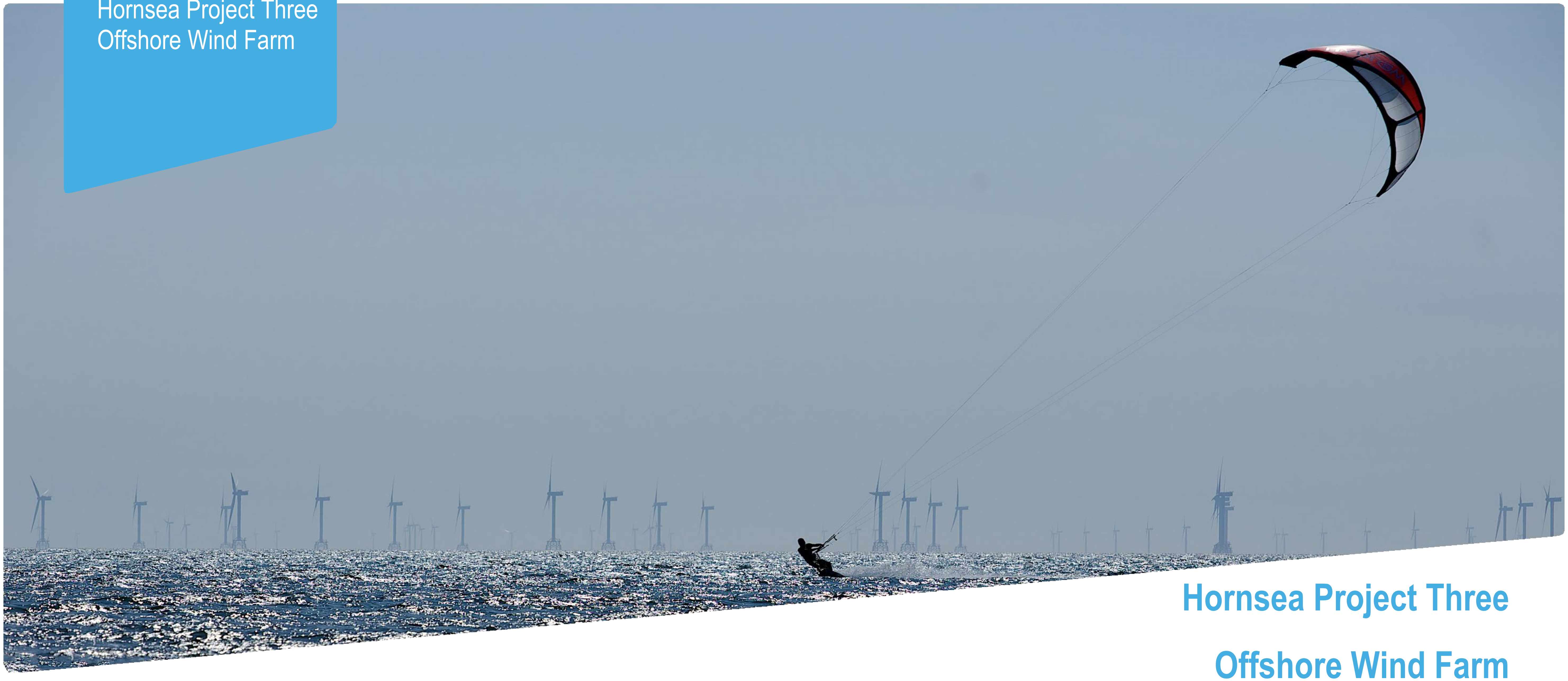
Hornsea Project Three
Offshore Wind Farm



Hornsea Project Three

Offshore Wind Farm

Environmental Statement:
Volume 5, Annex 2.3 – Marine Conservation Zone Assessment

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Hornsea 3
Offshore Wind Farm

Ørsted

Environmental Impact Assessment

Environmental Statement

Volume 5

Annex 2.3 – Marine Conservation Zone Assessment

Report Number: A6.5.2.3

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Glossary

Term	Definition
Amphipod	A group of crustaceans recognized by their laterally compressed bodies, lack of a carapace, and numerous, differently modified legs
Attribute	Measurable aspects/characteristics of a designated feature which best describe the feature's ecological integrity and which, if safeguarded, will enable achievement of the conservation objectives.
Benthic ecology	Benthic ecology encompasses the study of the organisms living in and on the sea floor, the interactions between them and impacts on the surrounding environment.
Biotope	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	Large, diverse arthropod taxonomic group which includes crabs, lobsters, shrimp and barnacles.
Epibenthic	Organisms living on the surface of the seabed.
Epifauna	Animals living on the surface of the seabed.
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.
Mollusc	Large group of soft-bodied invertebrates that are widespread in aquatic habitats, including snails, clams, squids, octopus, and cuttlefish.
Polychaete	A class of segmented worms often known as bristleworms.
Scour	Local erosion of sediments caused by local flow acceleration around an obstacle and associated turbulence enhancement.
Sessile	Organisms which are immobile or fixed to the substrate.
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
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CEA	Cumulative Effects Assessment
DCO	Development Consent Order
DDV	Drop Down Video
Defra	Department for Environment, Food and Rural Affairs
DMRB	Design Manual for Roads and Bridges
EcIA	Ecological Impact Assessment
EIA	Environmental Impact Assessment
FOCI	Feature of Conservation Interest
GBF	Gravity Base Foundations
HDD	Horizontal Directional Drilling
IFCA	Inshore Fisheries and Conservation Authority
IMO	International Maritime Organisation
INNS	Invasive and Non-Native Species
JNCC	Joint Nature Conservation Committee
MCAA	Marine and Coastal Access Act
MCZ	Marine Conservation Zone
MEEB	Measures of Equivalent Environmental Benefit
MHWS	Mean High Water Springs
MMO	Marine Management Organisation
MPA	Marine Protected Areas
PEIR	Preliminary Environmental Information Report
PEMMP	Project Environmental Management and Monitoring Plan
PINS	The Planning Inspectorate
PSA	Particle Size Analysis
rMCZ	Recommended Marine Conservation Zone
SAC	Special Area of Conservation
SACO	Supplementary Advice on Conservation Objectives
SAD	Site Assessment Document
SEA	Strategic Environmental Assessment
SNCB	Statutory Nature Conservation Bodies
SSC	Suspended Solids Concentrations
SoS	Secretary of State
TWT	The Wildlife Trusts
VER	Valued Ecological Receptor

Units

Unit	Description
%	Percent
Cm	centimetre
Km	Kilometre
M	Metre
m^2	Metre squared
m^3	Metre Cubed
mm	Millimetre
m/s	Metres per second
mg/kg	Milligrams per kilogram
mg/l	Milligrams per litre

1. Introduction

1.1.1.1 Orsted Power (UK) Ltd., on behalf of Orsted Hornsea Project Three (UK) Ltd. is promoting the development of the Hornsea Project Three offshore wind farm (hereafter referred to as Hornsea Three). Hornsea Three is a proposed offshore wind farm project within the former Hornsea Zone, and includes the associated Hornsea Three offshore cable route corridor and onshore infrastructure. The proposal is for an offshore wind farm which will be situated within the Hornsea Three array area in the east of the former Hornsea Zone. Hornsea Three is in the central region of the North Sea, approximately 121 km from the UK coast (at Tringham, Norfolk) and approximately 10.1 km west of the median line between UK and Netherlands waters.

1.1.1.2 RPS was commissioned to undertake a Marine Conservation Zone (MCZ) assessment for Hornsea Three and this document provides the final MCZ Assessment to accompany the Hornsea Three Development Consent Order (DCO) application. It is intended that this document, alongside supporting information, will be used to inform an assessment undertaken by the Secretary of State (SoS).

1.1.1.3 Specific consideration of MCZs is required for any marine licence or DCO applications in English or UK waters. Under section 126 of the Marine and Coastal Access Act (2009) (MCAA), public authorities (i.e. the Marine Management Organisation (MMO) for marine licence applications or the SoS for DCO applications) have specific duties for MCZs in relation to certain decisions. Section 126 applies where:

- *(a) A public authority has the function of determining an application (whenever made) for authorisation of the doing of an act, and*
- *(b) The act is capable of affecting (other than insignificantly) -*
    - *(i) The protected features of an MCZ; or*
    - *(ii) Any ecological or geomorphological process on which the conservation of any protected feature of an MCZ is (wholly or in part) dependent.*

1.1.1.4 This report has been produced to provide evidence on whether the potential impacts of Hornsea Three give rise to a significant risk of hindering the conservation objectives of the three identified MCZs (further discussed in section 3):

- Cromer Shoal Chalk Beds MCZ;
- Markham's Triangle rMCZ; and
- Wash Approach rMCZ.

1.1.1.5 This document is informed by guidance published by the MMO (2013) on how these assessments should be undertaken and by advice from the Statutory Nature Conservation Bodies (SNCBs) during consultation in the pre-application phase. The MCZ Assessment has been undertaken based on the Hornsea Three information detailed within volume 1, Chapter 3: Project Description.

1.1.1.6 This MCZ Assessment should be read alongside the following chapters of the Environmental Statement, all of which have been drawn upon and referred to throughout this document:

- Volume 5, annex 2.1: Benthic Ecology Technical Report;
- Volume 2, chapter 2: Benthic Ecology;
- Volume 5, annex 1.1: Marine Processes Technical Report; and
- Volume 2, chapter 1: Marine Processes.

1.1.1.7 This report is structured as follows:

- Section 1: Introduction
- Section 2: Methodology, including description of the staged approach to the MCZ Assessment following the relevant published guidelines, and how information presented in the Environmental Statement has been used to support the assessments presented herein;
- Section 3: Screening of MCZs and recommended MCZs (rMCZ) which have conservation objectives with the potential to be affected by Hornsea Three;
- Section 4: Background information on MCZs and rMCZs considered in the Stage 1 assessment;
- Section 5: Stage 1 assessment; and
- Section 6: Conclusion.

1.2 Consultation

1.2.1.1 This MCZ Assessment has been informed by consultation with key stakeholders, including the MMO, Natural England, The Wildlife Trusts (TWT) and the Planning Inspectorate (PINS), through the Hornsea Three MCZ Working Group. Four MCZ workshops have been undertaken with the MCZ Working Group, in February 2017, May 2017, December 2017 and February 2018. A summary of the key issues raised during consultation is outlined in Table 1.1 below, together with how these issues have been considered in the production of this report. This included agreement on the baseline characterisation, development of the MCZ Assessment methodology and key concerns from stakeholders about the potential effects of Hornsea Three on MCZ features, and in particular the Subtidal Chalk features of the Cromer Shoal Chalk Beds MCZ.

1.2.1.2 Initial discussions with the MCZ Working Group focussed on baseline characterisation for the purposes of the MCZ Assessment. The relevant MCZ/rMCZs were characterised using a combination of desktop data sources and Hornsea Three site specific survey data (e.g. geophysical data and benthic ecology data via grab and drop down video (DDV) sampling). Full details of the baseline characterisations of the relevant MCZ/rMCZs considered are presented in section 4 and these were discussed and agreed with the MCZ Working Group throughout the pre-application phase of the project (see Table 1.1).

1.2.1.3 The MCZ Assessment methodology was informed by guidance published by the MMO (MMO, 2013), although the approach presented in this assessment (fully described in section 2) was developed in consultation with the MCZ Working Group. This included provision by Natural England of the draft Supplementary Advice on Conservation Objectives (SACO) for the Cromer Shoal Chalk Beds MCZ in May 2017 (Note: this was provided as informal advice). Natural England's recommendation was that the MCZ Assessment should be undertaken using information on attributes and targets for the protected features of the MCZ, as detailed within the SACO. The assessment methodology is fully detailed in section 2, with further details of how feedback from the MCZ Working Group have influenced the assessment methodology outlined in Table 1.

1.2.1.4 One of the key stakeholder concerns raised during MCZ Working Group discussions with respect to the MCZ Assessment was in relation to the effect of cable installation on the protected features of the Cromer Shoal Chalk Beds MCZ, particularly the Subtidal Chalk features of the MCZ. The original Hornsea offshore cable corridor considered several routes through the MCZ and stakeholders expressed concerns about the effect of cable installation (including cable burial) within features with limited recovery potential, i.e. Subtidal Chalk and Peat and Clay Exposures (see section 4 for further details on the locations of these relative to Hornsea Three). Following publication of the Preliminary Environmental Information Report (PEIR) and subsequent Section 42 consultation responses (see Table 1.1), Hornsea Three investigated the feasibility of a nearshore re-route of the Hornsea Three offshore cable corridor, to minimise the length of the cable passing through the Cromer Shoal Chalk Beds MCZ. This proposed re-route was the subject of further formal consultation under Section 42(1) of the Planning Act 2008 (Orsted, 2017) and was discussed during the third MCZ Working Group workshop (4 December 2017). During and following the third workshop, Hornsea Three detailed the implications of the nearshore re-route and the PEIR route for the Cromer Shoal Chalk Beds and Wash and North Norfolk Coast Special Area of Conservation (SAC) to the MCZ Working Group (i.e. via a Hornsea Three Nearshore Re-route Note). Following feedback from the MCZ Working Group (see Table 1.1) and other Section 42 consultation responses, the nearshore re-route was taken forward for inclusion in the final DCO application and is therefore the Hornsea Three offshore cable corridor route considered within this MCZ Assessment.

Table 1.1: Summary of key consultation issues raised during consultation activities undertaken for Hornsea Three relevant to MCZs.

Date	Consultee and type of response	Key issues raised	Response to issue raised and/or where considered in this chapter
December 2016	PINS/Natural England/MMO, Scoping Opinion	Concern about long-term, permanent impacts on the Cromer Shoal Chalk Beds MCZ, if the chalk within the MCZ is cut during the cable installation. Consideration should be given to alternative cable routes to avoid these features and if this is not possible, consideration of measures of equivalent environmental benefit may be required.	The assessment in section 5.1 considers the effects on the Cromer Shoal Chalk Beds MCZ. The nearshore re-route to the Hornsea Three offshore cable corridor, which occurred as a result of consultation received from stakeholders on the Scoping Report and PEIR (see paragraph 1.2.1.4), avoids Subtidal Chalk features of the Cromer Shoal Chalk Beds MCZ, and therefore there will be no direct impacts on this feature.
December 2016	PINS/Natural England/MMO, Scoping Opinion	The MMO suggested that existing MCZ characterisation survey data be supplemented with the use of drop-down video (DDV) surveys to inform the Environmental Impact Assessment (EIA). This would limit the potential impact of destructive survey techniques on protected MCZ features.	Section 4 of this report provides background information on the MCZs/rMCZs considered in the assessment, with a full, detailed description of the subtidal benthic ecology characterisation, including those within the MCZ/rMCZ sites considered in this report, provided in volume 5, annex 2.1: Benthic Ecology Technical Report.
December 2016	PINS/Natural England/MMO, Scoping Opinion	Recommended MCZs (rMCZs) are not a material consideration for new developments until designation proposals are put out for public consultation. Formal consultation on Tranche Three MCZs is planned for 2017, with designation planned for the following year. MMO welcomes applicant's approach to screen in potential impacts upon rMCZs, given the development timescale.	Public consultation on Tranche Three is likely to be in 2018, although a timetable for designation is to be confirmed. rMCZs are fully considered in the Screening (section 3) and Stage 1 assessment (section 5).
1 February 2017	TWT and Natural England, First MCZ Working Group Workshop and post workshop correspondence.	Concern raised by TWT and Natural England about the Hornsea Three offshore cable corridor and principally its proximity to Subtidal Chalk features.	Due to the nearshore re-routing of the Hornsea Three offshore cable corridor (see paragraph 1.2.1.4), the Hornsea Three offshore cable corridor does not coincide with the Subtidal Chalk feature and therefore there will be no direct impacts on this feature (section 5.1).
1 February 2017	TWT and Natural England, First MCZ Working Group Workshop and post workshop correspondence.	Discussion and agreement of baseline datasets (including site specific surveys) to be used to inform the MCZ Assessment.	Section 4 of this report provides background information on the MCZs/rMCZs considered in the assessment, with a full, detailed description of the subtidal benthic ecology characterisation, including those within the MCZ/rMCZ sites considered in this report, provided in volume 5, annex 2.1: Benthic Ecology Technical Report.
1 February 2017	TWT and Natural England, First MCZ Working Group Workshop and post workshop correspondence.	Discussion of proposed approach to MCZ Assessment.	Approach to the MCZ Assessment was circulated by Hornsea Three and discussed at the subsequent MCZ Working Group Workshop (22 May 2017).
1 February 2017	TWT and Natural England, First MCZ Working Group Workshop and post workshop correspondence.	Natural England advised that the Conservation Advice Package for Cromer Shoal Chalk Beds MCZ was being prioritised and a draft would be provided to Hornsea Three once available.	Draft Conservation Advice Package for Cromer Shoal Chalk Beds MCZ was provided to Hornsea Three in May 2017 and as outlined in section 2.3.2, this is fully considered in the Stage 1 assessment (section 5.1).
22 May 2017	TWT and Natural England, Second MCZ Working Group workshop	Natural England highlighted a concern regarding the potential for scarring in mixed sediments from jack-ups and cable installation, and concerns regarding recovery in mixed sediments.	Effects on Subtidal Mixed Sediment habitat features, including associated communities are fully assessed in section 5.1.
22 May 2017	TWT and Natural England, Second MCZ Working Group workshop	Draft conservation advice for Cromer Shoal Chalk Beds MCZ would be provided to Hornsea Three by end of May 2017 and following this, it would be published for consultation (at the end of 2017), with a final package available in March 2018. Natural England advised that this draft conservation advice package should be used to support the MCZ Assessment. In the absence of the updated conservation advice for the Cromer Shoal Chalk Beds MCZ, Natural England suggested that the Conservation Advice Package for Thanet Coast MCZ could be used as a 'proxy' for the MCZs/rMCZs being considered by Hornsea Three.	The draft Conservation Advice Package for Cromer Shoal Chalk Beds MCZ was provided to Hornsea Three in May 2017 and as outlined in section 2.3.2, this is fully considered in the Stage 1 assessment (section 5.1). Consideration has also been given in this report to the Thanet Coast MCZ Conservation Advice Package, specifically in relation to Natural England's "Advice on Operations" screening tool.
22 May 2017	TWT and Natural England, Second MCZ Working Group workshop	In response to Hornsea Three's MCZ Assessment methodology paper (provided to the MCZ Working Group in advance of the meeting), Natural England recommended that the assessment be revised to specifically consider attributes and targets for individual protected features.	The draft Conservation Advice Package for Cromer Shoal Chalk Beds MCZ was provided to Hornsea Three in May 2017 and as outlined in section 2.3.2, this is fully considered in the Stage 1 assessment (section 5.1).
20 September 2017	Natural England - Section 42 Consultation Response	Concerns that Hornsea Three export cable installation will have a significant impact on the interest features of the Cromer Shoal Chalk Bed MCZ, due to cable installation causing direct loss of habitat and loss in the quality of the surrounding habitat, thus hindering the conservation objectives for the site.	The Stage 1 MCZ Assessment presented in section 5 fully considers the impacts associated with export cable installation and the draft Conservation Advice Package provided by Natural England.
20 September 2017	Natural England - Section 42 Consultation Response	Qualitative chalk reefiness assessment criteria have been devised by Natural England (provided to Hornsea Three post Section 42 consultation; 1 November 2017) and should be considered in final MCZ Assessment.	Qualitative chalk reefiness assessment criteria have been considered in the baseline characterisation (see section 4.2 and volume 5, annex 2.1: Benthic Ecology Technical Report)

Date	Consultee and type of response	Key issues raised	Response to issue raised and/or where considered in this chapter
		Concern regarding the effect of existing offshore wind farm cables (i.e. Sheringham Shoal and Dudgeon) on the Cromer Shoal Chalk Beds MCZ and that these may be influencing ability of the site to be restored to a more natural state. Recommendation that Hornsea Three collect geophysical and video data of these areas.	During Hornsea Three site specific surveys (see section 4.2) attempts were made to undertaken DDV sampling over these cables, although due to fishing conflicts this was not possible. Note: the Sheringham Shoal export cables were installed in 2010, prior to designation of the Cromer Shoal Chalk Beds MCZ in January 2016. Dudgeon cables were installed in May 2016, prior to site specific surveys of the Hornsea Three offshore cable corridor and therefore are part of the baseline characterisation for the Environmental Statement.
		Use of cable protection within the Cromer Shoal Chalk Beds MCZ will risk conservation objectives for some interest features being permanently hindered if not decommissioned due to alteration of seabed characteristics. May also be implications for interruption/disruption of wave action and/or sediment transport.	Effects of cable protection of protected features of this MCZ are considered fully, including effects on physical processes, in section 5.1.3.
		Markham's Triangle rMCZ: The Natural England/Joint Nature Conservation Committee (JNCC) current recommendation to the Department for Environment, Food and Rural Affairs (Defra) is to consider the features that need restoration. We expect the final application to include the following: • Assessment based on recover to favourable condition conservation objective; and • Assessment of all potential features, including Subtidal Mixed Sediments. Natural England/JNCC are satisfied that there is no overlap of activity on Subtidal Mud feature.	The MCZ Assessment on Markham's Triangle rMCZ is presented in 5.2, including consideration of the Subtidal Mixed Sediment feature and assuming a general management approach of "recover to a favourable condition".
19 September 2017	The Wildlife Trust (joint response from Norfolk WT and TWT) - Section 42 Consultation Response	Concern raised regarding permanent removal of Subtidal Chalk and subtidal Peat and Clay Exposures (reference to Sweetman case). A more detailed assessment required against the conservation objectives for Subtidal Chalk. TWT suggest that more than one subtidal chalk biotope should be considered as part of the assessment.	Full consideration of Subtidal Chalk features of the Cromer Shoal Chalk Beds MCZ are presented in section 5.1. Due to the nearshore re-routing of the Hornsea Three offshore cable corridor (see paragraph 1.2.1.4), the Hornsea Three offshore cable corridor does not coincide with either the Peat and Clay Exposures or the Subtidal Chalk features and therefore there will be no direct impacts on these.
		Assessment of the Cromer Shoal Chalk Beds MCZ should consider all features listed in the designation order, including High Energy Circalittoral Rock, High Energy Infralittoral Rock, Moderate Energy Circalittoral Rock, Moderate Energy Infralittoral Rock.	Moderate and High Energy Circalittoral Rock features are coincident with Subtidal Chalk shown in Figure 4.1 (Defra, 2015) and as such, any consideration of the Subtidal Chalk habitat Feature of Conservation Interest (FOCI) also implicitly considers these two Circalittoral Rock features. Infralittoral rock was not recorded within the MCZ (see section 4.2).
		If HDD is chosen as a mitigation option in relation to the MCZ, TWT would expect to see an assessment against all features of the MCZ from this activity.	Full consideration of the effects of HDD operations are presented in section 5.1, although this is not considered to be effective mitigation for the effects of Hornsea Three on the Cromer Shoal Chalk Beds MCZ.
		Recommended that a detailed cumulative/in combination impact assessment is undertaken as part of the MCZ Assessment. For Cromer Shoal Chalk Beds MCZ this should consider existing impacts on the site such as cabling routes and fishing activity.	As detailed in the response to Natural England's Section 42 consultation (20 September 2017) and in volume 4, annex 4.5.1: Cumulative Effects Screening Matrix, the benthic ecology characterisation against which the impacts from Hornsea Three were assessed (i.e. site specific data collection), includes the presence of these export cables and ongoing fishing activities (see section 5.1.5).
		Comment on temporary habitat loss effects on Subtidal Sand feature of Markham's Triangle rMCZ. TWT request further information on resilience and recoverability of this habitat feature and other habitat features which may be subject to temporary loss within the rMCZ.	Section 5.2 provides a full, detailed assessment on the features of Markham's Triangle rMCZ, including further detail on the communities associated with these habitat features.
20 September 2017	Eastern Inshore Fisheries and Conservation Authority (IFCA) - Section 42 Consultation Response	Concern raised about direct impacts on Subtidal Chalk and Peat and Clay Exposures features of the Cromer Shoal Chalk Beds MCZ and irreversible effects on these, should cable installation occur in these areas. The Eastern IFCA agree in general that the direct effects of cable installation on broadscale habitats (i.e. Subtidal Sand, Subtidal Coarse Sediments and Subtidal Mixed Sediments) and their associated benthic communities will be short-term, localised to a relatively small proportion of the habitat extent and of temporary nature.	Full consideration of Subtidal Chalk features of the Cromer Shoal Chalk Beds MCZ are presented in section 5.1. Due to the nearshore re-routing of the Hornsea Three offshore cable corridor (see paragraph 1.2.1.4), the Hornsea Three offshore cable corridor does not coincide with the Subtidal Chalk feature and therefore there will be no direct impacts on this feature.
		Commented on the indirect effects of cable installation activities on designations, including effects of increased SSC and associated sediment deposition on Subtidal Chalk and Peat and Clay Exposures.	Full consideration of Subtidal Chalk features of the Cromer Shoal Chalk Beds MCZ, including effects of increased SSC and sediment deposition, are presented in section 5.1.

Date	Consultee and type of response	Key issues raised	Response to issue raised and/or where considered in this chapter
21 September 2017	Updated Hornsea Three MCZ Assessment provided to MCZ Working Group	Revised MCZ Assessment was completed based on the draft SACO for Cromer Shoal Chalk Beds MCZ (provided by Natural England May 2017)	N/A
16 October 2017	TWT - Consultation on Updated MCZ Assessment (September 2017)	TWT does not feel that sufficient site specific information has been presented in the draft MCZ Assessment to support the conclusions made within the assessment. Eastern IFCA are currently undertaking an MCZ Assessment for Cromer Shoal Chalk Beds MCZ and it is recommended that Hornsea Three contact the Eastern IFCA about this.	Further site specific and desktop information has been provided in section 4 and the MCZ Assessment in section 5 has been appropriately updated to fully account for this updated baseline. Hornsea Three met the Eastern IFCA on 14th November 2017 and enquired about the MCZ Assessment they are progressing, as suggested by TWT, however Eastern IFCA were unable to share any information on this assessment for inclusion in the final DCO application.
		In relation to the Screening conclusions, permanent loss of habitat should be included.	Permanent habitat loss has been included in the Screening conclusions (section 3.3).
		Valued Ecological Receptors (VERs) should not be included in the MCZ Assessment. Instead, designated features should be focused upon as part of the assessment, with reference to the specific biotopes and communities within the MCZ.	The Stage 1 assessment presented in section 5 has been revised to specifically consider features of the MCZs, based on the baseline information in section 4. This does not include reference to VERs.
23 November 2017	Natural England - Consultation on Updated MCZ Assessment (September 2017)	Natural England reiterated the concerns outlined in their Section 42 consultation response.	No response required.
4 December 2017	MMO, TWT, Natural England and JNCC, Third MCZ Working Group workshop	Discussion on 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).	No response required.
		Discussion on the approach to baseline characterisation of nearshore area, including Cromer Shoal Chalk Beds MCZ, and the use of site specific survey data and desktop data sources. Further detail provided by Hornsea Three via a post workshop note (2 January 2018).	Section 4 of this report provides background information on the MCZs/rMCZs considered in the assessment, including a full, detailed description of the subtidal benthic ecology characterisation of MCZ/rMCZ sites considered. Approach to baseline characterisation agreed following provision of further detail after the workshop.
		Discussion of Hornsea Three offshore cable corridor re-route in the nearshore area, resulting in a reduced footprint within the Cromer Shoal Chalk Beds MCZ. Further detail provided by Hornsea Three via a post workshop note (2 January 2018).	Stage 1 MCZ Assessment considers the nearshore re-route which results in a reduced footprint within the Cromer Shoal Chalk Beds MCZ (see section 5).
		Project description changes, including: • Concerns raised by Natural England about the construction phase: Boulder clearance and HDD operations (including HDD exit pit excavation and jack-up operations); and • Operation and maintenance phase. Concerns raised by Natural England and JNCC regarding the use of cable/scour protection within MCZs. Included discussion of alternative cable protection measures e.g. use of rock protection with grain sizes reflective of baseline environment.	Stage 1 MCZ Assessment has been updated with these project description changes (see section 5).
		Agreement with JNCC on the approach to Markham's Triangle MCZ Assessment (i.e. assuming the maximum number of foundations within the rMCZ as a proportion of the overall total number of foundations) as outlined in section 5.2.	See section 5.2 for full description of Markham's Triangle rMCZ Assessment, including assumptions.
		Discussion on the approach to the MCZ Assessment, including updating assessment using attributes and targets for individual features, as set out in the conservation objectives. Natural England requested that reference to EIA conclusions should be removed. TWT recommended that the MCZ Assessment should focus on specific features of each MCZ, using scientific evidence on sensitivity and recovery of biotopes/species/communities to support conclusions.	Reference to EIA conclusions removed from Stage 1 assessment and MCZ Assessment has been updated to consider sensitivity and recoverability of biotopes/communities/species recorded in the baseline characterisation, focussing specifically on MCZ features (see section 5).
		Screening: Agreement that the Wash Approach rMCZ could be screened out of the MCZ Assessment.	No response required.

Date	Consultee and type of response	Key issues raised	Response to issue raised and/or where considered in this chapter
		Agreement that the MCZ Assessment does not need to further consider mussel or oyster beds as potential features to be designated under Tranche Three.	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.	No response required.
22 January 2018	Natural England - Letter response to Hornsea Three Nearshore Re-route Note (2 January 2018)	Reiterated concerns regarding cable installation within the Cromer Shoal Chalk Beds MCZ (and Wash and North Norfolk Coast SAC), including: • Feasibility of cable installation along the offshore cable corridor; • Consideration of effects of pre-construction activities; • Cable protection measures for both cable route options; and • Effects of cable protection on sediment transport in the area. Natural England consider that a Stage 2 assessment will be required due to the placement of cable protection within the MCZ.	Stage 1 MCZ Assessment gives full consideration to the effects of cable installation and operation on the features of the MCZ (see section 5). The Stage 1 assessment conclusion is presented in section 5.1.6. No significant risks to the achievement of the MCZ conservation objectives have been identified in the Stage 1 assessment (see in section 5.1.6) and, therefore, a Stage 2 assessment is not required.
		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.	No response required.
23 February 2018	MMO, TWT, Natural England and JNCC, Fourth MCZ Working Group workshop	Presentation and discussion of project envelope included in DCO application (see volume 1, chapter 3: Project Description), including the importance of cable burial as a means of protection, potential risks to successful cable burial and the requirement for cable protection in cases where cable burial is not possible.	No response required.
		Update on MCZ Assessment, including: • Nearshore re-route of Hornsea Three offshore cable corridor; • Update on assessment of effects on marine processes as a result of HDD operations; and Proposed designed in mitigation and monitoring proposals.	No response required.
		Natural England informed Hornsea Three that SACO for Cromer Shoal Chalk Beds will be published on the Natural England website in March 2018. Specific attributes and targets for the feature of geological interest have been removed and therefore the Stage 1 assessment should use attributes and targets for broadscale habitat features and habitat FOCI as a proxy.	Stage 1 assessment has been undertaken using attributes and targets for broadscale habitat features and habitat FOCI as a proxy for the feature of geological intertest.

2. Methodology

2.1.1.1 Guidance published by the MMO (2013) describes how MCZ Assessments could be undertaken in the context of marine licensing decisions (Note: there is no published PINS guidance or advice on MCZ Assessments for DCO applications). These MMO guidelines recommend a staged approach to the assessment, with three sequential stages: Screening, Stage 1 assessment and Stage 2 assessment (see Figure 2.1). Full details of each of these stages of the approach have been provided in the following sections.

2.1.1.2 If certain activities, sites or impacts are screened into the MCZ Assessment process, these are then considered within the Stage 1 assessment, followed by a Stage 2 assessment if significant risks to the achievement of the MCZ conservation objectives have been identified in the Stage 1 assessment.

2.1.1.3 This MCZ Assessment has considered MCZs that have been designated during the first two tranches of MCZ designations (Tranche One in 2013 and Tranche Two in 2016). For the purposes of this assessment, rMCZs have also been considered where these have the potential to be brought forward during the process of consenting for Hornsea Three (i.e. consultation on Tranche Three likely to be in 2018, although a timetable for designation is to be confirmed).

2.1.1.4 The methodology employed in this assessment has been developed in consultation with the MCZ Working Group as outlined in Table 1.1 and refined during the pre-application phase to take feedback from the MCZ Working Group into account. The key feedback received was in relation to the conservation objectives for the MCZ/rMCZs considered in the assessment, which were not available at the time of drafting the PEIR. In May 2017, Natural England provided Hornsea Three and the MCZ Working Group with the draft SACO for the Cromer Shoal Chalk Beds MCZ and recommended that the Stage 1 assessment be undertaken against these conservation objectives, or used as a proxy for rMCZs where conservation objectives are not yet available. Further details of the assessment methodology used are described in the following sections.

2.2 Screening

2.2.1.1 According to the MMO (2013) guidelines, all marine licence applications need to be screened to determine whether section 126 should apply. The MMO (2013) guidelines are stated to apply if it is determined through the course of screening that:

- *The licensable activity is taking place within or near an area being put forward or already designated as an MCZ; and*
- *The activity is capable of affecting (other than insignificantly) either (i) the protected features of an MCZ; or (ii) any ecological or geomorphological process on which the conservation of any protected feature of an MCZ is (wholly or in part) dependant.*

2.2.1.2 The MMO recommend the use of a risk based approach when determining the "*nearness*" of an activity to MCZs, including applying an appropriate buffer zone to the MCZ protected features under consideration as well as a consideration of risks for activities at greater distances from protected features of the MCZ(s).

2.2.1.3 In determining "*insignificance*", the likelihood of an activity causing an effect, the magnitude of the effect should it occur, and the potential risk any such effect may cause to either the protected features of an MCZ or any ecological or geomorphological process on which the conservation of any protected feature of an MCZ is (wholly or in part) dependent, should be considered (MMO, 2013).

2.2.1.4 For the purposes of the Hornsea Three MCZ Screening, MCZs and rMCZs considered within the assessment were identified through the Scoping Report (DONG Energy, 2016) and the benthic ecology EIA (see volume 2, chapter 2: Benthic Ecology). This initial screening identified designated sites (including MCZs and rMCZs) based on proximity to Hornsea Three, as follows:

- Sites with spatial overlap with Hornsea Three; and
- Sites with relevant protected features located within one tidal excursion (approximately 12 km) of the Hornsea Three array area and/or offshore cable corridor.

2.2.1.5 Following identification of the MCZs and rMCZs considered in this initial screening, information presented within the Environmental Statement has been reviewed to further refine this list of sites where Hornsea Three is capable of significantly affecting the protected/proposed features of those sites, or any ecological or geomorphological processes on which the conservation objectives of those features may depend (see Figure 2.1). This included review of outputs from volume 2, chapter 1: Marine Processes to identify potential far field effects (e.g. increases in suspended sediment concentrations (SSC), and changes to the tidal and wave regime due to the operational Hornsea Three offshore wind farm). Where robust evidence is available to screen out MCZs or rMCZs, this evidence has been referenced and justification presented within section 3 below.

2.2.1.6 Individual impacts on designated protected features of the MCZs and proposed features of the rMCZs are also considered in the MCZ Screening. Some impacts identified and assessed in volume 2, chapter 2: Benthic Ecology were considered to be of sufficiently low risk of resulting in a significant effect on protected/proposed MCZ/rMCZ features and have therefore been screened out (i.e. are considered insignificant). This may have been due, for example, to the extremely limited extent and/or duration of the impact, a lack of sensitivity of the receptors to the impact, or due to control measures to be implemented by Hornsea Three to minimise the risk of any significant effect occurring.

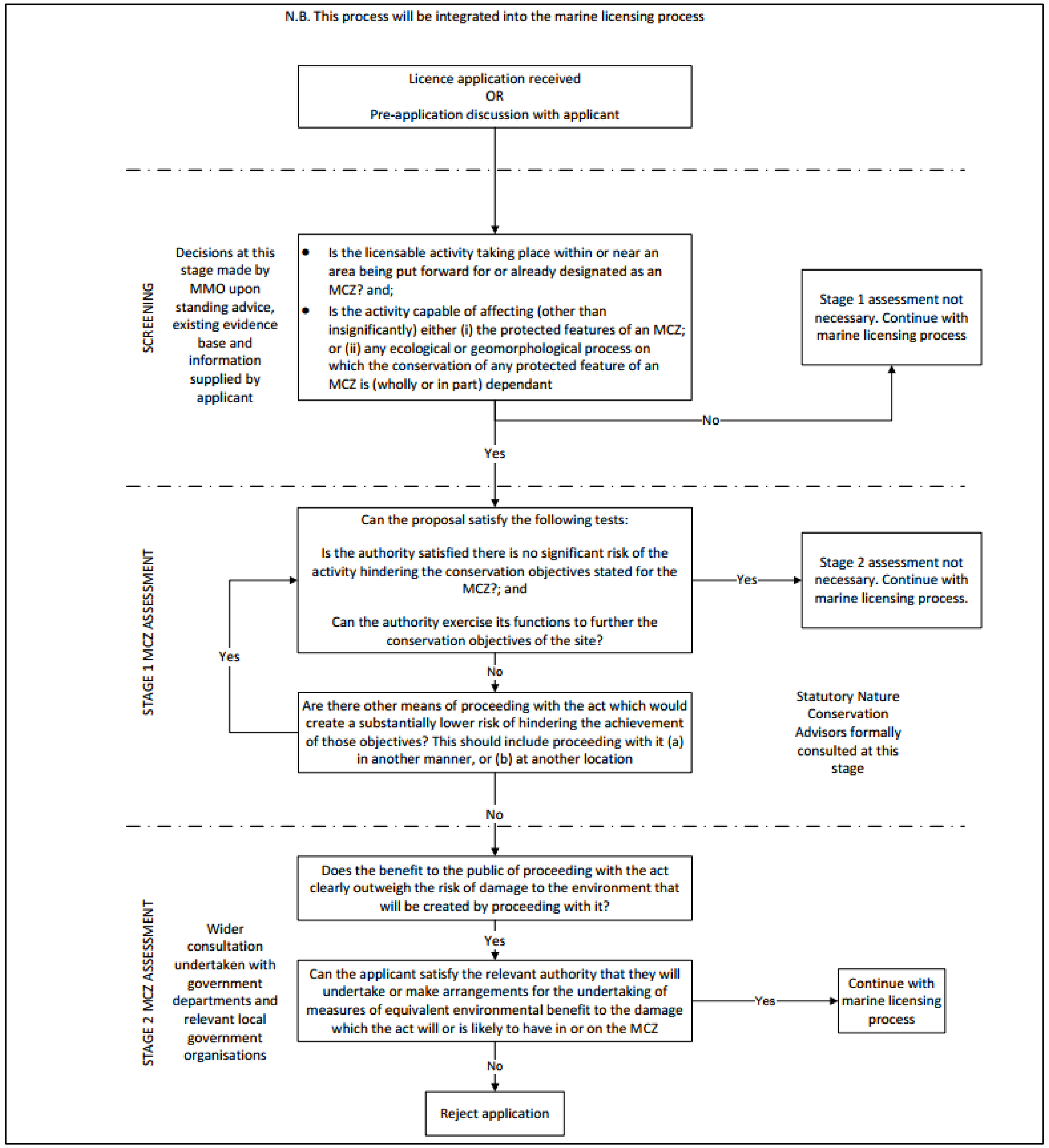

Figure 2.1: Flow chart summary of the MCZ Assessment process used by the MMO during marine licence determination (MMO, 2013).

2.3 Stage 1 Assessment

2.3.1.1 The Stage 1 assessment (if/as required) considers whether the conditions in section 126(6) of the MCAA can be met, namely can the decision-maker be satisfied there is no significant risk of the activity hindering the achievement of the conservation objectives stated for the MCZ (conservation objectives for the MCZ/rMCZs considered in the Stage 1 assessment are presented in section 4). In doing so the MMO guidelines suggest the decision-maker would use the information supplied by the applicant with the licence application, advice from the SNCBs and any other relevant information to determine whether:

- *There is no significant risk of the activity hindering the achievement of the conservation objectives stated for the MCZ.*

2.3.1.2 If the condition in section 126(6) cannot be met, the Stage 1 assessment considers whether the condition in section 126(7)(a) of the MCAA can be met. In doing so the decision-maker determines whether:

- *There is no other means of proceeding with the act which would create a substantially lower risk of hindering the achievement of the conservation objectives stated for the MCZ. This should include proceeding with it (a) in another manner, or (b) at another location.*

2.3.1.3 In undertaking a Stage 1 assessment the decision-maker formally consults with SNCBs for a period of 28 days (under sections 126(2) and (3) of the MCAA) unless the SNCB notifies the decision-maker that it need not wait or the decision-maker determines that there is an urgent need to grant authorisation (in accordance with section 126(4) of the MCAA).

2.3.1.4 Within this stage of assessment, the MMO advise that "hinder" would be any act that could, either alone or in combination:

- *In the case of a conservation objective of "maintain", increase the likelihood that the current status of a protected feature would go downwards (e.g. from favourable to degraded) either immediately or in the future (i.e. these protected features would be placed on a downward trend); or*
- *In the case of a conservation objective of "recover", decrease the likelihood that the current status of a protected feature could move upwards (e.g. from degraded to favourable) either immediately or in the future (i.e. these protected features would be placed on a flat or downward trend).*

2.3.1.5 When considering whether an activity may hinder the conservation objectives of a site, consideration should be given to the direct impact of an activity upon a protected feature as well as any applicable indirect impacts. Such an indirect impact could include changing the effectiveness of a management measure put in place to further the conservation objectives.

2.3.1.6 The MMO advise that the applicant should be able to demonstrate for the purposes of the condition in section 126(7)(a) that any "*other means*" of proceeding reduces the risk such that the act no longer has a significant risk of hindering the conservation objectives of the site.

2.3.1.7 If mitigation to reduce the impacts to an acceptable level cannot be secured, and there are no other means that substantially lower the risk of hindering the achievement of those objectives, then a Stage 2 assessment would be required. Should a Stage 2 assessment be required, this would follow the MMO guidance (MMO, 2013) on the two staged approach for undertaking an MCZ Assessment.

2.3.1.8 In determining 'insignificance', the MMO (2013) guidance states "*this should take into account the likelihood of an activity causing an effect, the magnitude of the effect should it occur, and the potential risk any such effect may cause on either the protected features of an MCZ or any ecological or geomorphological process on which the conservation of any protected feature of an MCZ is (wholly or in part) dependant*." This approach is presented in Hornsea Three's interpretation of the MMO (2013) guidance as outlined in the following section.

2.3.2 Assessment of risk to conservation objectives

2.3.2.1 Volume 2, chapter 1: Marine Processes and volume 2, chapter 2: Benthic Ecology have presented assessments of the impacts of Hornsea Three on the physical and ecological marine environment respectively, with definitions of impact, effect and significance of effects on the identified receptors (including protected/proposed features of MCZs/rMCZs) drawn from guidelines published in the Design Manual for Roads and Bridges (DMRB) (Highways Agency, 2008). These definitions have also been used within this MCZ Assessment, with the term 'effect' to express the consequence of an impact. This is expressed as the 'significance of effect' and is determined by considering the magnitude of the impact alongside the importance, or sensitivity, of the receptor or resource, in accordance with defined significance criteria.

2.3.2.2 Volume 2, chapter 2: Benthic Ecology presents significance levels according to EIA/Ecological Impact Assessment (EcIA) methodologies. While this MCZ Assessment will draw on the information presented in volume 2, chapter 2: Benthic Ecology to support the conclusions made about effects of the project on the achievement of conservation objectives for the relevant MCZ/rMCZs, the EIA/EcIA approach has not been used to inform the conclusions made (as agreed with the MCZ Working Group; see Table 1.1, 4 December 2017).

2.3.2.3 As discussed in section 2.3, the Stage 1 assessment has considered whether there is a risk that Hornsea Three could hinder the achievement of the current conservation status of protected features and conservation objectives for the MCZs. This includes assessing the risks in the context of the conservation status of each of the individual MCZ protected features and to the specific management approach which applies to each of the protected features, where these have been made available.

2.3.2.4 These conservation objectives and management approaches are detailed in section 4 for the sites and the protected/proposed features which have been considered in the Stage 1 assessment. For the Cromer Shoal Chalk Beds MCZ, further information on the conservation objectives for each of the protected features was provided by Natural England to Hornsea Three in the informal draft SACO for the site (available at Natural England's Designated Sites System; Natural England, 2018). The Supplementary Advice tables present attributes which are characteristics of the designated protected species and habitats within a site. The attributes are considered by Natural England to be those which best describe the site's ecological integrity and which, if safeguarded, will enable achievement of the conservation objectives (Natural England, 2017). The attributes have a target which is either quantitative or qualitative, depending on the available evidence and the target identifies, as far as possible, the desired state to be achieved for the attribute.

2.3.2.5 For the purposes of the Stage 1 assessment, attributes were broadly categorised as either physical or ecological attributes. For example, physical attributes and associated targets for the Subtidal Coarse Sediment feature of the Cromer Shoal Chalk Beds MCZ include (for a full list of attributes and targets for all features, see draft SACO for this MCZ; available at Natural England's Designated Sites System; Natural England, 2018):

- Extent and distribution - Target: Maintain the total extent of Subtidal Coarse Sediment at 148 km², and spatial distribution as defined on the map, subject to natural variation (discussed further in section 4.2);
- Structure: sediment composition and distribution - Target: Maintain the distribution of sediment composition types across the feature;
- Supporting processes: energy/exposure - Target: Maintain the natural physical energy resulting from waves, tides and other water flows, so that the exposure does not cause alteration to the biotopes and stability, across the habitat;
- Supporting processes: sediment movement and hydrodynamic regime - Target: Maintain all hydrodynamic and physical conditions such that natural water flow and sediment movement are not significantly altered or prevented from responding to changes in environmental conditions; and
- Supporting processes: water quality - turbidity - Target: Maintain natural levels of turbidity (e.g. concentrations of suspended sediment, plankton and other material) across the habitat.

2.3.2.6 Ecological attributes and associated targets for the Subtidal Coarse Sediment feature of the Cromer Shoal Chalk Beds MCZ include, for example:

- Distribution: presence and spatial distribution of biological communities - Target: Maintain the presence and spatial distribution of Subtidal Coarse Sediment communities;
- Structure: species composition of component communities - Target: Maintain the species composition of component communities; and
- Structure: non-native species and pathogens - Target: Restrict the introduction and spread of non-native species and pathogens, and their impacts.

2.3.2.7 The Stage 1 assessment considers each of the attributes for all protected features of the relevant MCZs (where available), where there is a clear impact-receptor pathway, to help determine whether there is a significant risk to the conservation objectives of the MCZ. This draws on information presented within the relevant chapters of the Environmental Statement (see paragraph 1.1.1.6). When considering ecological attributes, the sensitivities of the species and communities (often represented by biotopes; see section 4) associated with the MCZ features have been defined by the following, according to the Marine Evidence based Sensitivity Assessment (MarESA; Tillin *et al*., 2010):

- Intolerance or resistance, which is the likelihood of damage due to a pressure; and
- Recoverability or resilience, which is the rate of (or time taken for) recovery once the pressure has abated or been removed. Recoverability is the ability of a habitat to return to the state 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.

2.3.2.8 Therefore, where sensitivity levels have been presented within the Stage 1 assessment of this document, these are the definitions according to the MarESA (Tillin *et al.,* 2010) and not according to the definitions used to inform the EIA in volume 2, chapter 2: Benthic Ecology, the latter also considering the importance (e.g. conservation, commercial or ecological) of the receptors. Use of the MarESA definitions also ensures consistency with Natural England conservation advice for the Cromer Shoal Chalk Beds MCZ and other marine protected areas (discussed further in paragraph 2.3.2.9). Information on these aspects of sensitivity of the species, communities and biotopes to given impacts has been informed by the best available evidence following environmental impact or experimental manipulation in the field and evidence from the offshore wind industry and analogous activities such as those associated with cable installation and operations, aggregate extraction and oil and gas industries. Where applicable, the MarESA has also been drawn upon to support the assessments of sensitivity, including evidence of sensitivity to particular activities and benchmarks for the relevant pressures considered for each attribute.

2.3.2.9 In addition to the Cromer Shoal Chalk Beds informal draft SACO provided by Natural England (available at Natural England's Designated Sites System; Natural England, 2018), further information has also been used to inform the MCZ Assessment from the Conservation Advice Package for the Thanet Coast MCZ, which has been fully developed by Natural England (Natural England, 2017). The Thanet Coast MCZ Conservation Advice includes an "Advice on Operations" matrix which identifies pressures associated with commonly occurring marine activities, potential impact pathways between activities and protected features and presents information on the sensitivities of the relevant features to those activities, using appropriate sensitivity benchmarks (Note: the "Advice on Operations" matrix also draws on the MarESA, ensuring consistency throughout the assessment). Since the "Advice on Operations" has not yet been fully developed for the Cromer Shoal Chalk Beds MCZ, or rMCZs considered in the assessment, Natural England advised that the Thanet Coast MCZ was the most applicable to all MCZ/rMCZs considered in this MCZ Assessment, due to the common features with the sites considered in the Hornsea Three assessment (see Table 1.1). The "Advice on Operations" matrix for the Thanet Coast MCZ (Natural England, 2017) has therefore been used as a source of relevant information within the Stage 1 assessment and has been referred to where appropriate.

2.3.2.10 For rMCZs there are currently no specific conservation objectives available, nor are there attributes or targets for the proposed features for designation. As such, for the purposes of the Stage 1 assessment, conservation objectives, attributes and targets for the proposed features of rMCZs are assumed to be identical to those same protected features of the Cromer Shoal Chalk Beds MCZ, for the common features across these sites (see section 4.3).

2.3.2.11 Following consideration of the relevant impacts of Hornsea Three on attributes and targets of the individual MCZ/rMCZ features, conclusions are presented as to the potential risks of the activities associated with Hornsea Three hindering achievement of conservation objectives for the sites and consequently whether the conditions in section 126(6) of the MCAA can be met (see paragraph 2.3.1.1), i.e.:

- There is no significant risk of the activity hindering the achievement of the conservation objectives stated for the MCZ.

2.3.2.12 If it cannot be concluded that there is no significant risk of the activity hindering the achievement of the conservation objectives or the management approach for an MCZ, and that mitigation or consideration of alternative means of proceeding, would not create a substantially lower risk of hindering achievement of the conservation objectives (see paragraphs 2.3.1.6 and 2.3.1.7), a Stage 2 assessment would be required. A stage 1 assessment conclusion is provided for the Cromer Shoal Chalk Beds MCZ in Section 5.1.6 and for the Markham's Triangle rMCZ in Section 5.2.6.

3. Screening

3.1 MCZ Screening

3.1.1.1 As outlined in paragraph 2.2.1.1, according to the MMO (2013) guidelines, section 126 would apply if it is determined through the course of screening that "*the licensable activity is taking place within or near an area being put forward or already designated as an MCZ.*"

3.1.1.2 The MCZs identified in the Hornsea Three Scoping Report (DONG Energy, 2016) and the benthic ecology EIA (see volume 2, chapter 2: Benthic Ecology) as having the potential to be affected by Hornsea Three are listed below, with the location of these in the context of Hornsea Three shown in Figure 3.1.

- Cromer Shoal Chalk Beds MCZ (overlaps with part of the Hornsea Three offshore cable corridor);
- Markham's Triangle rMCZ (overlaps with part of the Hornsea Three array area); and
- Wash Approach rMCZ (within one tidal excursion of the Hornsea Three offshore cable corridor; Dong Energy, 2016).

3.1.1.3 These three rMCZ/MCZ sites either overlap with Hornsea Three or, in the case of the Wash Approach rMCZ, are within one tidal excursion of the Hornsea Three offshore cable corridor. These sites, and the impacts upon these, have therefore been considered within this MCZ Screening.

3.2 Screening of Sites and Protected/Proposed Features

3.2.1.1 As outlined in paragraph 2.2.1.1 and in the MMO (2013) guidelines, following identification of MCZs to be considered, section 126 would apply if it is determined through the course of screening that "*the activity is capable of affecting (other than insignificantly) either (i) the protected features of an MCZ; or (ii) any ecological or geomorphological process on which the conservation of any protected feature of an MCZ is (wholly or in part) dependant.*"

3.2.1.2 The proposed features for designation of the Wash Approach rMCZ (i.e. Subtidal Mixed Sediment and Subtidal Sand broadscale habitats and Subtidal Sands and Gravels habitat FOCI) were identified as having the potential to be affected by Hornsea Three in the Hornsea Three Scoping Report (DONG Energy, 2016) and based on the criteria outlined in paragraph 2.2.1.4 has been included in this MCZ Screening due to the site's proximity to the Hornsea Three offshore cable corridor. The marine processes EIA (volume 2, chapter 1: Marine Processes) concluded that increases in SSC and associated sediment deposition during cable installation would occur near the cable, with much of the sediments (i.e. sand and gravels) settling on the seabed within a few metres of the cable. Fine sediments would be transported over greater distances, but these would be expected to be near background SSCs within hundreds to a few thousands of metres. Sediment deposition due to cable installation would not be likely to settle to a measurable thickness beyond tens to hundreds of metres from the cable, with much of the sediment disturbed sediments (i.e. sand and gravels) deposited within a few metres of the cable trench.

3.2.1.3 Due to the distance between the Hornsea Three offshore cable corridor and the Wash Approach rMCZ (i.e. 4 km at the closest point; see Figure 3.1) and the transient nature and limited extent of impacts from cable installation (other Hornsea Three construction, operation and decommissioning activities would be more limited in extent), it can be concluded that there is no potential for a receptor-impact pathway that could result in an effect on the proposed features of the Wash Approach rMCZ from Hornsea Three. This rMCZ has therefore been screened out of this MCZ Assessment and this site has therefore not been considered further (as agreed with the MCZ Working Group; see Table 1.1; 4 December 2017).

3.2.1.4 Following the MMO guidelines, those impacts that are concluded to have an insignificant effect on protected/proposed features of MCZ/rMCZs can be screened out and not taken through to the Stage 1 assessment. Based on the information presented in volume 2, chapter 2: Benthic Ecology, the following impacts were considered to represent a low risk to these features or the ecological or geomorphological processes on which the conservation of these are (wholly or in part) dependent, so as to allow these impacts to be screened out at this stage:

- Accidental release of pollutants (e.g. from accidental spillage/leakage) during construction, operation and maintenance, and decommissioning phases: volume 2, chapter 2: Benthic Ecology predicted an effect of negligible significance primarily due to the control measures to be employed during construction, operation and maintenance, and decommissioning, which will minimise the risk of any release of pollutants and also minimise the magnitude of such a spill, in the unlikely event of this occurring;
- Seabed disturbance during the construction phase leading to release of sediment bound contaminants during the construction phase: as set out in section 2.8.2 of volume 2, chapter 2: Benthic Ecology, sediment contamination across the Hornsea Three array area and offshore cable corridor was low and therefore did not represent a significant risk to benthic ecology. As such this impact was scoped out of the EIA and is screened out of the MCZ Assessment; and
- Removal of foundations during the decommissioning phase, leading to loss of species/habitats colonising these structures: volume 2, chapter 2: Benthic Ecology predicted an effect of negligible significance and since this impact would not affect protected/proposed features of the relevant MCZs/rMCZs, this has not been considered further in this assessment.

3.3 Screening conclusions

3.3.1.1 For the Cromer Shoal Chalk Beds MCZ, the following impacts are screened into the Stage 1 assessment:

- Construction phase:
  - Temporary habitat loss/disturbance due to export cable installation; and
  - Increases in SSC and associated deposition due to export cable installation.
- Operation and maintenance phase:
  - Long term habitat loss due to export cable protection;
  - Maintenance operations during the operational phase, resulting in temporary seabed disturbances;
  - Colonisation of export cable protection; and
  - Increased risk of introduction or spread of invasive and non-native species (INNS) due to presence of subsea infrastructure and vessel movements.
- Decommissioning phase:
  - Temporary habitat loss/disturbance due to export cable removal;
  - Increases in SSC and associated deposition due to export cable removal; and
  - Permanent habitat loss due to presence of export cable protection left *in situ* post decommissioning.

3.3.1.2 For Markham's Triangle rMCZ, the following impacts are screened into the Stage 1 assessment:

- Construction phase:
  - Temporary habitat loss/disturbance due to array and substation interconnector cable laying operations, spud-can leg impacts from jack-up operations and seabed preparation works for gravity base foundations; and
  - Increases in SSC and associated deposition from cable and foundation installation and seabed preparation.
- Operation and maintenance phase:
  - Long term habitat loss through presence of foundations, scour protection, and array and substation interconnector cable protection;
  - Maintenance operations during the operational phase, resulting in temporary seabed disturbances;
  - Colonisation of offshore foundations, scour protection, and array and substation interconnector cable protection;
  - Increased risk of introduction or spread of INNS due to presence of subsea infrastructure and vessel movements; and
  - Alteration of seabed habitats arising from effects on physical processes, including scour effects and changes in the wave and tidal regimes.
- Decommissioning phase:
  - Temporary habitat loss due to operations to remove array cables, substation interconnector cables and jack-up operations to remove foundations;
  - Increases in SSC and deposition from removal of array and substation interconnector cables, and foundations; and
  - Permanent habitat loss due to presence of scour/cable protection left *in situ* post decommissioning.

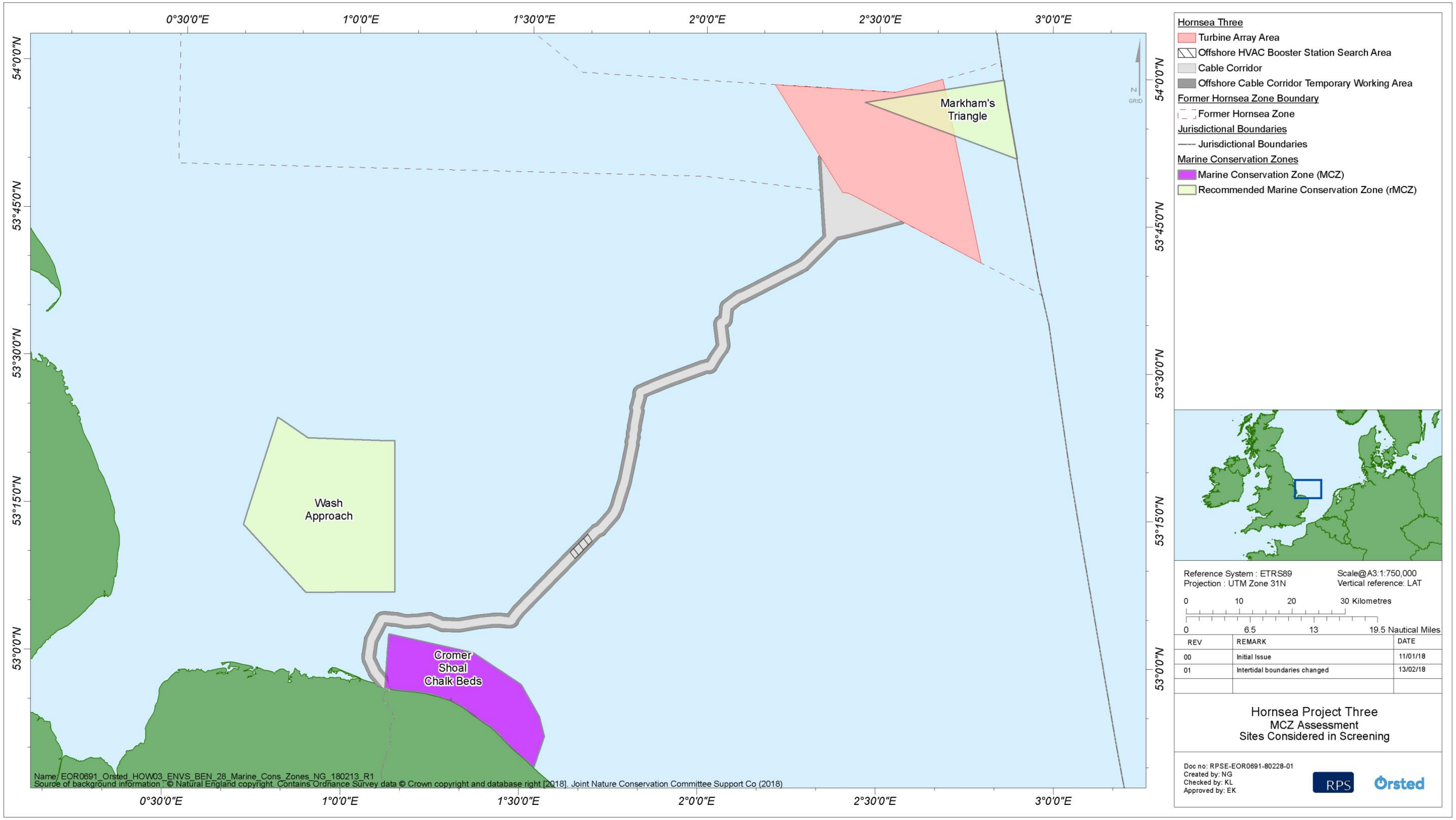

Figure 3.1: Marine Conservation Zones (MCZs) and recommended Marine Conservation Zones (MCZs) overlapping Hornsea Three or within one tidal excursion of Hornsea Three with relevant protected/proposed features.

4. Background Information on MCZs

4.1.1.1 This section provides a summary of the baseline information for each of the MCZs considered within the Stage 1 assessment.

4.2 Cromer Shoal Chalk Beds MCZ

4.2.1.1 The Cromer Shoal Chalk Beds MCZ, which came into effect on 29 January 2016 (Defra, 2016a), lies approximately 200 m from the low water mark off the north Norfolk coast and extends 10 km out to sea in waters of up to 25 m depth (Defra, 2015), covering a total area of approximately 321 km^2. The chalk and flint shores of north Norfolk represent one of the few coastal outcrops of bedrock in eastern England (Covey, 1998). The chalk shores are considered a rare habitat in northwest Europe (Covey, 1998). Off the east coast of England, notable areas of chalk shores occur at Flamborough Head in Yorkshire and on the Thanet coast in Kent, though the reef at North Norfolk is thought to be the longest, with a length of approximately 30 km (Spray and Watson, 2011a).

4.2.1.2 Volume 5, annex 2.1: Benthic Ecology Technical Report provides a detailed description of the nearshore section of the Hornsea Three offshore cable corridor, including the Cromer Shoal Chalk Beds MCZ. These included the following desktop and Hornsea Three site specific surveys (fully detailed in volume 5, annex 2.1: Benthic Ecology Technical Report) which were used to characterise the nearshore section in the vicinity of the Hornsea Three offshore cable corridor (as agreed with Natural England; see Table 1.1):

- Hornsea Three site specific geophysical surveys (i.e. bathymetry, sidescan sonar and sub-bottom profiler) of the Hornsea Three offshore cable corridor, including coverage within the Cromer Shoal Chalk Beds MCZ in 2016 and 2017;
- Hornsea Three site specific benthic grab sampling/DDV sampling of the Hornsea Three offshore cable corridor, including sampling within and adjacent to the Cromer Shoal Chalk Beds MCZ undertaken in 2016 and 2017;
- Hornsea Three site specific DDV sampling of subcropping rock and possible chalk bedrock exposures in inshore part of the Hornsea Three offshore cable corridor, including within and to the west of the Cromer Shoal Chalk Beds MCZ, undertaken in 2017;
- Sheringham Shoal offshore wind farm baseline characterisation (Scira Offshore Energy Ltd., 2006) and post construction monitoring data (Scira Offshore Energy Ltd., 2014);
- Dudgeon offshore wind farm export cable baseline characterisation data (Dudgeon Offshore Wind Limited, 2009);
- Dudgeon offshore wind farm pre construction baseline ecology study (Fugro EMU Ltd, 2015);
- Natural England data within the Wash and North Norfolk Coast SAC (immediately to the west of the MCZ; APEM, 2013);
- Data from Magic.defra.gov.uk and Marine Recorder (including Seasearch reports and data from the MCZ and SAC);
- Cromer Shoal Chalk Beds MCZ Post-Survey Site Report (Defra, 2015); and
- Diver surveys undertaken within the MCZ (Spray and Watson, 2011a; Watson, 2012).

4.2.1.3 Table 4.1 presents the protected features of the Cromer Shoal Chalk Beds MCZ, with their spatial extents within the MCZ (where these are available) and the general management approach as stated in Defra (2016b). These features, as mapped by Defra (2015), are shown relative to the Hornsea Three offshore cable corridor in Figure 4.1. The MCZ is characterised by an extensive area of Subtidal Chalk in the inshore area, which is located to the east of the Hornsea Three offshore cable corridor, and extends along most of the length of the MCZ. The areas of High Energy Circalittoral Rock and Moderate Energy Circalittoral Rock are coincident with the extent of Subtidal Chalk shown in Figure 4.1. High Energy Infralittoral Rock and Moderate Energy Infralittoral Rock were not recorded within the MCZ by Defra (2016b; see Table 4.1) or Hornsea Three site specific surveys. Much of the rest of the area of the MCZ mapped in Defra (2016b) is characterised by the Subtidal Coarse Sediment broadscale habitat feature. Less extensive areas of Subtidal Mixed Sediment have been reported, including in the west of the MCZ, to the east of the Hornsea Three offshore cable corridor. Subtidal Sand was present in the inshore section of the Hornsea Three offshore cable corridor and along the north western boundary of the MCZ and in inshore areas in southeast of the MCZ. Discrete areas of the Peat and Clay Exposures habitat FOCI has been recorded in the north western section of the MCZ (discussed further in paragraph 4.2.1.10 below).

4.2.1.4 For the Cromer Shoal Chalk Beds MCZ, the conservation objective is to ensure the relevant protected features are maintained or brought into a "favourable condition", which, for the habitat features, is when the **extent of the habitats is stable or increasing** and relevant **structures and functions, quality and composition of characteristic biological communities are in a healthy condition and not deteriorating** (see Cromer Shoal Chalk Beds Marine Conservation Zone Designation Order; Defra, 2016a).

4.2.1.5 In addition to the habitat features, the Cromer Shoal Chalk Beds MCZ lists the North Norfolk Coast Assemblage of Subtidal Sediment Features and Habitats as a geological feature. This geological feature is comprised of the individual subtidal sediment and rock habitats features listed in Table 4.1, although the conservation objectives consider the physical aspects of this protected geological feature, rather than the biological species detailed in the following paragraphs. With respect to the feature of geological interest, “favourable condition” is when its **extent, component elements and integrity** are maintained, its **structure and functioning are unimpaired** and its **surface remains sufficiently unobscured** for the purposes of determining whether the previous two conditions are satisfied.

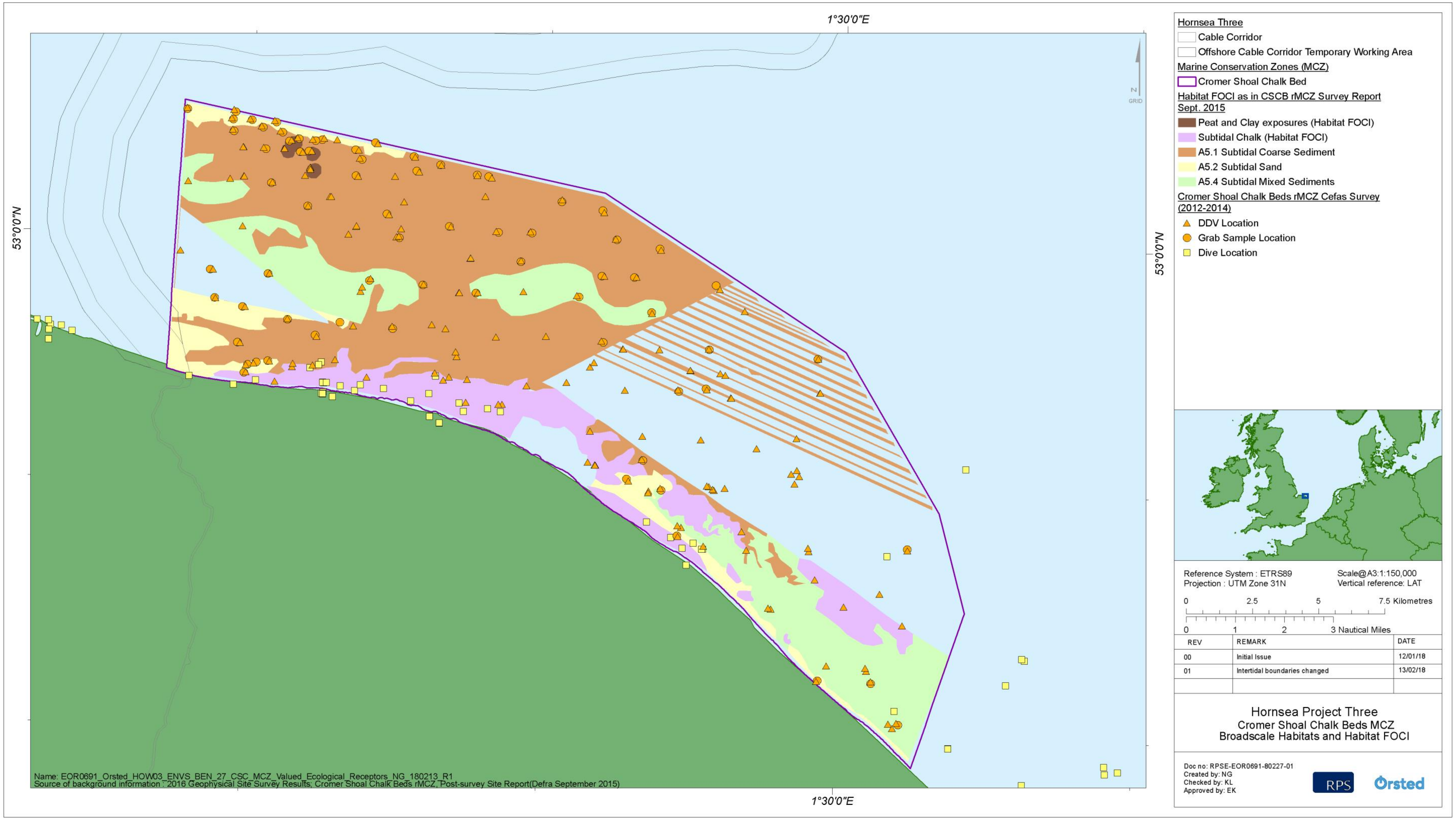

Figure 4.1: Hornsea Three offshore cable corridor and Cromer Shoal Chalk Beds MCZ broadscale habitat features and habitat FOCI.

Table 4.1: Protected features of the Cromer Shoal Chalk Beds MCZ, recorded extents (see Figure 4.1) and general management approach.

Protected feature (Defra, 2016a)	Spatial extents within MCZ (Defra, 2015)	General Management Approach
High Energy Circalittoral Rock	30 km² [a]	Maintain in favourable condition
Moderate Energy Circalittoral Rock		Maintain in favourable condition
High Energy Infralittoral Rock	Not confirmed present	Maintain in favourable condition
Moderate Energy Infralittoral Rock	Not confirmed present	Maintain in favourable condition
Subtidal Coarse Sediments	148 km²	Maintain in favourable condition
Subtidal Mixed Sediments	49 km²	Maintain in favourable condition
Subtidal Sand	18 km²	Maintain in favourable condition
Peat and Clay Exposures	Several point records in the northwest of MCZ	Maintain in favourable condition
Subtidal Chalk	30 km² [b]	Maintain in favourable condition
North Norfolk Coast Assemblage of Subtidal Sediment Features and Habitats (geological feature)	Combined extents above	Maintain in favourable condition

a Insufficient evidence (Defra, 2015) to refine the classification of the EUNIS biotope 'A4 Circalittoral rock'.

b While this extent is based on 78% survey coverage within the MCZ, the extent of Subtidal Chalk mapped by Defra (2015) is considerably less than the 189.37 km² predicted to be present (i.e. by modelling) in the Site Assessment Document (SAD) (Net Gain, 2011).

4.2.1.6 Figure 4.2 shows the subtidal biotopes mapped within and around the Cromer Shoal Chalk Beds MCZ from Hornsea Three site specific survey data and desktop sources detailed in paragraph 4.2.1.2. The process by which these biotopes were assigned is fully described in volume 5, annex 2.1: Benthic Ecology Technical Report. The section of the Hornsea Three offshore cable corridor which coincides with the Cromer Shoal Chalk Beds MCZ is primarily characterised by the *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand biotope (SS.SSa.IFiSa.NcirBat, hereafter referred to as NcirBat) which qualifies as the Subtidal Sand broadscale habitat feature of the MCZ. This biotope occurs in the shallow sublittoral and occurs in sandy sediments which are subject to physical disturbance, i.e. in this part of the North Norfolk coast, wave action. Characteristic species recorded during site specific surveys include the polychaetes *Nephtys cirrosa*, *Ophelia borealis* and *Travisia forbesii* and the amphipod *Bathyporeia elegans*, although abundances and diversity are typically low, due to the regular disturbance from wave action and therefore the species associated with this sediment type are typically robust pioneer species which can quickly colonise disturbed sediment. This biotope was also reported in this area in desktop sources (e.g. Scira Offshore Energy Ltd., 2006; 2014; Dudgeon Offshore Wind Limited, 2009; APEM, 2013); in line with the mapping of MCZ features shown in Figure 4.1.

4.2.1.7 Across the wider MCZ (though not coinciding with the Hornsea Three offshore cable corridor), characteristic biotopes include the *Moerella* spp. with venerid bivalves in infralittoral gravelly sand (SS.SCS.ICS.MoeVen, hereafter referred to as MoeVen). This biotope occurs in coarse gravelly sand sediments (i.e. the Subtidal Coarse Sediment broadscale habitat feature) and is characterised by relatively low abundances of robust bivalves and polychaetes. Species recorded during site specific surveys included low abundances of the polychaetes *Ophelia borealis*, *Lumbrineris cingulata*, *Travisia forbesii* and *Spionidae*, with the encrusting tubeworm *Spirobranchus lamarcki* and barnacle *Semibalanus balanoides* recorded on gravel and cobbles in grab samples. This biotope was recorded in both site specific surveys and desktop studies in the southwest and northwest of the MCZ (see Figure 4.2).

4.2.1.8 The main mixed sediment biotope (i.e. Subtidal Mixed Sediment broadscale habitat feature) within the Cromer Shoal Chalk Beds MCZ and near the Hornsea Three offshore cable corridor was the *Sabellaria spinulosa* on stable circalittoral mixed sediment biotope (SS.SBR.PoR.SspiMx, hereafter referred to as SspiMx). This biotope is typically more diverse than the aforementioned biotopes and was characterised by the tube building polychaete *S. spinulosa* and a range of other polychaete species (e.g. *Lumbrineris cingulata*, *Owenia* sp., *Harmothoe impar* and *Polycirrus* sp.), molluscs (e.g. *Abra prismatica Rissoa parva*) and crustaceans (e.g. *Ampelisca spinipes* and *Pisidia longicornis*). This biotope was also characterised by epifaunal species including the tubeworm *S. lamarcki* and the ascidians *Dendrodoa grossularia* and *Ascidiella aspersa*. This biotope occurred in the west of the MCZ (see Figure 4.2).

4.2.1.9 Epifaunal biotopes were also recorded during site specific DDV sampling, with the *Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment biotope (SS.SMx.CMx.FluHyd, hereafter referred to as FluHyd) present as an epifaunal overlay with the SspiMx and MoeVen biotopes (see Figure 4.2). Epifauna in these biotopes included bryozoans (e.g. *Flustra foliacea* and *Bicellariella ciliata*), hydroids (e.g. *Sertularia* spp., *Hydrallmania falcata* and *Nemertesia* sp.), polychaetes (e.g. *Serpulidae*), sea anemones (e.g. *Urticina* sp.), crustaceans (e.g. *Cancer pagurus*) and sea stars (e.g. *Crossaster papposus*).

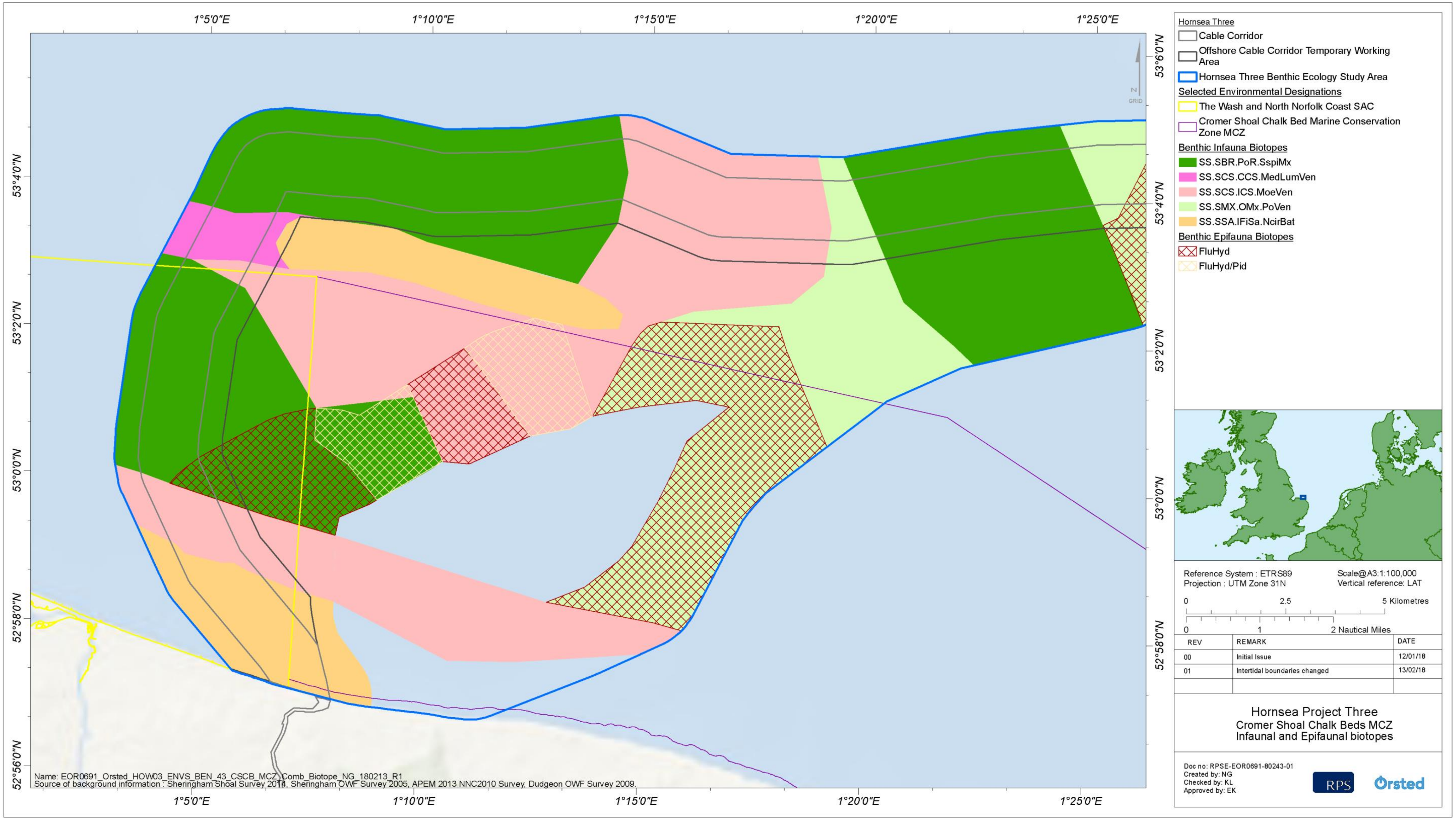

Figure 4.2: Infaunal and epifaunal biotopes in the nearshore section of the Hornsea Three offshore cable corridor, including within the Cromer Shoal Chalk Beds MCZ.

4.2.1.10 DDV sampling was also undertaken in the vicinity of the historic records of clay exposures in the north of the MCZ, to provide more up-to-date data on the locations of these habitat FOCI (i.e. Peat and Clay Exposures) of the MCZ. DDV sampling confirmed presence of clay exposures where these had been historically recorded (Defra, 2015; see Figure 4.1), with an additional area of seabed with clay exposures also recorded within the MCZ, to the southwest of those identified by Defra (2015; see Figure 4.2). The features, at all locations where observed, were found to support a relatively low epifaunal diversity dominated by burrowing piddocks (species not confirmed but expected to be the common piddock *Pholas dactylus*) in the very limited areas where there was no overlying sediment and was considered representative of the piddocks with a sparse associated fauna in sublittoral very soft chalk or clay biotope (CR.MCR.SfR.Pid, hereafter referred to as Pid). A more diverse epifaunal community, considered to be representative of the FluHyd biotope, was recorded where mixed/coarse sediments were present as an overlying veneer over the clay. At all DDV sampling locations, the areas comprising shallow veneers were considerably more extensive than the exposed clay features. As such, the matrix biotope FluHyd/Pid was considered representative of the seabed in these areas. The communities associated with the sediment veneer were dominated by erect bryozoans and hydroids including *Flustra* sp. *Nermetesia* sp. and *Sertularia* sp. together with large crustaceans, including the edible crab *C. pagurus* and the common lobster *Homarus gammarus*. All records (both historic and from Hornsea Three site specific data) of the Peat and Clay Exposures habitat FOCI were made outside the Hornsea Three offshore cable corridor, with the closest observation of this feature recorded approximately 3 km to the west of the offshore cable corridor.

4.2.1.11 In the most inshore section of the Hornsea Three offshore cable corridor, the Hornsea Three site specific inshore geophysical survey data (collected in 2017) identified an area of subcropping rock (i.e. subsurface rock with an overlying layer of sediment), to the northwest of the Hornsea Three intertidal zone and extending into the Cromer Shoal Chalk Beds MCZ. 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. Detailed bathymetry data shows that most of the seabed surface in this area is characterised by sand ripples of approximately 10 cm elevation and that the subcropping rock comes close to the surface (i.e. sediment veneer of <0.2 cm) in discrete areas. DDV transects were undertaken across this area in October 2017, specifically targeting nine areas where the geophysical data interpretation indicated that subcropping rock comes close to, or potentially outcrops (i.e. protrudes from), the surrounding sediment (see Figure 4.3).

4.2.1.12 The main aim of the survey was to identify any potential areas of exposed chalk which may qualify as the Subtidal Chalk habitat FOCI and/or Annex I stony reef habitats following the criteria identified by Irving (2009; see section 2.6.4 of volume 5, annex 2.1: Benthic Ecology Technical Report). It was agreed through the MCZ Working Group that in order to be described as the Subtidal Chalk habitat FOCI, an area of exposed chalk needed to meet certain criteria in terms of its structural complexity, such as elevation from the surrounding sediment and the presence of seabed features (e.g. fissures, crevices, stacks), as well its associated algal and epifaunal community composition. In the absence of any quantitative criteria to determine the quality of chalk reef habitat (or 'chalk reefiness'), Natural England provided qualitative descriptions of chalk reefs (with four categories: not a reef, low reef, medium reef and high reef) to inform the classification of chalk exposures for the purposes of the MCZ Assessment. These descriptions were based on independent Seasearch video data collected within areas of the subtidal chalk reef within the Cromer Shoal Chalk Beds MCZ (i.e. to the east of the Hornsea Three offshore cable corridor; see Figure 4.1) and were provided to Hornsea Three and the MCZ Working Group on 1 November 2017 (see Table 1.1).

4.2.1.13 The DDV transects confirmed that the inshore area was characterised primarily by sandy sediments (i.e. the NcirBat biotope as described in paragraph 4.2.1.6), with rippled sand recorded in both the DDV transects and in the geophysical survey interpretation (see Figure 4.3 and Figure 4.4). Where the subcropping rock was interpreted from the geophysical datasets as being close to the surface (i.e. sediment veneer of <0.2 m; black areas shown in Figure 4.3), increased proportions of mixed coarse sediments, including gravel, cobbles and occasional boulders, were recorded in the DDV footage (see Figure 4.4). With respect to the 'chalk reefiness' all the areas investigated via the DDV transects were classified as "not a reef" according to the qualitative descriptions of chalk reef provided by Natural England. The communities associated with these patches of coarse sediments were primarily epifaunal, with faunal turfs comprising hydroids (e.g. *Tubularia indivisa*, *Nemertesia antennina* and *H. falcata*) and bryozoans (e.g. *Alcyonidium diaphanum* and *F. foliacea*) and other epifauna including barnacles, tubeworms (e.g. *Spirobranchus* sp.), low abundances of sponges and the soft coral *Alcyonium digitatum*. Sea anemones were also recorded during DDV surveys within these areas of coarser sediments, including, *Sagartia* sp., *Urticina* sp. and *Metridium* sp. Red seaweeds were also recorded, although these were rare. Mobile species recorded in this area included the crustaceans *Necora puber* and *C. pagurus* and the sea stars *C. papposus* and *Asterias rubens*. The communities in these areas were consistent with the FluHyd epifaunal biotope overlay. As indicated in Figure 4.4, DDV transects showed that where these coarse sediments were observed, these were limited in extent and patchy, with areas of rippled sand with no epifauna (i.e. Infralittoral mobile clean sand with sparse fauna; SS.SSa.IFiSa.IMoSa) of tens of metres observed in DDV footage separating discrete areas of coarse sediments.

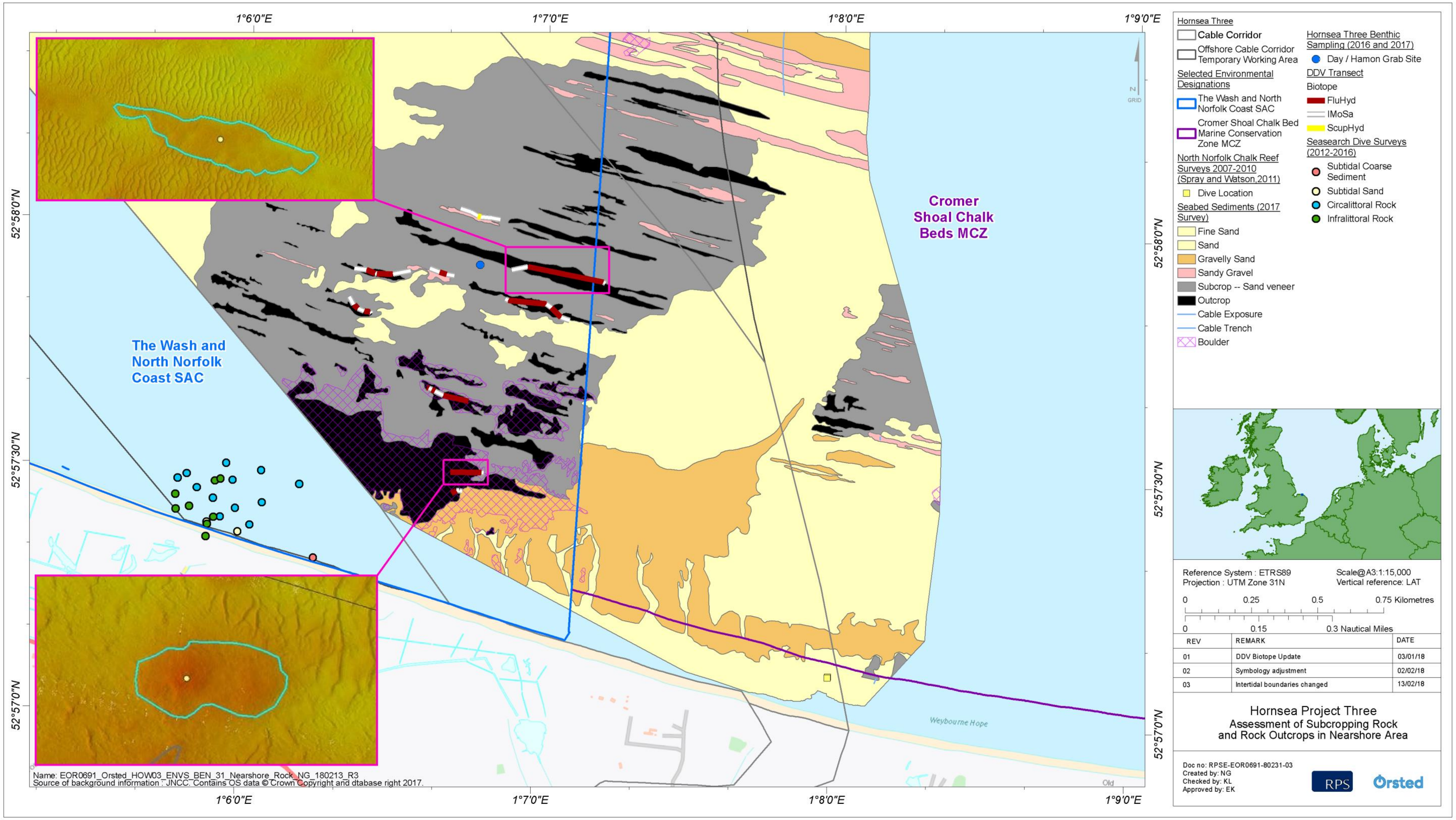

Figure 4.3: Hornsea Three nearshore geophysical seabed interpretation showing subcropping rock (grey) and areas of potential outcrop (black), DDV ground truthing transects with epifaunal biotopes identified and historic records of infralittoral and circalittoral rock in the nearshore area (Note: these historic records of infralittoral and circalittoral rock are outside the boundary of the Cromer Shoal Chalk Beds MCZ).

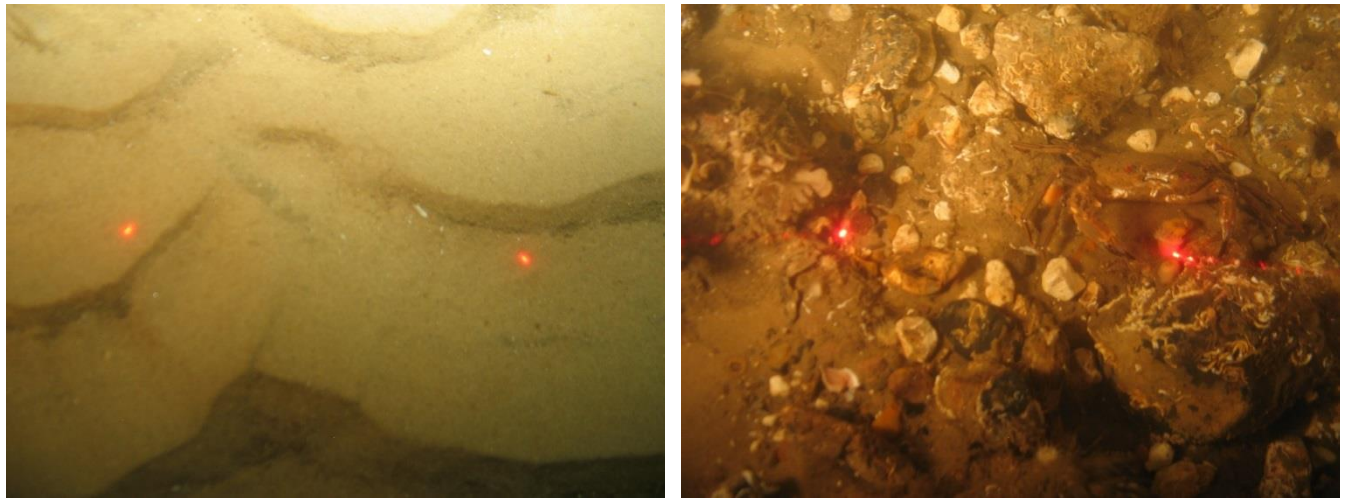

Figure 4.4: Representative images of seabed substrates in inshore areas from DDV transects in areas of subcropping rock (see Figure 4.3). Left image shows rippled sand with no epifaunal communities; right image shows coarse, mixed sediments of shell, gravel and occasional cobbles, with associated epifaunal communities.

4.2.1.14 During all site specific surveys, no areas of the Subtidal Chalk habitat FOCI (as defined by the qualitative descriptions of 'chalk reefiness' provided by Natural England; see paragraph 4.2.1.12) were recorded within or in close proximity to the Hornsea Three offshore cable corridor. However, as indicated in Figure 4.1, this habitat FOCI has been recorded to the east of the Hornsea Three landfall (i.e. approximately 400 m to the east of the Hornsea Three offshore cable corridor). The areas of Moderate and High Energy Circalittoral Rock features of the Cromer Shoal Chalk Beds MCZ are coincident with the areas of Subtidal Chalk shown in Figure 4.1 (Defra, 2015) and as such, any consideration of the Subtidal Chalk habitat FOCI within this assessment also implicitly considers these two circalittoral rock features.

4.3 Markham's Triangle rMCZ

4.3.1.1 Markham's Triangle rMCZ, which coincides with the northeast section of the Hornsea Three array area, is being considered for inclusion in a network of Marine Protected Areas (MPAs) in UK waters to address conservation objectives under the MCAA. Markham's Triangle is proposed for four broadscale habitats: Subtidal Coarse Sediment, Subtidal Mixed Sediments, Subtidal Sand and Subtidal Mud (see Table 4.2) as recommended by Net Gain (2011) and based on Hornsea Three's latest discussions with JNCC and Natural England (see Table 1.1). These broadscale habitats are also plotted spatially in Figure 4.5 based on mapping presented in Defra (2014).

4.3.1.2 Volume 5, annex 2.1: Benthic Ecology Technical Report provides a detailed description of the Hornsea Three array area, which coincides with the western section of Markham's Triangle rMCZ. The baseline characterisation of Markham's Triangle was based on the following desktop data sources, historic surveys across the former Hornsea Zone and Hornsea Three site specific surveys (fully detailed in volume 5, annex 2.1: Benthic Ecology Technical Report), including:

- Faunal and PSA data from a benthic survey carried out at Markham's Triangle rMCZ by Cefas, commissioned by Defra (Defra, 2014);
- Historic benthic ecology surveys across the former Hornsea Zone between 2010 and 2012;
- Faunal and PSA data from benthic grab sampling retained during geophysical survey ground-truthing campaigns in 2016 in the Hornsea Three array area;
- DDV sampling throughout the Hornsea Three array area, including Markham's Triangle, in 2017; and
- Hornsea Three site specific geophysical surveys (i.e. bathymetry, sidescan sonar and sub-bottom profiler) of the Hornsea Three array area in 2016.

4.3.1.3 The broadscale habitat Subtidal Coarse Sediment was dominant throughout the Markham's Triangle rMCZ, covering approximately three quarters of the site (Defra, 2014; Figure 4.5; Table 4.2). Subtidal Sand and Subtidal Mixed Sediments broadscale habitats were less prevalent. Mixed sediments were mostly confined to a swathe spanning the northern boundary of the rMCZ area, while bands of sand were found across the central section of the site, along the southern boundary and in the western corner of the rMCZ (Figure 4.5). Subtidal Mud was only reported by Defra (2014) in the east of the rMCZ, outside the Hornsea Three boundary, and therefore this feature has not been considered further in this assessment, as agreed through the MCZ Working Group (see Table 1.1). Shallow sandy sediments are a suitable habitat for sandeels (*Ammodytes* spp.; a species of conservation importance) which are an important food source for a range of marine species including fish, birds and marine mammals (see volume 5 annex 3.1: Fish and Shellfish Technical Report), however this species is not proposed as a feature of the rMCZ.

Table 4.2 Proposed habitat features of Markham's Triangle rMCZ and recorded extents (see Figure 4.5).

Recommended feature (Net Gain, 2011)	Spatial extents within MCZ (Defra, 2014)
A5.1 Subtidal Coarse Sediment	145.56 km² [a]
A5.2 Subtidal Sand	26.35 km² [b]
A5.3 Subtidal Mud	1.49 km²
A5.4 Subtidal Mixed Sediments	27.02 km²

a The area mapped by Defra (2014) was less than the 167.73 km² predicted in the SAD (Net Gain, 2011).

b The area mapped by Defra (2014) was less than the 30.76 km² predicted in the SAD (Net Gain, 2011).

4.3.1.4 Volume 5, annex 2.1: Benthic Ecology Technical Report provides a detailed characterisation of the benthic ecology in the Hornsea Three array area, including the western portion of Markham's Triangle rMCZ. This included identification of sediment types and classification of infaunal and epifaunal biotopes. Infaunal and epifaunal biotopes within the Hornsea Three array area, including Markham's Triangle rMCZ are shown in Figure 4.5. The biotope mapping shows that the majority of Markham's Triangle rMCZ was characterised by two biotopes: the polychaete-rich deep Venus community in offshore mixed sediments biotope (SS.SMx.OMx.PoVen; hereafter referred to as PoVen) and the *Kuritella* (*Mysella) bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment biotope (SS.SMx.CMx.MysThyMx; hereafter referred to as MysThyMx). These biotopes were recorded in areas of Subtidal Coarse Sediments (i.e. sand and gravel of varying proportions) and Subtidal Mixed Sediments (i.e. sand and gravel with a proportion of fine sediment) along the northern boundary of the rMCZ.

4.3.1.5 The PoVen biotope was characterised by a rich infaunal 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*. The MysThMx biotope was characterised by a similarly rich infaunal community including the bivalve *K. bidentata* and polychaetes such as *Glycera alba*, *Mediomastus fragilis* and *Goniada maculata*. The brittlestar *Amphiura filiformis* was also abundant at some sites. Epifaunal communities were generally relatively sparse across the Hornsea Three array area, including Markham's Triangle rMCZ, although scour tolerant epifaunal species and communities (e.g. bryozoans, hydroids, tubeworms and mobile epifauna) were recorded at varying proportions, with the FluHyd epifaunal biotope recorded in the northeast of the Hornsea Three array area.

4.3.1.6 Sandy areas of the Hornsea Three array area were characterised by the NcirBat biotope (see paragraph 4.2.1.6 and Figure 4.5) and the *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand biotope (SS.SSa.IMuSa.FfabMag; hereafter referred to as FfabMag). The FfabMag biotope was more diverse than the NcirBat biotope, occurring in more stable sandy sediments with infaunal communities characterised by venerid bivalves such as *Fabulina fabula*, *Chamelea striatula* and *Abra prismatica*, polychaetes including *Magelona johnstoni* and *Spiophanes bombyx* and the amphipods *Bathyporeia elegans*, *Bathyporeia tenuipes* and *Bathyporeia guilliamsoniana*. These two biotopes were recorded to the south of the southern boundary of Markham's Triangle rMCZ.

4.3.1.7 In the western corner of the rMCZ, the sediments were characterised by mixed and muddy sand sediments, with the *Amphiura filiformis*, *Mysella bidentata* and *Abra nitida* in circalittoral sandy mud biotope (SS.SMu.CSaMu.AfilMysAnit; hereafter referred to as AfilMysAnit) occurring in this area (Figure 4.5). Although this is typically a muddy sediment biotope, the sediments in this area comprised cohesive muddy sand at the edge of the Markham's Hole bathymetric depression, which reaches depths of up to approximately 73 m. The infaunal communities in this area were dominated by high abundances of the echinoderm *Amphiura filiformis*, the bivalves *Corbula gibba* and *K. bidentata*, polychaetes (including *Notomastus* sp., *Glycera lapidum* and *Aonides paucibranchiata*) and nemerteans.

4.3.1.8 Due to this site being an rMCZ, no information on the proposed features, conservation objectives, condition status or management approaches are currently available. Therefore, conservation objectives for the Cromer Shoal Chalk Beds MCZ have been used as a proxy (including details on attributes and targets; see paragraph 2.3.2.4). However, based on latest advice from the JNCC (see Table 1.1, Natural England/JNCC Section 42 consultation response), the rMCZ is not currently considered to be in favourable condition and as such, a general management approach of "recover to favourable condition" should be applied to Markham's Triangle rMCZ.

4.3.1.9 Based on the Net Gain Final Recommendations and the associated Vulnerability Assessments used to inform these recommendations (Net Gain, 2011), the pressures and activities outlined in Table 4.3 were identified as the main reasons for the "recover to favourable condition" general management approach. This was due to the medium to high vulnerability of the Subtidal Coarse Sediment and Subtidal Sand habitat features of Markham's Triangle rMCZ, based on the level of exposure to the activity and the sensitivity of the features. These features were found to have low vulnerability to all other pressures and activities. No vulnerability assessment was undertaken for the Subtidal Mixed Sediment feature, but for the purposes of this MCZ Assessment, these pressures and activities are expected to apply equally to this feature.

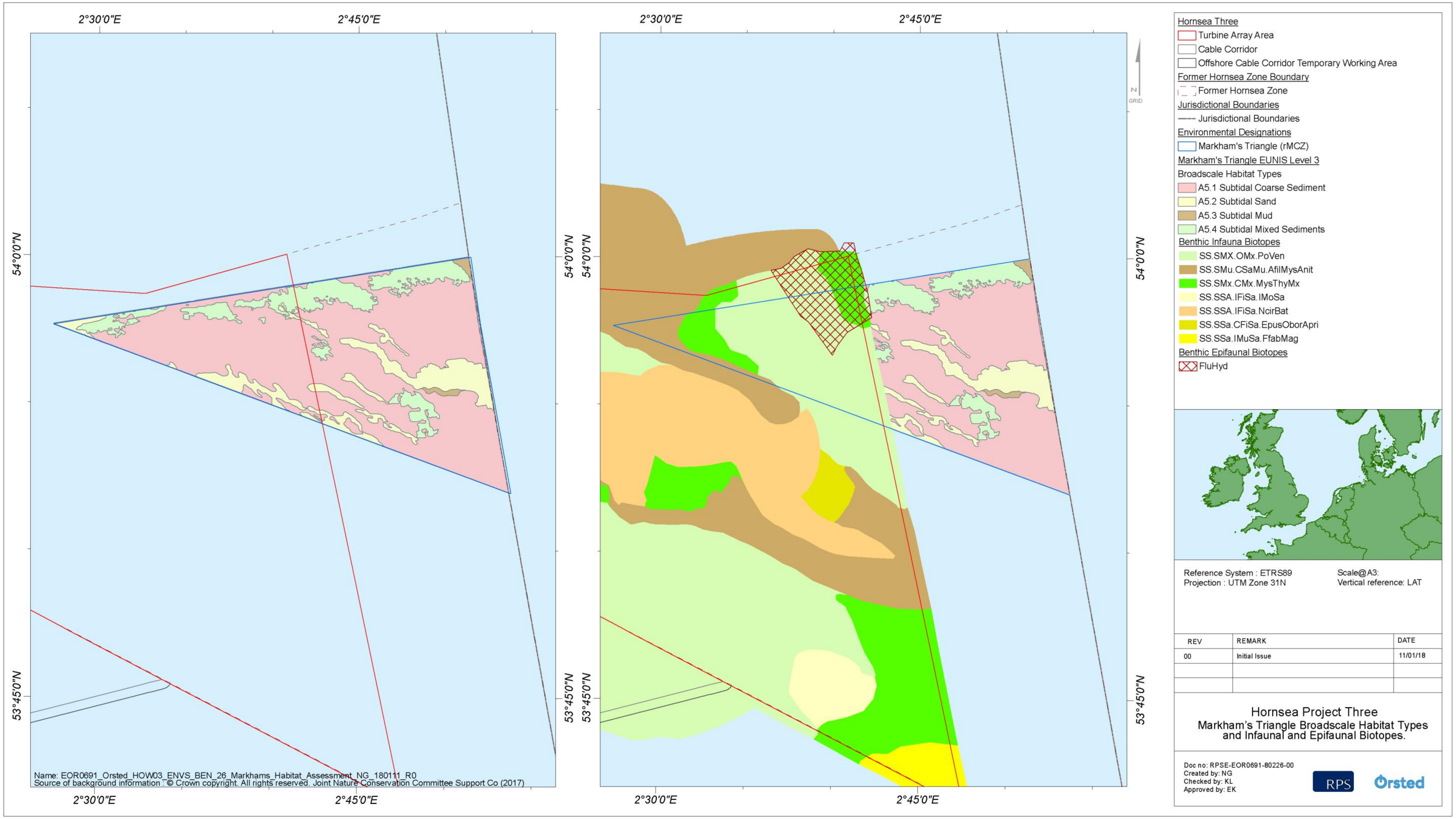

Figure 4.5: Markham's Triangle rMCZ broadscale habitat types and infaunal and epifaunal biotopes identified within the Hornsea Three array area.

Table 4.3: Pressures and activities representing risks to conservation objectives of features the Markham's Triangle rMCZ identified by Net Gain (2011) Vulnerability Assessments. The proposed Subtidal Coarse Sediment and Subtidal Sand features of Markham's Triangle rMCZ were found to be of moderate to high vulnerability to these pressures/activities, based on sensitivity and exposure, and therefore conservation objective was set to "recover" based on this.

Feature	Pressure	Activity	Sensitivity	Exposure
Subtidal Coarse Sediment	Removal of non-target species (lethal)	Fishing - benthic trawling	Not sensitive to Medium	Exposed
	Shallow abrasion/penetration: damage to seabed surface and penetration ≤25 mm	Fishing - benthic trawling	Low to Medium	Exposed
	Structural abrasion/penetration: Structural damage to seabed >25 mm	Fishing - benthic trawling	Low to Medium	Exposed
	Surface abrasion: damage to seabed surface features	Fishing - benthic trawling	Not sensitive to High	Exposed
Subtidal Sand	Removal of non-target species (lethal)	Fishing - benthic trawling	Not sensitive to Medium	Exposed
	Shallow abrasion/penetration: damage to seabed surface and penetration ≤25 mm	Fishing - benthic trawling	Low to Medium	Exposed
	Structural abrasion/penetration: Structural damage to seabed >25 mm	Fishing - benthic trawling	Low to Medium	Exposed
	Surface abrasion: damage to seabed surface features	Fishing - benthic trawling	Not sensitive to High	Exposed

4.3.1.10 The key activity which was identified by Net Gain (2011) as representing the main reason for Markham's Triangle rMCZ not being in favourable condition was benthic trawling (Table 4.3). Otter, beam and *Nephrops* trawling are not selective fishing methods and therefore will result in the removal of non-target species and communities. Epifaunal species are affected by benthic trawling through direct removal of individuals/colonies as well as abrasion and damage to seabed surface features. Infaunal species and communities may also be directly removed and may suffer injury and/or mortality through abrasion where trawls penetrate the sediment. Exposure to this activity within Markham's Triangle rMCZ was considered to be high, with both UK and non UK vessels operating in the area (though primarily the latter), although the extent of the impact will depend on the gear type.

5. Stage 1 Assessment

5.1 Cromer Shoal Chalk Beds MCZ

5.1.1.1 This section presents the Stage 1 assessment of the effects of Hornsea Three construction, operation and maintenance and decommissioning on the protected features of the Cromer Shoal Chalk Beds MCZ. Each of the impacts identified in the Screening stage (see paragraph 3.3.1.1) are discussed individually in the following sections and within each assessment, the effects on attributes and targets of the relevant protected features, and subsequently on the conservation objectives, are considered, using the best available scientific evidence to support the conclusions made. Due to the nature of the protected features of the Cromer Shoal Chalk Beds MCZ, there are similarities in the attributes and targets across groups of features and therefore effects of the proposed activities on these features would be expected to be similar. For that reason, for some of the impacts presented below and where it has been appropriate to do so, these features have been grouped in the assessments below, according to the type of protected features they represent, i.e.:

- Broadscale habitats:
  - Subtidal Coarse Sediment;
  - Subtidal Mixed Sediment; and
  - Subtidal Sand.
- Feature of Geological Interest: North Norfolk Coast Assemblage of Subtidal Sediment Features and Habitats.
- Habitat FOCI:
  - Peat and Clay Exposures; and
  - Subtidal Chalk.

5.1.1.2 Table 5.1 below presents a summary matrix of the individual feature attributes of the Cromer Shoal Chalk Beds MCZ considered within each assessment. As described in paragraph 2.3.2.5, attributes were broadly categorised as either physical or ecological attributes. As discussed during the MCZ Workshop on 23 February 2018 (see Table 1.1), specific attributes and targets for the feature of geological interest, i.e. North Norfolk Coast Assemblage of Subtidal Sediment Features and Habitats, are not currently available. Natural England advised that in the absence of these, the attributes for the broadscale habitat features and habitat FOCI should be used as a proxy (see Table 1.1), to inform conclusions with respect to the conservation objectives for this feature. Impacts which had the potential to affect the chemical attributes of MCZ features (i.e. accidental release of pollutants and resuspension of sediment bound contaminants; see section 3.2), were screened out due to the low risk that these impacts pose to the relevant features and therefore are not presented in Table 5.1 (see SACO for details of these, available at Natural England's Designated Sites System). Table 5.1 provides signposting to the relevant paragraph references of the Stage 1 assessment below, which provide justification for the conclusions made with respect to the attributes of the protected features of the Cromer Shoal Chalk Beds MCZ. The colour coding represents the conclusions made within the Stage 1 assessment of this report. Colour coding is as follows:

- Blue: No significant effect on attribute or target(s); and
- Grey: No attribute - impact pathway (not applicable).

5.1.2 Construction Phase

Cable installation in the Cromer Shoal Chalk Beds MCZ leading to temporary habitat loss/disturbance

5.1.2.1 Direct temporary loss/disturbance of subtidal habitat within Hornsea Three at Cromer Shoal Chalk Beds MCZ will occur because of the cable installation activities (including pre-construction sandwave and boulder clearance, burial of the export cables and anchor placements associated with cable burial). The maximum design scenario for temporary habitat loss/disturbance within the Cromer Shoal Chalk Beds MCZ is presented in Table 5.2 and further detail on the project envelope assumptions with respect to cable installation is provided in volume 2, chapter 2: Benthic Ecology. This assessment is equivalent to the following pressures identified by Natural England's Advice on Operations for the Thanet Coast MCZ for "Power cable: laying, burial and protection" (Natural England, 2017):

- *Abrasion/disturbance of the substrate on the surface of the seabed*;
- *Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion*;
- *Habitat structure changes - removal of substratum (extraction); and*
- *Smothering and siltation rate changes (Heavy, i.e. >5 cm).*

5.1.2.2 This assessment considers the effects of cable installation and resulting temporary habitat loss on the attributes and targets for the Subtidal Sand broadscale habitat and, by proxy, the feature of geological interest, the North Norfolk Coast Assemblage of Subtidal Features and Habitats (Table 5.1) and therefore the assessment has been subdivided according to these feature types (as per paragraph 5.1.1.1). Temporary habitat loss due to cable installation will not result in direct impacts on any other broadscale habitat (i.e. Subtidal Coarse Sediments and Subtidal Mixed Sediments) or habitat FOCI (Peat and Clay Exposures and Subtidal Chalk) and as such these have not been considered for this impact (see Table 5.1).

<u>Broadscale Habitat: Subtidal Sand</u>

5.1.2.3 Of the total area of seabed predicted to be affected by cable installation during the construction phase within the Hornsea Three offshore cable corridor, a maximum of 191,200 m^2 will be affected within the Cromer Shoal Chalk Beds MCZ. This total comprises pre-construction activities (e.g. sandwave clearance and associated material deposition), cable burial and associated anchor placements and jack-ups (see Table 5.2 and maximum design scenario table in Section 2.8 of volume 2, chapter 2: Benthic Ecology). All temporary habitat loss/disturbance within the Cromer Shoal Chalk Beds MCZ during the construction phase will occur entirely within the Subtidal Sand broadscale habitat feature within the Hornsea Three offshore cable corridor, with no direct impacts on any of the other protected features. The 191,200 m^2 of temporary habitat loss/disturbance comprises approximately 1.04% of the total extent of the Subtidal Sand feature within the MCZ (see Table 4.1) and 0.06% of the total area of the MCZ. The total duration of the Hornsea Three construction phase is up to eight years over two phases, although the export cable installation will only comprise a small proportion of this (i.e. up to three years over up to two phases).

5.1.2.4 All cable installation activities (including pre-construction sandwave clearance, cable burial and anchor placement; Table 5.2) will occur within the Hornsea Three offshore cable corridor or temporary working areas (although cables will only be installed within the Hornsea Three offshore cable corridor). Cable burial will be completed by, one or a combination of, trenching, mechanical cutting, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development. The material arising from any potential sandwave clearance activities within the Cromer Shoal Chalk Beds MCZ will be deposited locally to ensure material is not lost from the local sediment transport system (see volume 1, chapter 1: Marine Processes). So far as is reasonably practical, the material will be deposited within the boundary of the MCZ. Habitat disturbance associated with cable burial (e.g. via ploughing, cutting or trenching) will follow pre-construction activities (e.g. sandwave clearance or boulder clearance) but will only occur within the footprints of effect of these pre-construction activities. Therefore, whilst there will be potential for repeat disturbance to these areas (see paragraph 5.1.2.23 for discussion of this), cable burial activities will not add further to the total area of temporary habitat disturbance.

Table 5.1: Attribute versus impact signposting and summary matrix for Stage 1 assessment of Hornsea Three on the Cromer Shoal Chalk Beds MCZ. Colour coding relates to conclusions with respect to impacts on attributes: Blue - no significant effect on attribute or target(s); Green - potential for significant effect on attribute or target(s); Grey - no attribute - impact pathway.

Attribute type	Attribute	Construction		Operation				Decommissioning		
		Cable installation in the Cromer Shoal Chalk Beds MCZ leading to temporary habitat loss/disturbance	Increases in SSC and associated deposition due to export cable installation	Placement of cable protection in the Cromer Shoal Chalk Beds MCZ leading to long term habitat loss	Maintenance operations during the operational phase, resulting in temporary seabed disturbances	Colonisation of export cable protection within the Cromer Shoal Chalk Beds MCZ	Increased risk of introduction or spread of INNS due to presence of subsea infrastructure and vessel movements	Cable removal in the Cromer Shoal Chalk Beds MCZ leading to temporary habitat loss/disturbance	Increases in SSC and associated deposition due to export cable removal	Permanent habitat loss due to presence of cable protection left in situ post decommissioning
Subtidal Coarse Sediment										
Ecological	Distribution: presence and spatial distribution of biological communities	N/A	Paragraphs 5.1.2.34 to 5.1.2.39	N/A	N/A	N/A	N/A	N/A	Paragraph 5.1.4.3	N/A
Physical	Extent and distribution	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ecological	Structure: non-native species and pathogens	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Physical	Structure: sediment composition and distribution	N/A	Paragraphs 5.1.2.29 to 5.1.2.33	N/A	N/A	N/A	N/A	N/A	Paragraph 5.1.4.3	N/A
Ecological	Structure: species composition of component communities	N/A	Paragraphs 5.1.2.34 to 5.1.2.39	N/A	N/A	N/A	N/A	N/A	Paragraph 5.1.4.3	N/A
Physical	Supporting processes: energy/exposure	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Physical	Supporting processes: sediment movement and hydrodynamic regime	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Physical	Supporting processes: water quality - turbidity	N/A	Paragraphs 5.1.2.29 to 5.1.2.33	N/A	N/A	N/A	N/A	N/A	Paragraph 5.1.4.3	N/A

Attribute type	Attribute	Construction		Operation				Decommissioning		
		Cable installation in the Cromer Shoal Chalk Beds MCZ leading to temporary habitat loss/disturbance	Increases in SSC and associated deposition due to export cable installation	Placement of cable protection in the Cromer Shoal Chalk Beds MCZ leading to long term habitat loss	Maintenance operations during the operational phase, resulting in temporary seabed disturbances	Colonisation of export cable protection within the Cromer Shoal Chalk Beds MCZ	Increased risk of introduction or spread of INNS due to presence of subsea infrastructure and vessel movements	Cable removal in the Cromer Shoal Chalk Beds MCZ leading to temporary habitat loss/disturbance	Increases in SSC and associated deposition due to export cable removal	Permanent habitat loss due to presence of cable protection left in situ post decommissioning
Subtidal Mixed Sediment										
Ecological	Distribution: presence and spatial distribution of biological communities	N/A	Paragraphs 5.1.2.34 to 5.1.2.39	N/A	N/A	N/A	N/A	N/A	Paragraph 5.1.4.3	N/A
Physical	Extent and distribution	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ecological	Structure: non-native species and pathogens	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Physical	Structure: sediment composition and distribution	N/A	Paragraphs 5.1.2.29 to 5.1.2.33	N/A	N/A	N/A	N/A	N/A	Paragraph 5.1.4.3	N/A
Ecological	Structure: species composition of component communities	N/A	Paragraphs 5.1.2.34 to 5.1.2.39	N/A	N/A	N/A	N/A	N/A	Paragraph 5.1.4.3	N/A
Physical	Supporting processes: energy / exposure	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Physical	Supporting processes: sediment movement and hydrodynamic regime	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Physical	Supporting processes: water quality - turbidity	N/A	Paragraphs 5.1.2.29 to 5.1.2.33	N/A	N/A	N/A	N/A	N/A	Paragraph 5.1.4.3	N/A

Attribute type	Attribute	Construction		Operation				Decommissioning		
		Cable installation in the Cromer Shoal Chalk Beds MCZ leading to temporary habitat loss/disturbance	Increases in SSC and associated deposition due to export cable installation	Placement of cable protection in the Cromer Shoal Chalk Beds MCZ leading to long term habitat loss	Maintenance operations during the operational phase, resulting in temporary seabed disturbances	Colonisation of export cable protection within the Cromer Shoal Chalk Beds MCZ	Increased risk of introduction or spread of INNS due to presence of subsea infrastructure and vessel movements	Cable removal in the Cromer Shoal Chalk Beds MCZ leading to temporary habitat loss/disturbance	Increases in SSC and associated deposition due to export cable removal	Permanent habitat loss due to presence of cable protection left in situ post decommissioning
Subtidal Sand										
Ecological	Distribution: presence and spatial distribution of biological communities	Paragraphs 5.1.2.18 to 5.1.2.24	Paragraphs 5.1.2.29 to 5.1.2.33	Paragraphs 5.1.3.4 to 5.1.3.7 and 5.1.3.9	Paragraphs 5.1.3.13 to 5.1.3.15	Paragraphs 5.1.3.17 and 5.1.3.20	Paragraphs 5.1.3.23 and 5.1.3.28	Paragraph 5.1.4.2	Paragraph 5.1.4.3	Paragraphs 5.1.4.5 to 5.1.4.8
Physical	Extent and distribution	Paragraphs 5.1.2.3 to 5.1.2.17	N/A	Paragraphs 5.1.3.4 to 5.1.3.8	Paragraphs 5.1.3.13 to 5.1.3.15	N/A	N/A	Paragraph 5.1.4.2	N/A	Paragraphs 5.1.4.5 to 5.1.4.8
Ecological	Structure: non-native species and pathogens	N/A	N/A	N/A		N/A	Paragraphs 5.1.3.23 and 5.1.3.28	N/A	N/A	N/A
Physical	Structure: sediment composition and distribution	Paragraphs 5.1.2.3 to 5.1.2.17	Paragraphs 5.1.2.29 to 5.1.2.33	Paragraphs 5.1.3.4 to 5.1.3.8	Paragraphs 5.1.3.13 to 5.1.3.15	N/A	N/A	Paragraph 5.1.4.2	Paragraph 5.1.4.3	Paragraphs 5.1.4.5 to 5.1.4.8
Ecological	Structure: species composition of component communities	Paragraphs 5.1.2.18 to 5.1.2.24	Paragraphs 5.1.2.29 to 5.1.2.33	Paragraphs 5.1.3.4 to 5.1.3.7 and 5.1.3.9	Paragraphs 5.1.3.13 to 5.1.3.15	Paragraphs 5.1.3.17 and 5.1.3.20	Paragraphs 5.1.3.23 and 5.1.3.28	Paragraph 5.1.4.2	Paragraph 5.1.4.3	Paragraphs 5.1.4.5 to 5.1.4.8
Physical	Supporting processes: energy/exposure	Paragraphs 5.1.2.3 to 5.1.2.17	N/A	Paragraphs 5.1.3.4 to 5.1.3.8	N/A	N/A	N/A	N/A	N/A	Paragraphs 5.1.4.5 to 5.1.4.8
Physical	Supporting processes: sediment movement and hydrodynamic regime	Paragraphs 5.1.2.3 to 5.1.2.17	N/A	Paragraphs 5.1.3.4 to 5.1.3.8	Paragraphs 5.1.3.13 to 5.1.3.15	N/A	N/A	Paragraph 5.1.4.2	N/A	Paragraphs 5.1.4.5 to 5.1.4.8
Physical	Supporting processes: water quality - turbidity	N/A	Paragraphs 5.1.2.29 to 5.1.2.33	N/A		N/A	N/A	N/A	Paragraph 5.1.4.3	N/A

Attribute type	Attribute	Construction		Operation				Decommissioning		
		Cable installation in the Cromer Shoal Chalk Beds MCZ leading to temporary habitat loss/disturbance	Increases in SSC and associated deposition due to export cable installation	Placement of cable protection in the Cromer Shoal Chalk Beds MCZ leading to long term habitat loss	Maintenance operations during the operational phase, resulting in temporary seabed disturbances	Colonisation of export cable protection within the Cromer Shoal Chalk Beds MCZ	Increased risk of introduction or spread of INNS due to presence of subsea infrastructure and vessel movements	Cable removal in the Cromer Shoal Chalk Beds MCZ leading to temporary habitat loss/disturbance	Increases in SSC and associated deposition due to export cable removal	Permanent habitat loss due to presence of cable protection left in situ post decommissioning
Subtidal Chalk										
Ecological	Distribution: presence and spatial distribution of biological communities	N/A	Paragraphs 5.1.2.34 to 5.1.2.39	N/A	N/A	N/A	N/A	N/A	Paragraph 5.1.4.3	N/A
Physical	Extent and distribution	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ecological	Structure: non-native species and pathogens	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Physical	Structure: physical structure of rocky substrate	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ecological	Structure: species composition of component communities	N/A	Paragraphs 5.1.2.34 to 5.1.2.39	N/A	N/A	N/A	N/A	N/A	Paragraph 5.1.4.3	N/A
Physical	Supporting processes: energy / exposure	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Physical	Supporting processes: sedimentation rate	N/A	Paragraphs 5.1.2.29 to 5.1.2.33	N/A	N/A	N/A	N/A	N/A	Paragraph 5.1.4.3	N/A
Physical	Supporting processes: water quality - turbidity	N/A	Paragraphs 5.1.2.29 to 5.1.2.33	N/A	N/A	N/A	N/A	N/A	Paragraph 5.1.4.3	N/A

Attribute type	Attribute	Construction		Operation				Decommissioning		
		Cable installation in the Cromer Shoal Chalk Beds MCZ leading to temporary habitat loss/disturbance	Increases in SSC and associated deposition due to export cable installation	Placement of cable protection in the Cromer Shoal Chalk Beds MCZ leading to long term habitat loss	Maintenance operations during the operational phase, resulting in temporary seabed disturbances	Colonisation of export cable protection within the Cromer Shoal Chalk Beds MCZ	Increased risk of introduction or spread of INNS due to presence of subsea infrastructure and vessel movements	Cable removal in the Cromer Shoal Chalk Beds MCZ leading to temporary habitat loss/disturbance	Increases in SSC and associated deposition due to export cable removal	Permanent habitat loss due to presence of cable protection left in situ post decommissioning
Peat and Clay Exposures										
Ecological	Distribution: presence and spatial distribution of biological communities	N/A	Paragraphs 5.1.2.34 to 5.1.2.39	N/A	N/A	N/A	N/A	N/A	Paragraph 5.1.4.3	N/A
Physical	Extent and distribution	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ecological	Structure: non-native species and pathogens	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Physical	Structure: physical structure of rocky substrate	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ecological	Structure: species composition of component communities	N/A	Paragraphs 5.1.2.34 to 5.1.2.39	N/A	N/A	N/A	N/A	N/A	Paragraph 5.1.4.3	N/A
Physical	Supporting processes: energy / exposure	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Physical	Supporting processes: sedimentation rate	N/A	Paragraphs 5.1.2.29 to 5.1.2.33	N/A	N/A	N/A	N/A	N/A	Paragraph 5.1.4.3	N/A
Physical	Supporting processes: water quality - turbidity	N/A	Paragraphs 5.1.2.29 to 5.1.2.33	N/A	N/A	N/A	N/A	N/A	Paragraph 5.1.4.3	N/A

Table 5.2: Temporary habitat loss within Cromer Shoal Chalk Beds MCZ during the construction phase.

Project Element	Temporary habitat loss/ disturbance (m^2)	Assumptions (see maximum design scenario table in Section 2.8 of volume 2, chapter 2: Benthic Ecology for full description of Hornsea Three maximum design scenario)
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 along the Hornsea Three offshore cable corridor, assuming a volume of up to 1,400 m^3 of sandwave clearance material.
Cable burial	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 MCZ [a]	191,200	-

a 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.

5.1.2.5 The maximum design scenario for temporary habitat loss/disturbance assumes that pre-construction sandwave clearance would occur along the entire extent of the export cables within Cromer Shoal Chalk Beds MCZ (see Table 5.2). 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, or areas where neither boulder clearance nor sandwave clearance is required. Although boulder clearance will not contribute to any additional habitat loss, the process will effectively redistribute boulders within discrete areas and potentially concentrate these in the areas either side of the 25 m boulder clearance corridor. Given the existing patchiness of the distribution of boulders and cobbles in the nearshore area (as recorded during the inshore geophysical and DDV surveys; see paragraph 4.2.1.11), 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, 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 (i.e. within the Cromer Shoal Chalk Beds MCZ) and up to 15 mm (pebble gravel) in deeper nearshore areas (up to 14 m). Over time, the action of waves and currents will redistribute the material such that cobbles may be moved back in to the areas which were cleared, thus partially restoring the topography of the area (volume 2, chapter 1: Marine Processes).

5.1.2.6 A post-construction survey at Humber Gateway offshore wind farm examined the effects of export cable and inter 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 on 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.

5.1.2.7 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. the Cromer Shoal Chalk Beds MCZ). 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 within the Cromer Shoal Chalk Beds MCZ are largely sandy and mixed in nature, with only patchy distributions of cobbles and boulders, none of which comprised cobble reef (see volume 5, annex 2.1: Benthic Ecology Technical Report). 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).

5.1.2.8 With regard to cable installation through the intertidal (outside the MCZ boundary), this may be via open cut trenching or HDD under the intertidal. HDD operations within the Cromer Shoal Chalk Beds MCZ may lead to temporary habitat loss/disturbance of subtidal habitat as described in Table 5.2 (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 Table 5.2 as an open cut scenario for cable installation leads to a greater total area of subtidal habitat affected within the MCZ. Jack-up operations associated with HDD operations (also not included in calculations in Table 5.2 as open cut results in a greater area affected) could affect up to approximately 181 m^2 within the Cromer Shoal Chalk Beds MCZ. Monitoring at offshore wind farm sites have shown the presence of depressions on the seabed from jack-up operations during wind turbine installation. 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 within or around the MCZ and will infill over time (see volume 2, chapter 1: Marine Processes).

5.1.2.9 Monitoring data of footprints adjacent to two turbine locations in the L&ID offshore wind farm showed that PSA 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 within and outside the footprints were found 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 recover into these areas, as the sediment infills the depressions (further discussion of sensitivity of communities associated with the Subtidal Sand feature, including to jack up operations, is presented in paragraph 5.1.2.18 *et seq*. below).

5.1.2.10 It should be noted, however, that the jack-up footprints for Barrow and L&ID are considerably larger (i.e. several metres in diameter) than those employed for HDD exit pits (i.e. leg diameter of up to 1.2 m). Furthermore, Barrow and L&ID offshore wind farms are much further offshore (i.e. several km) than the proposed jack-ups for HDD operations for Hornsea Three offshore cable installation (i.e. <1km from the shore) and it would therefore be expected that the mobile sediments in the vicinity of the Hornsea Three landfall would quickly infill any seabed depressions and associated fauna will rapidly recover into these areas (discussed further in paragraph 5.1.2.18 *et seq*.).

5.1.2.11 Following cable installation, sediments from surrounding areas will infill the cable trench, through tidal and wave action, returning quickly to a baseline state within weeks to months in areas where mobile sediments are present and over months to years in offshore areas or where surficial cover is thin or absent (volume 2, chapter 1: Marine Processes). As the sediments infill and return to a baseline state, associated faunal communities will recover into these areas (discussed further below). It should also be noted that the predicted habitat loss/disturbance is likely to be intermittent throughout the duration of the construction phase, with cables being laid within the MCZ over a maximum of two phases, with only a proportion of the total habitat loss/disturbance predicted to occur at any one time and recovery of associated communities commencing immediately after cable installation.

5.1.2.12 In addition to the direct impacts of cable installation on broadscale habitat types, there are a number of pathways which may affect physical processes, with consequent effects on the Subtidal Sand broadscale habitat feature of the MCZ, including the following attributes: Supporting processes: energy/exposure and Supporting processes: sediment movement and hydrodynamic regime. These are in relation to the excavation of HDD exit pits in the inshore area (likely within the boundary of the MCZ). As discussed in section 1.11 of volume 1, chapter 1: Marine Processes, there are a number of pathways by which the morphology of the inshore environment (including the MCZ) could potentially be impacted by HDD exit pits during the construction phase:

- Excavation of the seabed could potentially enable more wave energy to propagate further inshore as waves experience less friction and shoaling/breaking effects over and in the lee of the HDD exit pits. The local change in water depth may also cause changes to patterns of wave refraction, slightly changing the direction of travel for wave crests over the excavated area;
- The HDD exit pits could potentially intercept and trap naturally occurring alongshore and cross-shore movement of sediment through passive infilling, theoretically resulting in slight changes to sediment budgets;
- Deposition of the excavated material would lead to an increase in local seabed elevation, with the potential to alter the nearshore wave regime; and
- The presence of the cofferdams could modify the nearshore wave regime, influencing rates of alongshore sediment transport. The cofferdams could also physically block the transport of sediment locally.

Effects on wave energy due to excavated HDD exit pits

5.1.2.13 The greatest potential for modification of the local wave regime in response to the HDD exit pits is expected to occur during periods of low water during storm conditions. At this time, waves could theoretically break slightly further inshore (i.e. approximately 50 m further inshore). If the HDD exit pits were located at their most inshore location (i.e. 200 m from MHWS), small changes to waves could potentially extend to the lower beach. However, owing to the limited spatial extent of the HDD exit pits (footprint and volume), the potential for a significant morphological change is considered to be low. It is also noted that individual HDD exit pits will only be open for a maximum of four months (which consists of: one month site setup (including pit excavation); two months pit fully open, drilling and duct pull-in occurring; and one month reinstatement (including backfill)) and therefore the potential for localised effects on marine processes and morphology will be limited to this period.

Effects on sediment transport due to excavated HDD exit pits

5.1.2.14 The HDD exit pits could be located within those parts of the inshore area actively involved in sediment transport, including the intertidal, meaning that during storm events, material removed from the beach may be transported across the location of the HDD exit pits. Given the relatively steep gradient of the side slopes and overall depth of HDD exit pits, sediment entering the HDD exit pits would likely remain there. If a HDD exit pit were to be entirely infilled, this would represent ~1,000 m³ to 2,500 m³ of material. However, total infilling of the exit pit is generally unlikely to happen given the short duration of time that the HDD exit pits will be operational. Moreover, there will be no net loss of material volume from the local area as material excavated from the HDD exit pit will be side-cast and remain locally available for transport.

Deposition of materials excavated from HDD exit pits

5.1.2.15 The material dredged to excavate the exit pits would be side-cast adjacent to each exit pit and subsequently used as backfill. Depending upon the proximity of these mounds to the coast and the water depth in which they are situated, they may have the potential to modify the nearshore wave regime and therefore beach morphology in the inshore environment and at the landfall. In particular, localised changes in water depth over the pits and mounds could allow greater or differently distributed transmission of wave energy to the coast resulting in a localised morphological response. Any such effects on the inshore environment would be expected to be of limited spatial extent and temporary, for the following reasons:

- The mounds will be temporary features that would only be present for a short period of time (up to ~4 months);
- The footprint of the mounds will be small relative to the wave length of larger incident waves and as such, any wave refraction/ diffraction effect is expected to be limited and localised;
- The greatest potential for changes to the inshore environment and adjacent beach via modification of the wave regime will be during storm events when nearshore sands and gravels are likely be mobilised over relatively larger areas and at a relatively higher rate compared to ‘everyday’ wave conditions. Storms only occur intermittently (and large storms even less frequently) and therefore there is a limited likelihood of storms (especially larger storms) occurring during the limited time that these temporary features are present (see volume 2, chapter 1: Marine Processes);
- The excavated material in the mounds will comprise sands and gravels of the same type as the surrounding seabed so the sediments at the surface of the mound will be mobilised at the same rate and in the same manner as the surrounding seabed; and
- Mobilised sediments would be re-distributed by natural sediment transport processes. Depending on the magnitude and pattern of net sediment transport during the limited time that they are present, the mounds may evolve from their initial form towards another naturally stable equilibrium shape (likely a relatively lower height and wider extent) over time. This evolution will tend to progressively reduce any potential effect of the mound on waves and so also the rate of change in the mound shape.

Effects of coffer dams on wave energy and sediment transport

5.1.2.16 Up to two cofferdams may be in place simultaneously for up to four months during HDD operations, although it is possible that up to four cofferdams may be present for a period of a few days. Under the maximum design scenario, the landward end of cofferdams could be located at a minimum distance of ~200 m from the MHWS mark (i.e. within the MCZ). Although the cofferdam structures are therefore potentially situated relatively close to the beach, it is considered unlikely that they will cause widespread morphological impacts to the beach for the following reasons:

- The long axis of the cofferdams would be orientated close to perpendicular to the adjacent shoreline and would therefore present limited blockage to the passage of larger waves which (due to refraction) tend to become similarly aligned with the orientation of the coast in nearshore area;
- The cofferdams will not be present within the intertidal. Sediment will be able to bypass the structures and therefore they will provide only limited blockage to alongshore sediment transport;
- Cross shore sediment transport will be largely unaffected; and
- At lower tidal states, larger waves (which will have the greatest potential to influence beach morphology) will have broken before reaching the cofferdams.

5.1.2.17 Based on the information presented above, the following can be concluded with respect to the physical attributes of the Subtidal Sand broadscale habitat feature (see Table 5.1):

- **Extent and distribution:** This will not be significantly affected due to cable installation, with any habitat loss/disturbance effects predicted to be temporary and reversible and only affecting a small proportion of this habitat feature within the Cromer Shoal Chalk Beds MCZ;
- **Structure: sediment composition and distribution:** This will not be significantly affected, with baseline sediments during cable burial operations disturbed, but recovering following cable installation, with sediments from surrounding areas infilling any cable trench and sediment composition within the trench returning to baseline levels. Any material arising from any potential sandwave clearance activities within the Cromer Shoal Chalk Beds MCZ will be deposited locally to ensure material is not lost from the local sediment transport system (see volume 1, chapter 1: Marine Processes). So far as is reasonably practical, the material will be deposited within the boundary of the MCZ, avoiding features sensitive to smothering (e.g. Subtidal Chalk, or similar reef features); and
- **Supporting processes: sediment movement and hydrodynamic regime:** Sediment disturbance is expected to be highly localised to the immediate vicinity of the cable trench, HDD exit pits, or sandwave clearance corridor, with short lived effects only occurring before and during cable installation and returning to baseline levels following cable burial. As discussed in section 1.11 of volume 2, chapter 1: Marine Processes, where depressions in the substrate remain post construction (e.g. from the cable trench or jack-up footprints), these will infill over time and sediment transport in the nearshore environment will not be affected. Sediment transport will therefore not be significantly affected during cable burial. The presence of HDD exit pits, in certain conditions (e.g. during storm events), have the potential to affect sediment transport systems within the MCZ, however any such effects will be highly localised and short term duration and as such sediment transport systems within and around the MCZ will be maintained.
- **Supporting processes: Energy/exposure:** Construction operations within the Cromer Shoal Chalk Beds MCZ, including excavation and presence of HDD exit pits, deposition of excavated material and presence of coffer dams may, in certain circumstances (i.e. during periods of low water and storm conditions), result in highly localised and short term effects on wave energy. Due to the short term and localised effects on wave climate, the risk of significant alteration of water flow or sediment movement is low. As such, the natural physical energy resulting from waves and tides will be maintained and the exposure will not cause alteration to the biotopes and stability, across the habitat feature.

5.1.2.18 The Subtidal Sand broadscale habitat feature is the only protected feature of the Cromer Shoal Chalk Beds MCZ which will be directly affected by temporary habitat loss/disturbance. As detailed in section 4.2, the only biotope which coincides with the Hornsea Three offshore cable corridor within the MCZ is the NcirBat biotope and is typical of high energy environments and are therefore naturally subject to, and tolerant of, physical disturbance. The communities that characterise this biotope are predominantly infaunal mobile species including polychaetes and crustaceans, which can re-enter the substratum following disturbance (Budd, 2008a; Tillin, 2016a). For example, 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).

5.1.2.19 The recoverability of communities associated with the NcirBat biotope 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. It is important to acknowledge however, that the activities associated with aggregate extraction are quite different to (i.e. greater than) those associated with offshore wind farm construction activities (i.e. aggregate extraction involves 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 more likely to occur within one year (Foden *et al*., 2011).

5.1.2.20 For deposition of sandwave clearance material, although the deposition of this material may result in the mortality of characterising amphipods, isopods and polychaetes (e.g. *N. cirrosa*,) biotope resistance is assessed as low but resilience is assessed as high. Full recovery of the Subtidal Sand broadscale habitat feature of the Cromer Shoal Chalk Beds MCZ will occur within five years following cable installation (see volume 2, chapter 2: Benthic Ecology for further information on recoverability of communities associated with Subtidal Sand biotopes).

5.1.2.21 As detailed in paragraph 4.2.1.11, discrete areas of more diverse epifauna were recorded within the Hornsea Three offshore cable corridor, along the western boundary of the MCZ, characterised by the FluHyd epifaunal biotope. It would be expected that activities during pre-construction (e.g. boulder clearance and sandwave clearance disposal) and construction (e.g. cable burial and anchor placements) would lead to impacts (i.e. loss and disturbance) on these communities. Some permanently attached species such as epifaunal hydroids and bryozoans will suffer mortality when removed from the substratum, 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. Mobile epifauna (e.g. crustaceans) may be able to escape unharmed and redistribute into neighbouring areas not directly affected by cable installation and returnpost construction. Hydroids and bryozoans have a high recovery potential, with Sebens (1985, 1986) noting that bryozoans and hydroids covered scraped areas within four months in spring, summer and autumn (Readman, 2016). Although these communities have low resilience to direct impacts (e.g. abrasion or penetration of the substrate), resilience of these communities is considered to be medium (Readman, 2016) due to the good recovery potential of the associated species. In areas where boulders are cleared within the Hornsea Three offshore cable corridor (i.e. in discrete corridors where cables have been installed), it would be expected that the displaced boulders would be quickly recolonised by the associated species. As detailed in paragraph 5.1.2.5, boulder clearance may result in displacement of boulders to a distance of up to 12.5 m from their previous location (assuming a 25 m wide boulder clearance corridor) and given the existing patchiness of the distribution of cobbles and boulders in the nearshore area (as recorded during the inshore geophysical and DDV surveys; see paragraph 4.2.1.11), 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.

5.1.2.22 In areas affected by the disposal of sandwave clearance materials, smothering by tens of centimetres would result in reduced feeding and reproductive ability and in many cases death of individuals. However, as the sediment is redistributed into the wider sediment transport processes and the seabed returns to background, these epifaunal communities will quickly recolonise any suitable coarse substrates (e.g. gravel and cobbles), where these substrates occur. Overall, the high recoverability of the component epifaunal communities associated with the FluHyd biotope indicate that damaged or reduced populations will recover numbers and percentage cover within months, with full recovery within five years (Readman, 2016).

5.1.2.23 Repeat disturbance of the Subtidal Sand feature is not predicted to occur during the construction phase following cable installation. 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 within which these activities may occur, the Subtidal Sand feature of the Cromer Shoal Chalk Beds MCZ is 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. Cable installation will affect discrete corridors (i.e. up to 30 m wide for sandwave clearance and up to 15 m wide for cable burial) and there is 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 only potential for repeat disturbance of Subtidal Sand during the construction phase is related to increases in SSC and associated sediment deposition, i.e. where the seabed over installed cables is subjected to increases in SSC and deposition during installation of adjacent cables. Full consideration of the effect of SSC and sediment deposition on features of the MCZ is provided in paragraph 5.1.2.27 *et seq*., although due to the limited sensitivity of the relevant biotopes (i.e. NcirBat and FluHyd) to increases in SSC and deposition and the intermittent nature and short duration of the impact, it is not expected that recovery of these biotopes following temporary habitat loss/disturbance from cable installation would be delayed as a result of installation of cables in adjacent areas.

5.1.2.24 Based on this information, the following can be concluded with respect to the ecological attributes of the Subtidal Sand broadscale habitat feature (Table 5.1):

- **Distribution: presence and spatial distribution of biological communities:** Presence and spatial distribution of the biological communities will be maintained following cable installation. Only a relatively small proportion of the Subtidal Sand broadscale habitat will be affected within the Cromer Shoal Chalk Beds MCZ and where biological communities are affected (e.g. mortality leading to reductions in species richness), these will occur in discrete areas (e.g. a linear corridor through cleared sandwaves of 30 m width or cable trench of less than 15 m width) and will not affect communities (as temporary habitat loss) outside these discrete areas. Following cable installation, full recovery of these communities will occur within a maximum of five years; and
- **Structure: species composition of component communities:** Species composition will not be affected, with only a small proportion of the habitat available to these communities affected by cable installation. Where cable installation occurs, this will lead to localised and temporary reductions in species richness, although full recovery of these communities into areas affected would be expected soon after cable installation, maintaining the species composition of the protected habitat across the MCZ.

5.1.2.25 With respect to the conservation objectives for the Cromer Shoal Chalk Beds MCZ, it can be concluded that there is no significant risk of cable installation during the construction phase (and associated pre-construction activities), with consequent habitat loss/disturbance effects, hindering the achievement of the conservation objectives of the broadscale sediment features as set out in Table 4.1 (i.e. to maintain protected features in favourable condition) for the following reasons:

- While temporary habitat loss/disturbance is predicted to affect a small proportion of the Subtidal Sand protected habitat intermittently during the construction phase, this habitat will quickly recover (i.e. full recovery within months to a maximum of 5 years) with the **extent of the protected feature** remaining stable following the construction phase; and
- The **structures and functions, quality and composition of characteristic biological communities** associated with the Subtidal Sand broadscale habitat feature will remain in a condition which is **healthy and not deteriorating**. Recovery of the seabed sediments will occur in the months following cable installation, with complete recovery within the areas affected within a maximum of five years, with associated communities predicted to recolonise disturbed sediments within months to years of cable installation; as supported by analogous studies from the aggregates, offshore wind and oil and gas industry.

<u>Feature of Geological Interest</u>

5.1.2.26 As advised by Natural England, the specific attributes and targets for the North Norfolk Coast Assemblage of Subtidal Sediment Features and Habitats feature of geological interest has not been included in the latest SACO for Cromer Shoal Chalk Beds MCZ. As such, and as advised by Natural England, the assessment against the attributes and targets for the Subtidal Sand broadscale habitat feature has been used as a proxy for the feature of geological interest protected feature of the MCZ. With respect to the conservation objectives of the protected geological interest features of the Cromer Shoal Chalk Beds MCZ (i.e. North Norfolk Coast Assemblage of Subtidal Sediment Features and Habitats) and considering the attributes and targets of the Subtidal Sand broadscale habitat feature, it can be concluded that there is no significant risk of cable installation during the construction phase hindering the achievement of the conservation objectives set out in Table 4.1 (i.e. to maintain protected features in favourable condition) for the following reasons:

- As detailed above, cable burial will lead to temporary loss/disturbance of a small proportion of one of the component elements (i.e. Subtidal Sand) of the designated protected geological feature, although any such effects will be limited in extent and reversible, with any disturbed sediment being reworked by wave and tidal action and returning to baseline conditions. It can therefore be concluded that the **extent, component elements and integrity** are maintained;
- Cable installation will not impair the **structure and functioning** of the protected geological feature, with the component elements (i.e. Subtidal Sand) returning to baseline levels soon after cable installation (paragraph 5.1.2.11). Also, as discussed in paragraphs 5.1.2.12 to 5.1.2.17, the effects on energy, sediment transport and the wider seabed morphology will be highly localised and short term duration, with a minimal risk to the structure and functioning of the protected geological feature; and
- Burial of cables beneath surface sediments will also ensure that the protected geological feature's **surface remains sufficiently unobscured**.

Increases in SSCs and associated deposition due to cable installation in the Cromer Shoal Chalk Beds MCZ

5.1.2.27 Increases in SSC and associated sediment deposition are predicted to occur during the construction phase because of cable installation. This assessment is equivalent to the following pressures identified by Natural England's Advice on Operations for the Thanet Coast MCZ for "Power cable: laying, burial and protection" (Natural England, 2017):

- *Changes in suspended solids (water clarity)*; and
- *Smothering and siltation rate changes (Light)*.

5.1.2.28 This assessment considers the effects of increases in SSC and associated sediment deposition on all broadscale habitat features (Subtidal Sand, Subtidal Coarse Sediments and Subtidal Mixed Sediments) and habitat FOCI (Peat and Clay Exposures and Subtidal Chalk) of the MCZ. Due to the similarity in the sensitivities of these protected features, the assessment is presented for all features combined, rather than subdivided by feature type. This impact will not affect the North Norfolk Coast Assemblage of Subtidal Sediment Features and Habitats feature of geological interest.

5.1.2.29 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 specific assessment with respect to increases in SSC and subsequent sediment deposition, with a summary of maximum design scenarios associated with this impact presented in volume 2, chapter 1: Marine Processes.

5.1.2.30 The maximum design scenario for increases in SSC associated with export cable installation is predicted to occur because of installation by mass flow excavator (see volume 2, chapter 1: Marine Processes and volume 2, chapter 2: Benthic Ecology 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 associated deposition) near to the point of release. SSC generated during cable burial will be locally elevated in close proximity to active burial operations (i.e. 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 (see volume 2, chapter 1: Marine Process). 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.

5.1.2.31 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 (volume 2, chapter 1: Marine Processes).

5.1.2.32 The installation of cables within or in proximity to the Cromer Shoal Chalk Beds MCZ may occur in areas of seabed where chalk is present at or close to the surface of the seabed (Note: this did not qualify as the Subtidal Chalk feature; see paragraphs 4.2.1.11 to 4.2.1.14). 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 (in the 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 (i.e. background concentrations) 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.

5.1.2.33 Based on this information, the following can be concluded with respect to the physical attributes of all protected features (Table 5.1):

- **Sediment composition and distribution (broadscale habitats)** will not be affected due to increases in SSC and associated deposition, with most of the sediment (primarily sands and gravels) mobilised during cable installation falling out of suspension in close proximity to the cable trench (i.e. within the same broad sediment type). Fine sediments and chalk will be advected further away from the cable trench, although where these settle, they will not settle to a measurable thickness and therefore will not affect the sediment composition;
- **The sedimentation rate (habitat FOCI)** will be maintained. As detailed above, any effects of mobilisation of sediments will be highly localised in extent and of short term duration and will therefore not affect the natural sedimentation and the degree to which these habitat features are exposed or buried. As discussed in section 4.2, habitat FOCI, i.e. Subtidal Chalk and Peat and Clay Exposures, are located 400 m and 3 km from the Hornsea Three offshore cable corridor, respectively, thereby further reducing the risk of effects on these features; and
- **Water turbidity (all features)** will be affected temporarily during cable installation, although any effects will be highly limited both spatially and temporally, occurring intermittently throughout the construction phase and returning to background levels soon after cable installation has occurred.

5.1.2.34 As discussed in section 4.2, the only subtidal biotope recorded within the Hornsea Three offshore cable corridor in the Cromer Shoal Chalk Beds MCZ (and therefore expected to be most acutely affected by this impact) is the NcirBat, with discrete areas of the FluHyd epifaunal overlay. The NcirBat biotope is not sensitive to smothering, being characterised by infaunal species which are capable of burrowing through any sediment deposition. For increases in SSC, these conditions are a natural feature of the environment in which these habitats occur (e.g. the inshore environment off the North Norfolk coast; Tillin, 2016a). Although high levels of SSC (i.e. over 100 mg/l over one month, the MarESA benchmark for increases in SSC) may potentially clog the gill filaments of active suspension and filter feeders (Nicholls *et al.*, 2003) such as bivalves, these species are likely to be able to clear these structures with limited effects of mortality on most of the associated species. It should be noted, however, that high levels of SSC (i.e. over 100 mg/l) will only occur in close proximity to cable installation activities and will rapidly disperse to levels close to background over a short period of time (see paragraph 5.1.2.30). 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. The communities associated with the FluHyd biotope are not considered to be sensitive to increases in SSC, as although it may result in extra energy expenditure due to cleaning, this would not result in increased mortality (Readman, 2016). Similarly, these communities are not considered to be sensitive to smothering; as these species occur in areas where water flow and/or wave action would remove sediment rapidly (e.g. as evidenced by the rippled sand visible in Figure 4.3) and as this biotope is naturally sand scoured, some tolerance to deposition is expected (Readman, 2016).

5.1.2.35 Subtidal Coarse Sediment and Subtidal Mixed Sediment features of the MCZ occur outside the Hornsea Three offshore cable corridor and will therefore be subject to considerably lower SSCs and little or no sediment deposition. Coarse sediments in this part of the MCZ were characterised by the MoeVen biotope. The sensitivity of the MoeVen biotope communities to both smothering and increased SSC is low (Tillin, 2016b) as the communities are largely infaunal and increases in SSC or deposition, may lead to increased energy expenditure due to cleaning or reduced feeding efficiency, although this is unlikely to result in mortality of individuals/populations. The mixed sediments in proximity to the Hornsea Three offshore cable corridor within the Cromer Shoal Chalk Beds MCZ were characterised by SspiMx biotope. *S. spinulosa* is tolerant of increased SSC (Tillin and Marshall, 2015) and is not considered sensitive to the MarESA smothering benchmark (i.e. an overburden of 5 cm in a discrete event, considerably greater than would be expected for this biotope within the MCZ; Tillin and Marshall, 2015). Communities associated with Subtidal Coarse Sediment and Subtidal Mixed Sediment features of the MCZ will therefore not be significantly adversely affected by increases in SSC and sediment deposition from cable installation.

5.1.2.36 Communities associated with the Subtidal Chalk and Peat and Clay Exposures habitat FOCI are expected to have some tolerance to increases in SSC (De-Bastos and Hill, 2016b; 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, 2016b) 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 (see volume 5, annex 2.1: Benthic Ecology Technical Report). Piddocks have increased sensitivity to sediment deposition as these species 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).

5.1.2.37 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 (e.g. the *Polydora* sp. tubes on moderately exposed sublittoral soft rock biotope; CR.MCR.SfR.Pol). 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, 2016b). Therefore, this biotope is considered to be not sensitive to smothering. The Hornsea Three offshore cable corridor is located several hundred metres from historic records of Subtidal Chalk feature of the MCZ (see Figure 4.1) and several kilometres from the records of clay exposures within the MCZ. As such, any increases in SSC will be considerably diluted at these ranges (see paragraph 5.1.2.30) and deposition of fine sediments would be expected to be negligible.

5.1.2.38 The sensitivities outlined above for species and communities associated with both broadscale habitats and habitat FOCI broadly align with those presented by Natural England's Advice on Operations for the relevant pressures outlined in paragraph 5.1.2.27 (Natural England, 2017).

5.1.2.39 Based on this information, the following can be concluded with respect to the ecological attributes of all protected features (Table 5.1):

- **Presence and spatial distribution of biological communities** will be maintained following cable installation. The biological communities associated with the protected features of the Cromer Shoal Chalk Beds MCZ will not be significantly affected by increases in SSC and sediment deposition due to their relatively low sensitivity to this impact. Their presence and distribution across the MCZ, including in proximity to the cable installation operations, will therefore be unaffected; and
- **Species composition of component communities** will be maintained. As outlined above, the species associated with the protected features have relatively low sensitivity to this impact and therefore the species composition is not predicted to be significantly affected even in proximity to cable installation operations.

5.1.2.40 With respect to the conservation objectives of the Cromer Shoal Chalk Beds MCZ, it can be concluded that there is no significant risk of increases of SSC and associated sediment deposition due to cable installation hindering the achievement of the conservation objectives set out in Table 4.1 (i.e. to maintain protected features in favourable condition) for the following reasons:

- The **extent of the protected features** will not be affected by increases in SSC and associated deposition, remaining stable following the construction phase; and
- The **structures and functions, quality and composition of characteristic biological communities** will remain in a condition which is **healthy and not deteriorating**. Following completion of cable installation, the seabed sediments within the area affected by cable installation (and SSC and deposition) will be consistent with those present pre-construction. Many of the communities associated with the habitat features of the Cromer Shoal Chalk Beds MCZ show some tolerance to increases in SSC and sediment deposition, particularly given sediment mobility and background SSCs in this coastal area. Given the short term, intermittent and localised nature of the impact of SSC and sediment deposition, even those species with relatively higher sensitivity would not be expected to be adversely affected.

5.1.3 Operational Phase

Placement of cable protection in the Cromer Shoal Chalk Beds MCZ leading to long term habitat loss

5.1.3.1 Long term habitat loss will occur within the Cromer Shoal Chalk Beds MCZ during the operational phase where cable crossings and protection are required for sections of the export cables. This assessment is equivalent to the following pressure identified by Natural England's Advice on Operations for the Thanet Coast MCZ for "Power cable: operation and maintenance" (Natural England, 2017):

- *Physical change (to another sediment type)*.

5.1.3.2 This assessment considers the effects of placement of cable protection and resulting long term habitat loss on the attributes and targets for the Subtidal Sand broadscale habitat (Table 5.1) and the North Norfolk Coast Assemblage of Subtidal Sediment Features and Habitats feature of geological interest and therefore the assessment has been subdivided according to feature type (as per paragraph 5.1.1.1). Long term habitat loss due to cable protection will not result in direct impacts on any other broadscale habitat (i.e. Subtidal Coarse Sediments and Subtidal Mixed Sediments) or habitat FOCI (Peat and Clay Exposures and Subtidal Chalk) and as such these have not been considered for this impact (see Table 5.1).

5.1.3.3 Within the Cromer Shoal Chalk Beds MCZ, cable protection may be used over a maximum of 10% of the up to 6 km of export cables to be installed. The requirement for cable protection this will be confirmed by engineering studies, with all cables buried to an appropriate depth (subject to a cable burial risk assessment) and cable protection only used where burial has been shown to not be possible. Volume 2, chapter 2: Benthic Ecology provides further detail on the project envelope assumptions with respect to cable protection.

<u>Broadscale Habitat: Subtidal Sand</u>

5.1.3.4 Long term habitat loss as a result of placement of cable protection will affect a maximum of 4,200 m^2 of subtidal habitat within the MCZ, with all of this habitat loss occurring within the Subtidal Sand broadscale habitat feature. This equates to approximately 0.02% of the total extent of the Subtidal Sand feature within the MCZ (according to the estimates in Table 4.1) and 0.0013% of the total area of the MCZ. There will be no long term habitat loss within any other broadscale habitat features or the habitat FOCI of the Cromer Shoal Chalk Beds MCZ. Cable protection requirements will be detailed in the Cable Specification and Installation Plan that will be agreed with the MMO, in consultation with statutory consultees, pursuant to the relevant marine licence conditions.

5.1.3.5 Long term loss of the Subtidal Sand feature would be localised within the inshore sections of the Hornsea Three offshore cable corridor, in the south western corner of the MCZ. Cable protection within the MCZ will not include concrete mattressing. Hornsea Three will employ sensitive cable protection measures which consider the local seabed conditions, including sediment/substrate type, balanced with the engineering requirements to ensure suitable protection to the cable. Rock protection within the Cromer Shoal Chalk Beds MCZ may comprise gravel and cobbles, with a mean grain size of 100 mm and a maximum grain size of 250 mm. These grain sizes are reflective of areas of coarse and mixed sediments within the particle size analysis (PSA) from the Cromer Shoal Chalk Beds MCZ Post-Survey Site Report (Defra, 2015), which showed that in areas of Subtidal Mixed Sediments and Subtidal Coarse Sediments, grain sizes of >45 mm accounted for an average of over 16% and a maximum of over 40% of the PSA in these areas (noting that cobbles are underrepresented in grab samples). Coarse gravels and cobbles were also recorded in discrete areas between more extensive areas of mobile, rippled sand, within the inshore section of the Hornsea Three offshore cable corridor (see paragraph 4.2.1.11) and therefore, the introduction of small amounts of rock protection in discrete areas would not represent a considerable shift in the baseline situation.

5.1.3.6 As discussed in volume 2, chapter 1: Marine Processes, in situations where local sediment transport processes interact with cable protection, rock protection may locally prevent onward passage of sediments in transport, causing sediment to accumulate locally (i.e. over a period of months or less, depending on rates of sediment transport). As the volume of sediment accumulation increases, voids in the cable protection would become infilled and a sediment slope would develop on the updrift side. As a stable slope approaches the top of the cable protection, the blockage effect of the cable protection will progressively be reduced to near zero and sediment will continue to be transported over the obstacle. The process of sediment accumulation may take place over a period of a few months or less, depending on rates of sediment transport. It is also realistically possible that the cable protection may only cause partial or no measurable blockage of sediment transport, or associated sediment accumulation. In this case, the natural modes of sediment transport might be sufficient to collectively allow some or all sediment to simply pass over the obstacle presented by the cable protection with limited or no overall change or interruption to the natural rate or direction.

5.1.3.7 In cases where sediment accumulates over cable protection, the biological communities associated with the surrounding sediments would also be expected to colonise these sediments, with the mix of sandy sediments and coarse substrates associated with the rock protection reflecting the baseline environment within the MCZ. In addition to this, some of the epifaunal components of the biological communities associated with the discrete patches of gravel and cobbles (i.e. FluHyd biotope) and subtidal coarse and mixed sediment features in the wider MCZ would be expected to colonise the cable protection measures, with the appropriate cable protection grain sizes (paragraph 5.1.3.5) increasing the potential for colonisation by local epifaunal communities. 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.

5.1.3.8 Based on the information above, the following can be concluded with respect to the physical attributes of the broadscale habitat features (Table 5.1):

- **Extent and distribution** of broadscale habitat features will largely be maintained. While Hornsea Three is predicted to result in long term loss of a small proportion of the Subtidal Sand broadscale habitat feature (i.e. up to 0.02% of the Subtidal Sand within the MCZ), these sediments are expected to be subject to some natural variability (see paragraph 4.2.1.3). In addition, the use of sensitive cable protection measures accounting for the local sediment types is expected to limit the extent of any effects, allowing for some recovery of sediments (and communities) in these areas;
- **Energy/exposure** within the Cromer Shoal Chalk Beds MCZ and the nearshore environment will not be affected by placement of cable protection. As outlined in volume 2, chapter 1: Marine Processes, if and where cable protection measures are used in the shallow subtidal areas of the Cromer Shoal Chalk Beds MCZ, it would be installed with a sufficiently low profile relative to the surrounding bed to present a minimal barrier to the passage of waves and so cause no change to patterns of longshore sediment transport. within the MCZ and the nearshore environment will not be affected by placement of cable protection. In addition, cable protection in the nearshore area is unlikely to be orientated in a direction which will result in cross sectional interference to the passage of incoming waves (i.e. dominant wave direction of north and northeast);
- **Sediment movement and hydrodynamic regime** would be maintained following placement of cable protection. As detailed above (and in volume 2, chapter 1: Marine Processes), bedload sediment transport would not be adversely affected in the long term, with the potential for short term interruption in sediment movement as sediment accumulates against the cable protection. Once the sediment reaches the top of the cable protection, normal sediment transport patterns would continue. This sediment accumulation may take place over a period of a few months or less, depending on rates of sediment transport. Cable protection may affect natural seabed morphology and bedforms, although any such effects will be highly localised, affecting a very small proportion of the MCZ and natural sediment transport patterns will not be interrupted by the presence of cable protection; and
- **Sediment composition and distribution** will also largely be maintained across the Cromer Shoal Chalk Beds MCZ. Where cable protection is employed, these will be in discrete areas, with only localised effects on sediment composition (i.e. in the immediate vicinity of the cable protection). As detailed above, it would be expected that in some areas, the sediments from adjacent areas may naturally accumulate on parts of the cable protection and use of appropriate protection measures may also increase the potential for recovery of sediments in these areas.

5.1.3.9 Based on the information above, the following can be concluded with respect to the ecological attributes of the broadscale habitat features (Table 5.1):

- **Species composition of the component communities** across the Cromer Shoal Chalk Beds MCZ will be maintained following placement of cable protection. Although a small proportion of the habitat features will be lost for the lifetime of Hornsea Three (and potentially beyond; see section 5.1.4), the species composition of the communities associated within the areas of unaffected Subtidal Sand features (i.e. >99.98% of this feature within the Cromer Shoal Chalk Beds MCZ) will remain in the pre-construction baseline condition. As discussed above, many of the species associated with this habitat feature may colonise areas affected by cable protection placement, e.g. colonisation of sediment accumulated during natural sediment transport processes, or epifaunal colonisation of the cable protection itself; and
- **Presence and spatial distribution of the biological communities** will be maintained following placement of cable protection, with only a small proportion of these habitats affected in discrete areas. Due to the localised habitat loss effects, spatial distribution of biological communities across the Cromer Shoal Chalk Beds MCZ will be maintained.

5.1.3.10 With respect to the conservation objectives of the Cromer Shoal Chalk Beds MCZ, it can be concluded that there is no significant risk from placement of cable protection during the operational phase with consequent habitat loss effects, hindering the achievement of the conservation objectives of the broadscale sediment features as set out in Table 4.1 (i.e. to maintain protected features in favourable condition) for the following reasons:

- The **extent of the protected features** will not be significantly affected due to the very small proportion of the Subtidal Sand feature affected. In addition, there is potential for the recovery of the protected feature (i.e. sediments and habitats) into the areas affected, either through sediment transport processes or the use of sensitive cable protection, further reducing the extent of any effects; and
- The **structures and functions, quality and composition of characteristic biological communities** will remain in a condition which is **healthy and not deteriorating**. Although a small proportion of the Subtidal Sand habitat feature will be lost for the lifetime of Hornsea Three (effects beyond this are considered in section 5.1.4), the biological communities associated with the areas of unaffected Subtidal Sand (i.e. >99.98% of these features within the Cromer Shoal Chalk Beds MCZ) will remain in the pre-construction baseline condition, with no effects on the structures, functions, quality and composition of the communities.

Feature of Geological Interest

5.1.3.11 As advised by Natural England, the specific attributes and targets for the North Norfolk Coast Assemblage of Subtidal Sediment Features and Habitats feature of geological interest have not been included in the latest SACO for Cromer Shoal Chalk Beds MCZ. As such, and as advised by Natural England, the assessment against the attributes and targets for the Subtidal Sand broadscale habitat feature has been used as a proxy for the feature of geological interest protected feature of the MCZ. With respect to the conservation objectives of the protected geological interest feature of the Cromer Shoal Chalk Beds MCZ (i.e. North Norfolk Coast Assemblage of Subtidal Sediment Features and Habitats) and considering the attributes and targets of the Subtidal Sand broadscale habitat feature, it can be concluded that there is no significant risk of long term habitat loss hindering the achievement of the conservation objectives set out in Table 4.1 (i.e. to maintain protected features in favourable condition) for the following reasons:

- While it is predicted that Hornsea Three will result in long term loss of a small proportion of one of the qualifying features (i.e. <0.02% of the Subtidal Sand feature), these sediments are expected to be subject to some natural variability (see paragraph 4.2.1.3), with extents and distributions of these showing some natural variability within the Cromer Shoal Chalk Beds MCZ. As discussed in paragraph 5.1.3.5, the use of sensitive cable protection measures accounting for the local sediment types may serve to further limit the extent of any effects, allowing for recovery of habitats/communities in these areas. It can therefore be concluded that the overall **extent, component elements and integrity** of the protected geological interest feature of the Cromer Shoal Chalk Beds MCZ are maintained;
- The **structure and functioning** of the protected geological interest feature of the Cromer Shoal Chalk Beds MCZ will be unimpaired, with the presence of cable protection measures not predicted to have significant effects on sediment transport, energy (including wave regime) and the structure of the geomorphological features (e.g. bedforms). Although initially small scale, localised sediment accumulation may occur following installation of cable protection and sediments will continue to move over cable protection measures during the operational phase, with no significant effect on the overall sediment transport in the Cromer Shoal Chalk Beds MCZ. Any effects on the wave regime will also be highly limited in extent, with cable protection occupying a low profile within the water column relative to the depth, with minimal cross section interference to the passage of incoming waves; and
- As detailed in the previous bullet points, a limited proportion of the seabed within the Cromer Shoal Chalk Beds MCZ (i.e. 0.0013%) will be affected by long term habitat loss due to cable protection, resulting in some obscuring of the surface. However, this is not considered to present a significant risk to the extent, component elements and integrity or the structure and functioning of the protected geological interest feature. It can therefore be concluded that the **surface will remain sufficiently unobscured** for the purposes of determining that the conditions above are satisfied.

Maintenance operations within the Cromer Shoal Chalk Beds MCZ during the operational phase, resulting in temporary seabed disturbances

5.1.3.12 Direct loss/disturbance of subtidal habitat within the Cromer Shoal Chalk Beds MCZ may occur because of maintenance activities (i.e. export cable remedial burial and cable repair operations) during the Hornsea Three operational phase, should these be required. Volume 2, chapter 2: Benthic Ecology provides full details on the project envelope assumptions with respect to maintenance operations for export cables. This assessment is equivalent to the following pressures identified by Natural England's Advice on Operations for the Thanet Coast MCZ for "Power cable: laying, burial and protection" (Natural England, 2017):

- *Abrasion/disturbance of the substrate on the surface of the seabed;* and
- *Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion*.

5.1.3.13 Effects of temporary habitat loss due to export cable maintenance operations (if required) during the operational phase within the Cromer Shoal Chalk Beds MCZ may (if these are required) affect the same features, attributes and targets (i.e. Subtidal Sand broadscale habitat and the North Norfolk Coast Assemblage of Subtidal Sediment Features and Habitats feature of geological interest; Table 5.1) as the cable installation activities during the construction phase (see paragraph 5.1.2.1). Temporary habitat loss due to cable maintenance will not result in direct impacts on any other broadscale habitat (i.e. Subtidal Coarse Sediments and Subtidal Mixed Sediments) or habitat FOCI (Peat and Clay Exposures and Subtidal Chalk) and as such these have not been considered for this impact (see Table 5.1).

5.1.3.14 Export cable remedial burial and/or export cable repair activities may affect up to 18,076 m^2 of seabed sediments within the Cromer Shoal Chalk Beds MCZ over the 35 year design life of Hornsea Three. These activities would be completed over a period of days to weeks, with a maximum duration of three months for cable repairs. Effects of these activities on the Cromer Shoal Chalk Beds MCZ would be identical or less than those considered in the construction phase (see paragraph 5.1.2.1 *et seq*.). The only feature which may be directly affected by maintenance operations would be the Subtidal Sand broadscale habitat feature, with the up to 18,076 m^2 of habitat loss/disturbance representing 0.1% of the total area of Subtidal Sand within the Cromer Shoal Chalk Beds MCZ (according to the extents presented in Table 4.1). As detailed in paragraph 5.1.2.1 *et seq*., the subtidal sandy sediments and associated communities (represented by the NcirBat biotope with FluHyd epifaunal overlay) would recover following maintenance operations, with full recovery of communities occurring quickly following cessation of activities (i.e. maximum recovery period of up to five years).

5.1.3.15 With respect to the Subtidal Sand broadscale habitat feature attributes (see paragraphs 5.1.2.17 and 5.1.2.24), it can be concluded that temporary habitat loss/disturbance as a result of cable maintenance operations would not result in a significant risk of hindering the achievement of the conservation objectives set out in Table 4.1, for the same reasons outlined in the construction phase, although during maintenance operations the impact would be considerably reduced (both spatially and temporally). Similarly, effects on the protected feature of geological interest of the Cromer Shoal Chalk Beds MCZ (i.e. North Norfolk Coast Assemblage of Subtidal Sediment Features and Habitats) due to cable maintenance are predicted to be considerably less than those predicted for cable installation. It can therefore be concluded that there is no significant risk of cable removal hindering the achievement of the conservation objectives set out in Table 4.1 for the same reasons as those outlined in paragraph 5.1.2.26, although noting that the impacts would be considerable reduced (spatially and temporally) compared to the construction phase.

Colonisation of cable protection within the Cromer Shoal Chalk Beds MCZ

5.1.3.16 This assessment equivalent to the following pressure identified by Natural England's Advice on Operations for the Thanet Coast MCZ for " Power cable: operation and maintenance" (Natural England, 2017):

- *Physical change (to another sediment type)*.

5.1.3.17 This assessment considers the effects of placement of cable protection and resulting colonisation by faunal communities on the ecological attributes and targets for the Subtidal Sand broadscale habitat (no effects on physical attributes; Table 5.1). This impact will not result in direct impacts on any other broadscale habitat (i.e. Subtidal Coarse Sediments and Subtidal Mixed Sediments) or habitat FOCI (Peat and Clay Exposures and Subtidal Chalk) as cable protection will not be placed within these features and as such these have not been considered for this impact (see Table 5.1). Effects of colonisation will affect ecological attributes only and therefore the attributes of the North Norfolk Coast Assemblage of Subtidal Sediment Features and Habitats feature of geological interest will also not be affected.

5.1.3.18 As discussed in paragraph 5.1.3.1 *et seq.,* cable protection may be required for up to 10% of the 6 km of Hornsea Three export cables (i.e. six cables of 1 km length each) installed within the Cromer Shoal Chalk Beds MCZ, where cable burial has been shown to not be possible. This will lead to a total of 5,196 m^2 of new hard substrate within the MCZ (see section 2.8.1 of volume 2, chapter 2: Benthic Ecology). Associated increases in biodiversity will potentially affect the broadscale habitat feature of the Cromer Shoal Chalk Beds MCZ within which cable protection may be placed (i.e. Subtidal Sand). As detailed in paragraph 5.1.3.5, the cable protection within the MCZ will consider the seabed conditions within the MCZ, which may include use of cobble and gravel grain sizes (e.g. mean grain size of 100 mm and a maximum grain size of 250 mm which are reflective of grain sizes within coarse and mixed sediment areas). The use of similar grain sizes as those currently present in the MCZ (including discrete areas of the Subtidal Sand feature of the MCZ) will help to encourage colonisation by epifaunal communities present within the MCZ.

5.1.3.19 Epifaunal species and colonising fauna have been recorded within the Cromer Shoal Chalk Beds MCZ, including discrete patches of gravel and cobble within a wider area of mobile sands in the inshore area (as discussed in paragraph 4.2.1.11), as well as those associated with mixed and coarse sediment and subtidal rocky habitats (e.g. Subtidal Chalk). It is therefore expected that colonisation of hard substrates by common species and communities (e.g. represented by the FluHyd biotope), local to the Cromer Shoal Chalk Beds MCZ will occur. The existing communities associated with coarse sediments and hard substrates predominantly comprise an epifaunal assemblage, therefore the potential introduction of epifaunal communities associated with the new hard substrate is unlikely to incur a significant adverse impact on the function of the present community. Rather, should the introduction of new habitat be sensitive to the local sediment types (e.g. in terms of grain sizes, as discussed in paragraph 5.1.3.5) it may allow for some recovery of baseline communities into these areas.

5.1.3.20 Based on this information, the following can be concluded with respect to the ecological attributes of all protected features (Table 5.1):

- **Presence and spatial distribution of biological communities** will be maintained should cable protection be used within the MCZ. It is expected that biological communities already present within the Cromer Shoal Chalk Beds MCZ, particularly epifaunal components, will colonise the discrete areas of cable protection (which will cover only a small proportion of the MCZ), where these are required within the Cromer Shoal Chalk Beds MCZ. The presence and distribution of these communities across the MCZ, including in areas where cable protection is installed, will therefore be unaffected; and
- **Species composition of component communities** will be maintained. As outlined above, many of the species (particularly epifaunal species) associated with the protected features of the Cromer Shoal Chalk Beds MCZ would be expected to colonise cable protection, with no adverse effects on the species composition because of the presence of cable protection.

5.1.3.21 With respect to the conservation objectives of the Cromer Shoal Chalk Beds MCZ, it can be concluded that there is no significant risk of colonisation of hard substrates hindering the achievement of the conservation objectives set out in Table 4.1 (i.e. to maintain protected features in favourable condition) for the following reasons:

- The **extent of the broadscale rock protected habitat features** (e.g. circalittoral and infralittoral rock habitats; see Table 4.1) may be slightly increased with the introduction of limited amounts of hard substrates for cable protection and colonisation of these hard substrates by local epifaunal species/communities would be expected to occur; and

- The **structures and functions, quality and composition of characteristic biological communities** will remain in a condition which is healthy and not deteriorating. As detailed above, the species assemblage most able to colonise the introduced hard substrate are likely to be already present within the Cromer Shoal Chalk Beds MCZ (i.e. colonising coarse sediments and rocky substrates) and therefore introduction of discrete areas of hard substrate through cable protection represent a very limited small extension of the habitats within the Cromer Shoal Chalk Beds MCZ, without adversely affecting the structure, function, quality and composition of the characterising benthic assemblage.

Increased risk of introduction or spread of invasive and non-native species (INNS) due to presence of subsea infrastructure and vessel movements within the Cromer Shoal Chalk Beds MCZ

5.1.3.22 For the purposes of this assessment, the risks of introduction and spread of INNS from both the construction and the operational phase have been considered. This assessment is equivalent to the following pressure identified by Natural England's Advice on Operations for the Thanet Coast MCZ for "Power cable: operation and maintenance" (Natural England, 2017):

- *Introduction or spread of invasive non-indigenous species*.

5.1.3.23 This assessment considers the effects of placement of cable protection and resulting colonisation by faunal communities on the ecological attributes and targets for the Subtidal Sand broadscale habitat (no effects on physical attributes; Table 5.1). This impact will not result in direct impacts on any other broadscale habitat (i.e. Subtidal Coarse Sediments and Subtidal Mixed Sediments) or habitat FOCI (Peat and Clay Exposures and Subtidal Chalk) as cable protection will not be placed within these features and as such these have not been considered for this impact (see Table 5.1). INNS have the potential to affect ecological attributes only and therefore the conservation objectives of the North Norfolk Coast Assemblage of Subtidal Sediment Features and Habitats feature of geological interest will also not be affected.

5.1.3.24 As discussed in paragraph 5.1.3.17, up to 5,196 m^2 of new hard substrate in the form of cable protection will be introduced within the Cromer Shoal Chalk Beds MCZ site, which will provide new habitat for the potential colonisation by INNS. In addition, as detailed in the maximum design scenario table volume 2, chapter 2: Benthic Ecology there will be up to 10,474 round trips to port during the construction phase and up to 2,822 round trips to port by operational and maintenance vessels, which will contribute to the risk of introduction or spread of INNS in ballast water and/or hull fouling. These vessel movements are likely to be concentrated around the Hornsea Three array area, with minimal vessel activity in the nearshore section of the Hornsea Three offshore cable corridor within the Cromer Shoal Chalk Beds MCZ and where these do occur, these are likely to be of short duration (in comparison to those in the array).

5.1.3.25 It should also be noted that there is an existing baseline of vessel activity within the Cromer Shoal Chalk Beds MCZ, including fishing, cargo, recreational and wind farm support vessels, and therefore the small increase in vessel traffic in the MCZ associated with Hornsea Three will not represent an increased risk of introduction of INNS by ballast water. Designed-in measures including a biosecurity plan, a Project Environmental Management and Monitoring Plan (PEMMP) and vessels complying with the International Maritime Organization (IMO) ballast water management guidelines throughout all phases of the project (see designed-in mitigation table volume 2, chapter 2: Benthic Ecology) will ensure that the risk of potential introduction and spread of INNS will be minimised.

5.1.3.26 The sediments characterising the NcirBat biotope (the only biotope where cable protection will be installed) are mobile and frequent disturbance is expected to limit the establishment of INNS species as the habitat conditions are unsuitable for most species. This is supported by the presence of the FluHyd epifaunal overlay in the small patches of gravel and cobble within the wider area of sandy sediment in the inshore part of the Hornsea Three offshore cable corridor; this epifaunal overlay is characterised by species which are tolerant of sand scour and occasional smothering by mobile sediments. The communities are considered to have high resistance, high recoverability to INNS and are therefore considered to be not sensitive to this pressure (Tillin, 2016a).

5.1.3.27 All other features of the Cromer Shoal Chalk Beds MCZ would not be subject to increased risk of introduction or spread of INNS, as no cable protection will be placed in these areas, the distance between the Hornsea Three offshore cable corridor and these features, and the designed-in measures to minimise this risk as described above.

5.1.3.28 Based on this information, the following can be concluded with respect to the ecological attributes of all protected features (Table 5.1):

- **Presence and spatial distribution of biological communities** will be maintained following cable installation. As discussed in paragraphs 5.1.3.19 and 5.1.3.20, it would be expected that biological communities already present within the Cromer Shoal Chalk Beds MCZ, particularly epifaunal components, will colonise the limited amount of cable protection within the MCZ, with the presence and distribution of these communities unaffected across the MCZ, including in areas where cable protection is installed; and
- **Species composition of component communities** will be maintained, with many of the species (particularly epifaunal species) associated with the protected features of the Cromer Shoal Chalk Beds MCZ expected to colonise cable protection, with no adverse effects on the species composition.

- **Non-native species and pathogens:** The risk of introduction of non-native species and pathogens will be minimised through the implementation of appropriate measures as specified in paragraph 5.1.3.25. As detailed in Natural England's informal draft SACO for the Cromer Shoal Chalk Beds MCZ, INNS have been reported in the MCZ (e.g. American slipper limpet *Crepidula fornicata* has been reported at sampling stations within the Subtidal Coarse Sediments feature). However as detailed above, Hornsea Three will not increase the risk of the spread of INNS already known to occur within the Cromer Shoal Chalk Beds MCZ, nor the introduction of INNS not currently known to occur within the MCZ, due to the discrete areas of seabed affected and the relatively small increase in vessel traffic due to cable installation and operation.

5.1.3.29 With respect to the conservation objectives of the Cromer Shoal Chalk Beds MCZ, it can be concluded that the introduction or spread of INNS because of Hornsea Three subsea infrastructure within the Cromer Shoal Chalk Beds MCZ will not present a significant risk to hindering the achievement of the conservation objectives set out in Table 4.1 (i.e. to maintain protected features in favourable condition) for the following reasons:

- The **extent of the protected features** will not be affected by this impact, remaining stable (or increasing); and
- The **structures and functions, quality and composition of characteristic biological communities** will remain in a condition which is healthy and not deteriorating. The risk of introduction or spread of INNS in the Cromer Shoal Chalk Beds MCZ is low and this will be minimised further through the implementation of measures such as a biosecurity plan and a PEMMP. In addition, the communities within the Cromer Shoal Chalk Beds MCZ are not considered to be vulnerable to the introduction of INNS, with competition from local epifaunal communities likely to dampen any effects of INNS, in the unlikely event that non-native species were introduced.

5.1.4 Decommissioning Phase

Cable removal in the Cromer Shoal Chalk Beds MCZ leading to habitat loss/disturbance

5.1.4.1 This assessment is equivalent to the following pressures identified by Natural England's Advice on Operations for the Thanet Coast MCZ for "Power cable: Decommissioning" (Natural England, 2017):

- *Abrasion/disturbance of the substrate on the surface of the seabed;* and
- *Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion.*

5.1.4.2 Effects of temporary habitat loss during the decommissioning phase within the Cromer Shoal Chalk Beds MCZ would be no greater than but are expected to be less than those of the construction phase (see paragraph 5.1.2.1) and will affect the same features and attributes. Cable removal will lead to temporary habitat loss/disturbance within the Subtidal Sand broadscale habitat feature only, with no other features of the MCZ directly affected. As detailed in paragraph 5.1.2.1 *et seq*., this will affect a small proportion of the Subtidal Sand broadscale habitat feature and the sediments and associated communities will fully recover following cable removal within up to five years following decommissioning. With respect to the Subtidal Sand broadscale habitat feature attributes (see paragraphs 5.1.2.17 and 5.1.2.24), it can be concluded that temporary habitat loss/disturbance as a result of cable removal will not result in a significant risk of hindering the achievement of the conservation objectives set out in Table 4.1. Similarly, effects on the protected feature of geological interest of the Cromer Shoal Chalk Beds MCZ (i.e. North Norfolk Coast Assemblage of Subtidal Sediment Features and Habitats) due to cable removal are predicted to be similar to or less than those predicted for cable installation. It can therefore be concluded that there is no significant risk of cable removal hindering the achievement of the conservation objectives set out in Table 4.1 for the same reasons as those outlined in paragraph 5.1.2.26.

Increases in SSC and associated deposition due to cable removal in the Cromer Shoal Chalk Beds MCZ

5.1.4.3 Effects of increases in SSC and associated deposition due to cable removal in the Cromer Shoal Chalk Beds MCZ are expected to be equal or less than those of the construction phase (see paragraph 5.1.2.27), affecting the same protected features and their relevant attributes as outlined for the construction phase. Cable removal will lead to increases in SSC and subsequent deposition to levels similar, or identical to, those experienced during the construction phase (i.e. due to the similarity in some of the methods used to install and remove cables, e.g. jetting). The communities predicted to be affected will be identical to those during the construction phase (allowing for some natural variation in the communities), and as discussed in paragraph 5.1.2.27 *et seq*., these are predicted to have low sensitivity to increases in SSC and sediment deposition. As discussed in paragraphs 5.1.2.39 and 5.1.2.40, with respect to the feature attributes and conservation objectives of the Cromer Shoal Chalk Beds MCZ, it can be concluded that cable removal leading to increases in SSC and associated deposition will not result in a significant risk of hindering the achievement of the conservation objectives set out in Table 4.1.

Permanent habitat loss due to presence of cable protection left in situ post decommissioning within the Cromer Shoal Chalk Beds MCZ

5.1.4.4 The assessment of impacts during the Hornsea Three decommissioning phase, as presented in section 2.11.3 of volume 2, chapter 2: Benthic Ecology assumes that all offshore infrastructure will be removed from the seabed with the exception of cable protection, which it is currently assumed will be left *in situ*.

5.1.4.5 Consistent with the long term habitat loss operational phase impact, this assessment considers the effects on the attributes and targets for the Subtidal Sand broadscale habitat (Table 5.1) and the conservation objectives of the North Norfolk Coast Assemblage of Subtidal Sediment Features and Habitats feature of geological interest. Long term habitat loss due to cable protection will not result in direct impacts on any other broadscale habitat (i.e. Subtidal Coarse Sediments and Subtidal Mixed Sediments) or habitat FOCI (Peat and Clay Exposures and Subtidal Chalk) and as such these have not been considered for this impact (see Table 5.1).

5.1.4.6 As detailed in paragraph 5.1.3.1, the maximum design scenario assumes that during the operational phase cable protection may be installed over up to 10% of the maximum 6 km of export cables (i.e. six cables, each of 1 km length each) to be installed in the Cromer Shoal Chalk Beds MCZ, equating to up to 4,200 m^2 of permanent habitat loss, should cable protection be left *in situ* following decommissioning. As a proportion of the Subtidal Sand broadscale habitat feature of the Cromer Shoal Chalk Beds MCZ, this equates to 0.02% of the total area of this habitat within the MCZ or 0.0013% of the total area of the MCZ.

5.1.4.7 As discussed in paragraph 5.1.3.5, cable protection will be designed to reflect local seabed conditions, which will encourage recolonisation of these areas by fauna from surrounding areas in many areas where cable protection is used. In some areas, sediments may recover over part of the area affected, depending on the orientation of the cable protection. Where this sediment accumulation occurs, it would be expected that the biological communities associated with the surrounding sediments would also be expected to colonise these sediments. This suggests that although permanent 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.

5.1.4.8 As discussed in paragraphs 5.1.3.8 *et seq*., with respect to the feature attributes and conservation objectives of the Cromer Shoal Chalk Beds MCZ, it can be concluded that the presence of cable protection following decommissioning will not result in a significant risk of hindering the achievement of the conservation objectives set out in Table 4.1. Similarly, effects of cable protection on the protected feature of geological interest of the Cromer Shoal Chalk Beds MCZ (i.e. North Norfolk Coast Assemblage of Subtidal Sediment Features and Habitats) will not present a significant risk to the conservation objectives set out in Table 4.1, for the same reasons as those outlined in paragraph 5.1.3.11 *et seq.*

5.1.5 Cumulative Effects

5.1.5.1 The MCAA does not provide any legislative requirement for explicit consideration of cumulative effects on features of MCZs/rMCZs. However, the MMO guidelines (MMO, 2013) state that the MMO considers that in order for the MMO to fully discharge its duties under section 69 (1) of the MCAA, cumulative effects must be considered. In addition, feedback from the MCZ Working Group raised queries in relation to the cumulative effects of other projects on the Cromer Shoal Chalk Beds MCZ (see Table 1.1).

5.1.5.2 As outlined in volume 1, chapter 5: EIA Methodology, for the purposes of the Hornsea Three cumulative effects assessment (CEA), all projects, plans and activities that were built and operational at the time of Hornsea Three data collection (field surveys etc.) were screened out of the CEA. This is because the effects of these projects have already been captured within Hornsea Three specific surveys, and hence their effects have already been accounted for within the baseline assessment. The exclusion of built and operational projects that were in place at the time of data collection/survey in this way avoids the double-counting that would occur if projects were to be included within both the baseline and the CEA. With respect to the Cromer Shoal Chalk Beds MCZ, this includes commercial fishing activity within the MCZ and the installation of the Sheringham Shoal and Dudgeon export cables (installed in 2010 and 2016, respectively). There is currently no information on operation and maintenance activities associated with the Dudgeon or Sheringham Shoal export cables within the Cromer Shoal Chalk Beds (should any be required) and therefore it has not been possible to undertake a cumulative assessment on the effects of such activities on the protected features of this MCZ.

5.1.5.3 The only other project identified in the CEA Screening (see volume 4, annex 5.2: CEA Screening) within the boundary Cromer Shoal Chalk Beds MCZ is the Bacton Gas Terminal Coastal Defence Scheme, located approximately 23 km to the west of the Hornsea Three offshore cable corridor. There is, however, currently no detailed information on the impact the Bacton Gas Terminal Coastal Defence Scheme will have on features of the Cromer Shoal Chalk Beds MCZ, although the Scoping Report (Royal Haskoning, 2016) for this project has identified that an MCZ Assessment will be required to consider effects on the Cromer Shoal Chalk Beds MCZ. One of the key impacts identified in the Bacton Gas Terminal Coastal Defence Scheme Scoping Report (Royal Haskoning, 2016) was 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 paragraph 5.1.2.1), which will directly affect protected features of the Cromer Shoal Chalk Beds MCZ. However, due to the lack of detailed information on the impacts of Bacton Gas Terminal Coastal Defence Scheme on features of the Cromer Shoal Chalk Beds MCZ, it has not been possible to consider the cumulative effects of this project with Hornsea Three.

5.1.6 Stage 1 Assessment Conclusion

5.1.6.1 Based on the information presented in the preceding sections (assessments on the broadscale habitats, habitat FOCI and the feature of geological interest), it can be concluded that there is no significant risk of Hornsea Three construction, operation and decommissioning hindering the achievement of the conservation objectives for the Cromer Shoal Chalk Beds MCZ, as set out in Table 4.1 and section 4.2, in accordance with section 125(2)(a) of the MCAA.

5.2 Markham's Triangle rMCZ

5.2.1.1 This section presents the Stage 1 assessment of the effects of Hornsea Three construction, operation and decommissioning on the protected features of Markham's Triangle rMCZ. Each of the impacts identified in the Screening stage (see paragraph 3.3.1.2) are discussed individually in the following sections and within each assessment, the effects on attributes and targets of the relevant protected features, and subsequently on the conservation objectives, are considered, using the best available scientific evidence to support conclusions made. In contrast to the Cromer Shoal Chalk Beds MCZ, the features of Markham's Triangle rMCZ are all broadscale habitat features and therefore the assessments presented in this section have not been subdivided into types of protected features. Similarly, due to the nature of the impacts of Hornsea Three on Markham's Triangle rMCZ (i.e. construction and operation of wind farm array infrastructure), each impact considers the potential effects on all features of the rMCZ.

5.2.1.2 Table 5.3 below presents a summary matrix of the individual feature attributes of Markham's Triangle rMCZ considered within each assessment. As detailed in paragraph 2.3.2.5, there are currently no specific conservation objectives available for Markham's Triangle rMCZ, nor are there attributes or targets for the proposed features for designation. As such, for the purposes of the Stage 1 assessment below, attributes and targets for the proposed features of rMCZs are assumed to be identical to those same protected features of the Cromer Shoal Chalk Beds MCZ, for the common features across these sites (see section 4.3); all three of the features of Markham's Triangle rMCZ are also features of the Cromer Shoal Chalk Beds MCZ. As described in paragraph 2.3.2.5, attributes were broadly categorised as either physical or ecological attributes. Impacts which had the potential to affect the chemical attributes of rMCZ features (i.e. accidental release of pollutants and resuspension of sediment bound contaminants; see section 3.2), were screened out due to the low risk that these impacts pose to the relevant features and therefore are not presented in Table 5.3 (see SACO for details of these, available at Natural England's Designated Sites System; Natural England, 2018). As discussed in paragraph 4.3.1.8, based on current advice from JNCC, the rMCZ is not currently considered to be in favourable condition and as such, a general management approach of "recover to favourable condition" has been applied to Markham's Triangle rMCZ in the Stage 1 assessment.

5.2.1.3 Table 5.3 includes signposting to the relevant paragraph references of the Stage 1 assessment below, which provide justification for the conclusions made with respect to the attributes of the proposed features for designation of Markham's Triangle rMCZ. The colour coding represents the conclusions made within the Stage 1 assessment of this MCZ Assessment, with colour coding is as follows:

- Blue: No significant effect on attribute or target(s); and
- Grey: No attribute - impact pathway (not applicable).

5.2.2 Construction Phase

Temporary habitat loss/disturbance due to turbine foundation and cable installation in the Markham's Triangle rMCZ

5.2.2.1 Direct temporary loss/disturbance of proposed habitat features of the Markham's Triangle rMCZ will occur because of the jack-up barge operations to install foundations, seabed preparation prior to gravity base installation and the burial of array and substation interconnector cables, including sandwave and boulder clearance and anchor placements. The maximum design scenario table in section 2.8.1 of volume 2, chapter 2: Benthic Ecology provides full details on the project envelope assumptions with respect to temporary habitat loss for Hornsea Three. This assessment is equivalent to the following pressures identified by Natural England's Advice on Operations for the Thanet Coast MCZ for "Offshore wind: during construction" and " Power cable: laying, burial and protection" (Natural England, 2017):

- *Abrasion/disturbance of the substrate on the surface of the seabed;*
- *Habitat structure changes - removal of substratum (extraction);*
- *Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion; and*
- Smothering and siltation rate changes (Heavy, i.e. >5 cm depth).

5.2.2.2 For the purposes of this assessment, it is assumed that a maximum of 24% of the array infrastructure (i.e. foundation and cable infrastructure) could be placed in the part of the Hornsea Three array area which coincides with the rMCZ. This assumption is based on the maximum number of structures that could be placed within this part of the Hornsea Three array area, assuming a minimum spacing of 1 km between foundations (i.e. 76 foundations for turbines, substations and accommodation platforms, of a total 319 offshore structures). This would result in a maximum of 5,872,589 m^2 of habitat loss/disturbance within the Markham's Triangle rMCZ (see Table 5.4), equating to 2.94% of the entire area of the rMCZ.

5.2.2.3 The overall Hornsea Three offshore construction phase may be over up to eight years over two phases, although 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 in total (this also includes piling time and therefore seabed preparation will be a small proportion of this time), array cable installation will take place over a period of up to 2.5 years and export cable installation over a period of up to 3 years. Temporary habitat loss/disturbance will therefore represent intermittent occurrences, affecting a small proportion of the total 5,872,589 m^2 within Markham's Triangle rMCZ at any one time.

Table 5.3: Attribute versus impact signposting and summary matrix for Stage 1 assessment of Hornsea Three on the Markham's Triangle rMCZ. Colour coding relates to conclusions with respect to impacts on attributes: Blue - no significant effect on attribute or target(s); Grey - no attribute - impact pathway.

Attribute type	Attribute	Construction		Operation					Decommissioning		
		Temporary habitat loss/disturbance due to turbine foundation and cable installation in the Markham's Triangle rMCZ	Increases in SSC and associated deposition due to construction operations within the Markham's Triangle rMCZ	Long term habitat loss through presence of foundations, scour protection and cable protection in the Markham's Triangle rMCZ	Maintenance operations within Markham's Triangle rMCZ during the operational phase, resulting in temporary seabed disturbances	Colonisation of offshore foundations and scour and cable protection within Markham's Triangle rMCZ	Increased risk of introduction or spread of INNS due to presence of subsea infrastructure and vessel movements within Markham's Triangle rMCZ	Alteration of seabed habitats arising from effects on physical processes, including scour effects and changes in the wave and tidal regimes within Markham's Triangle rMCZ	Temporary habitat loss due to operations to remove inter-array cables, substation interconnector cables and jack-up operations to remove foundations within Markham's Triangle rMCZ	Increases in SSC and deposition from removal of inter-array cables and foundations within Markham's Triangle rMCZ	Permanent habitat loss due to presence of scour/cable protection left in situ post decommissioning within Markham's Triangle rMCZ
Subtidal Coarse Sediment											
Ecological	Distribution: presence and spatial distribution of biological communities	Paragraphs 5.2.2.4 to 5.2.2.19 and 5.2.2.21	Paragraphs 5.2.2.29 5.2.2.32	Paragraphs 5.2.3.2 to 5.2.3.6 and 5.2.3.9	Paragraphs 5.2.3.14 to 5.2.3.17 and 5.2.3.19	Paragraphs 5.2.3.23 and 5.2.3.26	Paragraphs 5.2.3.31 and 5.2.3.36	Paragraphs 5.2.3.42 to 5.2.3.44 and 5.2.3.46	Paragraph 5.2.4.1 and 5.2.4.2	Paragraph 5.2.4.3	Paragraphs 5.2.4.5, 5.2.4.6 and 5.2.4.8
Physical	Extent and distribution	Paragraphs 5.2.2.4 to 5.2.2.20	N/A	Paragraphs 5.2.3.2 and 5.1.3.8	Paragraphs 5.2.3.14 to 5.2.3.18	N/A	N/A	N/A	Paragraph 5.2.4.1 and 5.2.4.2	N/A	Paragraphs 5.2.4.5, 5.2.4.6 and 5.2.4.6
Ecological	Structure: non-native species and pathogens	N/A	N/A	N/A	N/A	N/A	Paragraphs 5.2.3.31 and 5.2.3.36	N/A	N/A	N/A	N/A
Physical	Structure: sediment composition and distribution	Paragraphs 5.2.2.4 to 5.2.2.20	Paragraphs 5.2.2.27 and 5.2.2.28	Paragraphs 5.2.3.2 and 5.1.3.8	Paragraphs 5.2.3.14 to 5.2.3.18	N/A	N/A	Paragraphs 5.2.3.39 to 5.2.3.41 and 5.2.3.45	Paragraph 5.2.4.1 and 5.2.4.2	Paragraph 5.2.4.3	Paragraphs 5.2.4.5, 5.2.4.6 and 5.2.4.6
Ecological	Structure: species composition of component communities	Paragraphs 5.2.2.4 to 5.2.2.19 and 5.2.2.21	Paragraphs 5.2.2.29 5.2.2.32	Paragraphs 5.2.3.2 to 5.2.3.6 and 5.2.3.9	Paragraphs 5.2.3.14 to 5.2.3.17 and 5.2.3.19	Paragraphs 5.2.3.23 and 5.2.3.26	Paragraphs 5.2.3.31 and 5.2.3.36	Paragraphs 5.2.3.42 to 5.2.3.44 and 5.2.3.46	Paragraph 5.2.4.1 and 5.2.4.2	Paragraph 5.2.4.3	Paragraphs 5.2.4.5, 5.2.4.6 and 5.2.4.8
Physical	Supporting processes: energy/ exposure	N/A	N/A	N/A	N/A	N/A	N/A	Paragraphs 5.2.3.39 to 5.2.3.41 and 5.2.3.45	N/A	N/A	N/A
Physical	Supporting processes: sediment movement and hydrodynamic regime	Paragraphs 5.2.2.4 to 5.2.2.20	N/A	N/A	Paragraphs 5.2.3.14 to 5.2.3.18	N/A	N/A	Paragraphs 5.2.3.39 to 5.2.3.41 and 5.2.3.45	Paragraph 5.2.4.1 and 5.2.4.2	N/A	Paragraphs 5.2.4.5, 5.2.4.6 and 5.2.4.6
Physical	Supporting processes: water quality - turbidity	N/A	Paragraphs 5.2.2.27 and 5.2.2.28	N/A	N/A	N/A	N/A	N/A	N/A	Paragraph 5.2.4.3	N/A

Attribute type	Attribute	Construction		Operation					Decommissioning		
		Temporary habitat loss/disturbance due to turbine foundation and cable installation in the Markham's Triangle rMCZ	Increases in SSC and associated deposition due to construction operations within the Markham's Triangle rMCZ	Long term habitat loss through presence of foundations, scour protection and cable protection in the Markham's Triangle rMCZ	Maintenance operations within Markham's Triangle rMCZ during the operational phase, resulting in temporary seabed disturbances	Colonisation of offshore foundations and scour and cable protection within Markham's Triangle rMCZ	Increased risk of introduction or spread of INNS due to presence of subsea infrastructure and vessel movements within Markham's Triangle rMCZ	Alteration of seabed habitats arising from effects on physical processes, including scour effects and changes in the wave and tidal regimes within Markham's Triangle rMCZ	Temporary habitat loss due to operations to remove inter-array cables, substation interconnector cables and jack-up operations to remove foundations within Markham's Triangle rMCZ	Increases in SSC and deposition from removal of inter-array cables and foundations within Markham's Triangle rMCZ	Permanent habitat loss due to presence of scour/cable protection left in situ post decommissioning within Markham's Triangle rMCZ
Subtidal Sand											
Ecological	Distribution: presence and spatial distribution of biological communities	Paragraphs 5.2.2.4 to 5.2.2.19 and 5.2.2.21	Paragraphs 5.2.2.29 5.2.2.32	Paragraphs 5.2.3.2 to 5.2.3.6 and 5.2.3.9	Paragraphs 5.2.3.14 to 5.2.3.17 and 5.2.3.19	Paragraphs 5.2.3.23 and 5.2.3.26	Paragraphs 5.2.3.31 and 5.2.3.36	Paragraphs 5.2.3.42 to 5.2.3.44 and 5.2.3.46	Paragraph 5.2.4.1 and 5.2.4.2	Paragraph 5.2.4.3	Paragraphs 5.2.4.5, 5.2.4.6 and 5.2.4.8
Physical	Extent and distribution	Paragraphs 5.2.2.4 to 5.2.2.20	N/A	Paragraphs 5.2.3.2 and 5.1.3.8	Paragraphs 5.2.3.14 to 5.2.3.18	N/A	N/A	N/A	Paragraph 5.2.4.1 and 5.2.4.2	N/A	Paragraphs 5.2.4.5, 5.2.4.6 and 5.2.4.6
Ecological	Structure: non-native species and pathogens	N/A	N/A	N/A	N/A	N/A	Paragraphs 5.2.3.31 and 5.2.3.36	N/A	N/A	N/A	N/A
Physical	Structure: sediment composition and distribution	Paragraphs 5.2.2.4 to 5.2.2.20	Paragraphs 5.2.2.27 and 5.2.2.28	Paragraphs 5.2.3.2 and 5.1.3.8	Paragraphs 5.2.3.14 to 5.2.3.18	N/A	N/A	Paragraphs 5.2.3.39 to 5.2.3.41 and 5.2.3.45	Paragraph 5.2.4.1 and 5.2.4.2	Paragraph 5.2.4.3	Paragraphs 5.2.4.5, 5.2.4.6 and 5.2.4.6
Ecological	Structure: species composition of component communities	Paragraphs 5.2.2.4 to 5.2.2.19 and 5.2.2.21	Paragraphs 5.2.2.29 5.2.2.32	Paragraphs 5.2.3.2 to 5.2.3.6 and 5.2.3.9	Paragraphs 5.2.3.14 to 5.2.3.17 and 5.2.3.19	Paragraphs 5.2.3.23 and 5.2.3.26	Paragraphs 5.2.3.31 and 5.2.3.36	Paragraphs 5.2.3.42 to 5.2.3.44 and 5.2.3.46	Paragraph 5.2.4.1 and 5.2.4.2	Paragraph 5.2.4.3	Paragraphs 5.2.4.5, 5.2.4.6 and 5.2.4.8
Physical	Supporting processes: energy/ exposure	N/A	N/A	N/A	N/A	N/A	N/A	Paragraphs 5.2.3.39 to 5.2.3.41 and 5.2.3.45	N/A	N/A	N/A
Physical	Supporting processes: sediment movement and hydrodynamic regime	Paragraphs 5.2.2.4 to 5.2.2.20	N/A	N/A	Paragraphs 5.2.3.14 to 5.2.3.18	N/A	N/A	Paragraphs 5.2.3.39 to 5.2.3.41 and 5.2.3.45	Paragraph 5.2.4.1 and 5.2.4.2	N/A	Paragraphs 5.2.4.5, 5.2.4.6 and 5.2.4.6
Physical	Supporting processes: water quality - turbidity	N/A	Paragraphs 5.2.2.27 and 5.2.2.28	N/A	N/A	N/A	N/A	N/A	N/A	Paragraph 5.2.4.3	N/A

Attribute type	Attribute	Construction		Operation					Decommissioning		
		Temporary habitat loss/disturbance due to turbine foundation and cable installation in the Markham's Triangle rMCZ	Increases in SSC and associated deposition due to construction operations within the Markham's Triangle rMCZ	Long term habitat loss through presence of foundations, scour protection and cable protection in the Markham's Triangle rMCZ	Maintenance operations within Markham's Triangle rMCZ during the operational phase, resulting in temporary seabed disturbances	Colonisation of offshore foundations and scour and cable protection within Markham's Triangle rMCZ	Increased risk of introduction or spread of INNS due to presence of subsea infrastructure and vessel movements within Markham's Triangle rMCZ	Alteration of seabed habitats arising from effects on physical processes, including scour effects and changes in the wave and tidal regimes within Markham's Triangle rMCZ	Temporary habitat loss due to operations to remove inter-array cables, substation interconnector cables and jack-up operations to remove foundations within Markham's Triangle rMCZ	Increases in SSC and deposition from removal of inter-array cables and foundations within Markham's Triangle rMCZ	Permanent habitat loss due to presence of scour/cable protection left in situ post decommissioning within Markham's Triangle rMCZ
Subtidal Mixed Sediments											
Ecological	Distribution: presence and spatial distribution of biological communities	Paragraphs 5.2.2.4 to 5.2.2.19 and 5.2.2.21	Paragraphs 5.2.2.29 5.2.2.32	Paragraphs 5.2.3.2 to 5.2.3.6 and 5.2.3.9	Paragraphs 5.2.3.14 to 5.2.3.17 and 5.2.3.19	Paragraphs 5.2.3.23 and 5.2.3.26	Paragraphs 5.2.3.31 and 5.2.3.36	Paragraphs 5.2.3.42 to 5.2.3.44 and 5.2.3.46	Paragraph 5.2.4.1 and 5.2.4.2	Paragraph 5.2.4.3	Paragraphs 5.2.4.5, 5.2.4.6 and 5.2.4.8
Physical	Extent and distribution	Paragraphs 5.2.2.4 to 5.2.2.20	N/A	Paragraphs 5.2.3.2 and 5.1.3.8	Paragraphs 5.2.3.14 to 5.2.3.18	N/A	N/A	N/A	Paragraph 5.2.4.1 and 5.2.4.2	N/A	Paragraphs 5.2.4.5, 5.2.4.6 and 5.2.4.6
Ecological	Structure: non-native species and pathogens	N/A	N/A	N/A	N/A	N/A	Paragraphs 5.2.3.31 and 5.2.3.36	N/A	N/A	N/A	N/A
Physical	Structure: sediment composition and distribution	Paragraphs 5.2.2.4 to 5.2.2.20	Paragraphs 5.2.2.27 and 5.2.2.28	Paragraphs 5.2.3.2 and 5.1.3.8	Paragraphs 5.2.3.14 to 5.2.3.18	N/A	N/A	Paragraphs 5.2.3.39 to 5.2.3.41 and 5.2.3.45	Paragraph 5.2.4.1 and 5.2.4.2	Paragraph 5.2.4.3	Paragraphs 5.2.4.5, 5.2.4.6 and 5.2.4.6
Ecological	Structure: species composition of component communities	Paragraphs 5.2.2.4 to 5.2.2.19 and 5.2.2.21	Paragraphs 5.2.2.29 5.2.2.32	Paragraphs 5.2.3.2 to 5.2.3.6 and 5.2.3.9	Paragraphs 5.2.3.14 to 5.2.3.17 and 5.2.3.19	Paragraphs 5.2.3.23 and 5.2.3.26	Paragraphs 5.2.3.31 and 5.2.3.36	Paragraphs 5.2.3.42 to 5.2.3.44 and 5.2.3.46	Paragraph 5.2.4.1 and 5.2.4.2	Paragraph 5.2.4.3	Paragraphs 5.2.4.5, 5.2.4.6 and 5.2.4.8
Physical	Supporting processes: energy/ exposure	N/A	N/A	N/A	N/A	N/A	N/A	Paragraphs 5.2.3.39 to 5.2.3.41 and 5.2.3.45	N/A	N/A	N/A
Physical	Supporting processes: sediment movement and hydrodynamic regime	Paragraphs 5.2.2.4 to 5.2.2.20	N/A	N/A	Paragraphs 5.2.3.14 to 5.2.3.18	N/A	N/A	Paragraphs 5.2.3.39 to 5.2.3.41 and 5.2.3.45	Paragraph 5.2.4.1 and 5.2.4.2	N/A	Paragraphs 5.2.4.5, 5.2.4.6 and 5.2.4.6
Physical	Supporting processes: water quality - turbidity	N/A	Paragraphs 5.2.2.27 and 5.2.2.28	N/A	N/A	N/A	N/A	N/A	N/A	Paragraph 5.2.4.3	N/A

5.2.2.4 As set out in Table 5.4, included in the temporary habitat loss/disturbance figures are the areas affected by sandwave clearance and disposal of dredged sandwave material. The material arising from sandwave clearance activities within the Markham's Triangle rMCZ will be deposited local to the dredged location and within the boundary of the rMCZ, so far as is reasonably practical (see section 1.11.5 in volume 1, chapter 1: Marine Processes). This is to ensure that no sediment is lost from the sediment transport system within the rMCZ. The patterns of processes governing the sediment transport system (the flow regime, water depths and sediment availability) are at a much larger scale than, and so would not be affected by, the local works within the Hornsea Three array area. As a result, sandwave clearance is not likely to influence the overall form and function of the system and recovery via natural processes is therefore expected. The rate of recovery would vary in relation to the rate of sediment transport processes, i.e. faster infill and recovery rates will be associated with higher local flow speeds and more frequent wave influence (see volume 1, 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.

5.2.2.5 Pre-construction boulder clearance may affect a corridor of between 25 m (for interconnector cables and export cables) and 15 m (for array cables), with cable burial affecting a corridor of up to 15 m width (coinciding with the boulder clearance corridor). Boulder clearance may result in a redistribution of boulders 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 boulders and cobbles within the Hornsea Three array, including the western section of the rMCZ (see section 2.7.1 of volume 2, chapter 2: Benthic Ecology) this is considered unlikely to represent a significant shift in the baseline situation and, since no sediment/substrate is being removed from the rMCZ, this will not act as a barrier for the recovery of any epifaunal communities impacted during the process.

5.2.2.6 Following offshore wind turbine installation, jack-up footprints may remain on the seabed for a number of years, particularly in cohesive sediments (see 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 (i.e. Barrow and L&ID offshore wind farms; BOWind, 2008; EGS, 2011). However, the volume and dimensions of the depression may reduce over time due to local seabed movement under gravity and in proportion to the rate of sediment transport through the area. The presence of such indentation features is not predicted to have implications for sediment transport across Hornsea Three and these footprints will infill over time (see section 1.11.2 of volume 2, chapter 1: Marine Processes).

Table 5.4: Temporary habitat loss/disturbance within Markham's Triangle rMCZ during the construction phase.

Project Element	Total habitat loss (m^2)	Assumptions (see maximum design scenario table in section 2.8 of volume 2, chapter 2: Benthic Ecology for full description of Hornsea Three maximum design scenario)
Pre-construction sandwave clearance	2,357,400	Assumes that 10% of the sandwave clearance within the Hornsea Three array area (23,574,000 m^2) will occur within Markham's Triangle rMCZ, affecting a corridor of 30 m width (see volume 1, chapter 3: Project Description).
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 m^3.
Deposition of material from seabed preparation for GBFs	1,009,150	Assumes maximum of 24% of the total 4,223,330 m^2 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 m^2 of temporary habitat loss from jack-up placements within the Hornsea Three array area.
Array, substation interconnector and export (within the Hornsea Three array area) cable (includes boulder clearance) burial	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 25 m (for boulder clearance; cable burial to affect a 15 m corridor).
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	-

5.2.2.7 This was shown 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 PSA 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 recover into these areas, as the sediment infills the depressions.

5.2.2.8 Using the spatial extents of the qualifying habitats mapped in Defra (2014; see Figure 4.5), the total predicted temporary habitat loss/disturbance to each of the proposed features of the Markham's Triangle rMCZ is as follows (Note: this represents the maximum adverse scenario for each broadscale habitat feature individually and therefore construction would not lead to a sum of the areas/proportions below being affected by temporary habitat loss):

- 5,872,589 m^2 of Subtidal Coarse Sediments equating to 4.03% of the total extent of this proposed feature 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 m^2 of Subtidal Sand sediment equating to 2.37% of the total extent of this proposed feature within the Markham's Triangle rMCZ – assuming that, as Subtidal Sand extends over approximately 10.6% of the area of the Markham's Triangle rMCZ coinciding with the Hornsea Three array area, 10.6% of the maximum temporary habitat loss/disturbance could occur within this habitat; and
- 760,787 m^2 of Subtidal Mixed Sediments equating to 2.76% of the total extent of this proposed feature 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.

5.2.2.9 As shown in Figure 4.5, the baseline characterisation identified that most of the area of Markham's Triangle rMCZ was characterised by the PoVen biotope with smaller areas of the MysThyMx biotope in the west and north east of the site. These biotopes are considered to represent the communities within the Subtidal Coarse Sediment and Subtidal Mixed Sediment broadscale habitat features within Markham's Triangle rMCZ.

5.2.2.10 The biological assemblage present in the PoVen biotope is characterised by species that are relatively tolerant of penetration and disturbance of the sediments. This biotope is characterised by relatively diverse communities of polychaetes and venerid bivalves and 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. 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, 2016c). 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 considered to be medium. For heavy deposition under sand wave clearance material, small bivalves can migrate through up to 50 cm of sand. The material will be deposited within similar habitats in the Markham's Triangle rMCZ, with individuals considered more likely to be able to escape from material that is similar to the material they are commonly found in (Tillin, 2016c). Resistance is assessed as low, resilience is assessed as medium and overall sensitivity is considered to be medium (Tillin, 2016c).

5.2.2.11 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 medium and to penetration of the surface is 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 or seabed preparation material is also predicted to be low as bivalve and polychaete species have been reported to migrate through depositions of sediment greater than the MarESA benchmark for the *Smothering and siltation rate changes (Heavy)* pressure (i.e. deposition of up to 30 cm of fine material added to a habitat in a single discrete event). As such, resistance is low, some mortality will occur but recovery is likely to be high. Extraction, including seabed preparation and sandwave clearance, 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 is assessed as medium.

5.2.2.12 The communities associated with the Subtidal Coarse Sediments and Subtidal Mixed Sediments will be directly affected by construction activities within the Hornsea Three array area during the construction phase, with some temporary declines in localised areas (i.e. in the immediate vicinity of construction operations). Recoverability in most cases is likely to be high and typically within five years or less, as a result of passive import of larvae and active migration of juveniles and adults from adjacent non-affected areas.

5.2.2.13 As detailed in paragraph 4.3.1.6, the sandy sediment biotopes within the Hornsea Three array area included NcirBat, FfabMag and AfilMysAnit in the western corner of Markham's Triangle rMCZ. NcirBat and FfabMag 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). At the sediment surface any displaced infauna may be vulnerable to predation from echinoderms and bottom feeding fish, however significant declines in overall species richness are unlikely to be seen and the recoverability of these communities is therefore assessed as high (Tillin, 2016a).

5.2.2.14 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%. Activities associated with aggregate extraction is analogous to some offshore wind farm construction activities (e.g. sandwave clearance), although compared to activities such as anchor disturbance and cable burial, aggregate extraction, involving complete removal of sediment, represents a greater impact on seabed sediments. 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).

5.2.2.15 With respect to abrasion/physical disturbance resulting from jack-up operations and anchor placements, the communities associated with the NcirBat and FfabMag biotopes are likely to be intolerant, although this intolerance will depend on the depths in the sediment in which infauna live and the depth of the disturbance. 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). Any epifaunal species (which were mostly absent from areas of Subtidal Sand) may also be vulnerable, including larger faunal species such as the echinoderm *A. rubens*. However, this species typically exhibits good powers of regeneration and high fecundity, and so recoverability is also likely to be high (Budd, 2008b).

5.2.2.16 Overall, the NcirBat and FfabMag biotopes have some tolerance to temporary habitat loss/disturbance, due to the natural levels of physical disturbance in their environment and the high recovery potential from a combination of recruitment from surrounding unaffected areas and larval dispersal, with full recovery of habitats expected within a maximum of five years following construction.

5.2.2.17 The biotope AfilMysAnit was recorded in the western boundary of the rMCZ. 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 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 *K. 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.

5.2.2.18 Overall sensitivity of the AfilMysAnit biotope was 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 the NcirBat and FfabMag biotopes (i.e. potentially greater than five years, but less than ten years). It should be noted, however, that the AfilMysAnit biotope present in the western section of Markham's Triangle rMCZ is not a typical version of this biotope, which is usually characterised by subtidal mud sediment. In the western part of the rMCZ, the sediments are classified as sand and muddy sand sediment (according to the Folk classification and consistent with the Subtidal Sand broadscale habitat feature of the rMCZ) and the AfilMysAnit biotope in this area is considered to be a transition between the shallower sandy sediments characterising Markham's Triangle and the deeper muddy sediments within Markham's Hole, to the south and west, outside the rMCZ boundary. As such, recovery of sediments (and thereafter the associated communities) would be expected to occur over a shorter period than would be expected for the more typical AfilMysAnit biotope in muddy sediment. The assumption of full recovery over a period of up to ten years (i.e. as per De-Bastos, and Hill, 2016a) should therefore be considered to be conservative.

5.2.2.19 Repeat disturbance of the proposed broadscale habitat features of Markham's Triangle rMCZ is not predicted to occur during the construction phase following installation of turbines and cables (disturbance during the operation and maintenance phase is considered in paragraphs 5.2.3.13 *et seq*.). 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 within which these activities may occur, the proposed broadscale habitat features of Markham's Triangle rMCZ habitats are not predicted to have substantially recovered within this timeframe and, as such, this is not considered to constitute repeat disturbance but rather a conitunation of the original disturbance activity. Cable installation will affect discrete corridors (i.e. up to 30 m wide for sandwave clearance and up to 15 m wide for cable burial) and there is 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 only potential for repeat disturbance during the construction phase is related to increases in SSC and associated sediment deposition, i.e. where the seabed over installed cables or adjacent to turbines are subjected to increases in SSC and deposition during other construction operations in adjacent areas (e.g. seabed preparation for foundation installation, or installation of cables, including sandwave clearance). Full consideration of the effect of SSC and sediment deposition on the broadscale habitat features of Markham's Triangle rMCZ is provided in paragraph 5.2.2.26 *et seq*., although due to the limited sensitivity of the relevant biotopes to increases in SSC and deposition and the intermittent nature and short duration of the impact, it is not expected that recovery of these biotopes following temporary habitat loss/disturbance from cable installation would be delayed as a result of increases in SSC and sediment deposition in adjacent areas.

5.2.2.20 Based on the information presented above, the following can be concluded with respect to the physical attributes of the proposed habitat features of Markham's Triangle rMCZ (Table 5.3):

- **Extent and distribution** of the proposed habitat features will be maintained following the construction phase, with only a small proportion of these habitats affected and these effects limited to the western portion of the Markham's Triangle rMCZ. In addition, any effects on proposed habitat features will be temporary and reversible with all displaced sediments retained within the rMCZ and recovery of sediments occurring following completion of construction;
- **Sediment movement and hydrodynamic regime:** Sediment movement associated with cable burial, jack-up footprints and anchor placements are expected to be highly localised, with short lived effects only occurring during the construction activities and returning to baseline levels following cessation of the activity. Seabed preparation for foundation installation and sandwave clearance will result in displacement of significant quantities of sediments, although these will be deposited at a location which ensures retention of the sediments within the local sediment transport system in the rMCZ. In addition, evidence drawn from aggregate dredging activities indicate that if any changes occur to the flow conditions or wave regime, these would be local to the dredge pocket, which for the aggregates industry cover a considerably larger spatial extent than those proposed for Hornsea Three (i.e. lengths and widths of several kilometres in the aggregates industry compared to tens up to 55 m diameter for foundation preparation). This indicates that there is likely to be little to no effect on the flow or wave regime and consequently no effect on the regional scale sediment transport processes across the Hornsea Three array area and offshore cable route (volume 2, chapter 1: Marine Processes); and
- **Sediment composition and distribution** will not be affected within the Markham's Triangle rMCZ, with baseline sediments during construction activities disturbed, but recovering following completion of these activities. Seabed preparation and sandwave clearance will result in disposal of sediments within the Markham's Triangle rMCZ, although the dredged sediments will be deposited close to their dredged location (i.e. in similar sediment type) and therefore will not result in a change to the sediment composition or a change in the distribution of the broadscale sediment types across the rMCZ.

5.2.2.21 Based on the information presented above, the following can be concluded with respect to the ecological attributes of the proposed habitat features of Markham's Triangle rMCZ (Table 5.3):

- **Species composition of the component communities** would not be affected, with only a small proportion (i.e. <4%) of the proposed habitat features affected during the entire construction phase and only a fraction of this proportion affected at any one time. Where temporary habitat loss occurs, this will lead to localised reductions in species richness, although full recovery of these communities into those areas affected would be expected within five years following disturbance for most biotopes (this may be longer for full recovery of the AfilMysAnit biotope), maintaining the species composition of the broad scale habitats across the Markham's Triangle rMCZ; and
- **Presence and spatial distribution** of the biological communities will be maintained across the Markham's Triangle rMCZ. Only a relatively small proportion of the proposed habitat features will be affected within the western section of the Markham's Triangle rMCZ and where biological communities are affected (e.g. mortality leading to reductions in species richness), these will occur in discrete area, with habitat loss/disturbance only affecting a small area at any one time. Following construction activities, full recovery of these communities is also predicted to occur.

5.2.2.22 As detailed in paragraph 2.3.1.5, when considering whether activities may hinder conservation objectives, consideration should be given to both direct impacts of an activity on a feature (e.g. as defined by effects on attributes and targets) and any indirect impact, such as on the effectiveness of management measures put in place to further conservation objectives. Conservation objectives are not currently available for the Markham's Triangle rMCZ and therefore those for the Cromer Shoal Chalk Beds MCZ have been used as a proxy (see paragraph 4.3.1.8). Following advice from JNCC (see Table 1.1) and the recommendations made by Net Gain (2011), it has been assumed that a general management approach of "recover to favourable condition" will be implemented for features of the Markham's Triangle rMCZ. As detailed in paragraph 4.3.1.10, the main reason for the "recover to favourable condition" conservation objective for this rMCZ is due to seabed disturbance from benthic trawling, including removal of benthic species, abrasion and penetration of the seabed.

5.2.2.23 The pressures associated with temporary habitat loss during construction (i.e. as detailed in paragraph 5.2.2.1) are similar to those associated with benthic trawling e.g. abrasion/disturbance of the substrate, penetration and/or disturbance of the substratum, albeit more localised to the construction footprint. As such, the Hornsea Three construction activities may affect the ability of the proposed features of Markham's Triangle rMCZ to recover to a favourable condition during the construction phase. However, construction operations for Hornsea Three will affect only a small proportion of the proposed features within the rMCZ, with discrete areas affected at any one time. Following construction, full recovery of these features to pre-construction baseline in the areas affected following installation of infrastructure will occur in the months to years following construction operations. Furthermore, in contrast to the pressures associated with benthic trawling, repeat disturbance of the same areas of seabed following installation of Hornsea Three infrastructure (e.g. cable installation) is not expected to occur. Therefore, the Hornsea Three construction operations are predicted to have an effect on the ability of a small proportion of the rMCZ features to recover to a favourable condition in the short term (i.e. during construction), although recovery to a pre-construction baseline will occur following construction. Due to the conservation objective for Markham's Triangle of "recover to favourable condition", recovery to a condition which is healthy and not deteriorating will likely require management measures relating to the ongoing trawling impacts.

5.2.2.24 It is not currently clear what (if any) management measures may be put in place to achieve the conservation objective of "recover to favourable condition" for the features of Markham's Triangle rMCZ and therefore it is not possible to consider the indirect impacts of this impact on such management measures. As detailed in this section of the assessment, any effects will be short term and temporary, with full recovery of associated communities occurring in the months to years following construction.

5.2.2.25 Considering the conservation objective for Cromer Shoal Chalk Beds MCZ (used as a proxy for Markham's Triangle rMCZ) the following conclusions can be made:

- While temporary habitat loss/disturbance because of Hornsea Three construction activities is predicted to affect a small proportion of the habitat features intermittently during the construction phase, these habitats will recover with the **extent of the proposed habitat features** remaining stable following the construction phase; and
- The **structures and functions, quality and composition of characteristic biological communities** will be maintained in their current condition. Hornsea Three construction will not preclude recovery to the pre-construction baseline, although as the conservation objective for Markham's Triangle is "recover to favourable condition", recovery to a condition which is healthy and not deteriorating will likely require management measures relating to trawling impacts. Recovery of the seabed sediments following Hornsea Three construction will occur in the months following construction operations, with complete recovery within the areas affected within a few years and associated communities predicted to recolonise disturbed sediments, with full recovery of characteristic biological communities within months to years of construction; as supported by analogous studies from the aggregates, offshore wind and oil and gas industry.

Increases in SSC and associated deposition due to construction operations within the Markham's Triangle rMCZ

5.2.2.26 Increases in SSC and associated sediment deposition are predicted to occur during the construction phase as a result of construction activities, including cable installation, seabed preparation and drilling for foundation installation and sandwave clearance. This assessment is equivalent to the following pressures identified by Natural England's Advice on Operations for the Thanet Coast MCZ for "Offshore wind: during construction" and " Power cable: laying, burial and protection" (Natural England, 2017):

- *Changes in suspended solids (water clarity); and*
- *Smothering and siltation rate changes (Light).*

5.2.2.27 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 specific assessment with respect to increases in SSC and subsequent sediment deposition, with a summary of the maximum design scenarios associated with this impact presented in the maximum design scenario table in section 1.8 of volume 2, chapter 1: Marine Processes. Volume 2, chapter 2: Benthic Ecology provides full details of the expected levels of SSC and associated deposition within the Hornsea Three array area, including Markham's Triangle rMCZ. These concluded that increases in SSC would be short term and intermittent, for example with seabed preparation for foundations resulting in SSCs of tens to hundreds of thousands of mg/l at the point of sediment release, reducing to the level of tens of mg/l within a plume extending between 3.5 km and 7 km from the point of sediment release. Sediment deposition effects were also predicted to be limited in extent, with most of the deposition (i.e. from coarse grained sand and gravel material) expected to be deposited close to the source (e.g. cable trench, dredge or disposal location) and finer grained material deposited over a wider area, although these are unlikely to settle to measurable thicknesses.

5.2.2.28 Based on this information, the following can be concluded with respect to the physical attributes of the proposed habitat features of Markham's Triangle rMCZ (Table 5.3):

- **Sediment composition and distribution** will not be affected due to increases in SSC and associated deposition, with most of the sediment (primarily sands and gravels) mobilised during construction operations falling out of suspension in close proximity to the source (i.e. within the same broad sediment type). Fine sediments will be advected further away, although where these settle, they will not affect the sediment composition; and
- **Water quality - turbidity:** This will be affected temporarily during construction operations, although any effects will be highly limited both spatially and temporally, occurring intermittently throughout the construction phase and returning to background levels soon after cessation of construction activities.

5.2.2.29 Within the section of the Markham's Triangle rMCZ that coincides with the Hornsea Three array area, the main characterising biotopes (associated with Subtidal Coarse Sediments and Subtidal Mixed Sediments broadscale habitat features) are the PoVen biotope with smaller areas of the MysThyMx biotope in the west and north east of the rMCZ site. 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 2016c). 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, 2016). *K. 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, 2016).

5.2.2.30 Communities associated with the Subtidal Sand broadscale habitat feature (as represented by the NcirBat, FfabMag and AfilMysAnit biotopes) have either low sensitivity or are not considered to be sensitive to increases in SSC and associated sediment deposition (De-Bastos and Hill, 2016a; Tillin and Rayment, 2016; Tillin, 2016a). As detailed in paragraph 5.1.2.34, 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 bivalves, although these species are likely to be able to clear these structures with limited mortality for most of the associated species (although as noted in 5.2.2.27, SSCs associated with Hornsea Three construction will only be >100 mg/l in close proximity to construction operations and for short periods of time). 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.

5.2.2.31 It can therefore be concluded that due to the low or no sensitivity of the broadscale habitat features of Markham's Triangle rMCZ to increases in SSC or sediment deposition (which aligns with Natural England, 2017) and the short term and intermittent nature of the activities, adverse effects on the communities associated with these features are unlikely to occur and this impact will not delay recovery of the communities affected by temporary habitat loss/disturbance (see paragraph 5.2.2.19).

5.2.2.32 Based on this information, the following can be concluded with respect to the ecological attributes of the proposed habitat features of Markham's Triangle rMCZ (Table 5.3):

- **Presence and spatial distribution of biological communities** will be maintained following construction operations. The biological communities associated with the proposed habitat features of Markham's Triangle rMCZ will not be significantly affected by increases in SSC and sediment deposition due to their relatively low sensitivity to this impact. Their presence and distribution across the Markham's Triangle rMCZ, including in proximity to the construction operations, will therefore be unaffected; and
- **Species composition of component communities** will be maintained. As outlined above, the species associated with the proposed features have relatively low sensitivity to this impact and therefore the species composition is not predicted to be significantly affected even in proximity to construction operations.

5.2.2.33 Based on the information presented here, it can be concluded that increases in SSC and associated deposition during the construction phase will not lead to a significant risk of hindering the achievement of the assumed conservation objectives for the features of the Markham's Triangle rMCZ (i.e. "recover to favourable condition"). As detailed in paragraph 4.3.1.10, the main reason for the "recover to favourable condition" conservation objective for this rMCZ is due to seabed disturbance from benthic trawling, including removal of benthic species, abrasion and penetration of the seabed, rather than pressures associated with changes in turbidity or light sediment deposition (see paragraph 5.2.2.26). As detailed above, due to the short term and intermittent nature of the impact and the low or no sensitivity of the communities associated with the habitat features of the rMCZ, any increases in SSC and sediment deposition associated with Hornsea Three construction will not affect the ability of the features of the rMCZ to recover to a favourable condition from the impacts of benthic trawling. Considering the conservation objective for Cromer Shoal Chalk Beds MCZ (used as a proxy for Markham's Triangle rMCZ) the following conclusions can be made:

- The **extent of the proposed habitat features** will not be affected by increases in SSC and associated deposition, remaining stable following the construction phase; and
- The **structures and functions, quality and composition of characteristic biological communities** will remain in (or recover to) a condition which is healthy and not deteriorating. Following completion of construction operations, the seabed sediments within the areas affected by SSC and deposition will be consistent with those present pre-construction. Many of the communities associated with the habitat features of Markham's Triangle rMCZ show tolerance or low sensitivity to increases in SSC and sediment deposition, primarily due to the dominance of infaunal communities.

5.2.3 Operational Phase

Long term habitat loss through presence of foundations, scour protection and cable protection in the Markham's Triangle rMCZ

5.2.3.1 Long term habitat loss will occur within the Markham's Triangle rMCZ directly under all foundation structures and associated scour protection and array, interconnector and export cables where cable protection is required. This assessment is equivalent to the following pressure identified by Natural England's Advice on Operations for the Thanet Coast MCZ for "Offshore wind: operation and maintenance" and "Power cable: operation and maintenance" (Natural England, 2017):

- *Physical change (to another sediment type).*

5.2.3.2 Full details of the infrastructure to be installed within the Hornsea Three array area (including Markham's Triangle rMCZ) are presented in the maximum design scenario table in section 2.8 of volume 2, chapter 2: Benthic Ecology. This long term habitat loss will directly affect the Subtidal Coarse Sediment, Subtidal Mixed Sediment and Subtidal Sand habitat features of the rMCZ.

5.2.3.3 As detailed in paragraph 5.2.2.4, for the purposes of this assessment, it is assumed that a maximum of 24% of the array infrastructure could be placed in the part of the Hornsea Three array area which coincides with the Markham's Triangle rMCZ. This assumption is based on the maximum number of structures that could be placed within this part of the Hornsea Three array area, assuming a minimum spacing of 1 km between foundations (i.e. 76 foundations for turbines, substations and accommodation platforms, of a total 319 offshore structures see paragraph 5.2.2.4). Based on this, long term habitat loss is predicted to affect up to 695,837 m^2 of seabed within the Markham's Triangle rMCZ (see Table 5.5), which equates to 0.35% of the total area of the rMCZ.

5.2.3.4 Long term habitat loss is predicted to affect each broadscale habitat feature of the Markham's Triangle rMCZ as follows (Note: this represents the maximum adverse scenario for each broadscale habitat feature individually and therefore the combined area/proportion of these habitats would not be affected by long term habitat loss/disturbance):

- Up to 695,837 m^2 of Subtidal Coarse Sediment, equating to 0.48% 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 73,939 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 10.6% of the area of the Markham's Triangle rMCZ coinciding with the Hornsea Three array area, 10.6% of the long term habitat loss could occur within this habitat; and
- 90,145 m^2 of Subtidal Mixed Sediment, equating to 0.33% 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.

5.2.3.5 Cables will be buried wherever possible (as described in paragraph 5.2.2.1 *et seq*.), however, where it is not possible to bury cables (e.g. due to unsuitable ground conditions), cable protection may be required. Cable protection, where required, would be placed over installed cables, i.e. within the same disturbance corridor affected by cable installation, including pre-construction boulder or sandwave clearance activities. Therefore the areas affected by long term habitat loss due to placement of cable protection would not be additional to those areas affected by temporary habitat loss during the construction phase (paragraph 5.2.2.1 *et seq*.).

Table 5.5: Long term habitat loss within Markham's Triangle rMCZ during the operational phase.

Project Element	Total habitat loss (m²)	Assumptions (see maximum design scenario table in section 2.8 of volume 2, chapter 2: Benthic Ecology for full description of Hornsea Three maximum design scenario)
Foundations	139,048	Assumes maximum of 24% of total long term habitat loss from GBF within the Hornsea Three array area (see volume 2, chapter 2: Benthic Ecology).
Scour protection	318,340	Assumes maximum of 24% of total long term habitat loss from scour protection associated with GBF within the Hornsea Three array area (see volume 2, chapter 2: Benthic Ecology).
Cable protection associated with inter array and substation interconnector cables	203,961	Assumes maximum of 24% of total habitat loss from cable protection associated with 830 km of inter array cables, 225 km of substation interconnector cables and 168 km of export cables within the Hornsea Three array area (10% of all cables requiring cable protection, affecting a corridor up to 7 m width (see volume 2, chapter 2: Benthic Ecology).
Cable protection associated with cable/pipeline crossings	20,846	Assumes a maximum of 24% of the total habitat loss associated with up to 35 cable/pipeline crossings within the array.
Total long term habitat loss	695,836	-

5.2.3.6 Cable protection requirements will be detailed in the Cable Specification and Installation Plan that will be agreed with the MMO, in consultation with statutory consultees, pursuant to the relevant marine licence conditions. Cable and scour protection may comprise a range of measures, including rock protection, but not including concrete mattressing. For example, cable protection measures may include integrated cable protection (which can be removed during decommissioning), although if this measure is employed, this would only be deployed in areas where it is certain that cable burial will not be possible (i.e. cable or pipeline crossings, or areas of rock substrate) prior to cable installation. The specific design of cable protection within the rMCZ will consider the baseline environment within the rMCZ including, for example, the grain size of rock protection to encourage recolonisation of these areas by fauna from surrounding areas (e.g. scour tolerant epifaunal communities, including the FluHyd biotope; see paragraph 4.3.1.5). This rock protection may comprise gravel and cobbles, with a mean grain size of 100 mm and a maximum grain size of 250 mm, which are reflective of areas of coarse and mixed sediments within the rMCZ; i.e. PSA from Markham's Triangle rMCZ Post-Survey Site Report (Defra, 2014) showed that in areas of Subtidal Mixed Sediments and Subtidal Coarse Sediments, grain sizes of >45 mm accounted for an average of 11-15% and a maximum of over 30% of the PSA in these areas (noting that cobbles are underrepresented in grab samples). Rock protection used as scour protection for foundations, if required, may be similarly sized, although would require a larger maximum diameter, e.g. up to 360 mm.

5.2.3.7 The sensitivity of the biotopes characterising the Subtidal Coarse Sediments, Subtidal Mixed Sediments (i.e. PoVen and MysThyMx) and Subtidal Sand (i.e. NcirBat, FfabMag and AfilMysAnit) broadscale habitat features to long term habitat loss is considered to be high (Tillin 2016c; De-Bastos and Hill, 2016a; Tillin and Rayment, 2016; Tillin, 2016a; De-Bastos and Marshall, 2016). It is anticipated that the sensitive design of cable protection, as indicated in paragraph 5.2.3.6, would reduce the extent of long term loss in these biotopes, allowing for some recovery of local communities in the areas affected. This would particularly be the case in the coarse and mixed sediment areas which have a significant gravel and cobble fraction and which cover almost 90% of the area of the rMCZ within the Hornsea Three array area, by minimising the change in sediment type within these areas. While the resulting coarser substrate used for cable protection would be suitable for colonisation by epifaunal communities, where sediment accumulation occurs over cable protection (e.g. though bedload transport and saltation; see paragraph 5.2.3.40), infaunal communities would also be expected to recolonise these areas.

5.2.3.8 Based on the information above, the following can be concluded with respect to the physical attributes of the proposed habitat features of Markham's Triangle rMCZ (Table 5.3):

- **Extent and distribution** of broadscale habitat features will be maintained. Hornsea Three is predicted to result in long term loss of a small proportion of the proposed habitat features (i.e. likely to be <0.5% of the proposed features of the Markham's Triangle rMCZ), although these habitats are extensive across the Markham's Triangle rMCZ and any potential losses will only occur in the western section of the rMCZ which coincides with the Hornsea Three array area. In addition, scour and cable protection measures which are appropriate for the local substrates (e.g. reflecting local sediments/substrates) and therefore will reduce the extent of any effects and allowing for some recovery of sediments (and communities discussed below) in these areas. The potential for removal of these scour and cable protection measures during decommissioning is also discussed in section 5.2.4; and
- **Sediment composition and distribution** will also largely be maintained across the Markham's Triangle rMCZ. Where habitats are lost beneath foundation structures and scour and cable protection, these will be in discrete areas, with only localised effects on sediment composition (i.e. in the immediate vicinity of the structures; further discussed in paragraph 5.2.3.38 *et seq.*). As detailed above, it would be expected that in some areas, the sediments from adjacent areas may naturally accumulate on parts of the scour and cable protection allowing for some recovery of sediments in these areas.

5.2.3.9 Based on the information above, the following can be concluded with respect to the ecological attributes of the proposed habitat features of Markham's Triangle rMCZ (Table 5.3):

- **Species composition of the component communities** across the Markham's Triangle rMCZ will be maintained following placement of cable protection. Although a small proportion of the habitat features will be lost for the lifetime of Hornsea Three, the species composition of the communities associated within the areas of unaffected Subtidal Coarse Sediment, Subtidal Mixed Sediment or Subtidal Sand features (i.e. >99.5% of these features within the Markham's Triangle rMCZ) will remain in the pre-construction baseline condition during the lifetime of Hornsea Three. As discussed above, many of the species associated with these habitat features may colonise areas affected by cable and scour protection placement (e.g. colonisation of accumulated sediment, or epifaunal colonisation of the cable and scour protection itself, as well as turbine foundations (discussed further in paragraph 5.2.3.22 *et seq*. below)) thereby somewhat reducing the effects of habitat loss; and
- **Presence and spatial distribution of the biological communities** will be maintained during the Hornsea Three operational phase, with only a small proportion of these habitats affected in discrete areas. Due to the localised habitat loss effects, limited to discrete parts of the western section of the Markham's Triangle rMCZ which coincides with Hornsea Three array area, spatial distribution of biological communities across the rMCZ will be maintained.

5.2.3.10 As detailed in paragraph 2.3.1.5, when considering whether activities may hinder conservation objectives, consideration should be given to both direct impacts of an activity on a feature (e.g. as defined by effects on attributes and targets) and any indirect impact, such as on the effectiveness of management measures put in place to further conservation objectives. Based on the information presented here, it can be concluded that long term habitat loss due to Hornsea Three infrastructure during the operational phase will not lead to a significant risk of hindering the achievement of the assumed conservation objectives for the features of the Markham's Triangle rMCZ (i.e. "recover to favourable condition"). As detailed in paragraph 4.3.1.10, the main reason for the "recover to favourable condition" conservation objective for this rMCZ is due to seabed disturbance from benthic trawling, including removal of benthic species, abrasion and penetration of the seabed.

5.2.3.11 The pressure associated with long term habitat loss (i.e. physical change (to another sediment type)) is fundamentally different to those associated with benthic trawling and as detailed in the preceding paragraphs, the proportion of the proposed features which may be affected by long term habitat loss is limited in the context of the extents of these features within the rMCZ. Furthermore, the use of sensitive scour and cable protection measures may allow for some recovery of communities associated with the proposed features of the rMCZ into areas affected by scour and cable protection. Long term habitat loss due to the presence of Hornsea Three infrastructure will therefore not affect the ability of the features of the rMCZ to recover to a favourable condition from the impacts of benthic trawling due to the highly discrete areas affected and the absence of repeat disturbance following installation of cable and scour protection. There is currently no information on the likely management measures which may be put in place to achieve the "recover to a favourable condition" conservation objective once the rMCZ is designated and therefore it is not possible to consider the indirect impacts of this impact on such management measures.

5.2.3.12 Considering the conservation objective for Cromer Shoal Chalk Beds MCZ (used as a proxy for Markham's Triangle rMCZ) the following conclusions can be made:

- Hornsea Three is predicted to result in long term loss of a small proportion of the qualifying features (i.e. <0.5% of the Subtidal Coarse Sediment, Subtidal Mixed Sediment or Subtidal Sand features), although as noted in section 4.3, these habitats are extensive across the Markham's Triangle rMCZ. This maximum proportion is likely to be precautionary, however, as recovery of sediments and communities into these areas is likely to occur in some conditions, both from natural processes and, as noted in paragraph 5.2.3.6, using sensitive cable and scour protection measures, further reducing the proportion of habitat affected. It can therefore be concluded that the **extent of the proposed habitat features** will not be significantly affected by long term habitat loss; and
- The **structures and functions, quality and composition of characteristic biological communities** across the Markham's Triangle rMCZ will remain in (or recover to) a condition which is healthy and not deteriorating. Although a small proportion of the habitat features will be lost for the lifetime of Hornsea Three (effects beyond this are considered in section 5.2.4), the biological communities across the unaffected >99.5% of the habitat features of the Markham's Triangle rMCZ will remain in the pre-construction baseline condition with no effects on the structures, functions, quality and composition of the communities as a result of Hornsea Three infrastructure. In addition, as discussed in paragraphs 5.2.3.6, some recovery of elements of the characteristic biological communities to areas affected by long term habitat loss would be expected.

Maintenance operations within Markham's Triangle rMCZ during the operational phase, resulting in temporary seabed disturbances

5.2.3.13 Direct loss/disturbance of subtidal habitat within Markham's Triangle will occur as a result of jack up operations and cable remedial burial and repair activities within the Hornsea Three array area. Volume 2, chapter 2: Benthic Ecology provides further detail on the project envelope assumptions with respect to cable installation. This assessment is equivalent to the following pressures identified by Natural England's Advice on Operations for the Thanet Coast MCZ for "Power cable: laying, burial and protection" (Natural England, 2017):

- *Abrasion/disturbance of the substrate on the surface of the seabed;* and
- *Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion*.

5.2.3.14 Over the 35 year design life of Hornsea Three, maintenance activities (i.e. jack up operations and cable remedial burial and repair activities) within the Hornsea Three array area will affect up to 1,625,776 m^2 of seabed within Markham's Triangle rMCZ. The activities associated with maintenance operations will be similar (or considerably less than) to those considered in the construction phase (see section 5.2.2). 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 could occur in the part of the Hornsea Three array which overlaps with the Markham's Triangle rMCZ (see paragraph 5.2.2.2 for a full explanation of this reasoning).

5.2.3.15 Using the spatial extents of the broadscale habitat features mapped in Defra (2014; see Figure 4.5), 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.

5.2.3.16 The sensitivities of the biotopes associated with the Subtidal Coarse Sediments and Subtidal Mixed Sediments (i.e. PoVen and MysThyMx biotopes) are discussed in paragraph 5.2.2.7 *et seq*. and show that the communities associated with the Subtidal Coarse Sediments and Subtidal Mixed Sediments will be directly affected by construction activities within the Hornsea Three array area during the construction phase, with some temporary declines in localised areas (i.e. in the immediate vicinity of construction operations). Recoverability in most cases is likely to be high and typically within five years or less, because of passive import of larvae and active migration of juveniles and adults from adjacent non-affected areas.

5.2.3.17 For Subtidal Sand biotopes, recovery is expected within months to years following maintenance operations, with full recovery within a maximum of five years for the NcirBat and FfabMag biotopes (see paragraph 5.2.2.13 *et seq*.). The AfilMysAnit biotope was considered to have higher sensitivity than other Subtidal Sand biotopes, and total recovery of this biotope following habitat loss/disturbance effects, could potentially take over five years, although this is considered to be conservative (see paragraph 5.2.2.17 *et seq*.).

5.2.3.18 Based on the information presented above, the following can be concluded with respect to the physical attributes of the proposed habitat features of Markham's Triangle rMCZ (Table 5.3):

- **Extent and distribution** of the proposed habitat features will be maintained following maintenance operations during the operational phase, with only a small proportion (i.e. <1.2% over the 35 year design life of Hornsea Three) of these habitats affected and these effects limited to highly discrete areas in the western portion of the Markham's Triangle rMCZ. In addition, any effects on proposed habitat features will be temporary and reversible and recovery of sediments will occur following completion of maintenance operations;
- **Sediment movement and hydrodynamic regime:** Sediment movement associated with maintenance operations are expected to be highly localised, with short lived effects only occurring during the jack-up operations and cable maintenance activities and returning to baseline levels following cessation of the activity; and
- **Sediment composition and distribution** will not be affected within the Markham's Triangle rMCZ, with highly localised disturbances to baseline sediments during maintenance activities, but recovering following completion of these activities;

5.2.3.19 Based on the information presented above, the following can be concluded with respect to the ecological attributes of the proposed habitat features of Markham's Triangle rMCZ (Table 5.3):

- **Species composition of the component communities** would not be affected, with only a small proportion (i.e. <0.8%) of the proposed habitat features affected during the design life of Hornsea Three and only a fraction of this proportion affected at any one time. Where temporary habitat loss occurs, this will lead to localised reductions in species richness, although full recovery of these communities into those areas affected would be expected within five years following disturbance for most biotopes (this may be longer for full recovery of the AfilMysAnit biotope), maintaining the species composition of the broad scale habitats across the Markham's Triangle rMCZ; and

- **Presence and spatial distribution of the biological communities** will be maintained across the Markham's Triangle rMCZ. Only a very small proportion of the proposed habitat features will be affected within the western section of the Markham's Triangle rMCZ and where biological communities are affected (e.g. mortality leading to reductions in species richness), these will occur in discrete areas, with habitat loss/disturbance only affecting highly restricted areas at any one time. Following construction activities, full recovery of these communities is also predicted to occur.

5.2.3.20 As discussed in paragraph 5.2.2.22 *et seq*., the pressures associated with temporary habitat loss/disturbance (i.e. paragraph 5.2.3.13) are similar to those associated with benthic trawling e.g. abrasion/disturbance of the substrate, penetration and/or disturbance of the substratum. The effects of maintenance activities on the features of Markham's Triangle rMCZ are similar to those of the construction phase, although impacts would be considerably reduced, with a smaller proportion of the features affected over a much longer period. As with the construction phase, full recovery of these features in the areas affected by maintenance operations will occur following completion of these activities. While maintenance activities may result in repeat disturbance to some areas of seabed during the 35 year lifetime of the project (e.g. jack-up operations), these would be expected to be intermittent, highly restricted in extent and most likely to only occur in close proximity to turbine foundations. Hornsea Three maintenance operations will therefore not hinder the ability ability of the rMCZ features to recover to a favourable condition during the lifetime of the project. As discussed for the construction phase (see paragraph 5.2.2.24), no information is available on what (if any) management measures may be put in place to achieve the conservation objective of "recover to favourable condition" for the features of Markham's Triangle rMCZ and therefore it is not possible to consider the indirect impacts of this impact on such management measures.

5.2.3.21 Considering the conservation objective for Cromer Shoal Chalk Beds MCZ (used as a proxy for Markham's Triangle rMCZ) the following conclusions can be made:

- Temporary habitat loss/disturbance is predicted to affect a very small proportion of the habitat features intermittently during the operational phase and these habitats will recover following disturbance with the **extent of the proposed habitat features** remaining stable following the construction phase; and
- The **structures and functions, quality and composition of characteristic biological communities** will remain in (or recover to) a condition which is healthy and not deteriorating. Recovery of the seabed sediments will occur in the months following maintenance operations, with complete recovery within the highly localised areas affected within a few years and associated communities predicted to recolonise disturbed sediments, with full recovery of characteristic biological communities within months to years of maintenance activities; as supported by analogous studies from the aggregates, offshore wind and oil and gas industry.

Colonisation of offshore foundations and scour and cable protection within Markham's Triangle rMCZ

5.2.3.22 Introduction of hard substrates because of the installation of foundation structures and associated scour protection, and cable protection for array, interconnector and export cables will occur within the Markham's Triangle rMCZ, and could result in colonisation of these hard substrates. This assessment is equivalent to the following pressure identified by Natural England's Advice on Operations for the Thanet Coast MCZ for "Offshore wind: operation and maintenance" and "Power cable: operation and maintenance" (Natural England, 2017):

- *Physical change (to another sediment type).*

5.2.3.23 Based on the assumptions set out in the maximum design scenario table in section 2.8 of volume 2, chapter 2: Benthic Ecology, a total of up to 944,322 m^2 of hard substrate may be introduced into the Markham's Triangle rMCZ for up to the 35 year design life Hornsea Three (i.e. as per paragraph 5.2.2.4, assuming a maximum of 24% of the array infrastructure in the rMCZ; see Table 5.6). This impact will indirectly affect the Subtidal Coarse Sediment, Subtidal Mixed Sediment and Subtidal Sand habitat features of the Markham's Triangle rMCZ.

5.2.3.24 Within Markham's Triangle rMCZ, extensive areas of hard substrates are relatively rare with a seabed characterised by sand and coarse sediments (see Figure 4.5) and therefore introduction of hard substrates to these soft sediment habitats will represent a change in the communities within the rMCZ, enabling establishment of species not usually associated with soft sediment habitats.

5.2.3.25 The introduction of new hard substrate will represent a potential shift in the communities within the Hornsea Three array area (including the western portion of Markham's Triangle rMCZ). Biodiversity and biomass are likely to increase, as has been observed at the Egmond aan Zee offshore wind farm (Lindeboom *et al*., 2011), and 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.

Table 5.6: Maximum surface area from introduction of hard substrate within Markham's Triangle rMCZ during the operational phase.

Project Element	Total surface area (m²)	Assumptions (see maximum design scenario table in section 2.8 of volume 2, chapter 2: Benthic Ecology for full description of Hornsea Three maximum design scenario)
Foundations	354,694	Assumes maximum of 24% of total habitat created from GBF within the Hornsea Three array area (see volume 2, chapter 2: Benthic Ecology).
Scour protection	316,544	Assumes maximum of 24% of total habitat created from scour protection associated with GBF within the Hornsea Three array area (see volume 2, chapter 2: Benthic Ecology).
Cable protection associated with inter array and substation interconnector cables	252,237	Assumes maximum of 24% of total habitat created from cable protection associated with 830 km of inter array cables, 225 km of interconnector cables and 168 km of export cables within the Hornsea Three array area (see volume 2, chapter 2: Benthic Ecology).
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 (see volume 2, chapter 2: Benthic Ecology).
Total surface area of introduced habitat	944,321	-

5.2.3.26 Other studies have shown similar findings, with the blue mussel *Mytilus edulis*, Anthozoa and *Jassa* spp. found to be the dominant species (particularly mussels in the 1 m zone on turbine foundation; 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. Presence of mussels and shell debris on the adjacent seabed 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 mussel 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.

5.2.3.27 The placement of scour protection material within Hornsea Three will also 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, the Greater Wash Strategic Environmental Assessment (SEA) (Linley *et al.,* 2007) reviewed evidence associated with European lobster *Homarus gammarus* and artificial reefs and discussed potential benefits for this species associated with offshore wind farm infrastructure (e.g. scour and cable protection). As detailed in paragraph 5.2.3.6, cable and scour protection within Markham's Triangle rMCZ will be designed to consider the local baseline conditions. Any rock protection used in this area may be limited to an average grain size of 100 mm to a maximum grain size of 250 mm. The use of cable and scour protection measures which reflect the baseline environment, will encourage colonisation by species and communities which already occur within the rMCZ. Given the presence of scour tolerant epifaunal species and colonising fauna within Markham's Triangle rMCZ (e.g. represented by the FluHyd biotope; Figure 4.5), colonisation of scour and cable protection will be dominated by local fauna, including bryozoans, hydroids, tubeworms and ascidians.

5.2.3.28 Based on this information, the following can be concluded with respect to the ecological attributes of the proposed habitat features of Markham's Triangle rMCZ (Table 5.3):

- **Presence and spatial distribution of biological communities** will be maintained during the operational phase. It is expected that the introduction of hard substrates will offer opportunities for epifaunal communities already present within Markham's Triangle rMCZ (e.g. scour tolerant species colonising coarse gravelly sediments, cobbles and boulders) to expand their range onto the introduced hard substrates. The presence and distribution of these communities across the MCZ, including in areas where foundation structures and cable and scour protection is installed, will therefore be unaffected; and
- **Species composition of component communities** will be maintained during the Hornsea Three operational phase. As outlined above, many of the species (particularly epifaunal species) associated with the proposed features of the Markham's Triangle rMCZ are expected to colonise foundation structures and scour and cable protection. Some reef effects may result in expansion of taxa normally associated with hard substrates colonising areas of Subtidal Coarse Sediment, Subtidal Mixed Sediment or Subtidal Sand, although these effects are likely to be limited to the immediate vicinity of offshore structures and will not result in changes to the species composition of communities associated with the proposed habitat features across the wider Markham's Triangle rMCZ. As noted above, the taxa with the greatest potential for opportunities are native to the southern North Sea (e.g. mussels and barnacles) as was evidenced from previous colonisation studies in the North Sea (e.g. Krone *et al*., 2013; Lindeboom *et al*., 2011). The use of cable and scour protection measures which reflect the local substrates (paragraph 5.2.3.6 *et seq*.) will also encourage colonisation by species local to the rMCZ.

5.2.3.29 Based on the information presented here, it can be concluded that colonisation of Hornsea Three infrastructure during the operational phase will not lead to a significant risk of hindering the achievement of the assumed conservation objectives for the features of the Markham's Triangle rMCZ (i.e. "recover to favourable condition"). As detailed in paragraph 4.3.1.10, the main reason for the "recover to favourable condition" conservation objective for this rMCZ is due to seabed disturbance from benthic trawling, including removal of benthic species, abrasion and penetration of the seabed. Effects related to colonisation of hard substrates (by species and communities occurring within the rMCZ) are fundamentally different pressure to that associated with benthic trawling and as such, there is no clear pathway whereby colonisation of hard substrates could affect the recovery of proposed features to a favourable condition. Considering the conservation objective for Cromer Shoal Chalk Beds MCZ (used as a proxy for Markham's Triangle rMCZ) the following conclusions can be made:

- The **extents of the proposed habitat features** will not be affected by this impact; and
- The **structures and functions, quality and composition of characteristic biological communities** across the Markham's Triangle rMCZ will remain in (or recover to) a condition which is healthy and not deteriorating, as detailed in paragraph 5.2.3.26.

Increased risk of introduction or spread of INNS due to presence of subsea infrastructure and vessel movements (e.g. ballast water) within Markham's Triangle rMCZ

5.2.3.30 For the purposes of this assessment, the risks of introduction and spread of INNS from both the construction and the operational phase have been considered. This assessment is equivalent to the following pressure identified by Natural England's Advice on Operations for the Thanet Coast MCZ for "Offshore wind: operation and maintenance" and "Power cable: operation and maintenance" (Natural England, 2017):

- *Introduction or spread of invasive non-indigenous species.*

5.2.3.31 As discussed in paragraph 5.2.3.22, up to 944,322 m^2 of hard substrate will be introduced to the Markham's Triangle rMCZ for the duration of the Hornsea Three operational phase, presenting opportunities for colonisation by INNS. There will also be a risk of introduction and spread of INNS in ballast water through the up to 10,474 round trips to port during the construction phase and up to 2,822 annual round trips to port during the operational phase of Hornsea Three.

5.2.3.32 There are two potential vectors which would represent a potential increased risk of impact by the introduction of INNS within the Hornsea Three array area. Firstly, the introduction of new surface area available for colonisation associated with the turbines and associated scour protection and cable protection which may be required within the Hornsea Three array area. Secondly, the array area 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 10,474 vessel movements during the construction phase to port by construction vessels will be to the Hornsea Three array area. Similarly, the majority of the 2,822 round trips to port per year, over 35 years, 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 the Hornsea Three array area.

5.2.3.33 While there is a potential risk of impacts by INNS within the Hornsea Three array area, where the majority of introduced habitat will be placed and most vessel movements will be focussed, the implementation of appropriate control measures will minimise this risk as much as is practical. These include a biosecurity plan, a PEMMP and vessels complying with the IMO ballast water management guidelines (see designed-in mitigation table in section 2.10 of volume 2, chapter 2: Benthic Ecology). For example, there is potential for INNS to be introduced into the rMCZ via hard structures (e.g. foundations, cable and scour protection), particularly if these originate from the marine environment. The biosecurity plan would provide details of the origin of the materials to be placed on the seabed and where there is an identified risk of introduction or spread of INNS, appropriate measures such as removal/cleaning of all biological material from structures and detailed inspections to minimise such a risk would be employed. Where materials come from a non-marine source, such a risk would not exist. The plan will also outline measures to ensure vessels comply with the 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.

5.2.3.34 Volume 2, chapter 2: Benthic Ecology provides a detailed description of the evidence surrounding INNS and identifying some of the key species of concern, including Japanese skeleton shrimp *Caprella mutica*, the carpet sea squirt *Didemnum vexillum* and the American slipper limpet. The habitats and communities within the Hornsea Three array area, including those associated with the Subtidal Coarse Sediment, Subtidal Mixed Sediment and Subtidal Sand features of Markham's Triangle, are considered to be sensitive to impacts from the introduction of INNS. This is because the installation of hard surfaces associated with Hornsea Three may 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 may be more likely to establish than local populations. According to the MarESA (De-Bastos and Marshall, 2016; 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*.

5.2.3.35 The use of cable and scour protection measures which reflect the background substrates (see paragraph 5.2.3.6) will help to reduce the risk of colonisation by INNS, by providing a substrate that is similar to those occurring within Markham's Triangle rMCZ, encouraging colonisation by scour tolerant epifaunal species native to the rMCZ. Furthermore, 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.

5.2.3.36 Based on this information, the following can be concluded with respect to the ecological attributes of the proposed habitat features of Markham's Triangle rMCZ (Table 5.3):

- **Presence and spatial distribution of biological communities** will be maintained during the Hornsea Three operational phase. As discussed in paragraphs 5.2.3.24 and 5.2.3.26, it would be expected that biological species and communities already present within the Markham's Triangle rMCZ, particularly epifaunal components, will colonise the introduced hard substrates, particularly if cable and scour protection take into account the baseline environment, with the presence and distribution of these communities predicted to be unaffected across the rMCZ;
- **Species composition of component communities** will be maintained, with many of the species (particularly epifaunal species) associated with the proposed habitat features of the Markham's Triangle rMCZ expected to colonise the hard substrates, with no adverse effects on the species composition; and
- **Non-native species and pathogens:** The risk of introduction of non-native species and pathogens will be minimised through the implementation of appropriate measures as specified in paragraph 5.2.3.30. As noted in paragraph 5.2.3.34, there is some evidence of non-native species being present within the former Hornsea Zone, and therefore the measures to be employed by Hornsea Three will seek to both minimise the risk of spread of these species, as well as minimising the risk of introduction of other INNS to the Markham's Triangle rMCZ.

5.2.3.37 Based on the information presented here, it can be concluded that the potential introduction and spread of INNS as a result of operation of Hornsea Three will not lead to a significant risk of hindering the achievement of the assumed conservation objectives for the features of the Markham's Triangle rMCZ (i.e. "recover to favourable condition"). As detailed in paragraph 4.3.1.10, the main reason for the "recover to favourable condition" conservation objective for this rMCZ is due to seabed disturbance from benthic trawling, including removal of benthic species, abrasion and penetration of the seabed, which is a fundamentally different pressure to that associated with this impact (i.e. introduction or spread of INNS). As such, there is no clear pathway whereby this impact could affect the recovery of proposed features to a favourable condition, particularly when considering the measures to be implemented to minimise the risk of introduction or spread of INNS. Considering the conservation objective for Cromer Shoal Chalk Beds MCZ (used as a proxy for Markham's Triangle rMCZ) the following conclusions can be made:

- The **extents of the proposed habitat features** will not be affected by this impact; and
- The **structures and functions, quality and composition of characteristic biological communities** across the Markham's Triangle rMCZ will remain in (or recover to) a condition which is healthy and not deteriorating. While the introduction and spread of INNS may have effects on characterising faunal communities of the habitat features of Markham's Triangle rMCZ, including the composition and quality of these, the designed-in measures to be adopted as part of Hornsea Three will minimise the risk of introduction and spread of INNS.

Alteration of seabed habitats arising from effects on physical processes, including scour effects and changes in the wave and tidal regimes within Markham's Triangle rMCZ

5.2.3.38 Volume 2, chapter 1: Marine Processes presents a detailed assessment of the changes to waves (in isolation and cumulatively), scour and tidal currents due to the presence of Hornsea Three infrastructure during the operational phase. These changes are summarised for impacts on benthic ecology receptors in volume 2, chapter 2: Benthic Ecology. This assessment is equivalent to the following pressure identified by Natural England's Advice on Operations for the Thanet Coast MCZ for "Offshore wind: operation and maintenance" and "Power cable: operation and maintenance" (Natural England, 2017):

- *Water flow (tidal current) changes, including sediment transport considerations; and*
- *Wave exposure changes.*

5.2.3.39 The presence of Hornsea Three would result in near-field changes to the tidal current only (i.e. largely spatially limited to within the Hornsea Three array area, or the western portion of Markham's Triangle rMCZ and a narrow region just outside of the boundary (in the order of 4 km; see volume 2, chapter 1: Marine Processes). Predicted maximum changes in current speeds vary from +0.04 m/s to -0.1 m/s. Baseline tidal currents across the former Hornsea Zone vary from approximately 0.6 m/s (at High Water) to 1 m/s (at Low Water) for peak mean spring tides and as such the existing tidal strength can be classified as moderately strong (McLeod, 1996). The extent to which these continuous but localised changes in flow speed could influence rates of bedload transport within and nearby to the turbine array will depend upon the magnitude of change relative to sediment mobilisation thresholds. For example, it is probable that the predicted localised flow reductions will lessen the frequency with which sediment particles are mobilised, therefore reducing rates of sediment transport. Conversely, marginally greater rates of sediment transport may be experienced where localised flow accelerations are found. The overall result of these slight changes in flow speed could potentially be a very small reduction in the net volume of material transported as bedload through the Hornsea Three array area (see volume 2, chapter 1: Marine Processes). However, baseline rates of sediment transport across the Hornsea Three array area are understood to be low and therefore the potential for wider (indirect) morphological change to the surrounding seabed (including sandbanks) is considered to be very limited.

5.2.3.40 As detailed in volume 2, chapter 1: Marine processes, installation of cable protection may lead to sediment accumulation (in certain circumstances, e.g. where the direction of net sediment transport is perpendicular to the cable protection), creating a smooth slope against the cable protection. The process of sediment accumulation formation may take place over a period of a few months or less, depending on rates of sediment transport. Sandy sediments are transported in two modes: bedload (the process by which sands move while still in contact with the seabed) and saltation (the process by which sands are moved up into the water column). Neither process would be significantly affected with suspended sands (i.e. saltation) expected to move relatively freely over the top of the armour, although these would also regularly be deposited upon it, filling void spaces. Once any void spaces have been infilled, the saltation process is expected to be largely unaffected by the presence of the cable protection such that existing transport process (including bed form migration) will remain unaffected. Bedload transport will be temporarily affected by cable protection up until such time that the armour is covered by sand and the slope gradient either side has been reduced in response to the accumulation of a sediment wedge with stable slope angles. Following this, bedload transport will continue because the slope angle presented by sections of protected cable would be within the natural range of bed slope angles associated with bed forms mapped within the Hornsea Three array area.

5.2.3.41 For scour effects, across the Hornsea Three array area as a whole, 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), while the greatest total turbine foundation global scour footprint is associated with an array of 342 smaller (32 m base diameter) piled jacket foundations (1,091,787 m^2, equivalent to approximately 0.16% of the Hornsea Three array area). As outlined in volume 1, chapter 3: Project Description, scour protection will be installed around foundations to reduce scour. Cables and cable protection within the Hornsea Three array area will only exert a highly localised influence on the tidal regime.

5.2.3.42 The broadscale habitat features of Markham's Triangle rMCZ are characteristic of areas subject to physical disturbance by weak to moderately strong tidal stream. The communities associated with these habitat features have typically intermediate to high intolerance to large increases and decreases in flow rates. In very strong currents (i.e. not typical of the Hornsea Three array area) 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 *Magelona* 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, 2016a; Tillin and Rayment, 2016; although this is not expected for Hornsea Three, see paragraph 5.2.3.44). 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.

5.2.3.43 The AfilMysAnit biotope typically occurs in deeper waters and is generally associated with areas of weak or very weak tidal streams and so is 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 and therefore 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 and Wilson, 2008). 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.

5.2.3.44 In summary, the communities associated with the broadscale habitat features of Markham's Triangle rMCZ are considered to be sensitive to large changes in water flow rates. However, the changes in flow rates, and other physical processes, associated with Hornsea Three will be small and well below the MarESA benchmark levels used to assess the sensitivity of the receptors. Communities associated with the proposed features are therefore not expected to be particularly sensitive to the predicted changes in physical processes during the operation of Hornsea Three. This is in line with sensitivity assessments presented in Natural England's Advice on Operations which indicates Subtidal Coarse Sediment is not sensitive to changes below benchmark levels and Subtidal Sand showing a range of sensitivities from not sensitive to medium sensitivity (the former being more applicable to the changes anticipated for Hornsea Three).

5.2.3.45 Based on the information above, the following can be concluded with respect to the physical attributes of the proposed habitat features of Markham's Triangle rMCZ (Table 5.3):

- **Energy/exposure** across the Markham's Triangle rMCZ will not be affected by the presence of Hornsea Three infrastructure during the operational phase. As outlined above and in volume 2, chapter 1: Marine processes, changes in the wave and tidal energy will be small in the context of the baseline regime and this will not result in significant changes to the seabed sediments within the western section of the Markham's Triangle rMCZ coinciding with Hornsea Three, or the wider rMCZ;
- **Sediment movement and hydrodynamic regime** would be maintained during the Hornsea Three operational phase. As detailed above (and in volume 2, chapter 1: Marine processes), sediment movement, either through saltation or bedload transport may be affected in localised areas over the short term (e.g. where cable protection presents an obstruction to sediment movement, leading to accumulation of sediments along the cable protection), although the wider sediment transport and hydrodynamic regimes would not be affected; and

- **Sediment composition and distribution** will largely be maintained across the Markham's Triangle rMCZ. Scour effects may lead to some minor, localised changes in sediments around turbine foundations, although these will not affect the overall sediment composition or the distribution of sandy and coarse sediments across the Markham's Triangle rMCZ. Similarly, as discussed in the preceding paragraphs, changes in tidal flow may lead to changes in sediment transport rates, although these effects are predicted to be small and within the range of natural variability for this part of the southern North Sea.

5.2.3.46 Based on the information above, the following can be concluded with respect to the ecological attributes of the proposed habitat features of Markham's Triangle rMCZ (Table 5.3):

- **Species composition of the component communities** across the Markham's Triangle rMCZ will be maintained, with anticipated changes in the physical processes across the rMCZ (and particularly the section of the rMCZ which coincides with Hornsea Three) expected to be too small to affect benthic communities; and
- **Presence and spatial distribution of the biological communities** will be maintained across the Markham's Triangle rMCZ with anticipated changes in the physical processes across the rMCZ (and particularly the section of the rMCZ which coincides with Hornsea Three) expected to be too small to affect benthic communities.

5.2.3.47 Based on the information presented here, it can be concluded that the potential alteration of seabed habitats arising from changes in marine processes during operation of Hornsea Three will not lead to a significant risk of hindering the achievement of the assumed conservation objectives for the features of the Markham's Triangle rMCZ (i.e. "recover to favourable condition"). As detailed in paragraph 4.3.1.10, the main reason for the "recover to favourable condition" conservation objective for this rMCZ is due to seabed disturbance from benthic trawling, including removal of benthic species, abrasion and penetration of the seabed, which is a fundamentally different pressure to that associated with this impact (i.e. changes in water flow and wave energy). As such, there is no clear pathway whereby this impact could affect the recovery of proposed features to a favourable condition, particularly when considering the small changes in physical processes as a result of Hornsea Three (i.e. below the pressure benchmark where any effects on ecology would occur). Considering the conservation objective for Cromer Shoal Chalk Beds MCZ (used as a proxy for Markham's Triangle rMCZ) the following conclusions can be made:

- The **extents of the proposed habitat features** will not be affected by this impact; and
- The **structures and functions, quality and composition of characteristic biological communities** across the Markham's Triangle rMCZ will remain in (or recover to) a condition which is healthy and not deteriorating, due to the small and highly localised changes predicted on marine processes.

5.2.4 Decommissioning Phase

Temporary habitat loss due to operations to remove array cables, substation interconnector cables and jack-up operations to remove foundations within Markham's Triangle rMCZ

5.2.4.1 Effects of temporary habitat loss during the decommissioning phase within Markham's Triangle rMCZ are expected to be similar to those of the construction phase (see paragraph 5.2.2.1), although with a smaller area affected as this will not include seabed preparation for foundation installation (see Table 5.4). This will result in temporary habitat loss affecting a smaller area of up to 4,863,439 m^2 equating to 2.43% of the area of the Markham's Triangle rMCZ. Based on the assumptions regarding spatial distributions of broadscale habitat features within Markham's Triangle rMCZ outlined in paragraph 5.2.2.8, temporary habitat loss/disturbance during decommissioning is predicted to affect the following proportions of broadscale habitat features of the rMCZ:

- Up to 3.34% of the Subtidal Coarse Sediments feature within the rMCZ;
- Up to 1.96% of Subtidal Sand feature within the rMCZ (see assumptions in paragraph 5.2.2.8); and
- Up to 2.29% of the Subtidal Mixed Sediment feature within the rMCZ (see assumptions in paragraph 5.2.2.8).

5.2.4.2 For the reasons outlined in paragraphs 5.2.2.20 and 5.2.2.22, with respect to the feature attributes and targets and conservation objectives of Markham's Triangle rMCZ, it can be concluded that there is no significant risk of temporary habitat loss/disturbance due to decommissioning activities hindering the achievement of the assumed conservation objectives for the features of the Markham's Triangle rMCZ.

Increases in SSC and deposition from removal of array cables and foundations within Markham's Triangle rMCZ

5.2.4.3 Effects of increases in SSC and associated deposition due to removal of foundations and electrical cabling within Markham's Triangle rMCZ are expected to be similar, or smaller than those of the construction phase (i.e. as it will not include seabed preparation for foundation installation). As discussed in paragraphs 5.2.2.32 and 5.2.2.33, with respect to the feature attributes and targets and conservation objectives of Markham's Triangle rMCZ, it can be concluded that increases in SSC and associated deposition during the decommissioning phase will not result in a significant risk of hindering the achievement of the assumed conservation objectives for the features of the Markham's Triangle rMCZ.

Permanent habitat loss due to presence of scour/cable protection left in situ post decommissioning within Markham's Triangle rMCZ

5.2.4.4 The assessment of impacts during the Hornsea Three decommissioning phase assumes that all offshore infrastructure will be removed from the seabed, apart from cable and scour protection which, it is currently assumed, will be left *in situ*. This assessment is equivalent to the following pressure identified by Natural England's Advice on Operations for the Thanet Coast MCZ for "Offshore wind: operation and maintenance" and "Power cable: operation and maintenance" (Natural England, 2017):

- *Physical change (to another sediment type).*

5.2.4.5 Of the up to 695,837 m^2 long term habitat loss discussed in paragraphs 5.2.3.1 *et seq.*, up to 541,352 m^2 comprised scour and cable protection and, for the purposes of this assessment, is assumed to be left *in situ* (see Table 5.7). This is considered to be a conservative assumption as it assumes the maximum possible volume of scour and cable protection within Markham's Triangle MCZ and in some cases, decommissioning of cable and scour protection may be possible. The total areas of permanent habitat loss equates to approximately 0.37% of the Subtidal Coarse Sediment habitat feature, 0.22% of the Subtidal Sand habitat feature and 0.25% of the Subtidal Mixed Sediment feature of Markham's Triangle rMCZ, based on the assumptions with regard to feature distribution outlined in paragraph 5.2.3.4. Permanent loss of the broadscale habitat features of the Markham's Triangle rMCZ will be localised within the western area of the rMCZ, affecting only a small proportion of the habitat features.

Table 5.7: Permanent habitat loss within Markham's Triangle rMCZ during decommissioning phase.

Project Element	Total habitat loss (m^2)	Assumptions (see maximum design scenario table in section 2.8 of volume 2, chapter 2: Benthic Ecology for full description of Hornsea Three maximum design scenario)
Scour protection from around foundations	316,544	Assumptions as per Table 5.5 (see volume 2, chapter 2: Benthic Ecology).
Cable protection associated with inter array and substation interconnector cables	203,961	Assumptions as per Table 5.5 (see volume 2, chapter 2: Benthic Ecology).
Cable protection associated with cable/pipeline crossings	20,846	Assumptions as per Table 5.5 (see volume 2, chapter 2: Benthic Ecology).
Total permanent habitat loss	541,351	-

5.2.4.6 As detailed in paragraph 5.2.3.6 *et seq.,* cable and scour protection will be designed considering the baseline substrates present in the rMCZ, to allow for some recovery of communities into the areas affected by placement of scour and cable protection.

5.2.4.7 Based on the information above, the following can be concluded with respect to the physical and ecological attributes of the proposed habitat features of Markham's Triangle rMCZ (Table 5.3):

- **Extent and distribution of broadscale habitat features** will be maintained. Cable and scour protection left *in situ* following decommissioning will result in permanent loss of a small proportion of the proposed habitat features (i.e. a maximum of <0.4% of the proposed features of the Markham's Triangle rMCZ), although these habitats are extensive across the Markham's Triangle rMCZ and any potential losses will only occur in the western section of the rMCZ which coincides with the Hornsea Three array area. In addition, the use of scour and cable protection measures which are appropriate for the local substrates (e.g. reflecting local sediments/substrates) and therefore may serve to limit the extent of any effects, allowing for some recovery of sediments (and communities discussed below) in these areas; and
- **Sediment composition and distribution** will also largely be maintained across the Markham's Triangle rMCZ. Where habitats are lost beneath scour and cable protection post decommissioning, these will be in discrete areas, with only localised effects on sediment composition (i.e. in the immediate vicinity of the structures; further discussed in paragraph 5.2.3.38 *et seq.*). As detailed above, it would be expected that in some areas, the sediments from adjacent areas may naturally accumulate on parts of the scour and cable protection and use of appropriate protection measures may also increase the potential for recovery of sediments in these areas.

5.2.4.8 Based on the information above, the following can be concluded with respect to the ecological attributes of the proposed habitat features of Markham's Triangle rMCZ (Table 5.3):

- **Species composition of the component communities** across the Markham's Triangle rMCZ will be maintained following placement of cable protection. Although a small proportion of the habitat features will be lost following decommissioning of Hornsea Three, the species composition of the communities associated within the areas of unaffected Subtidal Coarse Sediment, mixed sediment or Subtidal Sand features (i.e. >99.6% of these features within the Markham's Triangle rMCZ) will remain in, or recover to, the pre-construction baseline condition following decommissioning of Hornsea Three. As discussed above, many of the species associated with these habitat features will colonise areas affected by cable and scour protection placement (e.g. colonisation of accumulated sediment, or epifaunal colonisation of the cable and scour protection itself) thereby somewhat reducing effects of habitat loss; and
- **Presence and spatial distribution of the biological communities** will be maintained following decommissioning of Hornsea Three, with only a small proportion of these habitats affected in discrete areas. Due to the localised habitat loss effects, limited to discrete parts of the western section of the Markham's Triangle rMCZ which coincides with Hornsea Three array area, spatial distribution of biological communities across the rMCZ will be maintained.

5.2.4.9 Based on the information presented here, it can be concluded that permanent habitat loss following decommissioning will not lead to a significant risk of hindering the achievement of the assumed conservation objectives for the features of the Markham's Triangle rMCZ (i.e. "recover to favourable condition"). As detailed in paragraph 4.3.1.10, the main reason for the "recover to favourable condition" conservation objective for this rMCZ is due to seabed disturbance from benthic trawling, including removal of benthic species, abrasion and penetration of the seabed. The pressure associated with permanent habitat loss (i.e. Physical change (to another sediment type)) is fundamentally different to those associated with benthic trawling and as detailed in the preceding paragraphs, the proportion of the proposed features which may be affected is limited in the context of the extents of these features within the rMCZ. Furthermore, the use of sensitive scour and cable protection measures may allow for recovery of communities associated with the proposed features of the rMCZ into areas affected by scour and cable protection during the operational phase and beyond post decommissioning. Permanent habitat loss due to the presence of Hornsea Three infrastructure will therefore not affect the ability of the features of the rMCZ to recover to a favourable condition from the impacts of benthic trawling. As detailed in paragraph 5.2.3.11, there is currently no information on the likely management measures which may be put in place to achieve the "recover to a favourable condition" conservation objective once the rMCZ is designated and therefore it is not possible to consider the indirect impacts of this impact on such management measures.

5.2.4.10 Considering the conservation objective for Cromer Shoal Chalk Beds MCZ (used as a proxy for Markham's Triangle rMCZ) the following conclusions can be made:

- Cable and scour protection left *in situ* following Hornsea Three decommissioning will result in permanent loss of a small proportion of the qualifying features (i.e. <0.4% of the broadscale habitat features), although as noted in section 4.3, these habitats are extensive across the Markham's Triangle rMCZ. As noted in paragraph 5.2.3.6, use of sensitive cable and scour protection measures may also allow for some recovery of sediments and communities into these areas, further reducing the proportion of habitat affected. It can therefore be concluded that the **extent of the proposed habitat features** will not be significantly affected by permanent habitat loss post Hornsea Three decommissioning; and
- The **structures and functions, quality and composition of characteristic biological communities** across the Markham's Triangle rMCZ will remain in (or recover to) a condition which is healthy and not deteriorating. Although a small proportion of the habitat features will be lost following Hornsea Three decommissioning, the biological communities across the unaffected >99.6% of the habitat features of the Markham's Triangle rMCZ will remain in, or recover to, the pre-construction baseline condition with no effects on the structures, functions, quality and composition of the communities. In addition, as discussed in paragraph 5.2.3.6, some recovery of elements of the characteristic biological communities to areas affected by permanent habitat loss would be expected.

5.2.5 Cumulative Effects

5.2.5.1 The MCAA does not provide any legislative requirement for explicit consideration of cumulative effects on features of MCZs/rMCZs. However, the MMO guidelines (MMO, 2013) state that in order for the MMO to fully discharge its duties under section 69 (1) of the MCAA, cumulative effects must be considered. As outlined in volume 1, chapter 5: EIA Methodology, for the purposes of the Hornsea Three CEA, all projects, plans and activities that were built and operational at the time of Hornsea Three data collection (field surveys etc.) were screened out of the CEA. This is because the effects of these projects have already been captured within Hornsea Three specific surveys, and hence their effects have already been accounted for within the baseline assessment. The exclusion of built and operational projects that were in place at the time of data collection/survey in this way avoids the double-counting that would occur if projects were to be included within both the baseline and the CEA.

5.2.5.2 With respect to Markham's Triangle rMCZ, there were no plans or projects which were identified as having the potential to interact cumulatively with Hornsea Three and affect the features of this rMCZ (see volume 5, annex 5.2: CEA Screening and annex 5.3: Location of Cumulative Projects, Plans and Activities) and therefore there is no required for a CEA for this rMCZ.

5.2.6 Stage 1 Assessment Conclusion

5.2.6.1 Based on the information presented in the preceding sections, it can be concluded that there is no significant risk of Hornsea Three construction, operation and decommissioning hindering the achievement of the assumed conservation objectives for Markham's Triangle rMCZ, as set out in section 4.2 (in accordance with section 125(2)(a) of the MCAA.

6. Conclusion

6.1.1.1 This MCZ Assessment has been produced for Hornsea Three to provide the necessary information to allow the SoS to meet their specific duty for MCZs as outlined in section 126 of the MCAA (2009), where:

- *(a) A public authority has the function of determining an application (whenever made) for authorisation of the doing of an act, and*
- *(b) The act is capable of affecting (other than insignificantly):*
  - *(i) The protected features of an MCZ; or*
  - *(ii) Any ecological or geomorphological process on which the conservation of any protected feature of an MCZ is (wholly or in part) dependent.*

6.1.1.2 This report has been produced to provide the necessary evidence on the impacts of Hornsea Three on three identified MCZs/rMCZs: Cromer Shoal Chalk Beds MCZ, Markham's Triangle rMCZ and Wash Approach rMCZ. The MCZ Assessment has been informed by consultation with key stakeholders, including the MMO, Natural England, The Wildlife Trusts (TWT) and the Planning Inspectorate (PINS), through the Hornsea Three MCZ Working Group. This has included discussions on baseline characterisation, the MCZ Assessment methodology and effects on key MCZ/rMCZ features.

6.1.1.3 The first stage in the assessment process was Screening to identify those MCZs/rMCZs, proposed/protected features of MCZ/rMCZs and impacts which did not require full consideration in the latter Stage 1 assessment. The Screening concluded that there was no risk of Hornsea Three significantly affecting the features of the Wash Approach rMCZ. The Screening also concluded that there was no risk of chemical contamination (e.g. accidental release of pollutants or resuspension of contaminated sediments during construction) on any of the MCZ/rMCZs considered. The Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ were carried through to the Stage 1 assessment for full assessment against the relevant Conservation Objectives and having regard to the relevant attributes and targets, as advised by the MCZ Working Group.

6.1.1.4 Background information on the Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ were collected using a combination of desktop information and Hornsea Three site specific survey data. For the Cromer Shoal Chalk Beds MCZ, the Hornsea Three offshore cable corridor was found to coincide with the Subtidal Sand broadscale habitat feature with no overlap with the Subtidal Mixed Sediments and Subtidal Coarse Sediments broadscale habitats and the Subtidal Chalk and Peat and Clay Exposures habitat FOCI, although these were present in the wider area outside the Hornsea Three offshore cable corridor. The Hornsea Three array area coincided with three of the four broadscale habitat features, with the Subtidal Mud feature outwith the Hornsea Three array area.

6.1.1.5 The Stage 1 assessment considered the effects of Hornsea Three construction, operation and decommissioning on the protected features of the Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ, with each of the impacts identified in the Screening stage discussed individually. This included consideration of effects on attributes and targets of the relevant protected features, and subsequently on the conservation objectives, using the best available scientific evidence to support conclusions made. For Cromer Shoal Chalk Beds MCZ, the assessment was undertaken based on information presented with the draft SACO, provided by Natural England through the MCZ Working Group. Since Markham's Triangle is currently a rMCZ, there are no specific conservation objectives available for this site, nor are there attributes or targets for the proposed features for designation. As such, attributes and targets for the proposed features of the rMCZ were assumed to be identical to those same protected features of the Cromer Shoal Chalk Beds MCZ, where there are common features across these sites (as recommended by the MCZ Working Group). Based on current advice from JNCC, the rMCZ is not currently considered to be in favourable condition and as such, a general management approach of "recover to favourable condition" has been applied to Markham's Triangle rMCZ in the Stage 1 assessment.

6.1.1.6 The Stage 1 assessment of the Cromer Shoal Chalk Beds MCZ considered direct effects during construction on the Subtidal Sand broadscale habitat feature and the North Norfolk Coast Assemblage of Subtidal Features and Habitats feature of geological interest (of which Subtidal Sand is a subfeature). During construction, effects of temporary habitat loss/disturbance, including cable burial and HDD operations, were concluded to be short term, highly localised and reversible (similar effects of temporary habitat loss/disturbance during operation and decommissioning were considerably reduced from construction). Direct impacts of habitat loss will not affect the other broadscale habitat features or habitat FOCI (i.e. Subtidal Chalk and Peat and Clay Exposures) as these are outwith the Hornsea Three offshore cable corridor. Indirect effects during construction associated with increases in SSC and associated deposition during cable laying, were also considered for all broadscale habitat features and habitat FOCI. It was concluded that cable installation will result in only short term and localised increases in SSC and localised sediment deposition and the sensitivity of the communities associated with these features to this impact is low. As such there is no significant risk of cable installation during the construction phase hindering the achievement of the conservation objectives of the Cromer Shoal Chalk Beds MCZ.

6.1.1.7 The Stage 1 assessment also considered effects on protected features of the Cromer Shoal Chalk Beds MCZ during the Hornsea Three operational phase, with the key impact related to placement of cable protection, where it may not be possible to sufficiently bury export cables. Where cable protection is installed, this will result in long term habitat loss during the operational phase, and permanent habitat loss following decommissioning of the project (assuming all cable protection is left *in situ*). However, long term/permanent habitat loss due to placement of cable protection (if required) will affect a small proportion (i.e. 0.02%) of the Subtidal Sand broadscale habitat within the MCZ and the use of sensitive materials for cable protection (e.g. rock protection of grain sizes similar to the baseline environment) is expected to allow for some recovery of communities into the areas affected. In cases where sediment accumulates over cable protection, the biological communities associated with the surrounding sediments would be expected to colonise this sediment and, in addition to this, some of the epifaunal components of the biological communities would be expected to colonise the cable protection measures. Effects of cable protection on sediment transport processes are also predicted to be temporary and localised, should these occur at all. Rock protection will be colonised by epifaunal communities known to occur within the MCZ, with a low risk of introduction or spread of INNS during the construction and operational phases. As such, there is no significant risk of cable protection measures during the operational phase (or following the decommissioning phase) hindering the achievement of the conservation objectives of the Cromer Shoal Chalk Beds MCZ.

6.1.1.8 In cases where sediment accumulates over cable protection, the biological communities associated with the surrounding sediments would also be expected to colonise these sediments, with the mix of sandy sediments and coarse substrates associated with the rock protection reflecting the baseline environment within the MCZ. In addition to this, some of the epifaunal components of the biological communities associated with the discrete patches of gravel and cobbles (i.e. FluHyd biotope) and subtidal coarse and mixed sediment features in the wider MCZ would be expected to colonise the cable protection measures, with the appropriate cable protection grain sizes (paragraph 5.1.3.5) increasing the potential for colonisation by local epifaunal communities. 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.

6.1.1.9 The Stage 1 assessment of the Markham's Triangle rMCZ considered direct effects on the Subtidal Coarse Sediments, Subtidal Mixed Sediments and Subtidal Sand broadscale habitat features. During construction, effects of temporary habitat loss/disturbance, including foundation and cable installation, were concluded to be short term and affecting only a small proportion (i.e. up to a maximum of 4%) of these broadscale habitat features within the rMCZ. All effects on physical and ecological attributes were concluded to be reversible, with full recovery to the pre-construction baseline occurring following the construction phase (similar effects of temporary habitat loss/disturbance during operation and decommissioning were considerably reduced from construction). Effects of increases in SSC and associated deposition during construction were also considered for each of the broadscale habitat features of the rMCZ. Sensitivities of the communities associated with the broadscale habitat features are low, particularly to the SSC increases and level of sediment deposition predicted for Hornsea Three construction. As such there is no significant risk of Hornsea Three construction operations hindering the achievement of the assumed conservation objectives of Markham's Triangle rMCZ, which was set to "recover to favourable condition" due to ongoing pressure from benthic trawling within the rMCZ. There is currently no information on the likely management measures which may be put in place to achieve the "recover to a favourable condition" conservation objective once the rMCZ is designated and therefore it was not possible to consider the indirect impacts of this impact on such management measures.

6.1.1.10 The Stage 1 assessment also considered effects on proposed features of Markham's Triangle rMCZ during the Hornsea Three operational phase, with the key impact related to placement of foundations, associated scour protection and cable protection (i.e. where burial is not possible and/or at cable/pipeline crossings). In areas where such infrastructure is installed, this will result in long term habitat loss during the operational phase, and permanent habitat loss following decommissioning of the project (assuming all cable and scour protection is left *in situ*). Long term/permanent habitat loss due to placement of cable protection (if required) will affect a small proportion of the broadscale habitat features within the rMCZ (i.e. $<0.5\%$ during operation and $<0.4\%$ after decommissioning), with the vast majority of the proposed features unaffected by this impact. Furthermore, the use of sensitive materials for cable protection (e.g. rock protection of grain sizes similar to the baseline environment) will allow for some recovery of communities into the areas affected. Hard substrates associated with Hornsea Three infrastructure (i.e. turbine foundations, scour and cable protection) will be colonised primarily by epifaunal communities known to occur within the MCZ.

6.1.1.11 The risk of introduction or spread of INNS during the construction and operational phases (e.g. through colonisation of hard substrates or ballast water introductions) is low due to appropriate control measures, including a biosecurity plan for the project and vessels complying with the IMO ballast water management guidelines. Effects on the marine processes (including wave and tidal energy and sediment transport systems) will be localised and the changes too small to result in a significant change in either the physical attributes (e.g. sediment type) or the communities associated with the broadscale habitat features. As such, there is no significant risk of operation (or decommissioning) of Hornsea Three hindering the achievement of the assumed conservation objectives of Markham's Triangle rMCZ, which was set to "recover to favourable condition" due to ongoing pressure from benthic trawling within the rMCZ. Due to the lack of information from JNCC on the likely management measures which may be put in place once the rMCZ is designated, it was not possible to consider the indirect impacts of this impact on such management measures

6.1.1.12 Cumulative effects on features of the Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ were also considered in the Stage 1 assessment. For Cromer Shoal Chalk Beds MCZ, the identified activities and projects (i.e. commercial fishing and operational electrical cables) were considered as part of the baseline characterisation, while further detail on future projects (e.g. Bacton Gas Terminal Coastal Defence Scheme) were not available to undertake a cumulative assessment and therefore it was not possible to undertake a cumulative effects assessment on this MCZ. For Markham's Triangle, there were no identified projects which would represent a risk to the conservation objectives of the rMCZ cumulatively with Hornsea Three.

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