0.88	Values taken from Environmental Statement (TKOWFL, 2012).
Hornsea Project One Offshore Wind Farm	4.23	Values taken from Environmental Statement (SMart Wind, 2013).
Hornsea Project Two Offshore Wind Farm	5.45	Values taken from Environmental Statement (SMart Wind, 2015).
Total Offshore Wind Farms	15.29	-
Cables and pipelines		
PLU3122 and PL3121 Juliet to Pickerill A Gas Pipeline and Umbilical	0.01	Values taken from Environmental Statement (GDF Suez, 2012).
PL3088 - Cygnus to ETS Gas Pipeline	0.01	Values taken from Environmental Statement (GDF Suez, 2011).
Total Cables and Pipelines	0.02	-
Oil and gas decommissioning		
VDP1 (Viking CD, DD, ED, GD and HD platforms) / LDP1 (Vampire VO/Valkyrie, Viscount VO and Vulcan VR platforms)	0.049	Value taken from the Habitats Regulations Assessment undertaken for the VDP1 and the LDP1 (BEIS, 2017). All pipelines will remain *in situ* post decommissioning, but are buried so do not represent long term/permanent habitat loss (Conoco Phillips, 2017a and 2017b).
Audrey A and B platforms and associated pipelines	0.081	Values taken from Centrica (2017).
Total Oil and Gas	0.13	-
Total Tier 1	15.44	-

Project	Total predicted long term habitat loss (km²)	Source
Tier 2		
Cables and pipelines		
Viking Link Interconnector	0.14	Assumptions made for the cumulative assessment: cable protection of 6.5 m width for 23% of the 93 km cable within 50 km buffer of Hornsea Three (National Grid Viking Link Ltd., 2017).
Total Cables and Pipelines	0.14	-
Total Tier 2	15.58	-

2.13.3.4 If during decommissioning, offshore wind farm structures and pipelines are removed, the impacts will be reversible with recoverability of the affected habitats likely, within time scales similar to those outlined in paragraphs 2.11.1.24 to 2.11.1.36, following removal of the structures.

2.13.3.5 The cumulative impact of long term habitat loss will affect benthic subtidal receptors directly. It is predicted to be of regional spatial extent (but highly localised within each offshore wind farm), long term duration (i.e. for the lifetime of the projects), continuous and reversible. The magnitude for the Tier 1 assessment is therefore, considered to be minor.

<u>Sensitivity of the receptor</u>

2.13.3.6 As the majority of the species likely to be affected are infaunal and would therefore be lost along with the substratum, these species are all considered to be highly intolerant of, and therefore vulnerable to, complete habitat loss. However, none of the habitats likely to be affected are rare, geographically restricted or of specific conservation importance. The wide distribution of comparable habitats within the wider region suggests that component species and habitats will remain sufficiently represented. Although these habitats typically have high levels of recoverability as outlined in paragraphs 2.11.1.24 to 2.11.1.36, recoverability is not considered to be applicable to this impact as there will be no recoverability during the lifetime of the project although, as noted in paragraph 2.13.3.4 if structures are removed during decommissioning there would be the potential for the recovery of benthic habitats.

2.13.3.7 Benthic subtidal receptors are deemed to be of high vulnerability and regional to international value (recoverability is not deemed applicable for the duration of this impact). The sensitivity of the benthic receptors potentially affected is therefore, considered to be high.

<u>Significance of the effect</u>

2.13.3.8 There will be a direct, negative impact, of long term duration (i.e. for the lifetime of the project) but of relatively limited spatial extent, upon benthic subtidal habitats. However, all the habitats potentially affected are widely distributed in the southern North Sea benthic ecology study area and this loss is not considered likely to affect ecosystem functionality.

2.13.3.9 Overall, the sensitivity of the receptors is considered to be high and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms.

Tier 2

<u>Magnitude of impact</u>

2.13.3.10 The Tier 2 assessment includes all Tier 1 projects and the proposed Viking Link Interconnector project and the PL0221_HS D18-A to D15-FA-1 and PL0221_PR D18-A to D15-FA-1 projects (Table 2.33), although data on long term habitat loss to inform this assessment is only available for the Viking Link Interconnector project. The cumulative long term habitat loss from the Viking Link Interconnector is predicted to the 0.14 km² which has been calculated using project description information from the Environmental Statement (i.e. 23% of cable will require cable protection up to 6.5 m in width; National Grid Viking Link Ltd., 2017) and the assumption that this will apply to the 93 km of interconnector cable within the 50 km buffer of Hornsea Three. The total Tier 2 cumulative long term habitat loss is therefore estimated at 15.58 km² (Table 2.36).

2.13.3.11 The cumulative impact of long term habitat loss from Tier 2 projects will affect benthic subtidal receptors directly. It is predicted to be of regional spatial extent (but highly localised within each offshore wind farm), long term duration (i.e. for the lifetime of the projects), continuous and reversible. The magnitude for the Tier 2 assessment is therefore, considered to be minor.

<u>Sensitivity of the receptor</u>

2.13.3.12 Benthic subtidal receptors are deemed to be of high vulnerability and regional to international value (recoverability is not deemed applicable for this impact). The sensitivity of the benthic receptors potentially affected is therefore, considered to be high.

<u>Significance of the effect</u>

2.13.3.13 Overall, the sensitivity of the receptors is considered to be high and the magnitude of the impact is deemed to be minor. The effect of long term habitat loss from Tier 2 projects will, therefore, be of minor adverse significance, which is not significant in EIA terms.

North Norfolk Sandbanks and Saturn Reef SAC

2.13.3.14 Of the projects screened into the CEA for benthic ecology (Table 2.32), only the Tier 1 Oil and Gas decommissioning projects (VDP1 and LDP1) are located within the boundary of the North Norfolk Sandbanks and Saturn Reef SAC and so have the potential to result in cumulative long term habitat loss with Hornsea Three. There are no Tier 2 or Tier 3 plans/projects within the North Norfolk Sandbanks and Saturn Reef SAC, as such there are no Tier 2 or 3 assessments for this impact.

Magnitude of impact

2.13.3.15 The total predicted cumulative long term habitat loss of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC as a result of Hornsea Three and Oil and Gas decommissioning is up to 0.63 km^2 (i.e. 0.5 + 0.13 km^2). This equates to 0.02% of the total area of this habitat within the site (i.e. all Annex I sandbank habitat). As measures will be implemented for Hornsea Three to avoid direct impacts to Annex I reefs, where possible, within the North Norfolk Sandbanks and Saturn Reef SAC (see Table 2.18 and paragraph 2.11.2.14), there is no predicted cumulative long term loss of this habitats. All of the long term loss outlined above has the potential to be permanent on the basis that the rock placement installed during decommissioning is part of the decommissioning process and would not be subsequently removed and the assessment for Hornsea Three also assumes that, as a maximum design scenario, cable protection may be left in situ after decommissioning. It should be noted, however, that the Habitats Regulations Assessment for the VDP1 and LDP1 predicts that a proportion of the rock placed on the seabed will be buried and will therefore not cause on going long-term loss of habitat (BEIS, 2017). The impact of cumulative long term/permanent habitat loss within the North Norfolk Sandbanks and Saturn Reef SAC is predicted to be localised to discrete sections of the SAC, affecting a small proportion of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC. The impact will be continuous and irreversible and will affect receptors directly. The magnitude is considered to be minor.

Sensitivity of the receptor

2.13.3.16 The sensitivity of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' is as described in paragraphs 2.11.2.17 and 2.11.3.46 for long term and permanent habitat loss and overall is considered to be high due to their high vulnerability with no potential for recovery and their international importance.

Significance of the effect

2.13.3.17 Overall, the sensitivity of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' feature of the North Norfolk Sandbanks and Saturn Reef SAC is considered to be high and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms. Conclusions on the effects of Hornsea Three on the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

The Wash and North Norfolk Coast SAC

2.13.3.18 There are no Tier 1, Tier 2 or Tier 3 plans or projects that have been identified within The Wash and North Norfolk Coast SAC that may contribute to cumulative long term habitat loss with Hornsea Three. Therefore, there is no cumulative assessment of long term habitat loss for this site.

Markham's Triangle rMCZ

2.13.3.19 There are no Tier 1, Tier 2 or Tier 3 plans or projects that have been identified within the boundary of Markham's Triangle rMCZ that may contribute to cumulative long term habitat loss of any of the broadscale habitat features. Therefore, there is no cumulative assessment of long term habitat loss for this site.

Cromer Shoal Chalk Beds MCZ

2.13.3.20 There are no Tier 1, Tier 2 or Tier 3 plans or projects that have been identified within the boundary of the Cromer Shoal Chalk Beds MCZ that may contribute to cumulative long term habitat loss of any of the broadscale habitat features. Therefore, there is no cumulative assessment of long term habitat loss for this site.

Cumulative introduction of subtidal hard substrates (i.e. from offshore wind farm structures) and associated colonisation

2.13.3.21 As discussed in paragraphs 2.11.2.38 *et seq*. and 2.11.2.72 *et seq*., the introduction of hard substrate into areas of predominantly soft sediments has the potential to alter community composition and biodiversity and to facilitate the spread/introduction of non-indigenous species. The latter may be particularly important with regards to cumulative effects as several offshore structures in relatively close proximity could enable the 'stepping stone effect'.

2.13.3.22 The plans and projects which are screened into the Tier 1 assessment for cumulative effects from the introduction of hard substrate are other offshore wind farms which are consented, submitted or under construction (i.e. Tier 1), Oil and Gas decommissioning activities and cables/pipelines. The only Tier 2 projects which have been identified within the representative 50 km buffer are cable and pipeline protects (i.e. Viking Interconnector, PL0221_HS D18-A to D15-FA-1 and PL0221_PR D18-A to D15-FA-1), while no Tier 3 projects have been identified.

Tier 1

Magnitude of impact

2.13.3.23 It is difficult to accurately quantify the total area of hard substrate that will be introduced within a 50 km buffer of Hornsea Three, particularly since this is not quantified in the majority of the assessments for the other offshore wind farms included within the Tier 1 assessment (see Table 2.32). The extent of habitat creation will depend on the exact foundation size installed (which may be less than the worst case assessed in the Environmental Statements), and scour protection and cable armour requirements which will vary for each site. However, from a review of the relevant Environmental Statements and information acquired from developers' websites, it is estimated that approximately 1,654 turbines may be constructed from all projects included within Tier 1 (Table 2.37). It should be noted however, that this assessment is considered to be precautionary as the maximum design scenario has assumed the habitat created as a result of the installation of the maximum number of turbines consented for each offshore wind farm project which is likely, in reality, to be greater than the number of turbines actually constructed.

Table 2.37: Cumulative habitat creation for Hornsea Three and offshore wind farms in the Tier 1 assessment within a representative 50 km buffer of Hornsea Three.

Project	Maximum number of turbines	Total predicted habitat creation (m^2)	Source
Tier 1			
Offshore wind farms			
Hornsea Three	300	5,470,308	See Table 2.14.
Dudgeon Offshore Wind Farm	168	1,265,544	168 turbines (consented) x 7819 m^2 (i.e. predicted habitat creation per turbine as per Hornsea Three assumptions as value not specified in Environmental Statement).
Race Bank Offshore Wind Farm	206	1,551,798	206 turbines (consented) x 7,819 m^2 (i.e. predicted habitat creation per turbine as per Hornsea Three assumptions as value not specified in Environmental Statement).
Triton Knoll Offshore Wind Farm	288	2,169,504	288 turbines (consented) x 7,819 m^2 (i.e. predicted habitat creation per turbine as per Hornsea Three assumptions as value not specified in Environmental Statement).
Hornsea Project One Offshore Wind Farm	332	4,860,136	Values taken from Environmental Statement (SMart Wind, 2013). *It is noted however that the Applicant for Hornsea Project One gained consent for an overall maximum number of turbines of 240, as opposed to 332 considered in the Environmental Statement. Furthermore, the as built design for Hornsea Project One will be for 174 turbines and a HVAC transmission option (rather than the HVDC considered as the maximum adverse scenario within the Environmental Statement).*
Hornsea Project Two Offshore Wind Farm	360	6,239,991	Values taken from Environmental Statement (SMart Wind, 2015). *It is noted, however, that the Applicant for Hornsea Project Two gained consent for an overall maximum number of turbines of 300, as opposed to 360 considered in the Environmental Statement.*
Total Offshore Wind Farms	-	21,746,613	-
Cables and pipelines			
PLU3122 and PL3121 Juliet to Pickerill A Gas Pipeline and Umbilical	N/A	10,000	Values taken from Environmental Statement (GDF Suez, 2012).
PL3088 - Cygnus to ETS Gas Pipeline	N/A	114,000	Values taken from Environmental Statement (GDF Suez, 2011).
Total cable/pipeline protection	N/A	124,000	-
Oil and gas			
VDP1 (Viking CD, DD, ED, GD and HD platforms) / LDP1 (Vampire VO/Valkyrie, Viscount VO and Vulcan VR platforms)	N/A	49,000	Value taken from the Habitats Regulations Assessment undertaken for the VDP1 and the LDP1 (BEIS, 2017).
Audrey A and B platforms and associated pipelines	N/A	81,000	Values taken from Centrica (2017).
Total Oil and Gas	N/A	130,000	-
Total Tier 1 habitat creation	N/A	22,000,620	-

Project	Maximum number of turbines	Total predicted habitat creation (m^2)	Source
Tier 2			
Viking Link Interconnector	N/A	139,035	Assumptions made for the cumulative assessment: cable protection of 6.5 m width for 23% of the 93 km cable within 50 km buffer of Hornsea Three (National Grid Viking Link Ltd., 2017).
Total Cables and Pipelines	N/A	139,035	-
Total Tier 2 habitat creation	N/A	22,139,655	-

2.13.3.24 For the purposes of this assessment, it has been assumed that for all other projects where habitat creation numbers are not specified in the relevant Environmental Statement, the area of introduced hard substrate per turbine is the same as for the Hornsea Three foundations (i.e. 7,819 m^2 including scour protection). The total cumulative hard substrate associated with offshore wind farms which could be introduced within a 50 km buffer of Hornsea Three is estimated to be approximately 21,746,620 m^2. This is considered to be a highly precautionary maximum design scenario as in many cases smaller turbines than those assumed for the Hornsea Three assessment will be installed for the other offshore wind farms, and also fewer turbines may actually be constructed than the number consented (see paragraph 2.12.1.1). Therefore, although an estimation of substrate introduced because of the installation of cable protection for the other offshore wind farms within the Tier 1 assessment has not been included (except for Hornsea Project One and Hornsea Project Two) due to the difficulty in quantifying these areas, given the precaution included in the assessment these areas are expected to be well within the total cumulative estimate of 21,746,620 m^2.

2.13.3.25 The total maximum habitat creation resulting from cable/pipeline protection is estimated to be 124,000 m^2 and from Oil and Gas decommissioning activities for VDP1, LDP1 and Audrey decommissioning is estimated to be 130,000 m^2 (Table 2.37). As such, the total cumulative Tier 1 habitat creation is predicted to be up to 22,000,620 m^2. The maximum cumulative introduction of hard substrate equates to less than 0.09% of the subtidal habitat within a 50 km buffer of Hornsea Three.

2.13.3.26 The impact will extend over the regional area but will be highly localised within this area, will be of long term duration, continuous and irreversible during the lifetime of the projects. The magnitude of the impact is therefore, considered to be minor.

Sensitivity of the receptor

2.13.3.27 The sensitivity of subtidal receptors is as described in paragraphs 2.11.2.48 to 2.11.2.54. Naturally occurring hard substrate in this part of the southern North Sea benthic ecology study area is rare and therefore the introduction of a maximum of approximately 22.0 km^2 of artificial hard substrate represents a large shift in the baseline condition of the pre-construction area. Whether this effect is viewed as positive or negative for benthic receptors is subjective. For example, an increase in the abundance of a commercially important invertebrate (e.g. lobster) resulting from new habitat and shelter may be beneficial to commercial fisheries, although from an ecological perspective this may be perceived as a slight negative impact. Negative effects may also occur if non-indigenous species become established. Precisely which, if any, species may benefit is unknown and conversely which species may be adversely affected is also uncertain; INNS which have been recorded to date associated with offshore wind farm structures are discussed in paragraphs 2.11.2.79 to 2.11.2.83. There is generally very little information concerning the intolerance of different benthic biotopes to invasion by INNS, but as discussed in paragraph 2.11.2.79, monitoring of existing offshore wind farms has not demonstrated any significant negative impacts.

2.13.3.28 The VERs likely to be affected by an increase in hard substrate species diversity and INNS (Habitats A, B, C and D) are deemed to be of low vulnerability and regional to national value. The sensitivity of the receptor is therefore, considered to be low to medium.

Significance of the effect

2.13.3.29 Overall, the sensitivity of the receptors is considered to be low to medium and the magnitude of the impact is deemed to be minor. The effect of cumulative hard habitat creation resulting in community change and facilitating the spread of INNS will, therefore, be of minor adverse significance, which is not significant in EIA terms.

Tier 2

Magnitude of impact

2.13.3.30 The Tier 2 assessment includes all Tier 1 projects, the proposed Viking Link Interconnector project and the PL0221_HS D18-A to D15-FA-1 and PL0221_PR D18-A to D15-FA-1 projects (Table 2.33), although data on habitat creations is only available for the Viking Link Interconnector project. The cumulative habitat creation from the Viking Link Interconnector is predicted to be 139,035 m^2 which has been calculated using the assumptions detailed in paragraph 2.13.3.10 and Table 2.26. The total Tier 2 cumulative habitat creation is estimated at 22,139,655 m^2 (Table 2.37).

2.13.3.31 The impact will extend over the regional area but will be highly localised within this area, will be of long term duration, continuous and irreversible during the lifetime of the projects. The magnitude of the impact is therefore, considered to be minor.

Sensitivity of the receptor

2.13.3.32 Benthic subtidal receptors are deemed to be of low to medium sensitivity as described in paragraphs 2.13.3.6 to 2.13.3.7.

Significance of the effect

2.13.3.33 Overall, the sensitivity of the receptors is considered to be low to medium and the magnitude of the impact is deemed to be minor. The effect of Tier 2 cumulative hard habitat creation resulting in community change and facilitating the spread of INNS will, therefore, be of minor adverse significance, which is not significant in EIA terms.

North Norfolk Sandbanks and Saturn Reef SAC

2.13.3.34 Of the projects screened into the CEA for benthic ecology (Table 2.33), only the Tier 1 Oil and Gas decommissioning projects (VDP1 and LDP1) are located within the boundary of the North Norfolk Sandbanks and Saturn Reef SAC and so have the potential to result in cumulative habitat creation with Hornsea Three. There are no Tier 2 or Tier 3 plans/projects within the North Norfolk Sandbanks and Saturn Reef SAC, as such there are no Tier 2 or 3 assessments for this impact.

Magnitude of impact

2.13.3.35 The total predicted Tier 1 cumulative habitat creation within the North Norfolk Sandbanks and Saturn Reef SAC as a result of Hornsea Three (544,123 m^2; see Table 2.29) and Oil and Gas decommissioning (130,000 m^2; see Table 2.37) is up to 674,123 m^2. This equates to 0.02% of the total area of this habitat within the site (i.e. all Annex I sandbank habitat). As outlined in paragraph 2.13.3.15, the Habitats Regulations Assessment for the VDP1 and LDP1 states that a proportion of the hard substrate to be installed in the North Norfolk Sandbanks and Saturn Reef SAC during the decommissioning programmes is expected to become buried (BEIS, 2017). Therefore, the actual available habitat for colonisation by epifaunal species and/or INNS is expected to be less than that described here. In a subtidal sandbank habitat where encrusting epifaunal species area rare, this is likely to represent highly localised shifts in the baseline conditions; the magnitude is, therefore, considered to be minor.

Sensitivity of the receptor

2.13.3.36 Measures will be implemented for Hornsea Three to avoid direct impacts to Annex I reefs, where possible, within the North Norfolk Sandbanks and Saturn Reef SAC (see Table 2.18), and no *S. spinulosa* reef was located during surveys for the VDP1 and LDP1 decommissioning programmes. Consequently, no cumulative effects associated with habitat creation on Annex I reefs are predicted.

2.13.3.37 The sensitivity of the NcirBat and ApriBatPo biotopes associated with the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time is as described in paragraph 2.11.2.60 and is considered to be low.

Significance of the effect

2.13.3.38 Overall, the sensitivity of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' feature of the North Norfolk Sandbanks and Saturn Reef SAC is considered to be low and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms. Conclusions on the effects of Hornsea Three on the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC are presented in full within the RIAA for Hornsea Three (document reference number A5.2).

The Wash and North Norfolk Coast SAC

2.13.3.39 There are no Tier 1, Tier 2 or Tier 3 plans or projects that have been identified within The Wash and North Norfolk Coast SAC that may contribute to cumulative long term habitat creation with Hornsea Three. Therefore, there is no cumulative assessment of long term habitat creation for this site.

Markham's Triangle rMCZ

2.13.3.40 There are no Tier 1, Tier 2 or Tier 3 plans or projects that have been identified within the boundary of Markham's Triangle rMCZ that may contribute to cumulative long term habitat creation of any of the broadscale habitat features. Therefore, there is no cumulative assessment of long term habitat creation for this site.

Cromer Shoal Chalk Beds MCZ

2.13.3.41 There are no Tier 1, Tier 2 or Tier 3 plans or projects that have been identified within the boundary of the Cromer Shoal Chalk Bed MCZ that may contribute to cumulative long term habitat creation of any of the broadscale habitat features. Therefore, there is no cumulative assessment of long term habitat creation for this site.

Alteration of seabed habitats arising from effects on physical processes, wave and tidal regimes resulting in potential effects on benthic ecology

2.13.3.42 The cumulative presence of offshore structures associated with Hornsea Three and other offshore wind farms may introduce changes to the local hydrodynamic and wave regime, resulting in cumulative changes to the sediment transport pathways and associated effects on benthic ecology.

2.13.3.43 All plans/projects/activities screened into the assessment for cumulative effects of alteration of seabed habitats arising from effects on physical processes, wave and tidal regimes are either on-going activities (i.e. licensed and application aggregate extraction areas) or other offshore wind farms which are consented, submitted or under construction (i.e. Tier 1). No Tier 2 or Tier 3 projects have been identified. The maximum design scenario is as described in volume 2, chapter 1: Marine Processes.

Tier 1

Magnitude of impact

2.13.3.44 The Tier 1 assessment comprises offshore wind farms only, including Hornsea Three together with Hornsea Project One, Hornsea Project Two, Triton Knoll, Dudgeon and Race Bank offshore wind farms. With respect to currents, the cumulative presence of offshore wind farm structures is likely to result in near-field effects only (i.e. primarily within each offshore wind farm footprint). The presence of Hornsea Three alone is predicted to result in localised changes of approximately +0.04 ms^{-1} to -0.1 ms^{-1}. These are expected to be largely confined to within 4 km of the offshore wind farm footprint (see paragraph 2.11.2.110). The Hornsea Project One assessment (SMartWind, 2013) predicted localised changes to flow rates of up to approximately ±0.05 ms^{-1}, though these were expected to be largely confined to the immediate vicinity of the foundation structures with some reduction in flow speed within approximately 4 km of the boundary of the Hornsea Project One array area. As for Hornsea Project One, the Hornsea Project Two assessment (SMartWind, 2015) predicted changes of approximately +0.04 ms^{-1} to -0.1 ms^{-1}, although the Hornsea Project One project refinements detailed in paragraph 2.12.1.1 will likely result in a reduction on this. The Triton Knoll EIA (TKOWFL, 2012) predicted changes in currents ranging between -0.1 to +0.07 ms^{-1}, but for most of time there would be a slight reduction in current speed. Cumulative effects on currents, as assessed in volume 2, chapter 1: Marine Processes are predicted to be negligible.

2.13.3.45 Scour effects associated with the presence of offshore wind farm structures are also likely to be highly localised and spatially restricted to the immediate vicinity of the structures within the offshore wind farm arrays. For example, the Triton Knoll assessment predicted a maximum scour extent from foundations of 6.2 m (TKOWFL, 2012), which is considered indicative for the other offshore wind farms. Cumulative effects resulting from scour are therefore considered to be negligible.

2.13.3.46 The cumulative presence of the turbine foundations and associated infrastructure also has the potential to affect the wave regime which could lead to potential impacts on coastal habitats; this is fully assessed in volume 2, chapter 1: Marine Processes. The predicted changes to wave heights resulting from the operational presence of Hornsea Project One, Hornsea Project Two and Hornsea Three are expected to be very small (less than ~2.5%) as far west as Humber Gateway and Westermost Rough for any of the wave directions tested. Moreover, potential wave interactions between the offshore wind farms in the former Hornsea Zone, Westermost Rough offshore wind farm and Humber Gateway offshore wind farm will only occur for waves coming from an easterly direction. Waves from this sector only occur for approximately 15% of the time and the majority of these waves are shorter period wind waves which will have recovered in height before reaching the Humber Gateway and Westermost Rough offshore wind farms. Accordingly, the duration of time over which potential wave interaction could occur is very small (volume 5, annex 1.1: Marine Processes Technical Report). The assessment presented in volume 5, annex 1.1 Marine Processes Technical Report concludes that the cumulative reduction in wave height predicted due to the operational presence of Hornsea Three, Hornsea Project One, Hornsea Project Two, Triton Knoll and the other offshore wind farms presented above are considered to be of very small magnitude and are not predicted to have any measurable effects on sediment transport.

2.13.3.47 Cumulative impacts will extend over the regional area but will, overall, be highly localised to within the individual offshore wind farm areas, of long term duration, continuous and irreversible during the lifetime of the projects. It is predicted that the impact will affect the benthic receptors (Habitats A, B, C, D, E and the ocean quahog *A, islandica*) indirectly. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.13.3.48 Habitats A, B, C and D are deemed to be of low to medium vulnerability and regional value. The sensitivity of the receptors to the magnitude of changes predicted is therefore, considered to be low.

2.13.3.49 Habitat E and the ocean quahog *A. islandica* are deemed to be of low to medium vulnerability and national value. The sensitivity of the receptors to the magnitude of changes predicted is therefore, considered to be medium.

Significance of the effect

2.13.3.50 Overall, the sensitivity of Habitats A, B, C and D is considered to be low and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms.

2.13.3.51 Overall, the sensitivity of Habitat E and the ocean quahog *A. islandica* is considered to be medium and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms.

North Norfolk Sandbanks and Saturn Reef SAC

2.13.3.52 With respect to effects on offshore sandbanks in the North Norfolk Sandbanks and Saturn Reef SAC, the closest sandbanks to the Hornsea Three array area are the Indefatigable Banks which are located approximately 10 km to the southwest of the Hornsea Three array area. Owing to the (east – west) alignment of the Hornsea Three array area relative to Hornsea Project One and Hornsea Project Two, there is very limited potential for a cumulative reduction in wave energy at these nearby banks. Moreover, as the Indefatigable Banks are understood to be largely relict features, it is extremely unlikely that any reductions in wave activity over the bank crests would result in a corresponding morphological change. Predicted impacts along the Hornsea Three offshore cable corridor will be similar to the Hornsea Three array, but of a significantly reduced extent. As such, there is very limited potential for a cumulative reduction in wave energy at sandbanks which are slightly covered by water all the time with The Wash and North Norfolk Coast SAC.

Magnitude of impact

2.13.3.53 Cumulative impacts will extend over the regional area but will, overall, be highly localised to within the individual offshore wind farm areas, of long term duration, continuous and irreversible during the lifetime of the projects. It is predicted that the impact will affect the sandbanks which are slightly covered by water all the time and Annex I reefs, the magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.13.3.54 'Sandbanks which are slightly covered by seawater all the time' and *S. spinulosa* reefs in the North Norfolk Sandbanks and Saturn Reef SAC are considered to be of low vulnerability, high to immediate recoverability and of international importance. These features are therefore considered to be of medium sensitivity.

Significance of the effect

2.13.3.55 Overall, the sensitivity of 'Sandbanks which are slightly covered by water all the time' and Annex I reefs is considered to be medium and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms.

The Wash and North Norfolk Coast SAC

Magnitude of impact

2.13.3.56 Cumulative impacts will extend over the regional area but will, overall, be highly localised to within the individual offshore wind farm areas, of long term duration, continuous and irreversible during the lifetime of the projects. It is predicted that the impact will affect the sandbanks which are slightly covered by water all the time and Annex I reefs, the magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.13.3.57 'Sandbanks which are slightly covered by seawater all the time' and *S. spinulosa* reefs in The Wash and North Norfolk Coast SAC are considered to be of low vulnerability, high to immediate recoverability and of international importance. These features are therefore considered to be of medium sensitivity.

Significance of the effect

2.13.3.58 The magnitude of impact on 'sandbanks which are slightly covered by water all the time' and Annex I reefs is predicted to be minor and sensitivity of these features is medium. The effect is therefore considered to be minor adverse, which is not significant in EIA terms.

Markham's Triangle rMCZ

Magnitude of impact

2.13.3.59 Cumulative impacts will extend over the regional area but will, overall, be highly localised to within the individual offshore wind farm areas, of long term duration, continuous and irreversible during the lifetime of the projects. It is predicted that the impact will affect the broadscale features of the Markham's Triangle rMCZ (subtidal coarse sediments, subtidal sand and subtidal mixed sediments) indirectly. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.13.3.60 Sensitivity of the broadscale features (subtidal coarse sediments, subtidal sand and subtidal mixed sediments) in Markham's Triangle rMCZ are identical to those described in paragraph 2.13.3.48, but they are of national importance and therefore are considered to be of medium sensitivity.

Significance of the effect

2.13.3.61 Overall, the sensitivity of the broadscale features of the rMCZ (subtidal coarse sediments, subtidal sand and subtidal mixed sediments) is considered to be medium and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of minor adverse, which is not significant in EIA terms.

Cromer Shoal Chalk Beds MCZ

Magnitude of impact

2.13.3.62 Cumulative impacts will extend over the regional area but will, overall, be highly localised to within the individual offshore wind farm areas, of long term duration, continuous and irreversible during the lifetime of the projects. It is predicted that the impact will affect the broadscale features of the Cromer Shoal Chalk Beds MCZ (subtidal coarse sediments, subtidal sand, subtidal mixed sediments, subtidal chalk reef and peat and clay exposures)) indirectly. The magnitude is therefore, considered to be minor.

Sensitivity of the receptor

2.13.3.63 Sensitivity of the broadscale features (subtidal coarse sediments, subtidal sand and subtidal mixed sediments) in the Cromer Shoal Chalk Beds MCZ are identical to those described in paragraph 2.13.3.48, but, together with subtidal chalk reef and peat and clay exposures, they are all of national importance and therefore are considered to be of medium sensitivity.

Significance of the effect

2.13.3.64 Overall, the sensitivity of the broadscale features of the Cromer Shoal Chalk Beds MCZ (subtidal coarse sediments, subtidal sand, subtidal mixed sediments, subtidal chalk reef and peat and clay exposures) is considered to be medium and the magnitude of the impact is deemed to be minor. The effect will, therefore, be of minor adverse significance, which is not significant in EIA terms.

2.14 Transboundary effects

2.14.1.1 A screening of transboundary impacts has been carried out and is presented in annex 5.5: Transboundary Impacts Screening Note. This screening exercise identified that there was potential for significant transboundary effects on benthic ecology from Hornsea Three upon the interests of other EEA States.

2.14.1.2 There is a potential pathway through which Hornsea Three could impact the benthic subtidal ecology of another EEA state due to the proximity of the array area to the Dutch EEZ. The only transboundary impact that may result for Hornsea Three is increased SSC that may reach Klaverbank SCI. The Klaverbank SCI is 11 km from the Hornsea Three array area, within the Dutch jurisdiction. This site is designated for Annex I 'reefs', which is the primary reason for the designation of the site. However, as discussed in paragraph 2.7.3.1, elevations in SSC above background levels at distances of hundreds of metres to a few kilometres are predicted to be relatively low (i.e. less than ~20 mg/l) and within the range of natural variability and after 24 hours, elevations in SSC are predicted to typically be less than 5 mg/l. Therefore, by the time a plume might reach Klaverbank SCI, the SSC and any associated deposition are predicted to be at background levels, and are will therefore have negligible effects on benthic receptors in this site. Overall, the effect on features of the Klaverbank SCI will be of negligible significance. As such, any transboundary effects on Klaverbank SCI are predicted to be not significant.

2.15 Inter-related effects

2.15.1.1 Inter-relationships are considered to be the impacts and associated effects of different aspects of the proposal on the same receptor. These are considered to be:

- Project lifetime effects: Assessment of the scope for effects that occur throughout more than one phase of the project (construction, operational and maintenance, and decommissioning), to interact to potentially create a more significant effect on a receptor than if just assessed in isolation in these three key project stages (e.g. subsea noise effects from piling, operational turbines, vessels and decommissioning); and
- Receptor led effects: Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor. As an example, all effects on benthic ecology such as direct habitat loss or disturbance, sediment plumes, scour, jack-up vessel use etc., may interact to produce a different, or greater effect on this receptor than when the effects are considered in isolation. Receptor-led effects might be short term, temporary or transient effects, or incorporate longer term effects.

2.15.1.2 A description of the likely inter-related effects arising from Hornsea Three on benthic ecology is provided in volume 2, chapter 12: Inter-Related Effects (Offshore).

2.16 Conclusion and summary

2.16.1.1 The benthic habitats and species present within the Hornsea Three benthic ecology study area, as recorded during site-specific surveys and from a review of desktop information, were typical of the southern North Sea benthic ecology study area. Differences in the benthic communities recorded generally reflected the differences in the sediment types present. Sandy sediments supported communities of typically low infaunal diversity with sparse to non-existent epifaunal communities. The communities associated with coarse sediments were generally more infaunally diverse with, in places, more diverse epifaunal communities (characterised by hydroids, bryozoans, sponges and soft corals) associated with cobbles and pebbles. The mixed sediment biotopes supported the most diverse communities characterised by rich communities of epifaunal species including the tube building polychaete *S. spinulosa*. The only reef habitat recorded comprised *S. spinulosa* reef at a single location within the offshore cable corridor outside and SAC/SCI. Subcropping rock was recorded in the inshore section of the offshore cable corridor, but no chalk reef or Annex I stony reef was recorded in association with these features during the site specific surveys. The intertidal area comprises a barren shingle beach dominated by barren pebbles and cobbles.

2.16.1.2 A total of five subtidal VERs were identified within the Hornsea Three benthic ecology study area against which the assessment has been undertaken. In addition, where Hornsea Three coincides with nature conservation sites, an assessment of the effects of the project on the designated features of these sites (rather than the VERs) has also been undertaken. The nature conservation sites which have been scoped into the assessment are: North Norfolk Sandbanks and Saturn Reef SAC; The Wash and North Norfolk Coast SAC; Cromer Shoal MCZ; and Markham's Triangle rMCZ. No VERs were identified at the Hornsea Three intertidal area.

2.16.1.3 Construction activities within the Hornsea Three array area and offshore cable corridor have the potential to result in a range of potential impacts on benthic ecology. These include the removal or disturbance of sediments resulting in temporary habitat loss/disturbance and increased SSC and associated deposition. Table 2.38 provides a summary of the potential impacts, mitigation measures and residual effects during the construction phase with respect to benthic ecology. These impacts are predicted to result in effects on benthic receptors, including benthic features of designated sites, of minor adverse significance (not significant in EIA terms).

2.16.1.4 Maintenance operations may affect benthic subtidal ecology through the presence of infrastructure resulting in long term habitat loss, an increase in habitat for colonisation (including the potential for the introduction of INNS) and alterations to physical processes. Maintenance activities may also affect benthic ecology through the removal or disturbance of sediments resulting in temporary habitat disturbance. Table 2.38 provides a summary of the potential impacts, mitigation measures and residual effects during the operation and maintenance phase with respect to benthic ecology. These impacts are predicted to result in effects on benthic receptors and designated features of nature conservation sites of negligible or minor adverse significance (not significant in EIA terms).

2.16.1.5 Decommissioning activities are predicted to have effects of negligible or minor adverse significance (not significant in EIA terms) on benthic subtidal ecology.

2.16.1.6 Cumulative impacts upon benthic ecology from the construction, operation and decommissioning phases of Hornsea Three have been considered together with the construction and operation of other planned nearby wind farm projects, planned Oil and Gas operations, cables and pipelines, aggregate extraction activities (licensed and application) and coastal defence projects. Overall, the cumulative effects on benthic receptors and designated features of nature conservation sites will be of minor adverse significance (not significant in EIA terms).

2.16.1.7 A screening of transboundary impacts has been carried out and identified that there was potential for transboundary effects with regard to benthic ecology from Hornsea Three upon the interests of the Dutch EEA. The only transboundary impact that may result for Hornsea Three is increased SSC that may reach Klaverbank SCI. Overall, the effect on features of the Klaverbank SCI will be of negligible significance. As such, any transboundary effects on Klaverbank SCI are predicted to be not significant.

Table 2.38: Summary of potential environmental effects, mitigation and monitoring.

Description of impact	Measures adopted as part of the project	Magnitude of impact	Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
Construction Phase							
Temporary habitat loss/disturbance due to cable laying operations (including anchor placements and sandwave clearance), spud-can leg impacts from jack-up operations and seabed preparation works for GBFs, may affect benthic ecology.	A pre-construction survey will be undertaken along the Hornsea Three offshore cable corridor to determine the location, extent and composition of any Annex I reefs within SACs and/or biogenic or geogenic reefs outside SACs. Should such reef features be identified during pre-construction surveys of the Hornsea Three offshore cable corridor, appropriate measures will be discussed with statutory consultees to avoid direct impacts to these features, where possible, and on the basis of the extent of these features at the time of construction.	Minor (Habitats A to E, ocean quahog). Minor (Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef SAC and supporting habitat for Annex I sandbanks in The Wash and North Norfolk Coast SAC). Minor (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ and Subtidal sand in Cromer Shoal Chalk Beds MCZ). Negligible to minor (Potential future Annex I *S. spinulosa* reef).	Low (Habitats A and C). Medium (Habitats B, D and E). High (ocean quahog *A. islandica*). Low to medium (Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef SAC and supporting habitat for Annex I sandbanks in The Wash and North Norfolk Coast SAC). Low (Subtidal sand in Cromer Shoal Chalk Beds MCZ). Low to medium (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ). Medium (Potential future Annex I *S. spinulosa* reef).	Minor adverse (Habitats A to E, ocean quahog, Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef SAC and supporting habitat for Annex I sandbanks in The Wash and North Norfolk Coast SAC, Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ, and Subtidal sand in Cromer Shoal Chalk Beds MCZ). Negligible to minor adverse (Potential future Annex I *S. spinulosa* reef).	None	N/A	None
Temporary increases in suspended sediment concentrations and associated sediment deposition from cable and foundation installation and seabed preparation during the construction phase may affect benthic ecology.	-	Minor (Habitats A to E, ocean quahog). Minor (Annex I sandbanks and Annex I *Sabellaria* reefs in North Norfolk Sandbanks and Saturn Reef SAC and the Wash and North Norfolk Coast SAC). Minor (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ). Minor (Subtidal sand, subtidal chalk reef and peat and clay exposures in Cromer Shoal Chalk Beds MCZ).	Low (Habitats A to E, ocean quahog). Low (Annex I sandbanks and Annex *Sabellaria* I reefs in North Norfolk Sandbanks and Saturn Reef SAC and the Wash and North Norfolk Coast SAC). Low (Subtidal sand, Subtidal coarse and Subtidal mixed sediments in Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ). Medium (subtidal chalk reef and peat and clay exposures in Cromer Shoal Chalk Beds MCZ).	Minor adverse (Habitats A to E, ocean quahog, Annex I sandbanks and Annex I *Sabellaria* reefs in North Norfolk Sandbanks and Saturn Reef SAC and the Wash and North Norfolk Coast SAC, Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ, and subtidal chalk reef and peat and clay exposures in Cromer Shoal Chalk Beds MCZ).	None	N/A	None
Accidental release of pollutants (e.g. from accidental spillage/leakage) may affect benthic ecology.	A PEMMP will be developed and implemented to cover the construction and operation and maintenance phases of Hornsea Three. The PEMMP will include planning for accidental spills, contain a biosecurity plan (see below) to limit the spread INNS, address all potential contaminant releases and include key emergency contact details (e.g. the Environment Agency (EA), Natural England and MCA). A Decommissioning Programme will be developed to cover the decommissioning phase.	Negligible (Habitats A to E, ocean quahog, Annex I sandbanks and Annex I *Sabellaria* reefs in North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC, Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ, and Subtidal chalk reef and peat and clay exposures in Cromer Shoal Chalk Beds MCZ).	Low (Habitats A to D). Medium (Habitat E, ocean quahog, Annex I sandbanks and Annex I *Sabellaria* reefs in North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC, Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ, and Subtidal chalk reef and peat and clay exposures in Cromer Shoal Chalk Beds MCZ).	Negligible (Habitats A to E, ocean quahog, Annex I sandbanks and Annex I *Sabellaria* reefs in North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC, Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ, and Subtidal chalk reef and peat and clay exposures in Cromer Shoal Chalk Beds MCZ).	None	N/A	None

Description of impact	Measures adopted as part of the project	Magnitude of impact	Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
Operation Phase							
Long term loss of seabed habitat through presence of foundations, scour protection and cable protection, resulting in potential effects on benthic receptors.	A pre-construction survey will be undertaken along the Hornsea Three offshore cable corridor to determine the location, extent and composition of any Annex I reefs within SACs and/or biogenic or geogenic reefs outside SACs. Should such reef features be identified during pre-construction surveys of the Hornsea Three offshore cable corridor, appropriate measures will be discussed with statutory consultees to avoid direct impacts to these features, where possible, and on the basis of the extent of these features at the time of construction. Hornsea Three will employ sensitive cable and scour protection within the areas of designated sites that coincide with Hornsea Three. These cable and scour protection measures will not include concrete mattresses. The cable protection will consider the local seabed conditions, including sediment/substrate type. Within the designated sites this may include measures as follows: • Within the North Norfolk Sandbanks and Saturn Reef SAC: this may include measures which may encourage the burial of the scour/cable protection by the surrounding sediment or rock protection which takes into account the typical grain sizes known to occur naturally within the SAC (i.e. coarse gravel, cobbles and boulders); • Within The Wash and North Norfolk Coast SAC: this may include measures which may encourage the burial of the scour/cable protection by the surrounding sediment or rock protection which takes into account the typical grain sizes known to occur naturally within the SAC (i.e. coarse gravel and cobbles); • Within the Cromer Shoal Chalk Beds MCZ: cable protection may comprise gravel and cobbles with a mean grain size of 100 mm, maximum grain size of 250 mm; and • Within the Markham's Triangle rMCZ: cable protection may comprise gravel and cobbles with a mean grain size of 100 mm, maximum grain size of 250 mm, while scour protection for foundations, if required, may have a maximum diameter of 360 mm. Cable protection requirements will be detailed in the Cable Specification and Installation Plan which will be produced prior to construction and agreed in consultation with statutory consultees.	Minor (Habitats A to E, ocean quahog). Minor (Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef SAC). Minor (supporting habitat for Annex I sandbanks in The Wash and North Norfolk Coast SAC). Minor (Subtidal sand in Cromer Shoal Chalk Beds MCZ). Minor (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ).	High (Habitats A to E, ocean quahog). High (Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef SAC). High (supporting habitat for Annex I sandbanks in the Wash and North Norfolk Coast SAC). High (Subtidal sand in Cromer Shoal Chalk Beds MCZ). High (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ).	Minor adverse (Habitats A to E, ocean quahog, Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef SAC, supporting habitat for Annex I sandbanks in The Wash and North Norfolk Coast SAC, Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ, and Subtidal sand in Cromer Shoal Chalk Beds MCZ).	None	N/A	As outlined in the IPMP (document reference number 8.8), monitoring will be undertaken of a representative proportion of the Hornsea Three offshore cable corridor within designated sites in areas where sensitive cable protection material is employed. The aim of the surveys will be to determine the effectiveness of the sensitive cable protection measures in facilitating the recovery of benthic communities associated with the sediments.

Description of impact	Measures adopted as part of the project	Magnitude of impact	Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
Colonisation of foundations/cable protection/scour protection may affect benthic ecology and biodiversity.	-	Minor (Habitats A to E, ocean quahog). Minor (Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef SAC). Minor (supporting habitat for Annex I sandbanks in The Wash and North Norfolk Coast SAC). Minor (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ). Negligible (Subtidal sands in Cromer Shoal Chalk Beds MCZ).	Low (Habitats A to D, ocean quahog). Medium (Habitat E). Low (Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef SAC) Low (supporting habitat for Annex I sandbanks in The Wash and North Norfolk Coast SAC). Low (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ). Low (Subtidal sand in Cromer Shoal Chalk Beds MCZ).	**Minor** adverse or beneficial (Habitats A to E, ocean quahog, Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC, Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ, and Subtidal sand in Cromer Shoal Chalk Beds MCZ).	None	N/A	None
Increased risk of introduction or spread of invasive and non-native species (INNS) due to presence of subsea infrastructure and vessel movements (e.g. ballast water) may affect benthic ecology and biodiversity.	Development of a Biosecurity Plan.	Negligible (Habitats A to E, ocean quahog). Negligible (Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef SAC). Negligible (Annex I sandbanks and Annex I *Sabellaria* reefs in The Wash and North Norfolk Coast SAC). Negligible (Subtidal sands in Cromer Shoal Chalk Beds MCZ). Minor (Subtidal coarse sediments, subtidal sand and subtidal mixed sediments in Markham's Triangle rMCZ)	Medium (Habitats A to C, ocean quahog). Low (Habitats D and E). Not sensitive (Annex I sandbanks and Annex I *Sabellaria* reefs in North Norfolk Sandbanks and Saturn Reef SAC). Medium (Annex I sandbanks in The Wash and North Norfolk Coast SAC). Not sensitive (Subtidal sands in Cromer Shoal Chalk Beds MCZ). High (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ).	**Minor** adverse (Habitats A to C, ocean quahog, Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ). **Negligible** (Habitats D and E, Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef SAC, Annex I sandbanks and Annex I *Sabellaria* reefs in The Wash and North Norfolk Coast SAC, and Subtidal sand in Cromer Shoal Chalk Beds MCZ).	None	N/A	None

Description of impact	Measures adopted as part of the project	Magnitude of impact	Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
Alteration of 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 ecology.	-	Minor (Habitats A to C in the Hornsea Three array area). Negligible (Habitats A to E along the Hornsea Three offshore cable corridor). Minor (Annex I sandbanks and Annex I *Sabellaria* reefs in the North Norfolk Sandbanks and Saturn Reef SAC). Negligible (The Wash and North Norfolk Coast SAC). Negligible (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments, subtidal chalk reef and peat and clay exposures in Cromer Shoal Chalk Beds MCZ). Minor (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ).	Low (Habitats A to D). Medium (Habitat E; ocean quahog). Medium (Annex I sandbanks and Annex I *Sabellaria* reefs in North Norfolk Sandbanks and Saturn Reef SAC). Medium (Annex I sandbanks and Annex I *Sabellaria* reefs in The Wash and North Norfolk Coast SAC). Medium (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments, subtidal chalk reef and peat and clay exposures in Cromer Shoal Chalk Beds MCZ). Medium (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ).	**Minor** adverse (Habitats A to E, ocean quahog, Annex I sandbanks and Annex I *Sabellaria* reefs in North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC, Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ, and subtidal chalk reef and peat and clay exposures in Cromer Shoal Chalk Beds MCZ).	None	N/A	None
Maintenance operations may result in temporary seabed disturbances and potential effects on benthic ecology.	-	Negligible (Habitats A to E, ocean quahog). Negligible (Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef SAC). Negligible (supporting habitat for Annex I sandbanks in The Wash and North Norfolk Coast SAC). Negligible (Subtidal sand in Cromer Shoal Chalk Beds MCZ). Negligible (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ).	Low (Habitats A to D). Medium (Habitat E). High (ocean quahog). Low (Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef SAC). Low to medium (supporting habitat for Annex I sandbanks in The Wash and North Norfolk Coast SAC). Low (Subtidal sand in Cromer Shoal Chalk Beds MCZ). Low (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ).	**Minor** adverse (Habitats A to E, ocean quahog). **Negligible** (Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC; Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ; and Subtidal sand in Cromer Shoal Chalk Beds MCZ).	None	N/A	None

Description of impact	Measures adopted as part of the project	Magnitude of impact	Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
Accidental release of pollutants (e.g. from accidental spillage/leakage) may affect benthic ecology.	Implementation of an appropriate PEMMP.	Negligible (Habitats A to E, ocean quahog, Annex I sandbanks and Annex I *Sabellaria* reefs in North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC; Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ; subtidal chalk reef and peat and clay exposures in Cromer Shoal Chalk Beds MCZ).	Low (Habitats A to D). Medium (Habitat E, ocean quahog, Annex I sandbanks and Annex I *Sabellaria* reefs in North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC; Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ; subtidal chalk reef and peat and clay exposures in Cromer Shoal Chalk Beds MCZ).	Negligible (Habitats A to E, ocean quahog, Annex I sandbanks and Annex I *Sabellaria* reefs in North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC; Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ; subtidal chalk reef and peat and clay exposures in Cromer Shoal Chalk Beds MCZ).	None	N/A	None
Decommissioning Phase							
Temporary loss of habitat due to operations to remove array cables, interconnector cables and export cables, and jack-up operations to remove foundations, resulting in potential effects on benthic ecology.	A pre-construction survey of the cable route corridor will be undertaken to determine the location, extent and composition of any Annex I reefs within SACs and/or biogenic or geogenic reefs outside SACs. Should such reef features be identified, appropriate measures will be discussed with statutory consultees to avoid direct impacts to these features, where possible.	Minor (Habitats A to E, ocean quahog). Minor (Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef SAC and supporting habitat for Annex I sandbanks in The Wash and North Norfolk Coast SAC). Minor (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ and Subtidal sand in Cromer Shoal Chalk Beds MCZ).	Low (Habitats A and C). Medium (Habitats B, D and E). High (ocean quahog *A. islandica*). Low to medium (Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef SAC and supporting habitat for Annex I sandbanks in The Wash and North Norfolk Coast SAC). Low (Subtidal sand in Cromer Shoal Chalk Beds MCZ). Low to medium (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ).	Minor adverse (Habitats A to E, ocean quahog, Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef SAC and supporting habitat for Annex I sandbanks in The Wash and North Norfolk Coast SAC, Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ, and Subtidal sand in Cromer Shoal Chalk Beds MCZ).	None	N/A	None
Temporary increases in suspended sediment concentrations and deposition from removal of array cables, export cables and foundations resulting in potential effects on benthic ecology.	-	Minor (Habitats A to E, ocean quahog). Minor (Annex I sandbanks and Annex I *Sabellaria* reefs in North Norfolk Sandbanks and Saturn Reef SAC and the Wash and North Norfolk Coast SAC). Minor (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ). Minor (Subtidal sand, subtidal chalk reef and peat and clay exposures in Cromer Shoal Chalk Beds MCZ).	Low (Habitats A to E, ocean quahog). Low (Annex I sandbanks and Annex *Sabellaria* I reefs in North Norfolk Sandbanks and Saturn Reef SAC and the Wash and North Norfolk Coast SAC). Low (Subtidal sand, Subtidal coarse and Subtidal mixed sediments in Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ). Medium (subtidal chalk reef and peat and clay exposures in Cromer Shoal Chalk Beds MCZ).	Minor adverse (Habitats A to E, ocean quahog, Annex I sandbanks and Annex I *Sabellaria* reefs in North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC; subtidal coarse sediments, subtidal sand and subtidal mixed sediments in Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ; subtidal chalk reef and peat and clay exposures in Cromer Shoal Chalk Beds MCZ).	None	N/A	None

Description of impact	Measures adopted as part of the project	Magnitude of impact	Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
Removal of foundations leading to loss of species/habitats colonising these structures.	-	Minor (Habitats A, B, C; ocean quahog). Negligible (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ).	Low (Habitats A, B, C; ocean quahog). Low (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ).	**Negligible** (Habitats A, B, C; ocean quahog; Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ).	None	N/A	None
Permanent habitat loss due to presence of scour/cable protection left *in situ* post decommissioning, and potential effects on benthic ecology.	-	Minor (Habitats A to E; ocean quahog). Minor (Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef SAC and supporting habitat for Annex I sandbanks in The Wash and North Norfolk Coast SAC). Minor (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Markham's Triangle rMCZ; Subtidal sand in Cromer Shoal Chalk Beds MCZ).	High (Habitats A to E; ocean quahog). High (Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef SAC and supporting habitat for Annex I sandbanks in The Wash and North Norfolk Coast SAC). High (Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ; Subtidal sand in Cromer Shoal Chalk Beds MCZ).	**Minor** adverse (Habitats A to E; ocean quahog; Annex I sandbanks in North Norfolk Sandbanks and Saturn Reef SAC and supporting habitat for Annex I sandbanks in The Wash and North Norfolk Coast SAC; Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ; Subtidal sand in Cromer Shoal Chalk Beds MCZ).	None	N/A	None
Accidental release of pollutants (e.g. from accidental spillage/leakage) may affect benthic ecology.	Development of a Decommissioning Programme.	Negligible (Habitats A to E, ocean quahog, Annex I sandbanks and Annex I *Sabellaria* reefs in North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC, Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ, and Subtidal chalk reef and peat and clay exposures in Cromer Shoal Chalk Beds MCZ).	Low (Habitats A to D). Medium (Habitat E, ocean quahog, Annex I sandbanks and Annex I *Sabellaria* reefs in North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC, Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ, and Subtidal chalk reef and peat and clay exposures in Cromer Shoal Chalk Beds MCZ).	**Negligible** (Habitats A to E, ocean quahog, Annex I sandbanks and Annex I *Sabellaria* reefs in North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC, Subtidal coarse sediments, Subtidal sand and Subtidal mixed sediments in Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ, and Subtidal chalk reef and peat and clay exposures in Cromer Shoal Chalk Beds MCZ).	None	N/A	None

2.17 References

ABPmer (2010) Area 506 Dredging Licence Application: Coastal Impact Study. DEME Building Materials Ltd. September 2010, R.1677, 51pp.

ABPmer, (2013b) Application Area 483 and 484 Plume Study. For Emu. Report R.2080.

Adams, T.P., Miller, R.G., Aleynik, D. and Burrows, M.T. (2014) Offshore marine renewable energy devices as stepping stones across biogeographical boundaries. Journal of Applied Ecology, 51, 33-338.

Allen, J.H. (2012) Southern North Sea Synthesis (Offshore) Benthic Survey: End of Cruise Report. Maggie M. 8th to 22nd March 2012. Cefas Survey Report (DP319).

APEM (2013) Analysis of invertebrate communities and sediment composition of the subtidal sandbanks of The Wash and North Norfolk Coast. APEM Scientific Report no 412577.

Andrulewicz, E., Napierska, D. and Otremba, Z. (2003) The environmental effects of the installation and functioning of the submarine SwePol Link HVDC transmission line: a case study of the Polish Marine Area of the Baltic Sea. J Sea Res, 49:337–345.

Antizar-Ladislao, B. (2008) Environmental levels, toxicity and human exposure to tributyltin (TBT)-contaminated marine environment. Environment International, 34, pp. 292 - 308.

Barrio Froján, C., Callaway, A., Whomersley, P., Stephens, D. and Vanstaen, K. (2013) Benthic survey of Inner Dowsing, Race Bank and North Ridge cSAC, and of Haisborough, Hammond and Winterton cSAC. Cefas Report C5432/C5441.

Beaumont, A.R., Newman, P.B., Mills, D.K., Waldock, M.J., Miller, D. and Waite, M.E. (1989) Sandy-substrate microcosm studies on tributyltin (TBT) toxicity to marine organisms. Scientia Marina, 53, 737-743.

Bioconsult (2006) Benthic communities at Horns Rev, before, during and after construction of Horns Rev offshore wind farm. Final annual report 2005.

Blanchard, M. (1997) Spread of the slipper limpet Crepidula fornicata (L.1758) in Europe. Current state and consequences. Scientia Marina, 61, Supplement 9, 109-118.

Bohn, K., Richardson, C.A. and Jenkins, S.R., (2015) The distribution of the invasive non-native gastropod Crepidula fornicata in the Milford Haven Waterway, its northernmost population along the west coast of Britain. Helgoland Marine Research, 69 (4), 313.

BOWind (2008) Barrow Offshore Wind Farm Post Construction Monitoring Report. First annual report. 15 January 2008, 60pp.

Budd. G.C. (2008) Asterias rubens. Common starfish. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: https://www.marlin.ac.uk/species/detail/1194 [Accessed on 4 January 2018].

Centre for Environment, Fisheries and Aquaculture Science (Cefas) (2000) Monitoring and surveillance of non-radioactive contaminants in the aquatic environment and activities regulating the disposal of wastes at Sea, 1997. Aquatic Environment Monitoring Report Number 52.

Centre for Environment, Fisheries and Aquaculture Science (Cefas) (2009) Strategic Review of Offshore Wind Farm Monitoring Data Associated with FEPA Licence Conditions. Benthic Ecology Contract. ME1117.

Centre for Environment, Fisheries and Aquaculture Science (Cefas), Department for Environment, Food and Rural Affairs (Defra), Department of Trade and Industry (DTI) and Marine Consents and Environment Unit (MCEU) (2004) Offshore Wind Farms: Guidance Note for Environmental Impact Assessment in Respect of FEPA and CPA Requirements Version 2, Marine Consents Environment Unit, 48pp.

Centrica Energy (2009) Race Bank Offshore Wind Farm. Environmental Statement, Chapter 6 Biological Environment. 213pp.

Centrica (2017) A-Fields Decommissioning Saturn (Annabel) and Audrey Fields Environmental Impact Assessment. Document ID: CEU-DCM-SNS0096-REP-0009. September 2017.

Chartered Institute of Ecology and Environmental Management (2016) Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater and Coastal. Second Edition.

Connor, D.W., Allen, J.H., Golding, N., Howell, K.L., Lieberknecht, L.M., Northen, K.O. and Reker, J.B. (2004) The Marine Habitat Classification for Britain and Ireland. Version 04.05, JNCC, Peterborough.

ConocoPhillips (UK) Limited (2017) Viking and LOGGS Phase 1 decommissioning and Strategic Review of proposed further decommissioning at Viking and LOGGS. Department for Business, Energy and Industrial Strategy.

Conoco Phillips (2017a) LOGGS Satellites Vulcan UR, Viscount VO, Vampire OD and Associated Infield Pipelines Decommissioning Programme, Final Version. Report Reference COP-SNS-L-XX-X-PM-12-00001. November 2017.

Conoco Phillips (2017b) Viking Satellites DC, DD, ED, GD, HD, Infield Pipelines Decommissioning Programme, Final Version. Report Reference COP-SNS-V-XX-X-PM-12-00001. November 2017.

Crown Estate (2012) The area involved – 15th Annual Report. Marine Aggregate Dredging 2012.

De-Bastos, E. and Marshall, C.E. (2016a) Kurtiella bidentata and Thyasira spp. in circalittoral muddy mixed sediment. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: http://www.marlin.ac.uk/habitat/detail/374 [Accessed on 4 January 2018].

De-Bastos, E.S.R. and Hill, J. (2016b) Amphiura filiformis, Mysella bidentata and Abra nitida in circalittoral sandy mud. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: http://www.marlin.ac.uk/habitat/detail/368 [Accessed on 4 January 2018].

De-Bastos, E.S.R. and Hill, J. (2016c) Polydora sp. tubes on moderately exposed sublittoral soft rock. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: http://www.marlin.ac.uk/habitat/detail/247 [Accessed on 4 January 2018].

Department for Business, Energy and Industrial Strategy (BEIS) (2017) Record of the Habitats Regulations Assessment undertaken under Regulation 5 of the Offshore Petroleum Activities (Conservation of Habitats) regulations 2001 (As Amended). Viking and LOGGS Phase 1 decommissioning and Strategic Review of proposed further decommissioning at Viking and LOGGS. ConocoPhillips (U.K.) Limited. September 2017.

Department for Energy and Climate Change (DECC) (2011a) Overarching National Policy Statement for Energy (EN-1) Presented to Parliament pursuant to Section 5(9) of The Planning Act 2008. July 2011. London: The Stationery Office.

Department for Energy and Climate Change (DECC) (2011b) National Policy Statement for Renewable Energy Infrastructure (EN-3) Presented to Parliament pursuant to Section 5(9) of The Planning Act 2008. July 2011. London: The Stationery Office.

Department for Energy and Climate Change (DECC) (2011c) Offshore Energy Strategic Environmental Assessment: OESEA2 Environmental Report – Future Leasing/Licensing for Offshore Renewable Energy, Offshore Oil and Gas, Hydrocarbon Gas and Carbon Dioxide Storage and Associated Infrastructure. Department for Energy and Climate Change, February 2011. URN 10D/1024.De Montaudouin, X. and Sauriau, P.G., 1999. The proliferating Gastropoda Crepidula fornicata may stimulate macrozoobenthic diversity. Journal of the Marine Biological Association of the United Kingdom, 79, 1069-1077.

Department for Environment, Food and Rural Affairs (Defra) (2015) Cromer Shoal Chalk Beds rMCZ Post-survey Site Report. Contract Reference: MB0120. Report Number: 34. Version 5. September 2015.

Defra (2014) Markham's Triangle rMCZ Post-survey Site Report. Contract Reference: MB0120. Report Number: 13. Version 6. November 2014.

Department of Trade and Industry (DTI) (2001a) Cruise Report – North Sea Strategic environmental survey – Leg 2. May 2001.

Department of Trade and Industry (DTI) (2001b) Cruise Report – North Sea strategic environmental survey – Leg 3. June 2001.

Desprez, M. (2000) Physical and biological impact of marine aggregate extraction along the French coast of the Eastern English Channel: Short-and long-term post-dredging restoration. ICES Journal of Marine Science 57(5):1428-1438.

Dolphin, T. J., Silva, T. A. M. and Rees, J. M. (2011) Natural Variability of Turbidity in the Regional Environmental Assessment (REA) Areas. MEPF-MALSF Project 09-P114. Cefas, 41 pp.

DONG Energy (2017). Race Bank Offshore Wind Farm Export Cable Sandwave Levelling Monitoring Data (various). Available from https://marinelicensing.marinemanagement.org.uk (application reference: MLA/2015/00452/5) [Accessed on 29 March 2018].

Dudgeon Offshore Wind Limited (2009) Dudgeon Offshore Wind Farm. Environmental Statement, Section 10: Marine Ecology. Prepared on behalf of Dudgeon Offshore Wind Limited. 53pp.

Durkin, O.C. (2008) Moerella spp. with venerid bivalves in infralittoral gravelly sand. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 15/11/2013]. Available online: http://www.marlin.ac.uk/habitatsensitivity.php?habitatid=388&code=2004 [Accessed on 4 January 2018].

EGS (2011) Lynn and Inner Dowsing Offshore Wind Farms Post-Construction Survey Works (2010) Phase 2 – Benthic Ecology Survey Centrica Contract No. CREL/C/400012, Final Report. 184pp.

EGS (2012) Lynn and Inner Dowsing Offshore Wind Farms. Survey of Benthic Communities within Jack-up Footprints. Report for Centrica Renewable Energy Ltd. February 2012.

Elliott, M., Nedwell, S., Jones, N.V., Read, S.J., Cutts, N.D. and Hemingway, K.L. (1998) Intertidal sand and mudflats and subtidal mobile sandbanks (Vol. II) An overview of dynamic and sensitivity for conservation management of marine SACs. Prepared by the Scottish Association for Marine Science for the UK Marine SACs Project.

ERM (2012) Marine Aggregate Regional Environmental Assessment of the Humber and Outer Wash Region. Report for the Humber Aggregate Dredging Association. May 2012.

EUSeaMap2016 (2016) European Marine Observation Data Network (EMODnet) Seabed Habitats project (http://www.emodnet-seabedhabitats.eu/), funded by the European Commission's Directorate-General for Maritime Affairs and Fisheries (DG MARE).

Foden, J., Rogers, S.I. and Jones, A.P. (2009) Recovery rates of UK seabed habitats after cessation of aggregate extraction. Marine Ecology Progress Series, 390:15–26.

Foden, J., Rogers, S.I. and Jones, A.P. (2011) Human pressures on UK seabed habitats a cumulative impact assessment. Marine Ecology Progress Series, 428:33–47.

GDF Suez (2011) Cygnus Field Development Environmental Statement. DECC Ref: D/4119/2001.

GDF Suez (2012) Juliet Field Development Environmental Statement.

Gomez Gesteira, J. L., and Dauvin, J. C. (2000) Amphipods are good bioindicators of the impact of oil spills on soft-bottom macrobenthic communities. Marine Pollution Bulletin, 40, 1017–1027.

Haggera, J.A, Depledge, M.H. and Galloway, T.S (2005) Toxicity of tributyltin in the marine mollusc Mytilus edulis. Marine Pollution Bulletin, 51. 811 - 816.

Hendrick, V.J. and Foster-Smith, R.L. (2006) Sabellaria spinulosa reef: a scoring system for evaluating 'reefiness' in the context of the Habitats Directive. J.Mar.Biol.Ass.UK. 86: 665-677.

Hill, A.S., Brand, A.R., Veale, L.O. and Hawkins, S.J. (1997) Assessment of the effects of scallop dredging on benthic communities. Final Report to MAFF, Contract CSA 2332, Liverpool: University of Liverpool.

Hill, J. and Wilson, E. (2008) Amphiura filiformis. A brittlestar. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom (MarLIN). Available online: https://www.marlin.ac.uk/species/detail/1400 [Accessed on 4 January 2018].

Hill, J.M., Marzialetti, S. and Pearce, B. (2011) Recovery of Seabed Resources Following Marine Aggregate Extraction. Marine ALSF Science Monograph Series No. 2. MEPF 10/P148. (Edited by R. C. Newell and J. Measures) 44pp. ISBN: 978 0 907545 45 3.

Hitchcock, D.R. and Bell, S. (2004) Physical Impacts of Marine Aggregate Dredging on Seabed Resources in Coastal Deposits. Journal of Coastal Research, Volume 20, Issue 1: pp. 101 – 114.

Inger, R., Attril, M.J., Bearhop, S., Broderick, A.C., Grecian, W.J., Hodgson, D.J., Mills, C., Sheehan, E., Votier, S.C., Witt, M.J., and Godley, B.J. (2009) Marine renewable energy: potential benefits to biodiversity? An urgent call for research. Journal of Applied Ecology, 46. 1145-1153.

Jackson, A. and Hiscock, K. (2008) Sabellaria spinulosa. Ross worm. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 15/11/2013]. Available online: http://www.marlin.ac.uk/speciesfullreview.php?speciesID=4278 [Accessed on 4 January 2018].

Joint Nature Conservation Committee (JNCC) (2012) Offshore Special Area of Conservation: North Norfolk Sandbanks and Saturn Reef. Conservation Objectives and Advice on Operations. Version 6.0. September 2012.

Joint Nature Conservation Committee (JNCC) (2010) Offshore Special Area of Conservation: North Norfolk Sandbanks and Saturn Reef. SAC Site Selection Assessment Document. Version 5.0, 20th August 2010.

Kerckhof, F., Degraer, S., Norro, A. and Rumes, B. (2011) Offshore intertidal hard substrata: a new habitat promoting non-indigenous species in the Southern North Sea: an exploratory study, in: Degraer, S. et al. (Ed.) (2011) Offshore wind farms in the Belgian part of the North Sea: Selected findings from the baseline and targeted monitoring. 27-37.

Kröncke I (1995) Long-term changes in North Sea benthos. Senckenberg Marit, 26, 73-80.

Kröncke I (2011) Changes in Dogger Bank macrofauna communities in the 20th century caused by fishing and climate. Estuarine, Coastal and Shelf Science, 94: 234-245.

Krone, R., Gutow, L., Joschko, T.J. and Schroder, A. (2013) Epifauna dynamics at an offshore foundation – Implications of future wind power farming in the North Sea. Marine Environmental Research, 85, 1-12.

Langhamer, O. (2012). Artificial reef effect in relation to offshore renewable energy conversion. State of the art. Scientific World Journal.

Last, K.S., Hendrick, V.J., Beveridge, C.M. and Davies, A.J. (2011) Measuring the effects of suspended particulate matter and smothering on the behaviour, growth and survival of key species found in areas associated with aggregate dredging. Report for the Marine Aggregate Levy Sustainability Fund, Project MEPF 08/P76. 69 pp.

Limpenny, D.S., Foster-Smith, R.L., Edwards, T.M., Hendrick, V.J., Diesing, M., Eggleton, J. D., Meadows, W.J., Crutchfield, Z., Pfeifer, S. and Reach, I.S. 2010. Best methods for identifying and evaluating Sabellaria spinulosa and cobble reef. Aggregate Levy Sustainability Fund Project MAL0008. Joint Nature Conservation Committee, Peterborough, 134 pp.

Lindeboom, H.J., Kouwenhoven, H.J., Bergman, M.J.N., Bouma, S., Brasseur, S., Daan, R., Fijn, R.C., Haan, De d., Dirksen, S., Hal, R. van., Hille Ris Lambers, R., Hofsted, R ter., Krijgsveld, K.L., Leopold, M. and Scheidat, M. (2011) Short-term ecological effects of an offshore wind farm in the Dutch coastal zone; a compilation. Environmental Research Letters, 6 (3).

Linley E.A.S., Wilding T.A., Black K., Hawkins A.J.S. and Mangi S. (2007) Review of the reef effects of offshore wind farm structures and their potential for enhancement and mitigation. Report from PML Applications Ltd and the Scottish Association for Marine Science to the Department for Business, Enterprise and Regulatory Reform Contract No: RFCA/005/0029P (BERR).

Long, D. (2006) BGS detailed explanation of seabed sediment modified folk classification. Available online: http://www.searchmesh.net/PDF/BGS%20detailed%20explanation%20of%20seabed%20sediment%20modified%20folk%20classification.pdf. [Accessed on 4 January 2018].

Marine Biological Association (2016). Available online: http://beta.mba.ac.uk/2016/07/25/extensive-population-of-carpet-sea-squirt-found-off-herne-bay-south-east-uk/ [Accessed 11 December 2017].

Marine Climate Change Impacts Partnership (2013) Marine Climate Change Impacts Report Card 2013 http://www.mccip.org.uk/impacts-report-cards/full-report-cards/2013/ [Accessed on 4 January 2018].

Marine Climate Change Impacts Partnership (2015) Marine climate change impacts; implications for the implementation of marine biodiversity legislation. (Ed.) Frost M, Bayliss-Brown G, Buckley P, Cox M, Stoker B and Withers Harvey N. Summary Report. MCCIP, Lowestoft, 16pp. doi:10.14465/2015.mb100.001-016.

Marine Ecological Surveys Limited, (2008) Marine Macrofauna Genus Trait Handbook. Marine Ecological Surveys Limited, 24a Monmouth Place, Bath. BA12AY. 184pp.

Marine Management Organisation (MMO). (2014). East Marine Plans. Avialble online: https://www.gov.uk/government/publications/east-inshore-and-east-offshore-marine-plans. [Accessed 14 March 2017].

Marshall, C.E. (2008) Sabellaria spinulosa on stable circalittoral mixed sediment. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 15/11/2013]. Available online: http://www.marlin.ac.uk/habitatbenchmarks.php?habitatid=377&code=2004 [Accessed on 4 January 2018].

McIlwaine, P., Brown, L. and Eggett, A. (2017) CEND11/16 Cruise Report: Monitoring Survey of North Norfolk Sandbanks and Saturn Reef cSAC/SCI, Inner Dowsing, Race Bank and North Ridge cSAC/SCI & Haisborough, Hammond and Winterton cSAC/SCI. JNCC/Cefas Partnership Report Series Report No.13.

McIlwaine, P, Rance, J and Froján, C. B. (2014) Continuation of Baseline Monitoring of Reef Features in The Wash and North Norfolk Coast Special Area of Conservation (SAC). Cefas Report: C5814, July 2014, 56pp.

Meadows, B and Froján, C. B. (2012) Baseline Monitoring Survey of Large Shallow Inlet and Bay for The Wash and North Norfolk Coast SAC. Cefas Report: C5518, 22nd March 2012, 54pp.

Millward, G.E. and Glegg, G.A. (1997) Fluxes and the Retention of Trace Metals in the Humber Estuary. Estuarine, Coastal and Shelf Science, 44(A), 97-105.

National grid Viking Link Ltd. (2017) Viking Link. Volume 2: UK Offshore Environmental Statement. Document No VKL-07-30-J800-007. August 2017.

Natural England (2017) The Wash and North Norfolk Coast SAC Supplementary Advice. 15th September 2017.

Newell, R.C., Seiderer, L. J., Simpson, N. M. and Robinson, J.E. (2002) Impact of Marine Aggregate Dredging and Overboard Screening on Benthic Biological Resources in the Central North Sea: Production Licence Area 408, Coal Pit. British Marine Aggregate Producers Association, Technical Report No. ER1/4/02, 72pp.

Newell, R.C., Siederer, L.J., Simpson, N.M. and Robinson, J.E. (2004) Impacts of marine aggregate dredging on benthic macrofauna off the South Coast of the United Kingdom. Journal of Coastal Research, 20, 115-125.

Newelll, R.C., Seiderer, L.J. and Hitchcock, D.R. (1998) The impact of dredging works in coastal waters: a review of the sensitivity to disturbance and subsequent recovery of biological resources in the sea bed. Oceanography and Marine Biology: Annual Review, 36, 127-178.

Nicholls, P., Hewitt, J. and Halliday, J. (2003) Effects of suspended sediment concentrations on suspension and deposit feeding marine macrofauna. NIWA client report ARC 03267 prepared for Auckland regional Council, New Zealand [online]. Available online: http://www.aucklandcity.govt.nz/council/documents/technicalpublications/TP211%20Effects%20of%20suspended%20sediment%20concentrations%20on%20suspension%20and%20deposit%20feeding%20marine%20macrofauna.pdf [Accessed 15 November 2013].

Norling, P. and Kautsky, N. (2007) Structural and functional effects of Mytilus edulis on diversity of associated species and ecosystem functioning. Marine Ecology Progress Series, 351, 163-175.

North Sea Benthos Project (NSBP) (2010) North Sea Benthos Project [online] Available online: www.marbef.org [Accessed 2 November 2010].

Pearce, B. Taylor, J. and Seiderer, L.J. (2007) Recoverability of Sabellaria spinulosa Following Aggregate Extraction. Aggregate Levy Sustainability Fund MAL0027. Marine Ecological Surveys Limited, 24a Monmouth Place, BATH, BA1 2AY. 87pp. ISBN 978-0-9506920-1-2.

OSPAR Commission (2010) Quality Status Report 2010: Case Reports for the OSPAR List of threatened and/or declining species and habitats – Update. Sabellaria spinulosa reefs.

Pidduck, E., Jones, R., Daglish, P., Farley, A., Morley, N., Page, A. and Soubies, H. (2017). Identifying the possible impacts of rock dump from oil and gas decommissioning on Annex I mobile sandbanks. JNCC Report No. 603. JNCC, Peterborough.

PINS (2016) Scoping Opinion Proposed Hornsea Three Offshore Wind Farm. Planning Inspectorate Reference: EN010080. December 2016.

Precision marine Survey Ltd (PMSL) (2016) Humber Gateway Offshore Wind Farm: Annex I Post Construction Survey. Report to E.ON Climate and Renewables UK Limited.

Royal Haskoning (2016) Bacton Gas Terminal Coast Defence Scheme: Scoping report.

Sabatini, M., Pizzolla, P. and Wilding, C. (2008) Arctica islandica. Icelandic cyprine. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 15/11/2013]. Available online: http://www.marlin.ac.uk/speciessensitivity.php?speciesID=2588 [Accessed on 4 January 2018].

Scira Offshore Energy Ltd (2014) Sheringham Shoal Offshore Wind Farm. Second post-construction benthic monitoring survey. Marine Ecological Surveys Ltd. November 2014.

Scira Offshore Energy Ltd (2006) Sheringham Shoal Environmental Statement.

Shell UK Limited (2017) Leman BH Decommissioning Programme. Shell Report Number: LBT-SH-AA-7180-00001-001. Rev A10. 05 April 2017.

Silén, L. (1981) Colony structure in Flustra foliacea (Linnaeus) (Bryozoa, Cheilostomata) Acta Zoologica (Stockholm.), 62, 219-232.

SMart Wind (2013) Hornsea Project One Environmental Statement.

SMart Wind (2015) Hornsea Project Two Environmental Statement.

Tappin, D R, Pearce, B, Fitch, S, Dove, D, Gearey, B, Hill, J M, Chambers, C, Bates, R, Pinnion, J, Diaz Doce, D, Green, M, Gallyot, J,Georgiou, L, Brutto, D, Marzialetti, S, Hopla, E, Ramsay, E, and Fielding, H. (2011) The Humber Regional Environmental Characterisation. British Geological Survey Open Report OR/10/54. 357pp.

The Crown Estate (2017) The area involved – 19th annual report. Marine Aggregate Extraction 2016. Available online: https://www.thecrownestate.co.uk/media/1097988/bmapa-ce-19th-ann-rep-singles-021117.pdf [Accessed on 12 December 2017].

Tillin, H.M. and Hill, J.M. (2016) Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: http://www.marlin.ac.uk/habitat/detail/152 [Accessed on 4 January 2018].

Tillin, H.M. ad Marshall, C.M. (2015) Sabellaria spinulosa on stable circalittoral mixed sediment. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: http://www.marlin.ac.uk/habitat/detail/377 [Accessed on 4 January 2018].

Tillin, H.M. and Rayment, W. (2016). Fabulina fabula and Magelona mirabilis with venerid bivalves and amphipods in infralittoral compacted fine muddy sand. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: http://www.marlin.ac.uk/habitat/detail/142 [Accessed on 4 January 2018].

Tillin, H.M. (2016a) Echinocyamus pusillus, Ophelia borealis and Abra prismatica in circalittoral fine sand. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: http://www.marlin.ac.uk/habitat/detail/1131 [Accessed on 4 January 2018].

Tillin, H.M. (2016b) Nephtys cirrosa and Bathyporeia spp. in infralittoral sand. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: http://www.marlin.ac.uk/habitat/detail/154 [Accessed on 4 January 2018].

Tillin, H.M. (2016c) Moerella spp. with venerid bivalves in infralittoral gravelly sand. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: http://www.marlin.ac.uk/habitat/detail/1111 [Accessed on 4 January 2018].

Tillin, H.M. (2016d) Polychaete-rich deep Venus community in offshore gravelly muddy sand. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: http://www.marlin.ac.uk/habitat/detail/1117 [Accessed on 4 January 2018].

Tillin, H.M. (2016e) Abra prismatica, Bathyporeia elegans and polychaetes in circalittoral fine sand. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: http://www.marlin.ac.uk/habitat/detail/1133 [Accessed on 4 January 2018].

Tillin, H.M. (2016f) Mediomastus fragilis, Lumbrineris spp. and venerid bivalves in circalittoral coarse sand or gravel. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: http://www.marlin.ac.uk/habitat/detail/382 [Accessed on 4 January 2018].

Tillin, H.M. (2016g) Hiatella-bored vertical sublittoral limestone rock. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: http://www.marlin.ac.uk/habitat/detail/362 [Accessed on 4 January 2018].

Tillin, H.M. and Tyler-Walters, H. (2015) Finalised list of definitions of pressures and benchmarks for sensitivity assessment. May 2015. Available online: http://www.marlin.ac.uk/assets/pdf/Finalised-pressure-benchmarks-May2015.pdf [Accessed on 4 January 2018].

Triton Knoll Offshore Wind Farm Ltd (TKOWFL) (2012) Triton Knoll Offshore Wind Farm Environmental Statement Prepared on behalf of Triton Knoll Offshore Wind Farm Limited. January 2012.

Tyler-Walters, H. and Sabatini, M. (2017) Arctica islandica Icelandic cyprine. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Informpation Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom45m. Available online: http://www.marlin.ac.uk/species/detail/1519 http://www.marlin.ac.uk/habitat/detail/362 [Accessed on 4 January 2018].

Tyler-Walters, H. and Ballerstedt, S. (2007) Flustra foliacea. Hornwrack. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 15/11/2013]. Available online: http://www.marlin.ac.uk/speciesbenchmarks.php?speciesID=3342 http://www.marlin.ac.uk/habitat/detail/362 [Accessed on 4 January 2018].

UK Benthos data. Available online: http://oilandgasuk.co.uk/environment-resources.cfm [Accessed on 4 January 2018].

UK Offshore Energy Strategic Environmental Assessment 3 (OESEA3) (2016) Environmental Report. Appendix 1a.2 - Benthos.

Whalley, C., Rowlatt, S., Bennett, M., and Lovell, D. (1999) Total arsenic in sediments from the Western North Sea and the Humber Estuary. Marine Pollution Bulletin, 38, 394–400.

Witbaard, R. and Bergman, M.J.N. (2003) The distribution and population structure of the bivalve Arctica islandica L. in the North Sea: what possible factors are involved? Journal of Sea Research, 50, pp.11–25.