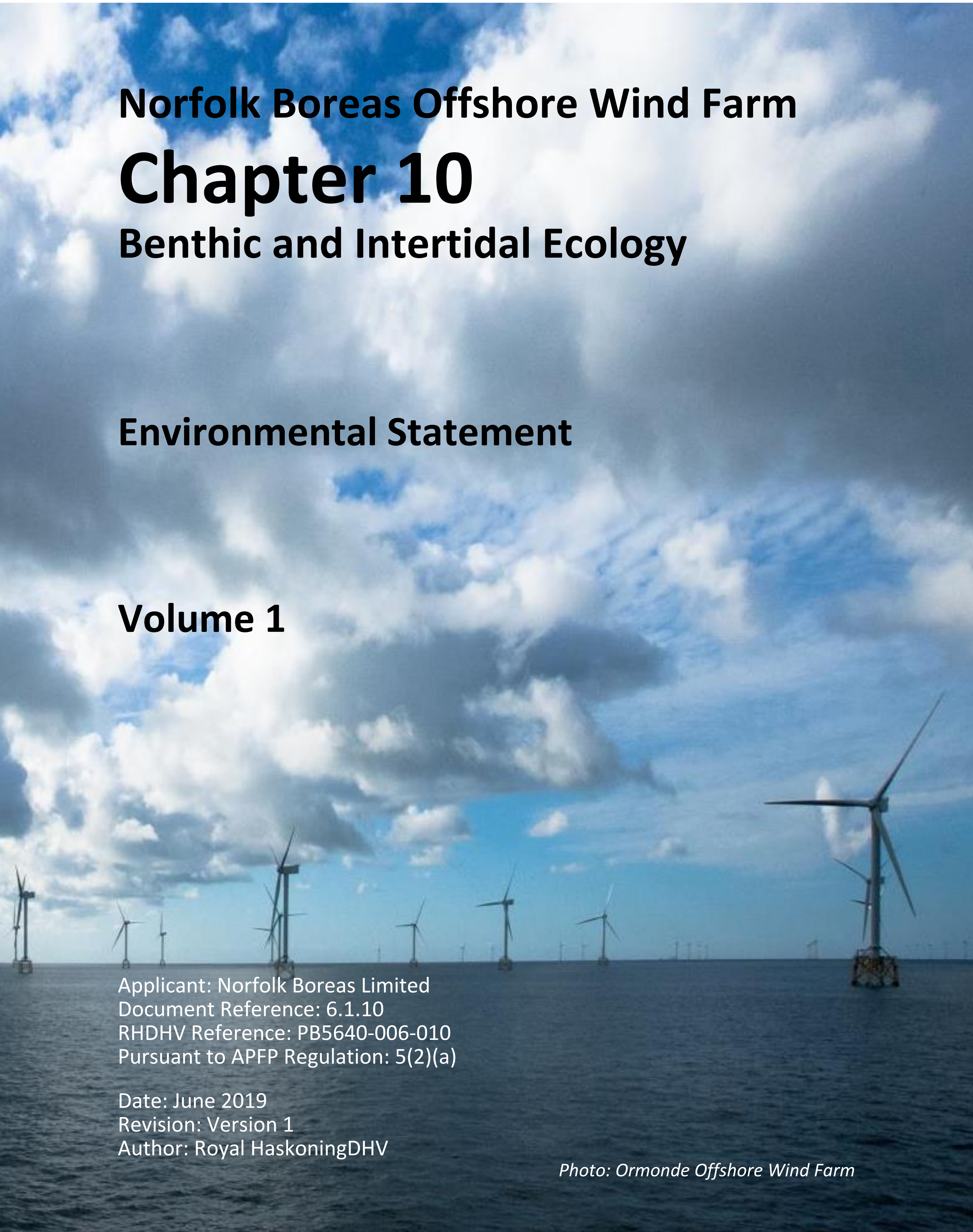

Norfolk Boreas Offshore Wind Farm

Chapter 10

Benthic and Intertidal Ecology

Environmental Statement

Volume 1

Applicant: Norfolk Boreas Limited
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Glossary of Acronyms

ANOSIM	Analysis of Similarities
BAP	Biodiversity Action Plan
CEMP	Construction Environmental Management Plan
CIA	Cumulative Impact Assessment
CIEEM	Chartered Institute of Ecology and Environmental Management
DCO	Development Consent Order
EAOW	East Anglia Offshore Wind
EC	European Commission
EMF	Electromagnetic Fields
EMODnet	European Marine Observation and Data Network
EIA	Environmental Impact Assessment
EIFCA	Eastern Inshore Fisheries Conservation Authority
EPP	Evidence Plan Process
ES	Environmental Statement
ETG	Expert Topic Group
FEPA	Food and Environment Protection Agency
FERA	Food and Environment Research Agency
GBS	Gravity Based Structure
HDD	Horizontal Directional Drilling
HPI	Habitats of Principal Importance
HRA	Habitats Regulations Assessment
HVDC	High Voltage Direct Current
IEEM	Institute of Ecology and Environmental Management
IPC	Infrastructure Planning Commission (now the Planning Inspectorate)
JNCC	Joint Nature Conservation Committee
LAT	Lowest Astronomical Tide
MarLIN	Marine Life Information Network
MarESA	Marine Evidence Based Sensitivity Assessment
MARPOL	International Convention for the Prevention of Pollution from Ships
MCZ	Marine Conservation Zone
MESL	Marine Ecological Surveys Limited
MHWS	Mean High Water Spring
MLWS	Mean Low Water Springs
MMO	Marine Management Organisation
MPS	Marine Policy Statement
NBN	National Biodiversity Network
NPL	National Physical Laboratory
NE	Natural England
NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project
NV East	Norfolk Vanguard East
NV West	Norfolk Vanguard West
ODPM	Office of the Deputy Prime Minister
O&M	Operation and Maintenance

OWF	Offshore Wind Farm
PEIR	Preliminary Environmental Information Report
REC	Regional Environmental Characterisation
RSBL	Reference Seabed Level
SAC	Special Area of Conservation
SIP	Site Integrity Plan
SMRU	Sea Mammal Research Unit
SNCB	Statutory Nature Conservation Body
SPA	Special Protection Area
SPI	Species of Principal Importance
SSC	Suspended Sediment Concentrations
UXO	Unexploded Ordnance
VWPL	Vattenfall Wind Power Limited
WT	Wildlife Trust
WCS	Worst Case Scenario
ZEA	Zonal Environmental Appraisal

Glossary of Terminology

Array cables	Cables which link the wind turbine to wind turbine and wind turbine to offshore electrical platform.
Evidence Plan Process	A voluntary consultation process with specialist stakeholders to agree the approach to the EIA and information to support HRA.
Interconnector cables	Offshore cables which link offshore electrical platforms within the Norfolk Boreas site
Landfall	Where the offshore cables come ashore at Happisburgh South
Landfall compound	Compound at landfall within which HDD drilling would take place.
Norfolk Boreas	The Norfolk Boreas wind farm boundary. Located offshore, this will contain all the wind farm array.
Offshore cable corridor	The corridor of seabed from the Norfolk Boreas site to the landfall site within which the offshore export cables will be located.
Offshore electrical platform	A fixed structure located within the Norfolk Boreas site, containing electrical equipment to aggregate the power from the wind turbines and convert it into a suitable form for export to shore.
Offshore export cables	The cables which bring electricity from the offshore electrical platform to the landfall.
Offshore project area	The area including the Norfolk Boreas site, project interconnector search area and offshore cable corridor.
Offshore service platform	A fixed structure providing accommodation for offshore personnel and /or helicopter refuelling facilities. An accommodation vessel may be used instead
Project interconnector cable	Offshore cables which would link either turbines or an offshore electrical platform in the Norfolk Boreas site with an offshore electrical platform in one of the Norfolk Vanguard sites.
Project interconnector search area	The area within which the project interconnector cable would be installed.
Scour protection	Protective materials to avoid sediment being eroded away from the base of the foundations as a result of the flow of water.

The Applicant	Norfolk Boreas Limited
The Norfolk Vanguard OWF sites	Term used exclusively to refer to the two distinct offshore wind farm areas, Norfolk Vanguard East and Norfolk Vanguard West (also termed NV East and NV West) which will contain the Norfolk Vanguard arrays.
The project	Norfolk Boreas Wind Farm including the onshore and offshore infrastructure.

10 BENTHIC AND INTERTIDAL ECOLOGY

10.1 Introduction

1. This chapter of the Environmental Statement (ES) describes the ecology of the seabed (benthic ecology) and the foreshore below the mean high water mark (intertidal), within the Norfolk Boreas project area and the wider southern North Sea region. Potential impacts are assessed and mitigation measures provided where appropriate.

2. It should be noted that impacts upon shellfish are assessed in Chapter 11 Fish and Shellfish Ecology and Chapter 14 Commercial Fisheries.

3. Other chapters that are linked with benthic ecology, or that cover impacts that may be related to those in this chapter are:

- Chapter 8 Marine Geology, Oceanography and Physical Processes;
- Chapter 9 Marine and Sediment Quality;
- Chapter 12 Marine Mammals; and
- Chapter 13 Offshore Ornithology;

4. This chapter is supported by the following Appendices:

- Appendix 10.1: Fugro (2018) Benthic Characterisation Report;
- Appendix 10.2: Statistical Analysis of benthic grab data;
- Appendix 10.3: Comparison of MarLIN and Norfolk Boreas sensitivity definitions for benthic receptors:
- Appendix 5.1 of the Information to Support HRA report (document Reference 5.3): Norfolk Boreas HRA Screening: Offshore;
- Appendix 7.2 of the Information to Support HRA (document Reference 5.3): Norfolk Vanguard and Norfolk Boreas Sabellaria Review; and
- Appendix 7.3 of the Information to Support HRA (document Reference 5.3): Norfolk Vanguard Benthic Characterisation report.

5. Vattenfall Wind Power Limited (VWPL) (the parent company of Norfolk Boreas Limited) is also developing Norfolk Vanguard, a 'sister project' to Norfolk Boreas. Norfolk Vanguard's development schedule is approximately one year ahead of Norfolk Boreas and as such the Development Consent Order (DCO) application was submitted in June 2018.

6. Norfolk Vanguard may undertake some enabling works for Norfolk Boreas, but these are only relevant to the assessment of impacts onshore. This assessment does however include interconnector cables between the Norfolk Boreas and Norfolk Vanguard projects (herein, 'the project interconnector'). If Norfolk Vanguard does not proceed then the project interconnector would not be required.

7. This chapter of the ES was written by Royal HaskoningDHV and incorporates survey results from Fugro Ltd and Marine Ecological Surveys Limited (MESL). Technical reports from Fugro, 2018 Norfolk Boreas Benthic Characterisation Report, are included in Appendix 10.1 in Volume 3. In addition, technical survey reports of MESL's Zone Environmental Appraisal (ZEA) survey for the former East Anglia Zone are available on the Planning Inspectorate website[1].

10.2 Legislation, Guidance and Policy

8. The characterisation of the benthic and intertidal ecology baseline and the assessment of potential impacts has been made with specific reference to the relevant National Policy Statements (NPS). These are the principal decision making guidance documents for Nationally Significant Infrastructure Projects (NSIP).

9. The Overarching NPS for Energy (EN-1) sets out the Government's policy for delivery of major energy infrastructure, with generic considerations which are further considered in the technology-specific NPSs such as the NPS for Renewable Energy Infrastructure (EN-3). Table 10.1 summarises the relevant guidance from EN-3 as well as providing the sections in this ES where each is addressed.

Table 10.1 NPS Assessment Requirements

NPS requirements	Section Reference
Section 2.6.81 of NPS EN-3: An assessment of the effects of installing cable across the intertidal zone should include information, where relevant, about: 1. Any alternative landfall sites that have been considered by the applicant during the design phase and an explanation for the final choice; 2. Any alternative cable installation methods that have been considered by the applicant during the design phase and an explanation for the final choice; 3. Potential loss of habitat; 4. Disturbance during cable installation and removal (decommissioning); 5. Increased suspended sediment loads in the intertidal zone during installation; and 6. Predicted rates at which the intertidal zone might recover from temporary effects.	There will be no impact on the intertidal zone due to the use of a long Horizontal Directional Drilling (HDD) as embedded mitigation (section 10.7.1.2).
Section 2.6.83 NPS EN-3: Applicants are expected to have regard to guidance issued in respect of Food and Environmental Protection Act (FEPA) [now Marine Licence] requirements.	Other relevant guidance, including in respect to the Marine Licence, is outlined further below in this section.
Section 2.6.113 of NPS EN-3:	Section 10.7.4 Potential Impacts during Construction

[1] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010056/EN010056-000287-6.3.10%20(2)%20Volume%203%20Chapter%2010%20Benthic%20Ecology%20Appendix%2010.2.pdf

NPS requirements	Section Reference
Where necessary, assessment of the effects on the subtidal environment should include: 1. Loss of habitat due to foundation type including associated sea bed preparation, predicted scour, scour protection and altered sedimentary processes; 2. Environmental appraisal of array cables and cable routes and installation methods; 3. Habitat disturbance from construction vessels' extendible legs and anchors; 4. Increased suspended sediment loads during construction; and 5. Predicted rates at which the subtidal zone might recover from temporary effects.	
Section 2.6.119 of NPS EN-3: Construction and decommissioning methods should be designed appropriately to minimise effects on subtidal habitats, taking into account other constraints. Mitigation measures which the Infrastructure Planning Commission (IPC) (now the Planning Inspectorate) should expect the applicants to have considered may include: • Surveying and micrositing of the export cable route to avoid adverse effects on sensitive habitat and biogenic reefs; • Burying cables at a sufficient depth, taking into account other constraints, to allow the seabed to recover to its natural state; and • The use of anti-fouling paint might be minimised on subtidal surfaces, to encourage species colonisation on the structures.	Mitigation measures embedded in the project design are outlined in section 10.7.1.

10. The Marine Policy Statement (MPS) (HM Government, 2011; discussed further in Chapter 3 Policy and Legislative Context) provides a high-level approach to marine planning and general principles for decision making that contribute to the NPS objectives. It also sets out the framework for environmental, social and economic considerations that need to be taken into account in marine planning. The high-level objective '*Living within environmental limits'* covers points relevant to benthic and intertidal ecology, and requires that:

- Biodiversity is protected, conserved and where appropriate recovered and loss has been halted;
- Healthy marine and coastal habitats occur across their natural range and are able to support strong, biodiverse biological communities and the functioning of healthy, resilient and adaptable marine ecosystems; and
- Our oceans support viable populations of representative, rare, vulnerable, and valued species.

11. The MPS is also the framework for preparing individual Marine Plans and taking decisions affecting the marine environment. England currently has nine marine plans; those relevant to Norfolk Boreas are The East Inshore and The East Offshore Marine Plans (HM Government, 2014). These contain the two objectives stated below, which are of relevance to marine and intertidal benthic ecology, as they cover policies and commitments on the wider ecosystem set out in the MPS:

- Objective 6: '*To have a healthy, resilient and adaptable marine ecosystem in the East Marine Plan areas*'; and
- Objective 7: '*To protect, conserve and, where appropriate, recover biodiversity that is in or dependent upon the East marine plan areas*'.

12. Other guidance on the requirements for wind farm studies are provided in the documents listed below:

- Cefas (2004) Offshore Wind Farms: Guidance Note for Environmental Impact Assessment in Respect of FEPA and CPA requirements: Version 2;
- Cefas (2010) Strategic Review of Offshore Wind Farm Monitoring Data Associated with FEPA licence conditions, with input from the Food and Environment Research Agency (FERA) and the Sea Mammal Research Unit (SMRU);
- Marine Management Organisation (MMO) (2014) Review of Post-Consent Offshore Wind Farm Monitoring Data Associated with Licence Conditions, with input from the British Trust for Ornithology (BTO), National Physical Laboratory (NPL) and the SMRU;
- Office of the Deputy Prime Minister (ODPM) (2001) Guidance on Environmental Impact Assessment in Relation to Dredging Applications; and
- Defra (2005) Nature Conservation Guidance on Offshore Windfarm Development. A guidance note on the implications of the EC Wild Birds and Habitats Directives for developers undertaking offshore windfarm developments. Version R1.9.

13. The principal guidance documents used to inform the baseline characterisation and the assessment of impacts are as follows:

- Cefas (2012) Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects;
- Wyn & Brazier (2001); Joint Nature Conservation Committee (JNCC) Marine Monitoring Handbook;
- Ware and Kenny (2011) Guidance for the Conduct of Benthic Studies at Marine Aggregate Extraction Sites;
- Institute of Ecology and Environmental Management (IEEM) (2010) Guidelines for Ecological Impact Assessment in Britain and Ireland – Marine and Coastal;

- Chartered Institute of Ecology and Environmental Management (CIEEM) (2016) Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater and Coastal, 2nd Edition[2]; and
- The British Standards Institution (2015) Environmental impact assessment for offshore renewable energy projects – Guide. PD 6900:2015.

10.3 Consultation

14. Consultation is a key part of the DCO application process. To date, consultation regarding benthic ecology has been conducted through: The Evidence Plan Process (EPP) Expert Topic Group (ETG) meetings, the Scoping Report (Royal HaskoningDHV, 2017), section 42 consultation on the Preliminary Environmental Information Report (PEIR) (Royal HaskoningDHV, 2018); the Offshore Order Limits change report and consultation on the draft Information to support HRA Report (document reference 5.3). Full details of the project consultation process and the EPP are presented within Chapter 7 Technical Consultation.

15. Detailed minutes and agreement logs of the ETG meetings are provided as appendices 9.4 and 28.1 to the Consultation report (document reference 5.1) which is submitted as part of the DCO application.

16. As Norfolk Boreas and Norfolk Vanguard share an offshore cable corridor, the pre-application consultation undertaken as part of Norfolk Vanguard has been used to inform the approach to the Norfolk Boreas benthic ecology assessment. Furthermore, information submitted as part of the Norfolk Vanguard examination, has also been incorporated. However, in order that the programmed submission of the Norfolk Boreas DCO has not been impacted it has been necessary to use a cut-off point of the 20th March 2019 (which coincided with Norfolk Vanguard Examination Deadline 5). After this date information provided at the Norfolk Vanguard examination as well as any wider information has not been included in this assessment unless it could be done without impacting the programme for submission. The information from Norfolk Vanguard which has been used to inform this assessment is also presented in Table 10.2.

[2] Note that the Chartered Institute of Ecology and Environmental Management (CIEEM) (2016) Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater and Coastal, 2nd Edition[2] have been created to update the 2006 guidelines and achieve alignment with the Marine and Coastal IEEM 2010 guidelines.

Table 10.2 Consultation Responses

Consultee	Document and date	Comment	Response / where addressed in the ES
Natural England and the Marine Management Organisation (MMO)	EPP Meeting 16th February 2016	Meeting to agree the scope of the benthic surveys.	Section 10.5.2
Secretary of State	Scoping opinion June 2017	The Applicant's attention is drawn to the suggestion of the MMO (see Appendix 3 of this Opinion) to inform site characterisation with newly published satellite Suspended Particulate Material (SPM) data covering 1998-2015, which is available on the Cefas Data Hub	These data are used to inform Chapter 8 Marine Geology, Oceanography and Physical Processes, which in turn informs the assessments in Sections 10.7.4.5 and 10.7.4.6
Secretary of State	Scoping opinion June 2017	An assessment of the potential impacts on Annex I sandbanks and biogenic reefs should be presented within the ES.	Section 10.7.4
Secretary of State	Scoping opinion June 2017	The Scoping Report identifies the presence of *Sabellaria spinulosa (S. spinulosa*) reef within the array area and the offshore cable corridor. The ES should consider potential direct impacts from construction, and also the potential impacts from maintenance activities on reef that may colonise the cables during the operational phase. The Applicant's attention is drawn to the comments of NE (see Appendix 3 of this Opinion) regarding *S. spinulosa*.	Section 10.7.4 and 10.7.55
Secretary of State	Scoping opinion June 2017	The SoS notes the offshore cable would pass through the Cromer Shoal Calk MCZ; in particular it could pass through the mixed sediment feature. The Applicant's attention is drawn to the concerns of NE (see Appendix 3 of this Opinion) that due to the features of the MCZ and the scale of the proposed works, there is a possibility that NE will consider the impacts on the MCZ are such that the conservation targets for the site cannot be met. The ES should consider mitigation and Measures of Equivalent Environmental Benefit (MEEB), as well as the longer term impacts and recoverability of the mixed sediment feature.	The offshore cable corridor has been amended and is outside of the MCZ. An assessment to impacts on the MCZ is included in Section 10.7.4

Consultee	Document and date	Comment	Response / where addressed in the ES
Secretary of State	Scoping opinion June 2017	When assessing the potential impacts from loss of habitat, the ES should give consideration not only to habitat loss resulting from scour that occurs around foundations, but also to habitat loss resulting from the introduction of required scour protection.	Section 10.7.4 and 10.7.5
Secretary of State	Scoping opinion June 2017	Consideration should also be given to the impacts of colonisation of hard structures by non-native species. The Applicant's attention is drawn to the comments of NE (see Appendix 3 of this Opinion) in this regard.	Section 10.7.1.10
Secretary of State	Scoping opinion June 2017	The Scoping Report proposes to scope out underwater noise and vibration during the operational phase. This is on the basis that monitoring studies of operational turbines (North Hoyle, Scroby Sands, Kentish Flats and Barrow wind farms) have shown noise levels from wind farms to be only marginally above ambient noise levels and there is no evidence to suggest that this low level of noise and vibration has a significant effect on benthic ecology. The SoS has had regard to the comments from the MMO (see Appendix 3 of this Opinion) in this respect, who note that there is some existing research which indicates that effects from noise to benthic ecology cannot be ruled out. On this basis, the SoS does not agree that this can be scoped out at this stage and recommends that further discussions are held with the MMO on this matter.	Section 10.7.4.10
Secretary of State	Scoping opinion (June 2017)	Paragraph 428 of the Scoping Report proposes to scope out electromagnetic fields (EMF) on benthic species as effects are likely to be highly localised, and as EMFs are strongly attenuated and decrease as an inverse square of distance from the cable. The Scoping Report references studies which show EMFs do not impact benthic species and habitats. The SoS accepts the evidence presented by the Applicant and is content with the proposed approach. The SoS notes that paragraph 201 of the Scoping Report suggests the cable would be buried between 1-3m deep. The applicant should be aware of the statements within NPS EN-3 that if it is proposed to install offshore cables to a depth of at least 1.5m below the sea bed, the applicant should not have to assess the effect of the cables on subtidal or intertidal habitat	Section 10.7.5.10

Consultee	Document and date	Comment	Response / where addressed in the ES
Secretary of State	Scoping opinion (June 2017)	The Scoping Report states that potential cumulative impacts with proposed adjacent offshore wind farms could occur. However, it also states that there is unlikely to be significant overlap in impact zones during construction given the predicted localised nature of potential impacts and staggered construction programmes. The SoS notes construction of the offshore elements of the Proposed Development would be between 2025-2028 and that the Norfolk Vanguard Scoping Report identified construction between 2023-2027. The SoS therefore considers that there is a high likelihood of overlapping construction periods. The Applicant should take this into account in the cumulative assessment.	Section 10.8
Secretary of State	Scoping opinion (June 2017)	The ES should provide evidence to support the assertion that the recoverability of the species found, mean that cumulative impacts are unlikely to be significant.	Section 10.7.4 and Section 10.7.5
Secretary of State	Scoping opinion (June 2017)	The SoS welcomes the consideration of mitigation measures at this stage and recommends these are discussed and agreed during the EPP.	Section 10.7.1
MMO	Section 42 Consultee Response (December 2018)	It was recommended in previous advice that the impacts of operational noise and vibration on benthic species are scoped in for further assessment and that conclusions should be drawn based on the best available evidence in the scientific literature. The report states this comment has been addressed in Section 10.7.4.10; however, it is not clear that operational noise has been assessed. The MMO expects that this will be addressed in the EIA.	An assessment of impacts of underwater noise during operation has been included in section 10.7.5.11
MMO	Section 42 Consultee Response (December 2018)	Section 10.7.3.7.1 of the PEIR states that regular maintenance of the wind turbines would be undertaken during operation of the wind farm. The MMO notes that the likely effects on the benthos of the operation and maintenance activities do not appear to have been considered in the PEIR and expect these will be addressed in the EIA.	Section 10.7.5.5 includes an assessment of regular maintenance of the wind turbines in relation to benthic ecology.
MMO	Section 42 Consultee Response (December 2018)	The MMO expects that post construction surveys should be conducted for a period of 3 years (non-consecutive e.g. 1, 3, 6 or 1, 5, 10 years) to determine any long-term effects due to installation of the Norfolk Boreas OWF, and that any monitoring requirements will be included in the DML.	Section 10.7.2 describes the approach to monitoring in relation to benthic ecology. Monitoring requirements would be agreed with the MMO in consultation with the relevant SNCBs

Consultee	Document and date	Comment	Response / where addressed in the ES
			as outlined in the In Principle Monitoring Plan (document reference 8.12).
MMO	Section 42 Consultee Response (December 2018)	In Chapter 10, the effects on the benthic assemblages encountered during the decommissioning phase are presented as being consistent with those encountered during the construction phase. The MMO would welcome further discussion on the justification for this assumption and for this prediction to be validated.	Section 10.7.6 outlines the impacts in relation to decommissioning. As discussed at the ETG meeting (Feb 2019). Further information has been provided using the most recent examples of offshore wind decommissioning.
MMO	Section 42 Consultee Response (December 2018)	Section 10.7.3.5.4 states that disposal of sediment arising from pre-sweeping the cable corridors will be in an area devoid of *S. spinulosa* reef and advises that further assessment will take place. The MMO recommends that the assessment should include an approach targeted at both the primary and secondary impact areas, ensuring the benthic assemblages (not solely *S. spinulosa*) within and outside of the disposal area are adequately characterised. The assessment should also demonstrate that they are able to recover from the proposed dredging and disposal activity.	Section 10.7.1.8 sets out the approach for sediment disposal, specifically all seabed material arising from the Haisborough, Hammond and Winterton SAC during cable installation would be placed back within the SAC using an approach, to be agreed with the MMO in consultation with the relevant SNCB, which would ensure that the sediment is available to replenish the sandbank features (Appendix 7.1 to the Information to inform HRA (document reference 5.3)). Sediment would not be disposed of within 50m of known *S. spinulosa* reef identified during pre-construction surveys (in accordance with advice provided to Norfolk Vanguard by Natural England in January 2018). Section 10.7.3.4.1 has been updated to reflect this.
MMO	Section 42 Consultee Response (December 2018)	Section 10.7.1.10 states that the ‘spreading [of] non-native species will be mitigated though [the] use of best practice techniques’. The MMO seeks to understand how the long term effects on the spread of non-native species will be addressed and would welcome further discussion with the developer.	Section 10.7.1.10 describes the relevant legislation and guidance that will be adhered to in relation to preventing the spread of non-native species.

Consultee	Document and date	Comment	Response / where addressed in the ES
MMO	Section 42 Consultee Response (December 2018)	The MMO requires the evidence/rationale be provided to support the conclusion in Section 10.7.4.2.3 that the perceived response from benthic assemblage's to cable laying abrasion equates to that of the bottom trawled fishing activity.	Section 10.7.4.2.2 has been rephrased. The impact assessment refers to other sources of disturbance occurring in the area including bottom trawled fishing activity.
MMO	Section 42 Consultee Response (December 2018)	The MMO notes the findings of the 2014 MMO review, and the limitations of the post-construction monitoring which was based on round 1 wind farms which are neither comparable in size to Norfolk Boreas OWF nor considered as a network of arrays with cumulative or combined effects. Uncertainty remains over the long term impact of these larger developments, therefore the MMO would welcome further discussion with the developer on whether monitoring should be restricted to Annex 1 habitats, and to consider the most appropriate monitoring approach.	Monitoring requirements would be agreed with the MMO in consultation with the relevant SNCBs as outlined in the In Principle Monitoring Plan (document reference 8.12). The current strategy for monitoring is provided in section 10.7.2.
MMO	Section 42 Consultee Response (December 2018)	The MMO considers the PEIR has characterised the existing environment appropriately using appropriate data.	Comment is noted and no changes have been made.
MMO	Section 42 Consultee Response (December 2018)	The MMO considers the proposed 'micrositing' (of cable route and turbines) for *Sabellaria spinulosa* reef and boulders appropriate mitigation.	Comment is noted and no changes have been made.
MMO	Section 42 Consultee Response (December 2018)	Section 3.1.2 of Appendix 10.2 introduces the ANOSIM test and caveats the interpretation of the results presented in section 3.2.4.4. The MMO considers that these results should be removed from the report as they are not appropriate.	The results of the ANOSIM have been removed from Appendix 10.2
Eastern Inshore Fisheries Conservation (EIFCA)	Section 42 Consultee Response (December 2018)	Any activity that disturbs the seabed has the potential to have negative impacts on habitats and biodiversity….Eastern IFCA recognise that the applicant has selected a landfall location that ensures the cables are not routed through the [Cromer Shoal Chalk Beds Marine Conservation Zone] MCZ.	Comment is noted and no changes have been made.
EIFCA	Section 42 Consultee Response	Despite this cable corridor not overlapping with Cromer Shoal Chalk Beds MCZ, there is still potential for cable installation activities to result in	Comment is noted and no changes have been made.

Consultee	Document and date	Comment	Response / where addressed in the ES
	(December 2018)	increased levels of suspended sediment and deposition within the MCZ……. Eastern IFCA consider that despite the close proximity of the cable corridor to the MCZ, the evidence supports that the project is unlikely to result in significant impacts on the MCZ.	
EIFCA	Section 42 Consultee Response (December 2018)	While we understand that *S. spinulosa* have high recruitment rates that allow for rapid recovery and regrowth of reefs in the right conditions, resulting in the conclusion that their recoverability is 'medium', this requires the appropriate habitat for recolonisation to be maintained. The conservation advice for the site includes objectives for conditions suitable for reef formation to be maintained (Natural England, 2018). The developer should demonstrate whether re-settlement of *S. spinulosa* is anticipated to occur in areas where seabed habitat conditions are changed because of the project.	Section 10.7.5.2 and 10.7.5.9 considers the potential for colonisation of Norfolk Boreas infrastructure by *S. spinulosa*. However, Natural England (2019) does not consider *S. spinulosa* colonised on artificial substrate as Annex I reef and it would not contribute to the favourable condition of a site designated for *S. spinulosa*.
EIFCA	Section 42 Consultee Response (December 2018)	Eastern IFCA would strongly encourage micrositing within the identified cable corridor around known areas of sensitive features including *Sabellaria spinulosa* reef following pre-construction surveys and Natural England's formal advice on the distribution and extent of reef in the area.	Section 10.7.1.6 describes that micrositing will occur within the cable corridor around known areas of *S. spinulosa* where possible.
EIFCA	Section 42 Consultee Response (December 2018)	As stated in Eastern IFCA's response to the Norfolk Vanguard Environmental Statement, we request that Vattenfall take note that Eastern IFCA are seeking to introduce fishing closures (via a byelaw) to protect sensitive features within the inshore section (within six nautical miles of the shore) of the SCI.	This comment is noted and at time of writing no further bylaws have been passed therefore no changes have been made to the chapter. Norfolk Boreas has continued to engage with the EIFCA (most recent correspondence 24th March 2019) and further engagement will be undertaken post application to monitor progress.
EIFCA	Section 42 Consultee Response (December 2018)	Section 10.7.4.11 of Chapter 10 'Benthic and Intertidal Ecology' states, "the Norfolk Boreas site does not overlap with any designated site and as such, receptors within designated sites have only been considered in relation to the offshore cable corridor". Eastern IFCA consider this statement incorrect, as the Norfolk Boreas site does overlap with a designated site – the Southern North Sea cSAC. We understand that the impact of the proposed works on the cSAC have been assessed in Chapter 12 'Marine Mammal Ecology' and Appendix	Section 10.7.4.1.1 has been updated to make it clear that the Norfolk Boreas site does not overlap with any designated sites for "benthic ecology" receptors.

Consultee	Document and date	Comment	Response / where addressed in the ES
		12.3 'Additional Assessment for the Southern North Sea cSAC'. We therefore ask that the statement in section 10.7.4.11 is amended to avoid any confusion, we would recommend making it clear that this statement refers to there being no MPAs designated for benthic and intertidal features that overlap with the Norfolk Boreas site, rather than stating that there is no overlap with any designated sites.	
Natural England	Letter in response to Offshore Order Limits change consultation (3rd December)	In relation to the potential requirement to undertake further surveys in 'the gap' between the projects/arrays, it is our understanding that due to the buffer included within the survey designs there is some data covering the gap and the immediate vicinity. We note that preconstruction surveys of the area will be conducted as part of the DCO. Natural England has no objection to the change to AfL being proposed.	Detail of the preconstruction surveys, including how they are secured within the DCO is included within the In Principle monitoring plan (document reference 8.12) which is submitted as part of the DCO application.
EIFCA	ETG (February 2019)	Nature conservation legislation requires certain activities to be excluded from areas where those activities would compromise the conservation objectives for habitats and species protected in SACs (and other marine protected areas). Within HHW SAC, Eastern IFCA has identified three areas where towed demersal fishing should be excluded, in order to protect *S. spinulosa*. Eastern IFCA is in discussion with Natural England regarding the size of the fishing closures. After stakeholder engagement, Eastern IFCA will make a formal decision to agree the closure areas to be implemented after Defra sign-off. The whole process is expected to take nine to 12 months. One of the proposed Eastern IFCA closed areas coincides with a part of the Norfolk Vanguard and Norfolk Boreas export cable route. This area is referred to as Winterton Shoal. Another potential area for closure is in the offshore part of the SAC beyond 6nm covering the entire offshore cable corridor.	At time of writing no further bylaws have been passed therefore no changes have been made to the chapter. Norfolk Boreas has continued to engage with the EIFCA (most recent correspondence 24th March 2019) and further engagement will be undertaken post application to monitor progress.

Consultee	Document and date	Comment	Response / where addressed in the ES
Relevant comments from the Norfolk Vanguard Examination			
MMO	Relevant Representations for Norfolk Vanguard (14th September 2018)	Other OWF DCO conditions and ESs have considered operation and maintenance activities such as bird waste removal, paint and repair, J-tube and ladder cleaning. If these activities are likely to be undertaken for Vanguard (Section 10.7.3.7.1 states that regular maintenance of the wind turbines would be undertaken during operation), then the likely effects to the benthos need to be assessed within the relevant chapter.	Cleaning of infrastructure during the O&M phase has been assessed in relation to water quality in section 9.7.4.2 Chapter 9 Marine Water and Sediment Quality. Impacts to water quality due to cleaning were determined to be negligible, therefore there is no pathway for impacts to benthic ecology. No further consideration of O&M cleaning is included in this chapter.
Natural England	Relevant Representations for Norfolk Vanguard (August 2018)	The report focuses heavily on MNCR codes, in particular SS.SBR.PoR.SspiMx. It is not clear why the report is framed in terms of MNCR codes, given the habitat it is reporting on is Annex I reef. SS.SBR.PoR.SspiMx can be Annex I Sabellaria spinulosa reef, and vice versa. However, this is not always the case. The focus should be Annex I reef, regardless of if it is also SS.SBR.PoR.SspiMx	It is recognised that '*Sabellaria spinulosa* on stable circalittoral mixed sediment' (SS.SBR.PoR.SspiMx) can be Annex I *S. spinulosa* reef. However, Annex I reefs are not always present where the biotope occurs. This chapter makes a distinction between Annex I *S. spinulosa* reef and SS.SBR.PoR.SspiMx which does not contain Annex I *S. spinulosa* reef.
Natural England	Relevant Representations for Norfolk Vanguard (August 2018)	We are unable to agree with the assessment of low sensitivity of the MCZ features to smothering – as it is unclear what features are found to be present as the applicant only states what is not.	Section 10.7.4.6.1 has been updated to show the biotopes that were recorded in the MCZ during the survey, the outcome of the assessment has not changed.
Natural England	Relevant Representations for Norfolk Vanguard (August 2018)	Using the Gubbay criteria, low reef is still reef, so why have areas with low reefiness been mapped as sediment? This table does not make it clear what thresholds have been used for determining whether a sample is reef. It also does not refer to the primary criteria described in Gubbay; elevation, patchiness and extent.	The Gubbay (2007) criteria have been used to assess *S. spinulosa* reefs present in the Norfolk Boreas site (Appendix 7.2 of the Information to Support HRA (document Reference 5.3). It is recognised that 'low reef' is still reef, however a classification of 'medium' or 'High reef' is required for Annex I habitat (Hendrick and Foster-Smith, 2006 and Gubbay 2007). Figure 10.12 shows the locations of 'low reef' and 'medium reef' recorded in the Norfolk Boreas site.

Consultee	Document and date	Comment	Response / where addressed in the ES
MMO	Relevant Representations for Norfolk Vanguard (August 2018)	Table 10.12 in Chapter 10 – Benthic and Intertidal Ecology, should consider colonisation of turbines with respect to decommissioning. It would be helpful to know whether a survey be undertaken pre-decommissioning to determine the extent of colonisation.	Consideration of colonisation of turbines with respect to decommissioning has been added to section 10.7.6. Decommissioning will be subject to separate licensing; any requirements with regards to pre-decommissioning surveys will be determined through the marine licence process at the time
Natural England	Relevant Representations for Norfolk Vanguard (August 2018)	Natural England notes that no cable protection associated with repairs has been included within the assessment and therefore should not be permitted in DML	A total volume/area of cable protection is included in the assessment regardless of whether this is installed at construction or later during repairs. Any cable protection greater than the totals included is not included in the DML
Natural England	Relevant Representations for Norfolk Vanguard (August 2018)	In our Advice on Operations *Sabellaria* has medium sensitivity to heavy smothering – therefore the table should be updated to reflect this	Table 10.15 , section 10.7.4.5 and Table 10.16 in section 10.7.4.7 have been updated to reflect this. The impact significance has not changed.
Natural England	Relevant Representations for Norfolk Vanguard (August 2018)	Please be advised that the sensitivity of coarse sediment to habitat loss or change is high. *Sabellaria spinulosa* has high sensitivity to habitat loss and medium sensitivity to habitat change. The assessment should be changed to reflect this. The same applies for section below and point 269. Subtidal sand also has high sensitivity to habitat loss or change.	In relation to permanent habitat loss, MarLIN sensitivity assessment of 'physical change to another seabed type' was used due to the introduction of artificial hard substrate. The MarLIN sensitivity of SS.SCS.CCS.MedLumVen and SS.SBR.PoR.SspiMx is high for this pressure (Tillin *et al*, 2018 and Tillin *et al*., 2016c) . The impact assessment for the O&M phase in relation to permanent loss of seabed has been updated to reflect this. in section 10.7.5.1 to 10.7.5.3 the outcome of the assessment for Impact 1 has not changed.

Consultee	Document and date	Comment	Response / where addressed in the ES
Natural England	Relevant Representations for Norfolk Vanguard (August 2018)	Natural England advice on operations sensitivity is based on the Marlin sensitivity: http://www.marlin.ac.uk/sensitivity/sensitivity_rationale. It is not clear whether the sensitivity definitions in table 10.3 are taken from Marlin or are bespoke for the ES. We would appreciate it if this could be clarified.	A comparison of the sensitivity used in this chapter and MarLIN sensitivity is provided in Appendix 10.3.
Natural England	Relevant Representations for Norfolk Vanguard (August 2018)	In advice on operations (NE conservation advice package) subtidal coarse sediment is not sensitive to low/light smothering and not sensitive to medium to heavy smothering – table should be updated to reflect this.	Section 10.7.4.6.1 has been updated to reflect this. The outcome of the assessment has not changed.
Natural England	Relevant Representations for Norfolk Vanguard (August 2018)	The process outlined in this paragraph takes different datasets and maps each multiple times and then compares them, which combines two issues; confidence in mapping techniques and distribution in *Sabellaria spinulosa* reef over time. Taking one dataset and using a number of methods to create maps, and then creating a consensus map from these maps would enable an assessment of confidence in the final map based on how many of the mapping techniques had indicated that area to be that habitat i.e. consensus based on one dataset mapped using a number of techniques. This could be used to consider whether an area is appropriate to support reef. Conversely, comparing habitat maps created from many different datasets (i.e. Fugro vs East Coast REC) could feasibly be used to consider temporal variation in reef extent and distribution (given a number of caveats and a robust method). If sufficient data was available this could then be used to consider how likely an area which is appropriate to support reef is to be supporting reef at a given time. The technique outlined in this paragraph therefore does not allow us to determine whether two maps do not agree because one is of low confidence, or because there was a change in habitat distribution over time.	A Comparison of the areas identified as potential Annex I reef (Envision, 2018 (Appendix 7.2 of the information to support HRA (document reference 5.3)) with the areas identified by Natural England and JNCC identified to be managed as *S.spinulosa* reef has been undertaken for the shared offshore cable corridor as part of evidence submitted for the Norfolk Vanguard Examination (Norfolk Vanguard Limited, 2019 (Figure 2.1)) . The figure shows that the two maps correlate relatively well within the offshore cable corridor.

10.4 Assessment Methodology

10.4.1 Impact Assessment Methodology

17. The general EIA methodologies are set out within Chapter 6. In principle, a matrix approach has been used to assess impacts following best practice, EIA guidance and the approach outlined in the Norfolk Boreas Scoping Report (Royal HaskoningDHV, 2017). An explanation of how this is applied to benthic and intertidal ecology within the Norfolk Boreas assessment is described below.

18. The data sources summarised in section 10.5.2 were used to characterise the existing environment (see section 10.6). Each impact, which has been identified using expert judgement and through consultation with Statutory Nature Conservation Bodies (SNCBs) via the Scoping Process and EPP, is then assessed in terms of its significance using the following methods. The definitions for the sensitivity, value and magnitude of effect were also agreed in consultation during the EPP.

10.4.1.1 Sensitivity

19. The sensitivity of communities will be reviewed based on expert judgement and informed by available biotope sensitivity information in the Marine Life Information Network (MarLIN) as well as review of online resources or through published research (Tyler-Walters *et al.* 2004; Tillin and Tyler-Walters 2014a and 2014b). It is recognised that the MarLIN assessments have limitations, particularly with reference to applicability of comparisons between MarLIN impacts and those assessed for Norfolk Boreas. Therefore, the nature of the impact described by MarLIN will be compared with the nature of the impact for Norfolk Boreas to determine whether the information is applicable. Where information is unavailable for the key species present at Norfolk Boreas, consideration will be given to potential proxies that are closely related and have similar habitat preferences.

20. The sensitivity of a receptor is determined through its ability to accommodate change and reflects on its ability to recover if it is affected. The sensitivity level of benthic receptors to each type of impact is justified within the impact assessment and is dependent on the following factors:

- Adaptability – The degree to which a receptor can avoid or adapt to an effect;
- Tolerance – The ability of a receptor to accommodate temporary or permanent change without a significant adverse effect; and
- Recoverability – The temporal scale and extent to which a receptor will recover following an effect.

Table 10.3 Definitions of Sensitivity Levels for Benthic and Intertidal Ecology

Sensitivity	Definition
High	Individual receptor (species or habitat) has very limited or no capacity to accommodate, adapt or recover from the anticipated impact e.g. receptor is killed/destroyed or damaged with recovery greater than 10 years.
Medium	Individual receptor (species or habitat) has limited capacity to accommodate, adapt or recover from the anticipated impact e.g. killed/destroyed with recovery in 1 to 10 years or damaged with recovery in 5 to 10 years.
Low	Individual receptor (species or habitat) has some tolerance to accommodate, adapt or recover from the anticipated impact. e.g. killed/destroyed with recovery with 1 year or damaged with recovery in 1 to 5 years.
Negligible	Individual receptor (species or habitat) is generally tolerant to and can accommodate or recover from the anticipated impact.

21. A comparison of the Norfolk Boreas benthic sensitivity definitions with the Marine Life Information Network (MarLIN) Marine Evidence Based Sensitivity Assessment (MARESA) definitions has been provided in Appendix 10.3. The comparison demonstrates that a conservative approach has been taken when identifying the sensitivity of benthic ecology receptors within this chapter.

10.4.1.2 Value

22. In addition, the 'value' of the receptor forms an important element within the assessment for instance if the receptor is a protected species or habitat. It is important to understand that high value and high sensitivity are not necessarily linked within a particular impact. A receptor could be of high value (e.g. Annex I habitat) but have a low or negligible physical/ecological sensitivity to an effect. Similarly, low value does not equate to low sensitivity and is judged on a receptor by receptor basis. The value will be considered, where relevant, as a modifier for the sensitivity assigned to the receptor, based on expert judgement.

Table 10.4 Definitions of Value Levels for Benthic and Intertidal Ecology

Value	Definition
High	Habitats (and species) protected under international law (e.g. Annex I habitats within an SAC boundary).
Medium	Habitats protected under national law (e.g. Annex I habitats not within an SAC boundary; UK BAP priority habitats and species) Species/habitat that may be rare or threatened in the UK.
Low	Regional UK BAP priority habitats Habitats or species that provide prey items for other species of conservation value
Negligible	Habitats and species which are not protected under conservation legislation and are not considered to be particularly important or rare.

10.4.1.3 Magnitude

23. The magnitude of effect will be considered in terms of the spatial extent, duration and timing (seasonality and / or frequency of occurrence) of the effect in question. Expert judgement has been employed to consider and evaluate the likely effect on the species, population or habitat identified.

Table 10.5 Definitions of Magnitude Levels for Benthic and Intertidal Ecology

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

10.4.1.4 Impact significance

24. Following the identification of receptor sensitivity and the magnitude of the effect, the impact significance will be determined using expert judgement. The matrix (provided in Table 10.6) will be used as a framework to aid determination of the impact assessment. Definitions of impact significance are provided in Table 10.7.

25. This chapter provides the criteria, including sources and justifications, for quantifying the different levels of impact to benthic and intertidal ecology. Where possible, this is based upon quantitative assessment, together with the use of value judgement and expert interpretation to establish to what extent an impact is significant.

Table 10.6 Impact Significance Matrix

		Negative Magnitude				Beneficial Magnitude			
		High	Medium	Low	Negligible	Negligible	Low	Medium	High
Sensitivity	High	*Major*	*Major*	*Moderate*	*Minor*	*Minor*	*Moderate*	*Major*	*Major*
	Medium	*Major*	*Moderate*	*Minor*	*Minor*	*Minor*	*Minor*	*Moderate*	*Major*
	Low	*Moderate*	*Minor*	*Minor*	*Negligible*	*Negligible*	*Minor*	*Minor*	*Moderate*
	Negligible	*Minor*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Minor*

Table 10.7 Impact Significance Definitions

Impact Significance	Definition
Major	Very large or large change in receptor condition, both adverse or beneficial, which are likely to be important considerations at a regional or district level because they contribute to achieving national, regional or local objectives, or, could result in an exceedance of statutory objectives and / or breaches of legislation.
Moderate	Intermediate change in receptor condition, which are likely to be important considerations at a local level.
Minor	Small change in receptor condition, which may be raised as local issues but are unlikely to be important in the decision making process.
Negligible	No discernible change in receptor condition.
No change	No impact, therefore no change in receptor condition.

26. For the purposes of this ES and specifically the benthic and intertidal ecology 'major' and 'moderate' impacts are considered to be significant. However, whilst 'minor' impacts would not be considered significant in their own right, they may contribute to significant impacts cumulatively (section 10.8) or through inter-relationships (section 10.9).

27. Embedded mitigation (as described in section 10.7.1) has been referred to and included in the initial assessment of significance of an impact. If an identified impact requires further mitigation then the residual impact is evaluated. If no further mitigation is required; is likely to have a positive ameliorating effect; or if no further mitigation is practicably achievable, then the assessment of significance of an impact would remain as the initial assessment.

10.4.2 Cumulative Impact Assessment

28. The overall assessment methodology for the CIA is set out within Chapter 6 and the specific methodology in relation to Benthic Ecology is provided below.

29. The potential for projects to act cumulatively on benthic ecology is considered in the context of the likely spatial and temporal extent of impacts with incorporation of physical processes, particularly sediment transportation influences, as well as the combined impact on a sensitive or important habitat or species in the wider region.

30. East Anglia THREE and Norfolk Vanguard offshore wind farms are considered in the assessment due to their proximity to Norfolk Boreas. All other offshore wind farms are screened out of the assessment due to their being beyond the range of potential impacts associated with Norfolk Boreas (see section 10.5.1) and therefore having no potential to act cumulatively.

31. Consideration is also given to any other nearby seabed activities, including marine aggregate extraction and marine disposal.

32. Each potential impact described for the construction and operation and maintenance (O&M) phases of Norfolk Boreas is considered in the CIA (section10.8).

10.4.3 Transboundary Impact Assessment

33. The localised nature of the potential impacts on the benthos means that significant transboundary impacts are unlikely. In accordance with the Scoping Report (Royal HaskoningDHV, 2017) and Scoping Opinion (the Planning Inspectorate, 2017), transboundary impacts have been screened out of the EIA for this topic.

10.5 Scope

10.5.1 Study Area

34. The Norfolk Boreas offshore project area comprises the Norfolk Boreas site, project interconnector search area and offshore cable corridor. The offshore project area is located in the southern North Sea, off the coast of Norfolk (see Figure 5.1). The Norfolk Boreas site is approximately 73km offshore from the Norfolk coastline (at the nearest points).

35. The offshore cable corridor, which is shared with Norfolk Vanguard (see Chapter 5 Project Description for further detail), joins the Norfolk Boreas site to the landfall at Happisburgh South. It should be noted that the offshore cable corridor has been refined following consultation and survey data collection (see Chapter 4 Site Selection and Assessment of Alternatives and section 10.5.2). The assessment provided in this chapter is based on the Norfolk Boreas offshore project area and the landfall described in Chapter 5 Project Description and shown in Figure 5.1 and Figure 5.3.

36. The study area for benthic and intertidal ecology is determined by the extent of the potential impacts; this study area is also described within the context of the wider former East Anglia Zone and is some cases the southern North Sea. Direct impacts would be located within the boundaries of the Norfolk Boreas offshore project area and indirect impacts are determined by the range of potential changes to Marine Physical Processes (see Chapter 8). The magnitude of changes to Marine Physical Processes in the far-field (beyond approximately 1km) is unlikely to be sufficient to result in a discernible impact on benthic ecology.

10.5.2 Data Sources

37. The primary sources of information for this section are provided by several different surveys, including:

- Surveys of the former East Anglia Zone;
- A survey of East Anglia THREE and the former East Anglia FOUR (now NV East);

- A survey of the Norfolk Vanguard offshore project areas and the shared offshore cable corridor; and
- A survey of the Norfolk Boreas site.

38. Benthic sampling of the former East Anglia Zone was conducted from September 2010 to January 2011. These surveys are herein referred to as the "ZEA surveys". These surveys include the majority of the Norfolk Boreas offshore project area. Further surveys were undertaken in 2013 for the former East Anglia FOUR project (and which therefore now cover Norfolk Vanguard East). These surveys included a combination of benthic grabs, trawls and seabed imagery.

39. As Norfolk Boreas and Norfolk Vanguard have a shared offshore cable corridor, geophysical and benthic surveys of the shared offshore cable corridor were completed as part of the 2016 survey campaign between 1st September and 15th November 2016 (Norfolk Vanguard Limited, 2018 also provided as Appendix 7.3 of the Information to support HRA document reference 5.3). These surveys also included most of what is now the project interconnector search area. These surveys are herein referred to as the 'offshore cable corridor surveys'

40. Geophysical and benthic surveys of the Norfolk Boreas site were undertaken in 2017. The benthic survey comprised 35 drop-down video stations and grab sample stations as well as sediment and contaminant sampling. All 35 stations were analysed using the drop-down video data. Grab samples from 10 stations were analysed in relation to the infaunal content and sediment contamination. The resulting Benthic Characterisation report is provided as Appendix 10.1. No epibenthic trawls were undertaken as part of this survey. The methodology for the Norfolk Boreas survey and subsequent data analysis was agreed with Natural England and the MMO (Table 10.2).

41. An ecology survey of the intertidal area at Happisburgh was undertaken in 2017. This comprised of five transects spaced evenly along the shore. At each transect sediment type, surface feature, redox layer and species presence and absence was recorded. A biotope was assigned to each area of shore within each transect. Since these surveys were completed a decision has been made to use long HDD to bring cables onshore. This removes any impacts on the intertidal area and therefore the Intertidal survey report is not submitted as part of the DCO application.

42. All surveys used to inform the baseline for the benthic and intertidal ecology assessment are summarised in Table 10.8 and sample locations are shown in Figure 10.1. These surveys are herein referred to as the "Norfolk Boreas site surveys".

Table 10.8 Data Sources

Data	Year	Coverage	Confidence	Comment
ZEA benthic survey (grabs, trawls and video) - Marine Ecological Surveys Ltd reported (EAOW, 2012a)	2010 - 2011	The Norfolk Boreas site, project interconnector search area, much of the cable corridor and the wider ZEA	Medium	Site specific surveys provide high confidence; however, data is seven years old.
ZEA Geophysical survey - Gardline Geophysical Ltd (reported in EAOW, 2012a)	2010	The Norfolk Boreas site, project interconnector search area, much of the cable corridor and the wider ZEA	Medium	Site specific surveys provide high confidence; however, data is seven years old.
Offshore cable corridor benthic survey (grabs and video) - Fugro EMU Ltd (Appendix 5.3 of document 5.3 Information to Support HRA) *	2016	Project interconnector search area and the offshore cable corridor	High	Site specific and recent
Offshore cable corridor geophysical survey - Fugro EMU Ltd (Norfolk Vanguard Limited, 2018)	2016	Offshore Cable Corridor	High	Site specific and recent
Norfolk Boreas site benthic surveys - Fugro (Appendix 10.1)	2017	The Norfolk Boreas site	High	Site specific and recent
Norfolk Boreas site geophysical surveys - Fugro (unpublished)	2017	The Norfolk Boreas site	High	Site specific and recent
Intertidal survey by Royal HaskoningDHV	2017	Landfall	High	Site specific and recent. However due to the commitment to a long HDD the project will not impact the intertidal
Regional Environmental Characterisation (REC) studies (Limpenny *et al.* 2011), covering the East Coast	2011	The offshore project area	Medium	Although the data is spatially relevant it is seven years old therefore scored as medium.
National Biodiversity Network (NBN) gateway, covering the East Anglia coast	Collation of various data sources	The offshore project area	Medium	Well- audited quality assurance procedures however not all sources can be verified.
Marine Life Information Network (MarLIN), providing UK species information	Collation of various data sources	The offshore project area	High	Well- audited quality assurance procedures so high confidence. As previously stated the nature of the impact described by MarLIN will be compared with the nature of the impact for Norfolk Boreas to

Data	Year	Coverage	Confidence	Comment
				determine whether the information is applicable before use.
UKSeamap 2010 Interactive Map, covering UK waters	Collation of various data sources up to 2010	The offshore project area	Medium	Well- audited quality assurance procedures however not all sources can be verified.
European Marine Observation and Data Network (EMODnet) Seabed Habitats, covering European waters	2004-2014	The offshore project area	Medium	Well- audited quality assurance procedures however not all sources can be verified.
Satellite Suspended Particulate Material (SPM), covering UK waters and UK Continental Shelf	1998 - 2015	The offshore project area	Medium	Well – audited quality assurance however not site specific.

*Also provided as Appendix 7.3 of the Information to support HRA document reference 5.3

43. Following discussions with Natural England in relation to potential impacts on the Haisborough, Hammond and Winterton SAC, specifically on the sandbank system and the biogenic reefs within the SAC, a detailed export cable installation study (Appendix 5.2) was commissioned by VWPL (summarised in Chapter 5 Project Description). This assessed the offshore cable corridor survey data and considered the potential for cable burial within the corridor. This study has informed the identification of the worst case installation scenarios (section 10.7.2) (in terms of area affected and sediment disturbance) and embedded mitigation (section 10.7.1). The study included:

- A review of site geology and available installation tools which showed that the sediments are conducive to cable burial;
- The calculation of a non-mobile reference seabed level (RSBL) below which the seabed will not fall during the lifetime of the wind farm in order to understand how to bury cables to reduce / remove the likelihood of re-exposure during the lifetime of the project;
- Calculations of sediment volumes which would require dredging during pre-sweeping works to enable cables to be buried below the RSBL, both inside and outside the Haisborough, Hammond and Winterton SAC. These volumes are likely to decrease as the route and installation tools are further refined;
- Identification of potential disposal areas within the Haisborough, Hammond and Winterton SAC for material removed from the SAC during pre-sweeping to preserve the form and function of the sandbank system; and
- Explanation of how offshore export cable route adjustments/micrositing can be undertaken due to contingency in the offshore cable corridor width, specifically to avoid certain bedforms and biogenic reefs.

10.5.3 Assumptions and Limitations

44. There is a large amount of data that has been collected during the ZEA and site-specific surveys as well as other available data which provides a wider understanding of the benthic communities within the region (Table 10.8). It is therefore considered that the current understanding of the existing benthic and intertidal environment relevant to the project is comprehensive and robust.

45. In terms of potential limitations associated with the available benthic data the main consideration is the original ZEA data were acquired nearly seven years ago. However, with respect to the ZEA data, there is no recommended duration of validity for benthic samples and comparison of survey data collected in 2017 with that collected in 2011 and to the REC data (Limpenny *et al.* 2011), is statistically similar (Appendix 10.2). This indicates that there has been little change in the benthic communities in the past seven years. Therefore, the ZEA data can be considered valid for this assessment.

46. With respect to sample consistency, further, statistical comparison of the ZEA, Norfolk Vanguard and Norfolk Boreas datasets (Appendix 10.2) shows the data are suitably consistent for the purposes of site characterisation.

47. As part of the benthic survey data analysis, Fugro Ltd used signatures from the sidescan sonar data and the benthic grab data to create a biotope map (Appendix 10.1 Figure 6.1). The biotope map can only be used to indicate the 'potential presence' of biotopes where grab and drop-down video samples are not available.

48. Following the consultation on the PEIR, the project interconnector search area was extended to allow for cables to be installed across the gap between the Norfolk Boreas site and Norfolk Vanguard East, shown in Figure 4.17. The extended area has not been subject to dedicated bathymetric surveys. However, data that covers the majority of this area are available from the Norfolk Boreas site geophysical survey and the East Anglia FOUR geophysical surveys (Table 8.9 in Chapter 8 Marine Geology, Oceanography and Physical Processes). Together, these survey data cover approximately 80% of the extended area (Figure 8.4) and show that large and medium sized features such as sand banks, troughs and sand waves appear to be continuous across the extended area (Figure 8.4) and therefore the assumption is made that the benthic communities within the additional area will be consistent with those surrounding it.

49. This approach was agreed with Natural England and the MMO through consultation on the Offshore Order Limits Change report (Appendix 27.4 and 27.6 of the Consultation report). Further detail on this consultation is provided in section 27 of the Consultation report (document reference 5.1)

50. There is a pipeline located within the partly surveyed section of the project interconnector search area (Chapter 18 Infrastructure and Other Users). Review of the existing geophysical data indicates that the pipeline is partly buried in sediment. Following a review of Kingfisher bulletins[3] which did not show any reports of pipeline spans and consultation with the pipeline owner it is concluded that there are no pipeline spans within the project interconnector search area.

51. Consultation with the pipeline owner has also revealed that during preinstallation surveys in 2006 which covered the entire pipeline route, no *Sabellaria* reef was detected within the extended part of the project interconnector search area. *Sabellaria* reef was encountered at a number of locations, including two areas which have been identified through Envision Mapping Ltd (2018) (Appendix 7.2 of the Information to Support HRA report (document reference 5.3) however none was located within the extension to the project interconnector search area.

52. Pre- and post-construction surveys will be used to provide additional bathymetric information where data are currently not available. Further details are provided in the In Principle Monitoring Plan (document reference 8.12).

10.6 Existing Environment

53. The environmental baseline, including descriptions of sediment type, infauna and epifauna, is presented for the Norfolk Boreas site, project interconnector search area and the offshore cable corridor which includes the intertidal area at the landfall. A description of protected areas and important species in the vicinity of the project is also provided. Analysis of the various benthic ecology data sets is provided in Appendix 10.2.

10.6.1 Sediment Types

54. The ZEA survey grab sampling campaign collected 101 samples from the Norfolk Boreas site (Figure 8.8) (MESL, 2011). A total of 14 samples also fell within the bounds of the offshore cable corridor (Figure 8.9). The offshore cable corridor surveys (Fugro, 2017b) collected a total of 33 grab samples (Figure 8.9) and the Norfolk Boreas site survey collected 35 grab samples (see Table 10.8 for survey details and Appendix 10.1). Seabed sediment distribution is described in full in Chapter 8 Marine Geology, Oceanography and Physical Processes and shown in Figure 10.2 with a summary of Norfolk Boreas offshore project area provided below.

[3] The Kingfisher Bulletin works across all offshore industries to keep the fishing industry up to date with information relating to the latest hazards, planned developments, new structures being installed and zones created, available at: https://www.seafish.org/article/kingfisher-bulletins

10.6.1.1 The Norfolk Boreas site

55. The dominant sediment type in the Norfolk Boreas site is sand (65-100% content in all samples) with median particle sizes mainly between 0.17 and 0.33mm (fine to medium sand). The mud content is less than 5% in 80% of the samples and less than 10% in 90%. However, 10% of the samples contain greater than 10% mud, ranging from 10% to 31%. The gravel content is less than 5% in 90% of the samples.

10.6.1.2 The Offshore cable corridor

56. Sediment distribution is variable depending on location within the offshore cable corridor. However, the dominant sediment size is sand. Higher proportions of mud (greater than 10%) were found in 25% of samples with two samples containing greater than 60% mud. Many samples closer to the coast contained greater than 50% gravel.

10.6.1.3 Project interconnector search area

57. The western part of the project interconnector search area has a dominant sediment type of medium-grained sand with median particle sizes mainly between 0.25 and 0.40mm. The mud content is less than 5% in 83% of the samples. However, 17% of the samples contain greater than 15% mud, ranging from 15% to 45%. The gravel content varies from zero to 9% in all the samples.

58. The eastern part of the project interconnector search area has a dominant sediment type of medium-grained sand (82-100% sand) with median particle sizes between 0.20mm and 0.37mm, with most samples (90%) containing less than 5% mud. The gravel content varies from zero to 7% in all the samples.

59. As stated in in section 10.5.3 it is assumed the sediment type within the un-surveyed section of the project interconnector search area is likely to be similar to that described here.

10.6.2 Infauna

60. To provide a comparison of the benthic ecology in the Norfolk Boreas offshore project area with the wider regions, data have been analysed in the context of the former East Anglia Zone as well as in the context of each of the three project areas; the Norfolk Boreas site, the offshore cable corridor and the project interconnector search area separately.

61. A total of 566 benthic grabs samples were collected and analysed during the ZEA survey for characterisation purposes, 65 during the offshore cable corridor surveys and 10 during the Norfolk Boreas site surveys. From these, 527 taxa were identified, with an average of 97 individuals and 16 taxa recorded per sample. Of these grab samples, 105 were taken within Norfolk Boreas site, 43 from within the Norfolk Boreas offshore cable corridor and 44 from within the project interconnector search

area. Figure 10.3 shows infaunal abundance per grab sample across the offshore project area, Figure 10.4 shows species richness per grab sample and Figure 10.5 shows infaunal biomass per samples. Infauna are described in full in Appendix 10.2 with summaries provided below.

10.6.2.1 The Norfolk Boreas site

62. The infaunal communities within the Norfolk Boreas site are dominated by many of the same species groups as the former East Anglia Zone (see Appendix 10.2, Plate 10.3 and Plate 10.1). Polychaete worms are the most numerous class in terms of individuals followed by Malacostraca (a class of Crustacea), representing 63.1% and 9.5% respectively of all individuals recorded within the Norfolk Boreas site.

63. 90 polychaete worm species were recorded in the Norfolk Boreas site representing 45.2% of all species recorded (species richness). 59 Malacostraca species were recorded in the Norfolk Boreas site representing 29.6% of all species recorded (Appendix 10.2, Plate 10.4).

10.6.2.2 Offshore cable corridor

64. The offshore cable corridor was also dominated by polychaetes and Malacostraca, with Ophiuroidea (brittlestars) also contributing (Appendix 10.2, Plate 10.5). In terms of species diversity in the offshore cable corridor, the most diverse group were again the polychaetes and Malacostraca*,* with Gastropoda, Ophiuriodea and Bivalvia also contributing (Figure 10.4 and Appendix 10.2, Plate 10.6). The samples which contained the highest biomass were located in the offshore cable corridor to the south west of the Norfolk Boreas site (Figure 10.5).

10.6.2.3 Project interconnector search area

65. The project interconnector search area was also dominated by polychaetes and Malacostraca, with Bivalvia and Nemertea also contributing (Figure 10.3 and Appendix 10.2, Plate 10.7). In terms of species diversity in the offshore cable corridor, the most diverse group were again the polychaetes and Malacostraca, with bivalves also contributing (Figure 10.4 and Appendix 10.2, Plate 10.8). As stated in section 10.5.3 it is assumed the Infauna within the un-surveyed section of the project interconnector search area is likely to be similar to that described here.

10.6.2.4 Multivariate analysis

66. Following the taxonomic comparison between the offshore project area and the former East Anglia Zone, statistical analysis was conducted to identify the faunal communities which exist within the offshore project area and the former East Anglia Zone. The results are provided in full in Appendix 10.2 and summarised below.

67. As agreed through the benthic ecology method statement and ETG meetings, infaunal benthic data sets from the ZEA survey, the offshore cable corridor survey and the Norfolk Boreas site survey were combined and multivariate analysis was

completed on this combined data set (see section 10.3.1 of Appendix 10.2 for details of the methodology used for the analysis). The aim of this analysis was to characterise the wider region, which in this case is represented by the former East Anglia Zone as well as the Norfolk Boreas offshore project area.

68. The multivariate analysis of the benthic infaunal data was carried out using the PRIMER V6 software package, the results of which are presented in Appendix 10.2 (section 10.3.2). Once the infaunal communities across the wider region had been characterised it was then possible to identify if any of the communities within the Norfolk Boreas offshore project area are typical of those within the region or if there are any which are distinctly different or rare.

69. Eighteen distinct faunal groups were identified across the former zone, and these are presented within section 10.4.4 of Appendix 10.2 and displayed in Figure 10.6. A summary of the communities found across the Norfolk Boreas offshore project area is provided below.

10.6.2.5 The Norfolk Boreas site

70. Four groups (k, i, n, and o) were found within the Norfolk Boreas site all of which apart from i were common across the former Zone. Group i was found at one location within the Norfolk Boreas site and at one location on the edge of the northern edge offshore cable corridor (Figure 10.6).

71. The main defining taxa of the groups found within the Norfolk Boreas site were:

- Group i, *Goniada maculata* and *Spiophanes bomby*x;
- Group k: Nemertea, and the polychaete worms S.spinulosa and S.bombyx;
- Group n: the polychaete worm *Nephtys cirrosa*; and
- Group o: the polychaete worm *S.bombyx, N. cirrosa* and *Polinices pulchellus*

72. The Norfolk Boreas site was dominated by group o (Figure 10.6).

10.6.2.6 Offshore cable corridor

73. The offshore cable corridor contained 11 different faunal communities. The greater range of faunal communities is to be expected as the depth range across the offshore cable corridor is far greater than that within the offshore wind farm sites (Chapter 8 Marine Geology, Oceanography and Physical Processes). The groups identified within the offshore cable corridor are described in Appendix 10.2 Table 10.3.

74. The faunal communities recorded in the Norfolk Boreas offshore project area are typical of the sediment and environmental conditions encountered, and contain common widely occurring species.

10.6.2.7 Project interconnector search area

75. The main groups found within the project interconnector search area were h, k, n, o and p) defining taxa of the groups were:

- Group h, was distinct from all other groups and was dominated by *Capitella* spp. (48 of the 54 individuals within the sample)
- Group k: Nemertea, and the polychaete worms *S.spinulosa* and *S.bombyx;*
- Group n: the polychaete worm *N. cirrosa*
- Group o: the polychaete worm *S.bombyx, N. cirrosa* and *P. pulchellus*;
- Group p: the polychaete worm *N. cirrosa*, *S. bombyx* and Nemertea

76. As stated in in section 10.5.3 it is assumed the infauna within the un-surveyed section of the project interconnector search area is likely to be similar to that described here.

10.6.3 Epifauna

77. As agreed through the EPP, no epibenthic trawls were undertaken as part of the Norfolk Boreas site surveys and therefore this type of survey data is not available for a large section of the offshore cable corridor; however, the results of the grab survey indicate the area of the offshore cable corridor which overlaps with the former Zone is broadly comparable with the benthic ecology in the Norfolk Boreas offshore project area.

78. A total of 78 epibenthic (seabed surface) trawls were taken during the ZEA survey of, of which 13 are located within the Norfolk Boreas offshore project area. Overall, the surveys identified 95 different taxa of macrofauna, with an average of 956 individuals and 24 taxa per trawl sample (EAOW, 2012a). The distribution of abundance and taxonomic richness across the former zone varies, with abundance generally higher in the north of the former zone and diversity showing no defined pattern (Figure 10.7 and Figure 10.8).

79. Epifaunal abundance ranged from 110 to 15,252 individuals per trawl within the former Zone, with the majority of trawls supporting less than 565 individuals (Figure 10.7). The distribution of taxonomic richness was very variable, with no strong geographical patterns appearing to govern the distribution of this faunal metric. Trawl stations supporting comparatively high levels of taxonomic richness were widely distributed across the EAOW zone. Common species recorded during the trawls include the shrimp *Crangon allmanni*, solenette *Buglossidium luteum*, Gobies *Gobiidae* and Dab *Limanda limanda*. Dab was widely distributed across the EAOW zone and also made a significant contribution to the total epifaunal biomass.

80. Multivariate analysis of the ZEA epifaunal data which was completed for the ZEA Zone (EAOW,2012) identified four faunal groups (Figure 10.9). The Norfolk Boreas

offshore project area is dominated by one group, which is characterised by the following key taxa:

- The flatfish *Buglossidium luteum*;
- The brittlestars *Ophiura ophiura* and *O. albida*;
- The fish family, *Gobiidae*; and
- The shrimp *Crangon allmanni*.

81. The multivariate analysis of the samples collected during the East Anglia Zone survey demonstrated that there was a significant relationship between biological communities and sediment type (EAOW, 2012). The strongest correlation was found between faunal communities and gravel, sand and fine sand, accounting for over 29% of the observed variations in faunal communities.

82. Analysis of the Norfolk Boreas video footage showed that the majority of the Norfolk Boreas site had fine sediments, analysed as mainly shelly sand or shelly gravelly sand. This corresponds to the ZEA survey results which found the sediments across the former East Anglia zone to be predominantly comprised of sandy substrates with varying levels of gravel composition. The epibenthic communities were found to reflect the sediment complexity.

10.6.4 Biotopes across the offshore project area

83. As part of the Norfolk Boreas site and offshore cable corridor surveys, Fugro Ltd. used the dropdown video footage and benthic grab samples to assign a biotope code at each sample location. Biotope code allocations were made using the Marine Habitat Classification for Britain and Ireland (JNCC, 2015). Further information on the process of allocating the biotope codes can be found in Appendix 10.1. Sidescan sonar data was then used to extrapolate an indicative biotope map for the entire survey area (see Figure 10.10). This process is also described further in Appendix 10.1. As discussed in section 10.5.3, the biotope map can only be used to indicate the 'potential presence' of biotopes where grab/video samples are not available.

10.6.4.1 The Norfolk Boreas Site

84. During the Norfolk Boreas site survey three biotopes were recorded:

- Sublittoral sands and muddy sands (SS.SSa, A5.2)
- *Sabellaria spinulosa (S. spinulosa)* on stable circalittoral mixed sediment (SS.SBR.PoR.SspiMx, A5.611);
- *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand (SS.SSA.IMuSa.FfabMag, A5.242).

85. SS.SSa (A5.2) was recorded by the seabed video footage at most stations. SS.SBR.PoR.SspiMx (A5.611) was recorded at three stations, which grouped together following multivariate analysis. This biotope was also recorded by the seabed video

footage at two of these stations which showed low lying consolidated aggregations of *S. spinulosa* tubes. SS.SSA.IMuSa.FfabMag (A5.242) was recorded at the remaining seven stations which grouped together following multivariate analysis.

10.6.4.2 Offshore cable corridor

86. The offshore section of the offshore cable corridor was predominantly defined as the following biotopes:

- The eastern section is mainly Circalittoral coarse sediment (SS.SCS.CCS);
- The middle section is predominantly 'Circalittoral fine sand' (SS.SSa.CFiSa); and
- The near shore section is dominated by 'Circalittoral mixed sediment' (SS.SMx.CMx) (Figure 10.10).

87. In addition, small areas of the following biotopes are interspersed along the corridor:

- '*Mediomastus fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel' (SS.SCS.CCS.MedLumVen); and
- '*S. spinulosa* on stable circalittoral mixed sediment' (SS.SBR.PoR.SspiMx).

10.6.4.3 Project interconnector search area

88. The project interconnector search area was video surveyed as part of the offshore cable corridor survey (Norfolk Vanguard Limited, 2018, Appendix 10.1). The biotope complex SS.SCS.CCS was the most common in the survey area (Figure 10.10).

89. Within the eastern part of the project interconnector search area, the biotope complex SS.SCS.CCS was assigned as characterising the site. Physical and biological data also identified biotope complex SS.SSa.CFiSa at three stations; and 'Circalittoral fine/muddy sand' (SS.SSa.CFiSa / SS.SSa.CMuSa) at one station, and one station of ''*Echinocyamus pusillus, Ophelia borealis* and *Abra prismatica* in circalittoral fine sand' (SS.SSa.CFiSa.EpusOborApri) (Figure 10.10). As mentioned in section 10.5.3, it is assumed the infauna within the un-surveyed section of the project interconnector search area is likely to be similar to that described here.

90. Within the western part of the project interconnector search area, the biotope SS.SCS.CCS was assigned to the majority of the area. In addition, areas of potential SS.SBR.PoR.SspiMx were assigned along the western edge, with three sample stations being characterised as SS.SBR.PoR.SspiMx.

10.6.5 Intertidal

91. The intertidal zone from Mean High Water Springs (MHWS) to Mean Low Water Springs (MLWS) within the Happisburgh South landfall search area has been classified as mobile barren littoral sands. The sediment is predominantly a clean fine sand veneer on top of coarse sand, gravel and pebbles. Larger cobbles were

recorded at some locations in the mid shore. No flora or fauna was recorded at any of the sample locations.

92. Norfolk Boreas Limited has taken the decision to use a long HDD at landfall (see Chapter 5 Project Description) which will avoid any direct or indirect impacts to the intertidal habitats. Therefore, the intertidal is not considered further within this assessment.

10.6.6 Protected Species and Habitats

10.6.6.1 Annex 1 Habitats

93. There are two habitat types listed in Annex I of the Habitats Directive that occur in the former East Anglia Zone and therefore have the potential to occur within the Norfolk Boreas offshore project area: sandbanks slightly covered by seawater all the time and biogenic reefs. Information to Support HRA will be submitted as part of the final DCO submission which assesses the impact on Natura 2000 sites. HRA Screening for benthic ecology was discussed and agreed with stakeholders as part of the ETG consultation in February 2018 and forms part of the HRA screening document (Appendix 5.1 of the Information to Support HRA report (document reference 5.3)).

94. The Haisborough, Hammond and Winterton SAC to the west of The Norfolk Boreas site is designated for 'Sandbanks slightly covered by sea water all the time' and 'Reefs' formed by *S. spinulosa*. The Conservation Objectives for this SAC are:

- Maintain the Annex I Sandbanks in Favourable Condition, implying that existing evidence suggests the feature to be in favourable condition; and
- Maintain or restore the Annex I reefs in Favourable Condition, implying that the feature is degraded to some degree (JNCC, 2016).

95. The offshore cable corridor runs through this site. Impacts to the designated features of this site will be assessed in the HRA assessment (document reference 5.3) which has been submitted as part of the DCO application.

96. Areas of the seabed permanently submerged and rising to a depth of less than 20m Lowest Astronomical Tide (LAT) were recorded within the offshore cable corridor (Norfolk Vanguard Limited, 2018, Appendix 10.1). These features are predominantly located in the middle section of the offshore cable corridor and are known as the Hearty Knoll and Newarp Banks. They form part of the Annex I Sandbanks which occur within the Haisborough, Hammond and Winterton SAC.

97. Biogenic aggregations made by *S. spinulosa* were identified as potential reef structures during the ZEA benthic surveys. *S. spinulosa* can form dense aggregations on the seabed, which can take the form of crusts or reef where aggregations are up to several metres across and up to 60cm in depth (Gubbay, 2007). The drop-down

video sites selected for the Norfolk Boreas site benthic survey were specifically targeted to areas considered likely to support *S. spinulosa* based on the analysis of the previously collected survey data. As discussed in section10.6.4, *S. spinulosa* biotopes were recorded in the Norfolk Boreas site. Areas identified during the Norfolk Boreas and ZEA surveys correspond well with Regional Environmental Characterisation (REC) data (Limpenny *et al.* 2011) collected in 2011 (see Figure 10.11).

98. Drop down video images containing *S. spinulosa* were categorised using Gubbay's scoring system for "reefiness" for determination of the presence of Annex I habitat, which states a classification of 'medium' or 'High reef' is required for Annex I habitat (Hendrick and Foster-Smith, 2006 and Gubbay 2007). 14% of grab samples in the former Zone contained *S. spinulosa* and of these, 19% (2.6% of grab samples) indicated the potential for presence of reef (EAOW, 2012a).

99. During the Norfolk Boreas site survey in 2017 two of the 33 drop down video samples showed *S. spinulosa* (site 5 and 14). At site 5 three additional drops were performed (5A-C), and at site 14 one additional drop was performed (14A) (Appendix 10.1). At each of these sites the *S. spinulosa* was not present in a reef formation and was therefore not classed as an Annex I habitat. The *S. spinulosa* aggregations encountered as part of the survey were considered to be either 'Not reef' or 'Low reef' (using the methodology defined in Gubbay, 2007 as far as is possible from live, onboard DDV review); and therefore, not Annex I habitat.

100. During the offshore cable corridor video survey two stations were recorded in the project interconnector search area with *S. Spinulosa* scoring 'Low reef' (Norfolk Vanguard Limited, 2018, Appendix 10.1) (Figure 10.12).

101. In 2006 side scan sonar data and subsequent ground truthing video data were collected as part of preconstruction surveys for the BBL pipeline. The BBL pipeline crosses the project interconnector search area in two places (Figure 18.2). These surveys detected four areas of potential *S.spinulosa* reef along the pipeline length one of which is located within the project interconnector search area and coincides with one of the areas detected in the offshore cable corridor (Norfolk Vanguard Limited, 2018 or Appendix 7. Of the Information to support HRA (document reference 5.3) of this application) (Figure 10.12).

102. These surveys did not detect any potential *S.spinulosa* reef within the part of the project interconnector search area which has not been subject to site specific surveys (see section 10.5.3).

103. Further work completed by Envision Mapping Ltd (2018) (Appendix 7.2 of the Information to Support HRA report (document reference 5.3) has interpreted a number of relevant data sets to provide the most comprehensive review of the likely

presence and extent of *S.spinulosa* reef within the offshore cable corridor. The study uses an ensemble mapping technique and incorporates regional sample data allowing a probabilistic approach to mapping to be incorporated along with the attribution of confidence to habitat areas which have been mapped. The ensemble mapping process does not dismiss any original findings or historic data but enables the data to be used to build a better understanding of the marine habitats and their likely distribution. The use of this system allows for future data to be incorporated and the habitat maps to be updated with new data and information as it becomes available. The ensemble mapping process has been given a confidence assessment score, based on whether the maps included in the process are in agreement with each other, rather than on the underlying confidence or accuracies of each individual map. Therefore, when several different sources of data show the same identified reef area in the same location this increases the level of confidence in the actual presence of the reef on the seabed. Further information on the methodology used is provided in Appendix 7.2 of the Information to Support HRA report (document Reference 5.3).

104. The mapping process focused on assessing the potential for reef in or near the SAC and showed that there was low confidence in the extents of the potential *S. spinulosa* reef to the east of the SAC in the offshore cable corridor (Appendix 7.2 of the Information to Support HRA report (document reference 5.3)) and indeed grab samples taken from that area did not indicate that reef was present. The central 'dog-leg' section of the offshore cable corridor contained the distributions of high confidence reef with small areas where all maps agreed and samples (video and grab) also provide supporting evidence (Figures 18 and 19 of (Appendix 7.2 of the Information to Support HRA report (document reference 5.3))).

105. The presence and extent of *S. spinulosa* reef in the section of offshore cable corridor west of the SAC is less certain with not all sources agreeing (Figures 21 and 22 of (Appendix 7.2 of the Information to Support HRA report (document reference 5.3))). The majority of sample points within these areas were classified as reef not present and of either circalittoral fine sand (SS.SSa.CFiSa) or circalittoral coarse sand (SS.SCS.CCS), rather than the *S. spinulosa* biotope SS.SBR.PoR.SspiMx.

106. A comparison of the potential Annex I reef derived from the Envision study (Appendix 7.2 of the information to Support HRA report (document reference 5.3)) and areas identified by Natural England and JNCC as being 'areas to be managed for *S. spinulosa* reef' has been undertaken and submitted as part of the Norfolk Vanguard examination (Norfolk Vanguard, 2019 Figure 2.1). The comparison shows fairly good correlation between predicted locations of potential Annex I reef within the offshore cable corridor.

107. Horse mussel *Modiolus modiolus* and common or blue mussel *Mytilus edulis* also have the ability to form aggregations which can be classed as reef. No mussels were recorded in the offshore cable corridor.

108. The offshore cable corridor overlaps with the Greater Wash Special Protection Area (SPA). The site is designed to protect red-throated diver *Gavia stellata,* Little gull *Hydrocoloeus minutus*, Sandwhich tern *Sterna sandvicensis*, common tern *Sterna hirundo* and little tern *Sternula albifrons* and common scoter *Melanitta nigra* both of which can include within their diet benthic species most notably small molluscs such as *M. edulis* as well as small crustaceans.

109. The impacts to the conservation objectives of The Greater Wash SPA will be considered further within the information to support HRA (document reference 5.3) which is submitted with the DCO application.

10.6.6.2 Habitats and Species of Principal Importance

110. Priority species and habitats that were identified under the former UK Biodiversity Action Plan (BAP) remain important and are now referred to as habitats of principal importance (HPI) and species of principal importance (SPI).

111. The following HPI are present within the former East Anglia Zone and of these, those shown in bold are also found within the Norfolk Boreas offshore project area:

- Mud habitats;
- ***S. spinulosa* reefs;**
- **Subtidal sands and gravels**;
- Subtidal chalk; and
- Peat and clay exposures.

112. Habitat mapping during the ZEA identified small areas of potential mud habitats in deep water in the north west of the former Zone. However, none of this potential mud habitat was identified within the Norfolk Boreas offshore project area. Figure 10.2, which includes ZEA and Norfolk Boreas site survey data, shows that the principal sediment components within the Norfolk Boreas site are sand. There are small amounts of mud present at only a few survey stations.

113. As discussed above potential for *S. spinulosa* reef has been identified within the Norfolk Boreas offshore project area (Figure 10.12).

114. Subtidal sands and gravels potentially cover large areas of the site.

115. Subtidal chalk and peat and clay exposures have been identified within the Cromer Shoal Chalk Beds MCZ (see section 10.6.6.3, below), outside and to the north of the offshore cable corridor.

116. Four SPI were identified in the ZEA surveys; mantis shrimp *Rissoides desmaresti*, spider crab *Achaeus cranchii*, the amphipod *Apherusa ovalipes*, and the polychaete *Streptosyllis* spp. (EAOW, 2012a).

10.6.6.3 Marine Conservation Zone features

117. The offshore cable corridor is located to the south of the Cromer Shoal Chalk Beds MCZ (Figure 10.13). The features of conservation importance within the MCZ are subtidal chalk as well as peat and clay exposures. Mapping of these features indicates that the southern part of the MCZ which is located close to the offshore cable corridor could include subtidal chalk as well as subtidal coarse sediment (Defra, 2016).

118. The offshore cable corridor benthic survey which overlapped with the MCZ did not observe chalk reef features in the survey area but concluded that the presence of chalk reef cannot be discounted as it may not be visible at the surveyed sediment surface. It should be noted that although the survey overlapped with the MCZ the project red line boundary does not (Figure 10.13) and the offshore cable corridor is located approximately 60m from the edge of the MCZ at its nearest point.

10.6.7 Context and Summary

119. The benthic species and biotopes found within the Norfolk Boreas offshore project area are considered broadly typical of those that exist within the former East Anglia Zone and wider southern North Sea (as shown in maps displayed on the Marine Habitat Classification Hierarchy website (JNCC, undated). Species abundance and diversity are broadly in keeping with that of the former Zone.

120. The predominant habitats are sands and gravels and these determine the infaunal and epifaunal communities which are present. The faunal communities are relatively homogenous across the former zone and the communities found within the Norfolk Boreas offshore project area are generally consistent with those found across the wider former zone. These are generally of low diversity containing species which recover rapidly and are typical of physically disturbed habitats.

121. The habitats and species found within the Norfolk Boreas offshore project area are analogous to findings of other surveys that have been conducted within the region. Examples include the Regional Environmental Characterisation (REC) studies (Limpenny *et al.*, 2011) and characterisation surveys for other offshore wind farm environmental impact assessments (Hornsea, Greater Gabbard Offshore Wind Farm, Galloper Wind Farm and Dogger Bank Creyke Beck).

122. Of particular relevance is the East Coast REC, which overlaps with the offshore cable corridor. This study found that sediment type was the greatest predictor for the benthic communities present and that the infauna was dominated by many of the

polychaetes which dominate the data from the Norfolk Boreas surveys such as *N. cirrosa, U. brevicornis* and *B. elegans* (Emu and University of Southampton, 2009).

123. No biogenic or rocky reef areas were confirmed in the combined survey and data analysis for the Norfolk Boreas offshore project area. However, areas of potential *S. spinulosa* biotope were identified in the offshore cable corridor. One station in the offshore cable corridor in the central 'dog-leg' section was recorded as having a medium score on the "reefiness" scale (Figure 10.12).

124. A section of the offshore cable corridor overlaps with the Haisborough, Hammond and Winterton SAC which is designated for sand bank and *S. spinulosa* reef (Figure 10.13).

10.6.8 Anticipated Trends in Baseline Conditions

125. The baseline conditions for benthic ecology are considered to be relatively stable within the offshore project area, with multiple data sets covering several years exhibiting similar patterns. For example, the findings of the ZEA surveys conducted are very similar to the findings of the Norfolk Boreas site surveys conducted in 2017.

126. The existing environment within the study area has been largely shaped by a combination of the physical processes which exist within the southern North Sea (Chapter 8 Marine Geology Oceanography and Physical Processes) and anthropogenic impacts in the area such as fishing, and in particular the high levels of beam trawling that currently exist across the study area (Chapter 14 Commercial Fisheries).

127. Some seabed areas within the Haisborough Hammond and Winterton SAC are "closed areas" to fishing (Chapter 14 Commercial Fisheries) and others are currently being considered by regulators (EIFCA, DEFRA, NE, JNCC and MMO) as potential closed areas. Some of the areas under consideration overlap with sections of the offshore cable corridor. The closure of these areas to fishing is anticipated to have beneficial effects on the benthic ecology of those areas by increasing abundance, species diversity and the potential for the establishment and growth of biogenic reef. At the time of writing (April 2019) the closed areas are not yet in force and the timescale over which a potential increase in abundance and diversity could be exhibited following fisheries closures is uncertain.

128. Warming sea temperatures may result in large scale changes to the marine ecosystem (Brierley & Kingsford 2009) with the migration of benthic species from the south to the north likely to occur, resulting in changes in benthic community structure. The timescale over which any discernible change in benthic community may occur as a result of increasing sea temperatures is largely unknown.

10.7 Potential Impacts

10.7.1 Embedded Mitigation

129. Norfolk Boreas Limited has committed to a number of techniques and engineering designs/modifications inherent as part of the project, during the pre-application phase, in order to avoid or reduce a number of impacts as far as possible. Embedding mitigation into the project design is a type of primary mitigation and is an inherent aspect of the EIA process.

130. A range of different information sources has been considered as part of embedding mitigation into the design of the project (for further details see Chapter 5 Project Description, Chapter 4 Site Selection and Assessment of Alternatives) including engineering requirements, ongoing discussions with stakeholders and regulators, commercial considerations and environmental best practice.

10.7.1.1 Site selection

131. Careful site selection of the Norfolk Boreas site and offshore cable corridor has been carried out to avoid, as far as possible, designated sites, including the Cromer Shoal Chalk Beds MCZ. It is not possible to avoid the Haisborough, Hammond and Winterton SAC (as detailed in Chapter 4 Site Selection and Assessment of Alternatives, section 4.7) however use of appropriate cable installation methodologies can ensure that any impacts are short term and reversible. The offshore cable corridor has been designed to avoid cable crossings where possible. Where cable crossings are required the corridor has been aligned in such a way that a crossing is made at 90^o angle where possible. This is for technical reasons but also serves to minimise the requirement for cable protection.

132. The offshore cable corridor takes the shortest, most direct route possible from the Norfolk Boreas site to landfall, whilst avoiding as many sensitivities as possible, thereby minimising the potential areas of disturbance and potential for cable protection.

10.7.1.2 Intertidal

133. Norfolk Boreas Limited has made a decision to use long HDD from an onshore location to the subtidal zone (at least -5.5m LAT). Therefore, there will be no direct or indirect impacts on the intertidal zone and therefore impacts on the intertidal zone are not considered further.

10.7.1.3 Reduction of turbine numbers and foundation footprint

134. Norfolk Boreas Limited has reduced the maximum number of turbines from 257, proposed during scoping (Royal HaskoningDHV, 2017) to 180, while maintaining the maximum capacity of 1,800MW by taking the decision to use fewer larger turbines.

135. Following the consultation on the PEIR, Norfolk Boreas Limited made the decision to remove floating foundations from the project design envelope which has resulted in a large reduction in the area of disturbance and habitat loss resulting from foundations.

10.7.1.4 Minimising export cabling

136. Norfolk Boreas Limited has made the decision to use an HVDC solution in order to reduce the number of export cables and volume of cable protection (as advised in Natural England's recommendations document (Natural England, 2018). This results in the following mitigating features:

- There would be two cable trenches instead of six for Norfolk Boreas;
- The volume of sediment arising from pre-sweeping and cable installation works is reduced;
- The area of disturbance for pre-sweeping and cable installation is reduced;
- The space required for cable installation is reduced, increasing the space available within the cable corridor for micrositing to avoid sensitive features including designated features within the Haisborough Hammond and Winterton SAC;
- The potential requirement for cable protection in the unlikely event that cables cannot be buried is reduced; and
- The number of existing cable and pipeline crossings and associated cable protection is reduced due to the reduction on number of export cables.

10.7.1.5 Pre-construction survey

137. A pre-construction survey would be undertaken in advance of cable and foundation installation works. The methodology for the pre-construction surveys would be agreed with the MMO in consultation with the relevant SNCBs. The results of this survey would be used to inform the location of wind turbines and the routeing of all Norfolk Boreas cables, including micrositing around sensitive feature where possible. The locations and cable routes would then be discussed and agreed with the MMO in consultation with the relevant SNCBs.

138. For subsequent phases of construction, it is likely that a further pre-construction survey would be undertaken should there be a gap of over 12 months between completion of the pre-construction survey and commencing the phased installation. Where possible, further small scale micrositing of the turbine locations and cable route would be undertaken, based on the latest survey results.

10.7.1.6 Micrositing

139. As discussed above, should seabed obstacles (e.g. Annex 1 *S. spinulosa* reef and UXO) be identified in the proposed wind turbine locations and/or cable routes during the pre-construction surveys, micrositing would be undertaken where possible, to

minimise potential impacts. There is the potential for *S. spinulosa* to be present in a formation that is not classified as Annex I reef ('Not reef' or 'Low reef', using the methodology defined in Gubbay, 2007), in which case micrositing would only occur in areas of high quality reef that is designated as Annex I habitat.

140. VWPL commissioned a Cable Constructability Assessment by Global Marine Systems Ltd (GMSL, 2016 unpublished) to determine an appropriate combined cable corridor for Norfolk Boreas and Norfolk Vanguard. This cable corridor includes contingency (shown in Plate 10.1) in order to allow micrositing around potential seabed obstacles (e.g. Annex 1 reef). The space available for micrositing within the offshore cable corridor is based on the following (see the Norfolk Vanguard ES (Norfolk Vanguard Limited, 2018)):

- A total width of approximately 1.35km (approximately 675m for each project) is required for Norfolk Boreas and Norfolk Vanguard[4]; which includes
  - Up to two export cable trenches per project with spacing between Norfolk Boreas and Norfolk Vanguard cable trenches as shown in Plate 10.1;
  - A contingency of 440m (0.4km),
  - An anchor placement zone; and
  - A buffer for potential cable replacement works.
- The width of the offshore cable corridor is between approximately 2km and 4.7km;
- The remaining width of the offshore cable corridor within the SAC is therefore approximately 0.65km to 3.35km plus the built-in contingency of 0.4km, resulting in approximately 1.05km to 3.75km available for micrositing.

[4] This assessment is for Norfolk Boreas alone; however, the worst case scenario for space availability within the cable corridor must take account of the space required for Norfolk Vanguard export cables. Norfolk Vanguard will be considered further in the cumulative impact assessment (section 10.8).

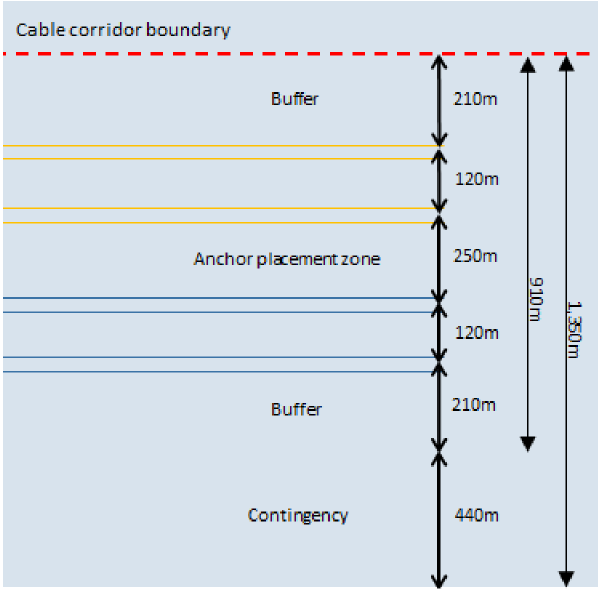

Plate 10.1 Export cables layout (two pairs of cables for Norfolk Boreas (blue) and two pairs of cables for Norfolk Vanguard (yellow)) based on 48m water depth[5]

10.7.1.7 Minimising cable protection

141. Norfolk Boreas Limited is committed to burying offshore export cables where possible, therefore reducing the need for surface cable protection. A detailed export cable installation study (Appendix 5.2) was commissioned by VWPL which confirmed that cable burial is expected to be possible throughout the offshore cable corridor, with the exception of cable and pipeline crossing locations.

142. An Outline Scour Protection and Cable Protection Plan (document reference 8.16) and an outline Site Integrity Plan (SIP) for the Haisborough Hammond and Winterton SAC (document reference 8.20) are included with the Norfolk Boreas DCO submission. These documents set out the key principles of how Norfolk Boreas Limited intends to manage the protection of cable and foundations from the effects of scour, both immediately post installation and throughout the operational life of the offshore wind farm; the later focusing solely on the section of the cable corridor within the SAC. A full cable burial risk assessment would be undertaken post consent, in consultation with the MMO and relevant SNCBs.

143. The exact method for cable crossings will be subject to crossing agreements with the relevant owners; however, the worst case scenario for cable protection is described in section 10.7.3.4.4.

[5] The separation between cables is determined by the potential space required to undertake a cable repair which is a factor of the water depth. Depth in the SAC is less than 48m and therefore this represents a conservative worst case scenario

10.7.1.7.1 Sand wave levelling

144. The option of sand wave levelling (pre-sweeping) to a stable reference seabed level would substantially reduce the potential that cables become unburied over the life of the project. Geophysical survey data of the offshore cable corridor was analysed to determine areas of sand waves which could require levelling and the depth of the reference level (variable throughout the corridor) in order to calculate the total volume of sediment associated with pre-sweeping (discussed in section 10.7.3.4.1).

10.7.1.7.2 Cable protection contingency

145. While it is expected that cable burial will be possible throughout the offshore cable corridor, a contingency for cable protection requirement is discussed in section 10.7.3.4.4 in order to provide a conservative and future-proofed assessment.

146. As previously discussed, analysis of geophysical data has shown that the substrate along the entire offshore cable corridor is expected to be suitable for cable burial. In the unlikely event that burial is not possible, this would be because hard substrate is encountered. In which case the seabed where cable protection would be placed would not be Annex 1 Sandbank.

10.7.1.8 Sediment disposal

147. All seabed material arising from the Haisborough, Hammond and Winterton SAC during cable installation would be placed back within the SAC using an approach, to be agreed with the MMO in consultation with the relevant SNCB, which would ensure that the sediment is available to replenish the sandbank features (Appendix 7.1 to the Information to inform HRA (document reference 5.3)).

148. Sediment would not be disposed of within 50m of known *S. spinulosa* reef identified during pre-construction surveys (in accordance with advice provided to Norfolk Vanguard by Natural England in January 2018).

10.7.1.9 Electromagnetic Fields (EMF)

149. Norfolk Boreas Limited is committed to burying offshore export cables where possible therefore reducing the effects of EMFs and the need for surface cable protection. As discussed in section 10.5.2, a detailed export cable installation study (Appendix 5.2) was commissioned by VWPL. This study confirmed that cable burial is expected to be possible throughout the offshore cable corridor with the exception of cable crossing locations.

150. By making the commitment to a HVDC electrical solution Norfolk Boreas Limited have reduced the maximum number of export cables from six (as would be the Worst case for a HVAC solution) to two. This will reduce the area of seabed over which EMF could be detected.

10.7.1.10 Non-native species

151. The risk of spreading non-native invasive species would be mitigated by following the relevant regulations and guidance including:

- International Convention for the Prevention of Pollution from Ships (MARPOL). The MARPOL sets out appropriate vessel maintenance
- The Environmental Damage (Prevention and Remediation (England) Regulations 2015, which set out a polluter pays principle where the operators who cause a risk of significant damage or cause significant damage to land, water or biodiversity will have the responsibility to prevent damage occurring, or if the damage does occur will have the duty to reinstate the environment to the original condition.
- The International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention), which provide global regulations to control the transfer of potentially invasive species.

152. These commitments would be secured in the Project Environmental Management Plan (PEMP) (document reference 8.14) which will be provided with the DCO.

10.7.2 Monitoring

153. An In-Principle Monitoring Plan (document reference 8.12) and outline PEMP (document reference 8.14) are included with the DCO application. It is recognised that monitoring is an important element in the management and verification of the actual project impacts. The requirement for appropriate design and scope of monitoring would be agreed with the MMO in consultation with the relevant SNCB prior to construction works commencing.

10.7.3 Worst Case

154. A single worst case project envelope is considered below. A summary of the worst case scenario is provided in Table 10.12.

155. The offshore project area consists of:

- The Norfolk Boreas site;
- The offshore cable corridor with landfall at Happisburgh South; and
- The project interconnector search area.

156. The detailed design of the Norfolk Boreas project (including numbers of wind turbines, layout configuration, requirement for scour protection etc.) has not yet been determined and may not be known until sometime after any DCO has been granted. Therefore, realistic worst case scenarios in relation to impacts on benthic and intertidal ecology are adopted which have been informed by a number of engineering studies undertaken or commissioned by VWPL.

157. The project design envelope on which the ES is based was “frozen” in January 2019 to allow the DCO to be completed and submitted in June 2019.

10.7.3.1 Foundations

158. Within the Norfolk Boreas site, different sizes of wind turbine are being considered in the range of 10MW to 20MW. In order to achieve the maximum 1,800MW capacity, there would be between 90 and 180 wind turbines.

159. In addition, up to two offshore electrical platforms, one service platform, two meteorological masts, two LiDAR platforms and two wave buoys, plus offshore cables are considered as part of the worst-case scenario.

160. A range of foundation options are currently being considered, these include:

- Wind turbines - jacket, gravity base structure (GBS), suction caisson, monopile and TetraBase;
- Offshore electrical platform – jackets with pin-pile or suction caissons, or multi-legged gravity base;
- Service platform – jackets with pin-pile or suction caissons, or multi-legged gravity base;
- Met masts - GBS, monopile or jacket with pin-pile;
- Lidar - floating with anchors or monopile; and
- Wave buoys – floating with anchors.

161. The largest seabed footprints are associated with GBS foundations.

10.7.3.2 Layout

162. The layout of the wind turbines will be defined post consent. It would have some form of regularity in plan, i.e. wind turbines would be set out in rows with between turbine spacing of 720m to 6060m.

10.7.3.3 Construction programme

163. Norfolk Boreas Limited is currently considering constructing the project in one of the following phase options.

- A single phase of up to 1,800MW; or
- Two phases of up to a combined 1,800MW capacity.

164. Phasing is only applicable to the assessment of construction and decommissioning impacts and not the assessment of impacts during the O&M phase. Where appropriate, each construction impact is assessed for the one and two phase scenarios to take account of the different temporal aspects of each option and to clearly demonstrate which is the worst case scenario. For certain impacts, phasing is not relevant and this is explained in the assessment. The infrastructure would be the same for each phasing scenario.

165. The full construction window is expected to be up to three years for the full 1,800MW capacity regardless of whether constructed using a single or two phased option. Table 10.9 and Table 10.10 provide indicative construction programmes for both options, respectively. Under the two phased option overall construction would take slightly longer to complete, however there is unlikely to be significant time gaps between the phases.

166. If Norfolk Vanguard is not progressed the construction programme of Norfolk Boreas as shown below could be bought forward by up to one year.

Table 10.9 Indicative Norfolk Boreas construction programme – single phase

		2024				2025				2026				2027				2028			
Indicative Programme	**Approximate duration**	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Pre-construction survey	9 months																				
UXO survey and licensing	9 months																				
UXO clearance following licencing	9 months																				
Foundation seabed preparation	3 months																				
Foundation installation	18 months																				
Scour protection installation	12 months																				
Offshore electrical platform installation works	12 months																				
Array & interconnector (or project interconnector) cable seabed preparation	6 months																				
Array & interconnector (or project interconnector) cable installation	18 months																				
Export cable installation seabed preparation	6 months																				
Export cable installation	18 months																				
Cable protection installation	18 months																				
Wind turbine installation	18 months																				
Total construction works	36 months																				

Table 10.10 Indicative Norfolk Boreas construction programme – two phases

		2024				2025				2026				2027				2028			
Indicative Programme	**Approximate duration**	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Pre-construction survey	9 months				■	■	■														
UXO survey and licensing	9 months				■	■	■														
UXO clearance following licencing	9 months							■	■	■											
Foundation seabed preparation	3 months									■											
Foundation installation	2 x 9 months										■	■	■		■	■	■				
Scour protection installation	2 x 6 months									■	■			■	■						
Offshore electrical platform installation works	2 x 6 months										■	■			■	■					
Array & interconnector (or project interconnector) cable seabed preparation	2 x 3 months									■				■							
Array & interconnector (or project interconnector) cable installation	2 x 9 months										■	■	■		■	■	■				
Export cable installation seabed preparation	2 x 3 months								■				■								
Export cable installation	2 x 9 months									■	■	■		■	■	■					
Cable protection installation	2 x 9 months										■	■	■		■	■	■				
Wind turbine installation	2 x 9 months														■	■	■		■	■	■
Total construction works	39 months								■	■	■	■	■	■	■	■	■	■	■	■	■

10.7.3.4 Cable installation footprints

167. Under the worst case scenario the cables that could be installed within the offshore project area are as follows:

- Array cables - cables that connect wind turbine to wind turbine and connect wind turbine to offshore electrical platform;
- Interconnector cables – one pair of HVDC cables and a single AC cable that connect two offshore electrical platforms within the Norfolk Boreas site; or
- Project interconnector cables – HVDC and AC cables which connect an offshore electrical platform or wind turbines within the Norfolk Boreas site with an offshore electrical platform within one of the Norfolk Vanguard OWF sites. These cables would be located within the project interconnector search area (Figure 5.1); and
- Export cables - cables that connect an offshore project substation within the Norfolk Boreas site with the landfall.

168. There would only be a requirement for either the interconnector cable or the project interconnector cables but never both. The need for the project interconnector cables could only occur if Norfolk Vanguard proceeds to construction and even then it would depend on the final electrical solution. Section 5.4.12 of Chapter 5 Project Description describes in further detail the three electrical solutions currently being considered.

169. When assessing the impacts caused by installation, operation and maintenance of the project interconnector cables it is only the parts of these located within the project interconnector search area that are considered and not the sections within the Norfolk Boreas site. This is due to the fact that the worst case scenario for impacts within the Norfolk Boreas site assess 90km (installed within 60km of cable trench) of interconnector cables and 600km of array cables. No matter which of the electrical solutions is eventually chosen cable installation within the Norfolk Boreas site will not exceed these distances.

10.7.3.4.1 Pre-installation works

Boulder clearance

170. Pre-construction surveys will identify any requirement for boulder clearance within the offshore project area. Norfolk Boreas Limited has reviewed the Norfolk Boreas site and offshore cable corridor geophysical data and, given the low proportion of boulders in the area, it is likely that micrositing around boulders will be possible however an allowance for clearing up to 153 boulders (105 in the Norfolk Boreas site and 22 in the offshore cable corridor and 28 in the project interconnector search area (2 of which are also in the offshore cable corridor)) of up to 5m in diameter has been included in the assessment in order to be conservative. Boulders would be

relocated within the offshore project area, outside the route of cable installation or the location of foundations. The footprint of the boulder being placed back on the seabed has also been assessed.

Pre-lay grapnel run

171. A pre-lay grapnel run would be undertaken to clear any debris in advance of any phase of cable installation. The maximum width of seabed disturbance along the pre-lay grapnel run would be 20m. This is encompassed by the maximum footprint of cable installation works associated with ploughing (30m disturbance width).

Pre-sweeping

172. The potential for sand wave levelling (pre-sweeping) has been assessed as a possible strategy for cable installation to ensure the cables are installed at a depth below the seabed surface that is unlikely to require reburial throughout the life of the project. Sand wave levelling may also be required to create a suitable surface for foundation installation. A final decision on this would be made after consent, in the Cable Specification, Installation and Monitoring Plan (required under Condition 14(1)(g) of DCO Schedules 9 and 10; Condition 9(1)(g) of DCO Schedules 11 and 12 and Condition 7 (1)(f) of DCO Schedule 13) following pre-construction surveys.

173. Indicative pre-sweeping volumes and area impacted for the offshore cable corridor and the project interconnector are outlined in Table 10.11. The sediment released at any one time would be subject to the capacity of the dredger. The maximum width of pre-sweeping in the offshore cable corridor would be approximately 37m depending on the depth of sand waves[6]. This would be in discrete areas and not along the full length of the corridor. It is assumed that approximately 80% of the pre-sweeping area[7] shown in Table 10.11 would overlap with the 30m ploughing disturbance area as a worst case scenario.

[6] 37m pre-sweeping width is based on sand wave depth of approximately 5m with a slope gradient of 1:3 and a width of 7m at the base of the dredged area.
[7] Based on the 30m proportion of the maximum 37m pre-sweep width that would be overlapping the ploughing footprint

Table 10.11 Parameters for pre-sweeping activity for the offshore export cable corridor and project interconnector search area.

Parameter	Maximum for the section of offshore cable corridor within the Haisborough, Hammond and Winterton SAC	Maximum for the offshore cable corridor (including the SAC volume and area)	Maximum for the entire project interconnector search
Volume of material to be moved			
Per trench (pair of export cables) (m^3)	250,000	1,800,000	5,520,000
Total for two trenches (m^3)	500,000	3,600,000	
Area of pre-sweeping			
Per trench (pair of export cables) (m^2)	125,000	480,000	1,840,000
Total for two trenches (m^2)	250,000	960,000	

174. Sediment arising from pre-sweeping in the Haisborough, Hammond and Winterton SAC would be disposed of in an area within the section of the offshore cable corridor overlapping the SAC. The exact location(s) for disposal of sediment would be determined in consultation with the MMO and relevant SNCBs following the pre-construction surveys. The area over which sediment may be deposited is therefore not known at this stage, however in order to provide a comprehensive assessment an area of approximately 3.6km^2 has been assumed for disposal within the SAC on the basis that it would be possible to locate a disposal site of this size to avoid any suspected areas of *S. spinulosa* reef. As described in section 10.7.1.8, sediment would not be disposed of within 50m of known *S. spinulosa* reef identified during pre-construction surveys (in accordance with advice provided to Norfolk Vanguard by Natural England in January 2018).

175. ABPmer (Appendix 7.1 to the Information to inform HRA (document reference 5.3)) have calculated the potential depth of sediment due to deposition in the indicative disposal area located within the SAC as a result of seabed levelling from one cable pair installation. This could range from a theoretical maximum of 4.2m over a small area to a value of 0.25m over a larger area depending on the environmental conditions and nature of disposal (Table 8 of Appendix 7.1 to the Information to inform HRA (document reference 5.3)), however as described in the Appendix 7.1 to the Information to inform HRA (document reference 5.3) and Chapter 8 Marine Physical Processes, the actual thickness of the deposited layer is more likely to range between 0.3m and 0.02m based on typical conditions for the site including water depth of 31m (the depth within an indicative disposal location), a current speed of 0.5m/s and grain size of 350µm (which would be expected to have a settling rate of 0.05m/s).

Removal of existing disused cables

176. There are up to seven[8] out-of-service cables in the offshore cable corridor (all of which are in the Haisborough Hammond and Winterton SAC). Four are intact and span the offshore cable corridor; it is assumed that these will be crossed subject to agreement with the cable owners. Two appear to have been cut previously and stop within the offshore cable corridor; it is proposed that these will be further cut subject to agreement with the cable owners and suitably sized clump weights will be placed on the cut ends. Finally, one enters and exits the southern edge of the cable corridor which would be avoided, where possible.

10.7.3.4.2 Cable burial

177. Following the cable pre-installation works as described in section 10.7.3.4.1, the cables would be installed and buried. The following methods may be used for cable burial and the final burial technique would be dependent on the results of the pre-construction surveys and post-consent procurement of the cable installation contractor:

- Ploughing (worst case scenario with a trench width of 10m and disturbance width of 30m);
- Trenching or cutting; or
- Jetting.

178. The maximum length of export cable trenches is 250km (200km of which would be in the offshore cable corridor and 50km of which would be in the Norfolk Boreas site) from the offshore electrical platforms in the Norfolk Boreas site to landfall, based on an average length of 125km per trench for a total of two trenches, each containing a pair of cables. The maximum volume of sediment disturbed by cable burial (using ploughing as the worst case method) would therefore be 3,750,000m^3 (3,000,000m^3 within the offshore cable corridor and 750,000 within the Norfolk Boreas site) based on a realistic worst case average burial depth of 3m with a V-shaped cross-section of 10m width at the seabed surface (see section 5.4.13.2.4 of Chapter 5 Project Description). Ploughing would create temporary mounds either side of the trench and therefore it is expected that only a small proportion of the 3,750,000m^3 would result in sediment plumes during cable installation.

[8] Data provided by KisOrca (2018) indicates that there are two in service cables and one disused cable that cross the offshore cable corridor, this data also concords with that supplied by The Crown Estate. However, data provided by Global Marine indicate that there could be a further eight out of service cables that cross the offshore cable corridor. There is very little confidence in Global Marine data as it is older (2010) and not verified by any other data set. However, it has been included here to capture the worst case scenario

10.7.3.4.3 Landfall

179. The export cable landfall would be made at Happisburgh South using long HDD and duct installation with cable burial on the seaward side of the drilling exit point. The landfall ducts will exit in the subtidal zone beyond 5.5m LAT and approximately 1km from the onshore drilling location. Therefore, there will be no works or access required to the intertidal zone that could result in an impact, therefore this is not assessed further.

10.7.3.4.4 Cable protection

Unburied cable

180. As discussed in section 10.7.1, cable burial is expected to be possible throughout the offshore cable corridor with the exception of cable crossing locations. In order to provide a conservative and future-proof impact assessment, a contingency estimate is included in the assessment, should cable burial not be possible due to unexpected hard substrate (i.e. not Annex 1 Sandbank). Up to 10km of protection per cable pair (20km in total) for the whole offshore cable corridor, of which, 4km per pair (8km in total) could be within the SAC has been assessed. The maximum width and height of cable protection for unburied cable (per pair of cables) would be 5m and 0.5m, respectively.

Cable or pipeline crossings

181. There are up to eleven existing cables and two pipelines, including the four disused cables described above, which the Norfolk Boreas export cables would need to cross (up to five cables and one pipeline within the SAC). Each crossing would require a carefully agreed procedure with the cable/pipeline owners.

182. At each crossing, protection would be installed to protect the obstacle being crossed. Each Norfolk Vanguard cable would then be placed on top of the layer of protection with a further layer of cable protection placed on top.

183. The maximum width and length of cable protection for cable and pipeline crossings would be 10m and 100m, respectively. The maximum height of crossings is 0.9m.

Types of cable protection

184. The following cable protection options may be used and this would be determined during the final design of the project:

- Rock placement - the laying of rocks on top of the cable;
- Concrete mattresses - prefabricated flexible concrete coverings that are laid on top of the cable. The placement of mattresses is slow and as such is only used for short sections of cable;

- Grout or sand bags - bags filled with grout or sand could be placed over the cable. This method is also generally applied on smaller scale applications;
- Frond mattresses - used to provide protection by stimulating the settlement of sediment over the cable. This method develops a sandbank over time protecting the cable but is only suitable in certain water conditions. This method may be used in close proximity to offshore structures; and
- Uraduct or similar - a protective shell which can be fixed around the cable to provide mechanical protection. Uraduct is generally used for short spans at crossings or near offshore structures where there is a high risk from falling objects. Uraduct does not provide protection from damage due to fishing trawls or anchor drags.

185. It is recognised that it may not be possible to retrieve all cable protection during decommissioning and therefore this would represent a permanent impact over a very small area. This is considered within O&M impacts 1a and 1b as Permanent loss of seabed habitat in the Norfolk Boreas site and offshore cable corridor (see section 10.7.5.1 and 10.7.5.2).

10.7.3.5 Vessel footprints

186. Anchor placement may be required during jointing of the offshore export cable and during foundation installation. As a worst case scenario, it is estimated that there may be two joints per export cable pair (one of which may be in the SAC). An average of one vessel placing anchor at each wind turbine has also been assessed. The seabed footprint associated with anchor placement would be approximately 150m^2 (based on six anchors per vessel).

187. In addition, jack-up vessels may be used during foundation installation and an estimate of two jack-up placements per turbine during construction has been assessed as a worst case. A worst case jack-up footprint of 792m^2 has therefore been assessed based on a leg diameter of up to 15m, with six legs per vessel.

10.7.3.6 Maintenance

10.7.3.6.1 Turbines

188. Regular maintenance of the wind turbines will be required during operation. On the whole, these works will have minimal impact on benthic ecology, however the placement of anchors or jack up vessels during maintenance activity has been considered in order to provide a comprehensive assessment. A maximum average of two turbine locations per day, visited by a jack-up vessel has been assessed.

10.7.3.6.2 Cable repairs

189. During the life of the project, there should be no need for scheduled repair or replacement of the subsea cables, however periodic inspection would be required and where necessary, reactive cable repairs and reburial could be undertaken. It is Norfolk Boreas Limited's aim to bury the cables to sufficient depth that reburial will not be required (Chapter 5 Project Description).

190. While it is not possible to determine the number and location of repair works that may be required during the life of the project, an estimate of two export cable repairs every five years (one repair every 10 years based on the length of cable located within the SAC) is included in the assessment. In addition, one inter-connector cable and two array cable repairs every five years has been assessed. Based on experience on other wind farms and initial assessments of the seabed this is considered very precautionary.

191. In most cases a cable failure would lead to the following operation:

- Vessel anchor placement (150m^2 footprint);
- Exposing/unburying the damaged part of the cable using jetting (3m disturbance width);
- Cutting the cable, assumed to be approximately 300m export cable or inter-connector cable length subject to the nature of the repair or whole length of an array cable (approximately 2km);
- Lifting the cable ends to the repair vessel;
- Jointing a new segment of cable to the old cable;
- Lowering the cable (and joints) back to the seabed; and
- Cable burial, where possible.

10.7.3.6.3 Cable reburial

192. As previously discussed, cables could become exposed due to migrating sand waves. An In Principle Monitoring Plan (document Reference 8.12) will be submitted with the final DCO application which will outline the types of monitoring that may be required, including a cable burial survey to ensure the cables remain buried and if they do become exposed, re-burial works would be undertaken. The details of any monitoring would be determined post consent in consultation with the MMO and relevant SNCB.

193. For the export cables installed without pre-sweeping, a worst case scenario of reburial of up to 20km length per export cable pair (40km in total) over the life of the project is assumed in order to provide a conservative assessment. Of this 20km, reburial of up to 10km per cable pair within the SAC has been estimated based on the worst case scenario that no pre-sweeping is undertaken. However, re-burial

requirements would be substantially lower if pre-sweeping is carried out prior to cable installation.

194. The worst case scenarios with regard to the impacts on benthic ecology are presented for each impact in Table 10.12.

Table 10.12 Worst Case Scenarios

Impact	Parameter	Worst Case	Rationale
Construction			
Impact 1A: Temporary habitat loss/disturbance in the Norfolk Boreas site	Disturbance footprints in the Norfolk Boreas site due to cable laying operations, jack-up operations and seabed preparation works for turbine foundations	Worst-case scenario for a single wind turbine foundation would be a GBS foundation for a 20MW turbine due to this having the largest single footprint. Seabed preparation may be required up to a sediment depth of 5m. The preparation volume for a single 20MW GBS foundation is 2,827m^3 (based on a 60m diameter preparation area). The worst case scenario for the site as a whole would be 180 x GBS foundations for the 10MW turbines. **The maximum total turbine seabed preparation area would be:** • 180 of the foundations (requiring preparation for a circular area with diameter of 50m) = 353,429m^2. • Two offshore electrical platforms, seabed preparation = 15,000m^2 (75m x 100m per platform) • One offshore service platform seabed preparation = 7,500m^2 (75m x 100m) • Two met masts based on a circular footprint 40m in diameter seabed preparation = 2,513m^2 (40m diameter per mast) • Array cable trench – 600km length with average 20m pre-sweeping width = 12,000,000m^2 • Interconnector or project interconnector cable trench within the wind farm site 60km with 20m pre-sweeping width = 1,200,000m^2 • Export cable trench within the wind farm site 50km with 30m pre-sweeping width = 1,500,000m^2 • Jack up vessel footprints assuming 2 vessel movements per turbine = 285,120m^2 (based on 180 turbines x 2 movements x vessel footprint of 792m^2) • Vessel anchor footprints (one vessel anchoring per turbine) = 27,000m^2 • Jack up vessel footprints assuming 2 vessel movements per offshore platform and met mast = 7,920m^2 • Boulder clearance – 105 boulders of up to 5m diameter being lifted and then placed back on the seabed = 4,1243m^2 Worst case scenario total disturbance footprint = **15.40km^2**	The temporary disturbance relates to seabed preparation and cable installation. The footprint of infrastructure is assessed as a long term or permanent impact in O&M Impact 1A. It should be noted that the seabed preparation area for foundations is less than the footprint of the foundation scour protection. The maximum potential interconnector length is greater than the amount of project interconnector which would be located within the site, therefore the interconnector represents the WCS

Impact	Parameter	Worst Case	Rationale
		Any other works associated with cable installation would be encompassed by the footprints outlined above.	

Impact 1B: Temporary habitat loss/disturbance in the offshore cable corridor	Disturbance footprints in the offshore cable corridor due to cable laying operations	• Boulder clearance = 22 boulders of up to 5m diameter being lifted and then placed back on the seabed = 864m^2
		• Pre-sweeping area which could be outside the ploughing area – 72,000m^2 (based on minimum overlap of pre-sweeping area and ploughing footprint, as described in 10.7.3.4)
		• Maximum temporary disturbance for cable installation by ploughing = 6,000,000m^2
		    ○ Maximum total export cable trench length of 200km.
		    ○ Maximum width of temporary disturbance is approximately 30m, based on the disturbance impact for ploughing of a 10m wide trench with approximately 10m of spoil either side of the cable trenches.
		• Anchor placement – 600m^2 (based on four cable joints, two per cable pair with a footprint of 150m^2 each, assuming up to 6 anchors per vessel)
		
		Worst case scenario total disturbance footprint = **6.07km^2.**
		
		Disturbance footprints within the Haisborough Hammond and Winterton SAC. Note these areas are included in the calculations above:
		• Boulder clearance = 864m^2 (up to 22 boulders of 5m diameter being lifted and replaced)
		• Pre-sweeping area which could be outside the ploughing area – 50,000m^2
		• Areas occupied by sediment disposal in the SAC = 2,407,681m^2
		• Maximum temporary disturbance for cable installation by ploughing = 2,400,000m^2
		    ○ Maximum total export cable trench length of 80km (40km per cable pair in the SAC).
		    ○ Maximum width of temporary disturbance is approximately 30m, based on the disturbance impact for ploughing of a 10m wide trench with approximately 10m of spoil either side for each export cable.
			As above, temporary disturbance relates to seabed preparation and cable installation. The permanent footprints associated with cable protection are considered in O&M Impact 1A

Impact	Parameter	Worst Case	Rationale
		• Anchor placement – 300m^2 (based on two cable joints in the SAC) • Area of disposal site located within the offshore cable corridor 2,407,681m^2 • Total disturbance footprint = 4.86km^2.	
Impact 1C: Temporary habitat loss/disturbance in the project interconnector search area		• Project Interconnector cable trench 92km with 20m pre-sweeping width = 1,840,000m^2 • Anchor placement (based on four cable joints two per cable pair) = 300m^2 • Boulder clearance – 28 boulders of up to 5m diameter being lifted and then placed back on the seabed = 1,100m^2 Worst case scenario total disturbance footprint = **1.84km^2.**	
Impact 2A: Temporary increases in suspended sediment concentrations and associated sediment deposition in the Norfolk Boreas site	Suspended sediment concentrations and associated sediment deposition from cable and foundation installation and seabed preparation in the Norfolk Boreas site	The worst case suspended sediment and deposition is described in the assessments in Chapter 8 Marine Geology, Oceanography and Physical Processes based on the following volumes: **Drill arisings** • Wind turbine foundations based on worst case volume associated with 20MW monopile (45 turbines (50%) x 30m depth x 10m diameter) = 397,608m^3 • Meteorological masts - 2 x pin-pile quadropod = 1,131m^3 • Service platform - 1 x six legged pin-pile = 848m^3 • Offshore electrical platforms - 2 x six legged 18 pin-piles = 14,137m^3 • Lidar - 2 x monopiles = 189m^3 Worst case scenario total = 413,913m^3 **Seabed preparation/ disposal** • 180 x GBS foundations for 10MW turbines (based on area described in Impact 1 and levelling depth of up to 5m) = 1,767,146m^3. • Two offshore electrical platforms based on area described in Impact 1 and 5m depth = 75,000m^3 • One offshore service platform based on area described in Impact 1 and 5m depth = 37,500m^3 • Two met masts based on area described in Impact 1 and 5m depth = 12,566m^3 • Array cable trench – 600km length with average 20m pre-sweeping width	Seabed preparation (dredging using a trailer suction hopper dredger and installation of a bedding and levelling layer) may be required up to a sediment depth of 5m. The worst case scenario considers the maximum volumes for the project. **NB** if piled foundations with drilling are used, the level of seabed preparation described above for GBS would not be required

Impact	Parameter	Worst Case	Rationale
		and 3m depth = 36,000,000m^3 • Interconnector cable trench - 60km of trench with average 20m pre-sweeping width and 3m depth = 3,600,000m^3 (connecting platforms within the Norfolk Boreas site) • Export cable trench within the Norfolk Boreas site 50km with average 30m disturbance width and 3m depth = 4,500,000m^3 Worst case scenario total disturbed sediment = **45,992,212m^3** It should be noted that seabed preparation is less likely to be required for piled foundations and, if required, would be significantly less than described above. Therefore, the volume of drill arisings and seabed preparation outlined above are not cumulative.	
Impact 2B: Temporary increases in suspended sediment concentrations and associated sediment deposition in the offshore cable corridor	Suspended sediment concentrations and associated sediment deposition from cable installation in the offshore cable corridor	The worst case suspended sediment and deposition is described in the assessments in Chapter 8 Marine Geology, Oceanography and Physical Processes based on the following volumes: The sediment disposed of as a result of the pre-sweeping activity for the offshore export cables within the offshore cable corridor would equate to about 600,000m^3 of sediment. Approximately 500,000m^3 would be within the Haisborough, Hammond and Winterton SAC (excluding the nearshore (10m water depth contour) where no pre-sweeping is proposed). Following pre-sweeping, the sediment disturbed due to trenching for the offshore export cables would equate to approximately **3,000,000m^3** of sediment, based on a maximum average depth of approximately 3m and a trench width of 10m with a V shaped profile. This would be back filled naturally or manually. WCS for total temporary increase in SSC due to pre-sweeping and trenching = **3,600,000m^3** ***Disturbance volumes within the Haisborough Hammond and Winterton SAC. Note these areas are included in the calculations above*** The sediment released due to disposal of pre-swept sediment in the SAC would equate to approximately 500,000m^3. The sediment released at any one time would be subject to the capacity of the dredger. Disposal would be at least 50m from *S.*	

Impact	Parameter	Worst Case	Rationale
		spinulosa reef identified during pre-construction surveys. The sediment released due to trenching for the offshore export cables would equate to approximately 1,200,000m^3 within the SAC (based on 10m trench width with a V shaped profile x 3m maximum average depth x 2 trenches x 40km length in the SAC). This would be back filled naturally or manually.	
Impact 2C: Temporary increases in suspended sediment concentrations and associated sediment deposition in the project interconnector search area	Suspended sediment concentrations and associated sediment deposition from project interconnector cable installation	The sediment released due to trenching and / or pre-sweeping in the project interconnector search area would equate to approximately **5,520,000m^3** of sediment, based on 92km of trench with a maximum average depth of approximately 3m and an average trench width of 20m. This would be back filled naturally or manually. Disposal would be at least 50m from *S. spinulosa* reef identified during pre-construction surveys.	
Impact 3: Impacts of changes to water quality due to re-mobilisation of contaminated sediments	Changes to water quality due to re-mobilisation of contaminated sediments	No significant contaminated sediments were recorded in the offshore project area. See Chapter 9 Marine Water and Sediment Quality for more detail.	
Impact 4: Underwater noise and vibration	Underwater noise from construction noise, in particular piling	Maximum hammer energy: • **2,700kJ (9MW-20MW pin-pile)** • **5,000kJ (20MW monopile)** Starting hammer energies of 10% will be used for 10 minutes. Ramp up will then be undertaken for the next 20 minutes up to the maximum hammer energy.	

Impact	Parameter	Worst Case	Rationale
Operation			
Impact 1A: Permanent loss of seabed habitat in the Norfolk Boreas site	The presence of wind turbine and platform foundations, scour protection, array cables, inter-connector cables, and cable protection	<u>Turbines</u> Total worst case scenario for turbine foundation footprints with scour protection across the Norfolk Boreas site is 180 GBS foundations with a footprint (foundation and scour) of a circular area 200m in diameter. For the site this equates to an area of 5,654,867m^2. <u>Array cable protection</u> Up to 60km of cable protection may be required in the unlikely event that array cables cannot be buried (based on 10% of the length) resulting in a footprint of 300,000m^2 (based on protection width of 5m). Array cable protection at turbines 100m cable length x 5m width x 180 turbines = 90,000m^2 Array cable crossings protection 10 crossings x 100m x 10m = 10,000m^2 <u>Export cable protection</u> Up to 5km of cable protection may be required in the unlikely event that export cables within the Norfolk Boreas site cannot be buried (based on 10% of the length) resulting in a footprint of 25,000m^2 (based on protection width of 5m). Export cable protection at platforms 50m cable length x 5m width x two cables = 1,000m^2 <u>Interconnector cable protection</u> Interconnector cable protection approaching platforms 100m cable length per cable x 5m width x 2 platforms = 4,000m^2 Surface laid interconnector cable protection 5m width x 6,000m (10% of the length) = 30,000m^2 Interconnector cable crossings protection crossings – captured within array cable crossing total	The export cable and Interconnector cable crossings within the Norfolk Boreas site are captured within array cable crossing total.

Impact	Parameter	Worst Case	Rationale
		<u>Platforms and other infrastructure</u> Two offshore electrical platforms with scour protection 35,000m^2 One service platform with scour protection 17,500m^2 Two met masts with scour protection 15,708m^2 Two wave buoys 300m^2 Two LiDAR monopiles with scour protection 157m^2 Overall worst case scenario total footprint within the Norfolk Boreas site is = **6.18km^2**	
Impact 1B: Permanent loss of seabed habitat in the offshore cable corridor	Cable protection	Cable protection would be required at locations where the export cables cross other cables or pipelines; at the landfall HDD exit points; in the unlikely event that cable burial is not possible; and/or during the operation and maintenance phase should cables become unburied. <u>Export cables</u> • Crossings A total of thirteen crossings (eleven cables and two pipelines) are required for each cable pair (i.e. up to 26 crossings in total) resulting in a total footprint of 26,000m^2 (based on a width of 10m and length of 100m of cable protection per crossing). • Nearshore (within 10m depth contour) Cable protection may be required at each of the landfall HDD exit points. This would entail one mattress (6m length x 3m width x 0.3m height) plus rock dumping (5m length x 5m width x 0.5m height) at each exit point (up to two cable pairs) resulting in a footprint of 86m^2 • Unburied cables In the unlikely event that cable burial is not possible due to hard substrate being encountered, up to 16km per cable pair outside the SAC and 4km inside the SAC per cable pair (20km in total) could require additional protection resulting in a footprint of 100,000m^2 (based on protection width of 5m).	

Impact	Parameter	Worst Case	Rationale
		Worst case scenario total footprint within the offshore cable corridor is **= 0.13km²** Of this total, 0.05km² could be within the Haisborough, Hammond and Winterton SAC at crossing locations and in the unlikely event that burial is not possible.	
Impact 1C: Permanent loss of seabed habitat in the project interconnector search area	Cable protection	Cable protection would be required at crossing points and where cable burial is not possible • Unburied cables Surface laid project interconnector cable protection 5m width x 92,000m (10% of the length) = 46,000m² • Cable crossings A total maximum of 10 crossings (all the BBL pipeline) are required for each cable or pair of cables (i.e. up to 10 crossings in total) resulting in a total footprint of 10,000m² (based on a width of 10m and length of 100m of cable protection per crossing). • Approach to electrical platform A total of 10 cables approaching platforms 100m cable length x 5m width = 5,000m²**.** Worst case scenario total footprint within the project interconnector cable search area is = **0.061km²**	
Impact 2A: Temporary seabed disturbances from maintenance operations in the Norfolk Boreas site	Cable repairs/reburial and maintenance vessel footprints	Unplanned repairs and reburial of cables may be required during O&M: • Reburial of 25% of array cable is estimated once every 5 years – 3m disturbance width x 150km length = **450,000m²** every 5 years • Two array cable repairs per year are estimated. An array cable may be up to 6km (based on turbine spacing) – 3m disturbance width x 6,000m x 2 = **36,360m²**. • One interconnector repair per year is estimated – 3m disturbance width x 300m repair length =**900m²**. Maintenance of wind turbines will be required during O&M. An estimate of up to two locations visited per day during O&M using a jack up vessel with a footprint of 792m² which would lead to a total area of up to 0.58km² per year (assumes large jack up with four legs each of 15m diameter).	

Impact	Parameter	Worst Case	Rationale
		Anchored vessels placed temporarily on site to maintain the wind turbines or during cable repairs. Worst case scenario is six anchors each with a footprint of 25m^2 equating to a total footprint of 150m^2 per installation.	
Impact 2B: Temporary seabed disturbances from maintenance operations in the offshore cable corridor	Cable repairs and reburial	One export cable repair per year with 300m sections removed and replaced. Disturbance width of 3m = **900m^2** per year. Reburial of up to 20km length per export cable pair over the life of the project (4km in the Haisborough, Hammond and Winterton SAC and 16km outside the SAC) = **200,000m^2** based on two cable pairs and a disturbance width of 10m. The need for reburial would be significantly less where pre-sweeping is used. **In Haisborough Hammond and Winterton SAC (encompassed within the above parameters)** One repair every 10 years is estimated within the SAC. It is estimated that 300m sections would be removed and replaced per repair. Disturbance width of 3m = 900m^2 every 10 years. Anchor placement associated with repair works – 150m^2 based on 6 anchors per vessel. Reburial of up to up to 10% (4km) per export cable pair every five years may be required should pre-sweeping not be undertaken. The disturbance width would be approximately 10m and therefore the total disturbance would be **80,000m^2.** If reburial is required, it is likely that this would be in relatively short sections (e.g. 1km) at any one time.	Overall totals are not provided as the impacts would occur at different times
Impact 2C: Temporary seabed disturbances from maintenance operations in the project interconnector search area	Cable repairs and reburial	One project interconnector repair per year is estimated – 3m disturbance width x 300m repair length =**900m^2**. Reburial of 25% of project interconnector cable is estimated once every 5 years – 3m disturbance width x 23km length = **69,000m^2** every 5 years.	Overall totals are not provided as the impacts would occur at different times

Impact	Parameter	Worst Case	Rationale
Impact 3: Colonisation of turbines/cable protection/scour protection	The presence of turbines, cable protection and scour protection	Based on the permanent infrastructure outlined for O&M Impact 1A and 1B	
Impact 4: EMF from installed array, interconnector, project connector and export cables	The presence of array cables, inter-connector cables, and export cables	The following lengths of cables may not be buried: <u>Array cable</u> Up to 60km of unburied cable in the unlikely event that array cables cannot be buried Unburied cable on approach to turbines =18,000m (100m (50m cable length x 2 cables) x 180 turbines) At cable crossings = 1,000m (10 crossings x 100m cable length) <u>Interconnector cable</u> Interconnector cable protection approaching platforms = 300m (100m cable length x 3 cables) Surface laid interconnector cable protection in the unlikely event that cables cannot be buried = 6,000m (10% of interconnector cable) <u>and, Project interconnector</u> Surface laid project interconnector cable protection in the unlikely event that cables cannot be buried = 9,200m Project interconnector cable protection approaching platforms = 1000m (100m cable length x 10 cables) At cable crossings = 1000m (10 crossings x 100m cable length) <u>Export cables</u> At cable crossings = 1,560m (26 crossings (13 per cable pair (2 pipelines and 11 cables) x length of 60m per crossing). In the unlikely event that cable burial is not possible due to hard substrate being encountered = 28km (based on 10km per cable pair outside the SAC and 4km inside the SAC per cable pair). The need for reburial and/or protection would be significantly less where pre-sweeping is used. Worst case scenario total length of cable that is not buried = **119.76km**	The maximum amount of near surface cable (that which requires cable protection) across the entire project would result in the worst case scenario. Either the project interconnector or the interconnector cable would be deployed and as the project interconnector cable is longer this is included in the worst case calculations.

Impact	Parameter	Worst Case	Rationale
Impact 5: Underwater noise and vibration	Underwater noise from O&M	Worst Case Scenario for O&M activities with the potential to generate underwater noise: Worst case scenario for operational structures: 180 wind turbines, Two offshore electrical platforms; A service platform; Worst case for repair work: Two turbine locations per day visited by a jack-up vessel. Worst case scenario for cable repairs Two export cables every five years (one repair every 10 years within the SAC) One interconnector repair and two array cable repair every 5 years Worst case scenario for cable reburial: Reburial of 20km per export cable (40km in total) for export cable installed without pre-sweeping (10km of cable repair within the SAC).	
Decommissioning			
Impact 1: Temporary habitat disturbance	Foundations (turbines and platforms)	Removal of foundations is likely to be limited to parts that are above the seabed. Impacts will be less than during the construction phase. Scour protection would likely be left in-situ.	
	Array cables and protection	Some or all of the array cables and interconnector cables may be removed. Cable protection would likely be left in-situ.	
	Export cables and protection	Some or all of the offshore export cables may be removed. Cable protection would likely be left in-situ.	
Impact 2: Temporary increases in suspended sediment concentrations and associated sediment deposition		See Chapter 8 Marine Geology, Oceanography and Physical Processes for more detail.	

Impact	Parameter	Worst Case	Rationale
Impact 3: Impacts of changes to water quality due to re-mobilisation of contaminated sediments		See Chapter 9 Marine Water and Sediment Quality for more detail.	
Impact 4: Underwater noise and vibration	Decommissioning noise e.g. from cutting foundation	Cutting of up to 180 foundations – less than the noise impacts of piling during construction.	

10.7.4 Potential Impacts during Construction

10.7.4.1 Impact 1A: Temporary habitat loss/disturbance in the Norfolk Boreas site.

195. Activities associated with the offshore construction works will result in direct temporary loss/disturbance to subtidal habitats within the Norfolk Boreas site. Activities include seabed preparation for the installation of cables and foundations as well as the installation works themselves (within the footprint of seabed preparation). Jack-up barge operations and anchor placements associated with construction will also contribute to temporary disturbance during the construction phase.

196. Due to the nature of the sediment and the dynamic physical processes in the area, recovery of the substratum is likely to be rapid in areas which are disturbed, thus aiding recovery of benthic communities in the area. Where disturbed sediments (e.g. preparation areas for foundations) are subsequently covered with infrastructure the permanent loss of habitat is assessed as an operational impact in section 10.7.5.1.

197. The maximum potential seabed preparation area has a total disturbance footprint of 15.40km^2 from within the Norfolk Boreas site (see Table 10.12).

198. The disturbance would be temporary during either 33 months for a single phase or 39 months for a two phased approach of construction activity (Table 10.9 and Table 10.10). Some elements of disturbance, such as that caused by jack-up vessels will only last days (Chapter 5 Project Description). This represents a low magnitude in relation to the site and the wider region due to the temporary nature of the impact and presence of comparable subtidal sands and gravel habitats throughout Norfolk Boreas as well as the wider former East Anglia Zone and southern North Sea.

10.7.4.1.1 Assessment of impacts – single phase

199. The Norfolk Boreas site does not overlap with any designated sites for benthic features and as such, receptors within designated sites have only been considered in relation to the offshore cable corridor (see section 10.7.4.2). The majority of the Norfolk Boreas site is comprised of sand consisting of fine to medium particles with communities typical of sand habitat in the Southern North Sea. Although *S. spinulosa* was identified it was not in reef form.

200. In terms of sensitivity to the effect of direct disturbance and loss of seabed habitat during construction the fine to medium sediment communities can be considered at the biotope level or in relation to the communities identified by the PRIMER analysis. At the biotope level, Sublittoral sands and muddy sands (SS.SSa, A5.2) were recorded at the majority of sites and is considered to have high recoverability and low sensitivity (Tyler-Walters, Lear and Allen, 2004).

201. In terms of the PRIMER analysis, the Norfolk Boreas site contained four infaunal groups (k, i, n, and o) all of which apart from i were common across the former Zone. The main defining taxa of the groups found within the Norfolk Boreas site were:

- Group i, *Goniada maculata* and *Spiophanes bombyx*
- Group k: *Nemertea*, and the polychaete worms *S.spinulosa* and *S.bombyx*;
- Group n: the polychaete worm *N. cirrosa*; and
- Group o: the polychaete worm *S.bombyx*, *N. cirrosa* and *P. pulchellus*

202. The Norfolk Boreas site was dominated by group o (Figure 10.6).

203. No information is available for the sensitivity of *N. cirrosa*, to physical disturbance however *Nephtys hombergii* represents a potential proxy, the two species being within the same genus occupying similar habitats and both occurring within the southern North Sea (MarLIN). It should be noted however that where proxies are used a level of caution must be applied to the assessment. *N. hombergii* has low sensitivity to physical disturbance and very high recoverability (Budd & Hughes, 2005). *S. bombyx* is an opportunistic polychaete and likely to recolonise disturbed areas before most other species after cessation of disturbances. It has been found to recolonise previously dredged areas within 10 months and return to maximum biomass in two to four years (Ager, 2005). This species has a low tolerance to physical disturbance, but a high recoverability resulting in low sensitivity. Budd (2007) provides an overview of evidence that *A. alba* would colonise available sediments within a year following environmental perturbation. Therefore, the sensitivity to physical disturbance is considered to be low. No sensitivity information is available for *P. pulchellus,* or appropriate proxy species. It is however, considered likely that these are less sensitive than species such as *S. spinulosa* for which there is appropriate information available.

204. Therefore, it is considered that whether looking at the biotope or species level the medium to fine sediment communities will generally be of low sensitivity. However due to the use of proxy species in this assessment it is noted that the level of confidence is less than it would be if all species sensitivities were available.

205. Two stations in the Norfolk Boreas site were found to have potential *S. spinulosa* reef, however they were characterised as either 'Not reef' or 'Low reef' using the method described in Gubbay (2007) (see Appendix 10.2). *S. spinulosa* is most frequently found in disturbed conditions and has a high rate of reproduction in order to live in unstable environments (Jackson and Hiscock, 2008).

206. High recruitment rates of *S. spinulosa* allow for rapid recovery and regrowth of reefs in the right conditions (Tillin and Marshall, 2015; Cooper *et al.*, 2007; Pearce *et al.*, 2007; Holt, 1998) and *S. spinulosa*, is often one of the first species to settle on newly exposed surfaces (Ospar Commission, 2010).

207. As the conditions across the Norfolk Boreas site are relatively homogeneous and surveys reveal areas with potential to support reefs within the site, it is likely that suitable conditions may occur to allow *S. spinulosa* to re-establish. Pearce *et al.* (2007) undertook surveys overlapping the Norfolk Boreas offshore cable corridor and recorded large numbers of individual *S. spinulosa* in one area during the summer following cessation of dredging activities, and found another area to be recolonised within 1.5 years, suggesting annual recruitment in this area. It is understood that recovery to high adult density and biomass of more mature reefs would take 3 to 5 years with successful annual larval recruitment (Pearce *et al.*, 2007). As the *S. spinulosa* in the Norfolk Boreas site has low or no reef characteristics, the sensitivity to disturbance would be low on the basis that recovery, in the form of recolonisation of individuals, is expected in approximately 1 year. However, taking a conservative approach that there is potential for *S. spinulosa* reef to be present in the area, the sensitivity is classified as medium.

208. The impact of physical disturbance during the construction phase to the benthic ecology at the Norfolk Boreas site is therefore assessed as **minor adverse**. This is due to a low magnitude of effect combined with a low to medium sensitivity of receptors to physical disturbance and substratum loss. There is medium to high confidence in this assessment due to the fact that site specific data is available and MarLIN/MarESA assessments of sensitivity have been completed for many species identified as defining the communities within the site.

10.7.4.1.2 Assessment of impacts– two phase

209. The maximum infrastructure requirements are the same for a single and a two phased construction approach and the impact of disturbance will be localised to the footprint of each activity. The two phased approach to construction would not result in recurring impact on the same area of seabed, as the work will be undertaken sequentially at each individual turbine location. For example, the seabed preparation would occur before the foundations are installed and the foundations would be installed before the scour protection is installed. Therefore, while the overall programme is longer under the two phased approach (up to 39 months, see Table 10.10), the temporal and spatial extent of direct disturbance at any one location of seabed would be no greater. The magnitude of effect on benthic species and habitats therefore remains low, as with the single phase scenario. The same receptors of low to medium sensitivity would also be affected and therefore the impact of temporary habitat loss/disturbance remains of **minor adverse** significance**.**

10.7.4.2 Impact 1B: Temporary habitat loss/disturbance in the offshore cable corridor

10.7.4.2.1 Assessment of impacts in the offshore cable corridor – single phase

210. Activities required as part of the cable installation process including boulder clearance and pre-sweeping would lead to temporary disturbance in the offshore cable corridor.

211. The area of habitat within the cable corridor that may be affected during the cable installation activities is 6.07km^2. This constitutes a small portion of similar habitat identified within the former zone resulting in the impact of physical disturbance and loss being assigned a low magnitude.

212. The effect of direct disturbance and loss of seabed habitat during cable installation activities has the potential to cause disturbance to the biotopes shown in Figure 10.10, which have been found within the offshore cable corridor. The sensitivities of these biotopes, based on the tolerance and recoverability from physical disturbance are also provided in Table 10.13.

Table 10.13 Sensitivities of biotopes within the offshore cable corridor to physical disturbance (source: Tyler-Walters, Lear and Allen, 2004; Tillin, 2014b; Tillin, 2016)

Biotope code	Biotope description	Tolerance	Recoverability	Overall sensitivity
SS.SCS.CCS	Circalittoral coarse sediment	Intermediate	High	Low
SS.SSa.CFiSa	Circalittoral fine sand	No information available		
SS.SMx.CMx	Circalittoral mixed sediment	Intermediate	Medium	Medium
SS.SCS.CCS.MedLumVen	*Mediomastus fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel	Medium	High	Low – Medium*
SS.SBR.PoR.SspiMx	*S. spinulosa* on stable circalittoral mixed sediment	Low - None	Medium	Medium

* based on assessments in Tillin (2014b) which focus on the species which define the biotope

213. The offshore cable corridor also passes through the Haisborough, Hammond and Winterton SAC, discussed further below.

214. The offshore cable corridor benthic survey (Norfolk Vanguard Limited, 2018 Appendix 10.1) identified areas of *S. spinulosa* aggregations within the offshore cable corridor; one station was classed as medium reefiness (this was located within the Haisborough, Hammond and Winterton SAC) while all other stations were assigned a low reefiness or 'not reef' score.

215. As discussed in section 10.6.6.1 work completed by Envision Mapping Ltd (2018) (Appendix 7.2 of the Information to Support HRA report (document reference 5.3)) identified four potential areas of *S. spinulosa* reef within the offshore cable corridor, two of which had relatively low confidence in their prediction and included samples which did not show any reef at all (areas to the east and west of the SAC) and two areas where there was high confidence in the detection of reef. These areas correlate relatively well with Natural England and JNCC's 'areas to be managed as *S. spinulosa* reef'. Figure 10.12 shows the likely extent of *S. spinulosa* reef within the central 'dog-leg' section of the offshore cable corridor and the section of the project interconnector search area that approaches NV West. In the dog-leg locations the areas of high confidence and those which have been confirmed by physical samples (video and grab) are shown to be relatively discrete patches of reef that do not extend across the cable corridor, leaving adequate space for two pairs of HVDC cables to be installed for Norfolk Boreas.

216. Any export cable installation and potential disposal sites would be located to avoid suspected sensitive habitats such as *S. spinulosa* reef, where possible. As discussed above in section 10.7.4.1.1 the sensitivity of *S. spinulosa* reef to temporary habitat loss is considered to be medium.

217. Taking the worst case of medium sensitivity, based on *S. spinulosa* reef and low magnitude of effect, the potential impact of temporary physical disturbance in the offshore cable corridor is assessed as **minor adverse**.

10.7.4.2.2 Assessment of impacts in the offshore cable corridor – two phase

218. Under the scenario where each export cable construction activity (cable installation seabed preparation, export cable installation and cable protection installation) would occur in two phases the duration of the impact would increase from one single event lasting 24 months (Table 10.9) to two separate events lasting a total of 27 months (Table 10.10); this would still be classed as a temporary impact and therefore in accordance with Table 10.5 would be classed as low magnitude.

219. Given that the benthic communities within the export cable corridor have been established against a background of regular disturbance, for example from bottom trawled fishing gear and, due to the nature of the sediment and the dynamic physical processes in the area, they are habituated to and recover quickly from disturbance. The sensitivity of benthic communities to the increased temporal nature of the impact caused by two phases per export cable installation activity would not differ from those assessed in section 10.7.4.2 above.

220. The footprint of disturbance as a result of installing cables in phases would predominantly be on adjacent areas of seabed rather than overlapping areas, and so the additive impact from each phase would be comparable to installation in one phase, rather than having a recurring impact on the same receptors. Therefore, impacts to benthic ecology would be **minor adverse** significance.

10.7.4.2.3 Haisborough Hammond and Winterton SAC

221. The offshore cable corridor runs through the Haisborough, Hammond and Winterton SAC and construction activities within this area have the potential to cause temporary loss and disturbance to priority features associated with this site (sandbanks and biogenic reefs).

222. The worst case maximum area of seabed within the SAC which could be affected by cable installation activities (including preparation e.g. pre-lay grapnel run and sand wave levelling) along with sediment disposal would be 4.86km^2 (see Table 10.12). This is approximately 0.33% of the 1,468km^2 SAC area.

223. As previously discussed, areas of Annex 1 sandbank have been identified within the offshore cable corridor. The sandbank type present within the SAC is both dynamic and mobile, therefore extent and distribution of sandbanks and the mobile sand waves upon them, is actively influenced by ongoing hydrodynamic processes and changes over time (Fugro, 2016).

224. The Haisborough, Hammond and Winterton SAC site selection assessment concluded that tops of sandbanks supported benthic communities “of low diversity” (JNCC, 2010). This was found to be the case in the most recent survey, with low diversity observed and no species of conservation importance found to be associated with this area (Fugro, 2016). As discussed in Chapter 8 Marine Geology, Oceanography and Physical Processes, sediments plumes arising from export cable installation along the offshore cable corridor within the Haisborough, Hammond and Winterton SAC would tend to be advected to the north, further across the SAC. In addition, Norfolk Boreas Limited has made a commitment that sediment arising from the SAC would be disposed of at a site within the offshore cable corridor and within the SAC from where it would be transported by tidal currents further into the SAC (i.e. to the north), resulting in no net loss of sediment from the designated site (Appendix 7.1 of the Information to Support HRA report (document reference 5.3)). The location of deposition, and footprint of potential secondary impacts including suspended sediment concentrations (SSC) and re-deposition of sediment would avoid any areas of Annex I *S. spinulosa* reef.

225. Norfolk Boreas Limited have committed to the production of a SIP for the Haisborough Hammond and Winterton SAC and this commitment is secured through the draft DCO (Condition 9(1)(m) of Schedules 11 and 12). The SIP will be the

framework for developing and agreeing mitigation and monitoring measures as is necessary to avoid adversely affecting the integrity of the sandbanks and *S.spinulosa* reef features of the site. An In Principle version of this document is submitted as part of the DCO application (document reference 8.20).

226. The potential impacts of temporary habitat loss/disturbance during the single phase and two phased approach will be considered against the conservation objectives of the SAC within the Information to Support HRA Report (document reference 5.3) which is submitted as part of the DCO application.

10.7.4.3 Impact 1C: Temporary habitat loss/disturbance in the project interconnector search area

10.7.4.3.1 Assessment of impacts in the project interconnector search area – single phase

227. Activities required within the project interconnector search area, cable trenching and pre-sweeping, would lead to temporary disturbance. The sea bed area within the project interconnector search area that may be affected by the cable installation activities is 1.84km^2. This constitutes a small portion of the biotopes, which have been identified across the former East Anglia Zone, resulting in the impact of physical disturbance and loss being assigned a low magnitude.

228. The effect of direct disturbance and loss of seabed habitat during cable installation activities has the potential to cause disturbance to the biotopes shown in Figure 10.10. The sensitivities of these biotopes, based on the tolerance and recoverability from physical disturbance are also provided in Table 10.14.

Table 10.14 Sensitivities of biotopes within the project interconnector search area to physical disturbance (source: Tyler-Walters, Lear and Allen, 2004; Tillin, 2014b; Tillin, 2016, Tillin 2016b)

Biotope code	Biotope description	Tolerance	Recoverability	Overall sensitivity
SS.SCS.CCS	Circalittoral coarse sediment	Intermediate	High	Low
SS.SBR.PoR.SspiMx	*S. spinulosa* on stable circalittoral mixed sediment	Low - None	Medium	Medium
SS.SSa.CFiSa	Circalittoral fine sand	No available information		
SS.SSa.MuSa	Circalittoral muddy sand	No available information		
SS.SSa.CFiSa.EpusOborApri	Echinocyamus pusillus, Ophelia borealis and Abra prismatica in circalittoral fine sand	None	Medium	Medium

* based on assessments in Tillin (2014b) which focus on the species which define the biotope

229. The project interconnector search area does not overlap with any designated site and as such, receptors within designated sites have only been considered in relation to the offshore cable corridor (see section 10.7.4.2).

230. Within the project interconnector search area, the biotope complex SS.SCS.CCS was the most common and was therefore assigned as characterising the site during the offshore cable corridor surveys (Norfolk Vanguard, 2018) and as shown in Figure 10.10

231. In terms of sensitivity to the effect of direct disturbance and loss of seabed habitat during construction the coarse sediment communities can be considered at the biotope level or in relation to the communities identified by the PRIMER analysis. At the biotope level, 'Circalittoral coarse sediment' SS.SCS.CCS is considered to have high recoverability and low sensitivity (Tyler-Walters, Lear and Allen, 2004).

232. The main defining taxa of the groups found within the project interconnector search area were:

- Group h, was distinct from all other groups and was dominated by *Capitella*
- Group k: Nemertea, and the polychaete worms *S.spinulosa* and *S.bombyx;*
- Group n: the polychaete worm *N. cirrosa*
- Group o: the polychaete worm *S.bombyx, N. cirrosa* and *P. pulchellus;* and
- Group p: the polychaete worm *N. cirrosa, S. bombyx* and *Nemertea*

233. As discussed in section 10.7.4.1.1, the dominant taxa recorded in the project interconnector search area are considered to have low sensitivity to physical disturbance. Along with the sensitivities of species discussed in section 10.7.4.1.1, species from group h were also present in the project interconnector. Ca*pitella* are known for their tolerance to disturbed habitats (Silva et al., 2017). Therefore, it is considered that whether looking at the biotope or species level the coarse sediment communities will generally be of low sensitivity. However, due to the use of proxy species in this assessment it is noted that the level of confidence is less than it would be if all species sensitivities were available.

234. The impact of physical disturbance during the construction phase to the benthic ecology within the project interconnector search area is therefore assessed as **minor adverse**. This is due to a low magnitude of effect combined with a low sensitivity of receptors to physical disturbance and substratum loss. There is medium to high confidence in this assessment due fact that site specific data is available and MarLIN/MarESA assessments of sensitivity have been completed for many species identified as defining the communities within the site.

10.7.4.3.2 Assessment of the impacts of the project interconnector search area – two phase

235. The maximum infrastructure requirements are the same for each phasing scenario and the impact of disturbance will be localised to the footprint of each activity. The phased approach to construction would not result in recurring impact on the same area of seabed, as each interconnector activity will occur sequentially and the interconnector cables will be laid adjacent to each other not on the same footprint of seabed. As a result, while the overall programme is longer under the two phased approach (39 month, see Table 10.10), the temporal and spatial extent of direct disturbance at any one location of seabed would be no greater. The magnitude of effect on benthic species and habitats therefore remains low, as with the single phase scenario. The same receptors of low to medium sensitivity would also be affected and therefore the impact of temporary habitat loss/disturbance remains of **minor adverse** significance regardless of the phasing scenario.

10.7.4.4 Impact 1 Summary: Temporary habitat loss/disturbance in the Norfolk Boreas offshore project area

236. The magnitude of physical disturbance on benthic ecology in the Norfolk Boreas site and offshore cable corridor is low and the greatest sensitivity is medium, regardless of the phased approach to construction and therefore the overall worst case impact of physical disturbance is considered to be of **minor adverse** significance.

237. The total worst case footprint for all temporary disturbance is 23.31km^2 of the Norfolk Boreas offshore project area and when taken in the context of rapid recoverability anticipated for the affected biotopes, this remains of low magnitude in the context of the offshore project area as well as the wider study area.

238. The confidence in this assessment is high. There is a lack of available information on the sensitivity of some species recorded in the offshore project area. However, it is considered likely that these are less sensitive than species such as *S. spinulosa* for which there is appropriate information available. The impact significance has been determined on the basis of the most sensitive receptor and the magnitude represents the maximum footprint of the project. Therefore, the resulting impact significance is considered to be conservative.

10.7.4.5 Impact 2A: Temporary increase in suspended sediment concentrations and associated sediment deposition in the Norfolk Boreas site

239. Increases in suspended sediment concentrations within the water column may occur as a result of seabed preparation and associated sediment disposal and through sediment disturbed due to installation of offshore infrastructure, including foundations and cables. Activities such as seabed disturbances from jack-up vessels and placement of cable protection are not expected to increase the suspended

sediment concentrations to the extent to which it would cause an impact to benthic ecology receptors. Chapter 8 Marine Geology, Oceanography and Physical Processes provides details of potential suspended sediment changes.

240. Increased suspended sediments have the potential to affect benthic ecology receptors by blocking feeding apparatus as well as by smothering sessile species upon deposition of sediment.

241. As described in Chapter 8 Marine Geology, Oceanography and Physical Processes, the majority of the sediment released during construction would be medium-grained sand. As a result, this would fall as a highly turbid dynamic plume upon its discharge, reaching the seabed within minutes or tens of minutes and within tens of metres along the axis of tidal flow from the location at which it was released. The deposited sediment would form a mound local to the point of release (likely to be tens of centimetres to a few metres high). The small proportion of fine sand and mud would stay in suspension for longer and form a passive plume. This plume (tens of mg/l) would be likely to exist for around half a tidal cycle (i.e. approximately six hours). Sediment would eventually settle to the seabed within approximately 1km along the axis of tidal flow from the location at which it was released within a short period of time (hours). These deposits would be very thin (millimetres). Chapter 8 Marine Geology, Oceanography and Physical Processes, describes a similar effect for both using the one or two phase construction scenarios. Taking into account the spatial and temporal extents of increased suspended sediments, this is considered to have a low impact magnitude on benthos.

242. Seabed preparation and disposal within the Norfolk Boreas site would result in up to 45,992,212m^3 of suspended sediment due to cable and foundation installation and seabed preparation. Alternatively, if drilling is required, arisings within the Norfolk Boreas site would result in approximately 413,913m^3 of sediment being bought up to the seabed surface. However, drilling would only be required if a monopile or jacket foundation were used and in that scenario less seabed preparation would be required (Table 10.12).

243. The sensitivity of the receptors in the Norfolk Boreas site to increases in suspended sediments and smothering are shown below in Table 10.15. The majority of receptors are not sensitive to increased suspended sediments and smothering. *S. spinulosa* and *S. bombyx* use sediment to build tubes and can therefore thrive in environments with increased suspended sediments. The maximum sensitivity is shown for *S. spinulosa,* where smothering reaches a level at which there is no tolerance, in which case the recoverability would be medium when the deposited sediments disperse resulting in medium sensitivity. The worst case scenario is therefore an impact of **minor adverse** significance.

Table 10.15 Sensitivities of receptors within the Norfolk Boreas site to increased suspended sediment and smothering by deposited sediment (source: Tyler-Walters 2004, Lear and Allen, 2004; Tillin et al., 2015; Jackson & Hiscock, 2008; Ager, 2005)

Receptor	Tolerance	Recoverability	Overall sensitivity
Light smothering – up to 5cm			
Sublittoral sands and muddy sands	Not available		
***S. spinulosa* on stable circalittoral mixed sediment**	High	High	Not sensitive
S. spinulosa	Low	Immediate	Not sensitive
S. bombyx	Low	High	Low
A. alba	Low	Immediate	Not sensitive
P. Pulchellus	Not available		
Heavy smothering – up to 30cm			
Sublittoral sands and muddy sands	Not available		
***S. spinulosa* on stable circalittoral mixed sediment**	None	Medium	Medium
S. spinulosa	Medium*		
S. bombyx	Not available		
A. alba	Not available		
P. Pulchellus	Not available		
Increased Suspended Sediment Concentrations			
Sublittoral sands and muddy sands	Not available		
***S. spinulosa* on stable circalittoral mixed sediment**	High	High	Not sensitive
S. spinulosa	Low	Immediate	Not sensitive
S. bombyx	Tolerant	N/A	Not sensitive
A. alba	Tolerant	N/A	Not sensitive
P. Pulchellus	Not available		

* Based on Natural England's advice during relevant representation for Norfolk Vanguard (Table 10.2).

10.7.4.6 Impact 2B: Temporary increase in suspended sediment concentrations and associated sediment deposition in the offshore cable corridor.

10.7.4.6.1 Assessment of impacts in the offshore cable corridor – single phase

244. As described in Chapter 8 Marine Geology, Oceanography and Physical Processes**,** pre-sweep activities associated with the export cable would result in the release of approximately 2,600,000m^3 of sediment. Approximately 500,000m^3 would be within the Haisborough, Hammond and Winterton SAC.

245. Following pre-sweeping, the sediment disturbed due to trenching for the export cables would equate to a maximum of 3,750,000m^3 (3,000,000m^3 within the offshore cable corridor and 750,000m^3 within the Norfolk Boreas site) of sediment. Approximately 1,200,000m^3 would be within the Haisborough, Hammond and Winterton SAC, and the remainder from the rest of the offshore cable corridor. Ploughing would create temporary mounds either side of the trench and therefore it is expected that only a small proportion of the 3,750,000m^3 would result in sediment plumes during cable installation.

246. Although a large quantity of material could be released, this would occur over a large area (the offshore cable corridor is approximately 236km^2) including up to two separate cables routes and over a period of up to 6 months. It is predicted that in water depths greater than -20m LAT (which are seen across the majority of the offshore cable corridor), peak suspended sediment concentrations would be typically less than 100mg/l, except in the immediate vicinity (a few tens of metres) of the release location. In shallow water nearer to shore (less than -5m LAT) the potential for dispersion is more limited and therefore the concentrations are likely to be greater, approaching 400mg/l at their peak. However, these plumes would be localised to within less than 1km of the location of installation and would persist for no longer than a few hours.

247. Following cessation of installation activities any plume would have been fully dispersed as a result of advection and diffusion.

248. There are no reliable data for nearshore on existing suspended sediment concentrations near Happisburgh, but data from further offshore in the region have shown concentrations to be up to several 100mg/l. Sand wave levelling in inshore areas is not expected as most sand waves occur further offshore.

249. The spoil from the pre-sweep activities would be deposited within a disposal site within the Norfolk Boreas offshore project area. Sediment from within the Haisborough Hammond and Winterton SAC would be deposited within an area of the offshore cable corridor which overlaps with the SAC to ensure the sediment remains within the SAC. As discussed in section 10.7.3.4 the exact location(s) for

disposal of sediment within the SAC would be determined in consultation with the MMO and relevant SNCB following the pre-construction surveys. ABPmer (Appendix 7.1 information to inform HRA (document reference 5.3) have calculated the potential depth of sediment due to deposition in an indicative disposal area located within the SAC as a result of seabed levelling. Theoretically this could range from 4.2m to 0.25m but the actual thickness of the deposited layer is more likely to range between 0.3m and 0.02m based on typical conditions for the site including water depth of 31m (see section 10.7.3.4).

250. In addition to the main trenching and disposal activities, excavation seaward of the landfall HDD exit point (see Chapter 5 Project Description) would lead to localised increases in suspended sediment. As discussed in Chapter 8 Marine Geology, Oceanography and Physical Processes the suspended sediment concentrations would be elevated above prevailing conditions, but are predicted to remain within the range of background nearshore levels (which will be high close to the coast because of increased wave activity) and lower than those concentrations that would develop during storm conditions.

251. Chapter 8 Marine Geology, Oceanography and Physical Processes concludes the magnitude of increase in suspended sediment concentrations to be medium in the near field[9] and negligible in the far field.

252. Sediment from cable laying activities would settle out onto the seabed potentially causing smothering; as discussed in Chapter 8 Marine Geology, Oceanography and Physical Processes. Following completion of the cable installation activity, theoretical bed level changes in excess of 0.2mm (and up to 0.8mm) are predicted at a distance of up to 20km from the cable trench and changes of up to 2mm within a few hundred metres of the inshore release locations. However, it is anticipated that under the prevailing hydrodynamic conditions, this material would be readily re-mobilised, especially in the shallow inshore area where waves would regularly stir the bed. Accordingly, outside the immediate vicinity of the offshore cable trench, bed level changes and any changes to seabed character are expected to be not measurable in practice.

253. Regardless of whether a single phase or two phase installation strategy is used, cable installation would likely be undertaken sequentially and sediment deposited for the first cable trench would become part of the northerly sediment transport regime as described in Appendix 7.1 to the Information to inform HRA (document reference 5.3). Therefore, some or all of the sediment (depending on the duration between

[9] The near-field effects are confined to a small area (likely to be of the order of several hundred metres up to a kilometre from the offshore cable corridor) and would not cover the whole offshore cable corridor.

phases) would have migrated away from the disposal site by the time disposal occurred for the second trench.

254. The strategy for disposal (i.e. concentrating the material in a small area, with a greater depth of material or dispersing it over a large area with small depth of material) would be determined in consultation with the MMO and relevant SNCB following the pre-construction surveys.

255. Given that the impact of deposited material would either be over a very small spatial scale or would involve only a thin layer of deposited material, the magnitude of this impact is considered to be low.

256. The assessment of changes in seabed level due to offshore export cable installation in Chapter 8 Marine Geology, Oceanography and Physical Processes predicts that the magnitude of affect would be low in the near field and negligible in the far field.

257. Taking account of both the expected levels of increase in suspended sediment and the expected level of sediment deposition the magnitude of this impact within the offshore cable corridor is considered to be low.

258. The key receptors in the offshore cable corridor for which there is available sensitivity information, are:

- Circalittoral coarse sediment - SS.SCS.CCS;
- Circalittoral mixed sediment - SS.SMx.CMx (nearshore);
- *Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel - SS.SCS.CCS.MedLumVen;
- *S. spinulosa* on stable circalittoral mixed sediment - SS.SBR.PoR.SspiMx; and
- *Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand - SS.SCS.CCS.Pkef (nearshore).

259. The sensitivity of these receptors to increases in suspended sediments and smothering are shown below in Table 10.16. As some areas of potential *S. spinulosa* reef were found along the offshore cable corridor, there is the potential for these areas to be impacted by increased suspended sediment concentrations and smothering. However, as *S. spinulosa* rely on suspended solids in order to filter feed and build tubes, they are often found in areas of high levels of turbidity and have been found to develop a few hundred metres from primary aggregate extraction sites (Davies et al., 2009).

Table 10.16 Sensitivities of receptors within the offshore cable corridor to increased suspended sediment and smothering by deposited sediment (source: Tillin, 2016; Tillin & Marshall, 2015; Tillin, 2016c)

Receptor	Tolerance	Recoverability	Overall sensitivity
Light smothering – up to 5cm			
Circalittoral coarse sediment	Not available		Not sensitive**
Circalittoral mixed sediment	Not available		
***Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel**	Medium	High	Not Sensitive* - Low
***S. spinulosa* on stable circalittoral mixed sediment**	High	High	Not sensitive
***Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand**	Not available		
Heavy smothering – up to 30cm			
Circalittoral coarse sediment	Not available		Not sensitive**
Circalittoral mixed sediment	Not available		
***Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel**	Medium	Medium	Medium
***S. spinulosa* on stable circalittoral mixed sediment**	None	Medium	Medium
***Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand**	Not available		
Increased Suspended Sediment Concentrations			
Circalittoral coarse sediment	Not available		
Circalittoral mixed sediment	Not available		
***Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel**	Medium	High	Low
***S. spinulosa* on stable circalittoral mixed sediment**	High	High	Not sensitive
***Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand**	High	High	Not sensitive*

* based on assessments in Tillin (2014b) which focus on the species which define the biotope

** Based on Natural England's advice during relevant representation for Norfolk Vanguard (Table 10.2).

260. As shown in Table 10.16 the greatest overall sensitivity of biotopes recorded within the offshore cable corridor to smothering or increased suspended sediment is likely to be medium, with this occurring when between 5cm and 30cm of sediment is deposited on the receptor.

261. In accordance with Table 10.16, a medium sensitivity, and low magnitude of effect for the offshore cable corridor means that this impact would likely be of **minor adverse** significance.

10.7.4.6.2 Assessment of impacts in the offshore cable corridor – two phase

262. Under the two phased construction programme the export cable installation activities (export cable seabed preparation, export cable installation and cable protection installation) will take approximately 27 months (Table 10.10). The worst case area of impact would remain the same as for a single phased construction. Chapter 8 Marine Geology, Oceanography and Physical Processes concludes that the magnitude of effects from increased suspended sediment and deposition would be low in the near field and negligible in the far field regardless of whether the export cables are installed in a single or two phased approach.

263. Under a two phased approach there would be 9 months between export cable installation seabed preparation for each phase, therefore benthic biotopes would have begun to recover from the first phase as the second phase begins construction. The largest source of increased suspended sediment would be the cable trenching itself. As the cables installed under different phases would be approximately 120m apart different areas of seabed would be affected during each phase.

264. Benthic communities within the disposal site would have also started to recover from sediment deposition following disposal during the first phase of cable installation when disposal for the second phase of installation occurs. As with the single phase, the impact of disposal would either be a large increase in sediment depth over a small area or a thin layer (likely to be between 0.3m and 0.02m) of sediment depth over a much larger area. The only difference between the single phase and two phased approach would be the time between disposal events and therefore the overall magnitude of effects for a two phased approach would be similar to that of a single phase. The magnitude of the impact is therefore considered to be low.

265. Therefore, it is concluded that impacts of increased suspended sediment and smothering due to a two phased construction would be at worst of **minor adverse** significance.

Haisborough, Hammond and Winterton SAC

266. As discussed above, some aggregations of *S. spinulosa* have been recorded along the offshore cable corridor within the SAC. Any impacts to these areas would be the same as for elsewhere within the offshore cable corridor. Disposal sites would be located to avoid likely *S. spinulosa* reef and where possible the biotope (SS.SBR.PoR.SspiMx) and locations where grab samples showed *S. spinulosa* reef to be present.

267. Areas of Annex 1 sandbanks have been identified within the area of offshore cable corridor which overlaps with the SAC. The sandbank type present in the SAC can be relatively mobile, therefore extent and distribution are actively influenced by ongoing hydrodynamic processes and changes over time (section 8.6.10 in Chapter 8).

268. The potential impacts of increases SSC and associated sediment deposition are considered against the conservation objectives of the SAC within section 7.4 of the Information to Support HRA Report (document 5.3).

Cromer Shoal Chalk Beds MCZ

269. The Norfolk Boreas offshore cable corridor is located approximately 60m to the south of the Cromer Shoal Chalk Beds MCZ. There is potential for cable installation activities to result in increased suspended sediment levels and deposition within the MCZ.

270. As discussed above, increased suspended sediment levels in the nearshore are likely to be within background levels and less than those experienced during storm conditions. Theoretical maximum bed level changes of only 0.8mm are predicted at a distance of up to 20km from cable trenches and changes of up to 2mm within a few hundred metres. Therefore, the magnitude of effects from suspended sediment and deposition within the MCZ are expected to be negligible.

271. As discussed in section 10.6.6.3 the MCZ is primarily designated for its subtidal chalk reef and peat and clay exposures. Due to the site designation, the value of the designated features are considered high, however during the benthic surveys which included a small section of the southern part of the MCZ (Norfolk Vanguard Limited, 2018 Appendix 10.1) no chalk bed or peat or clay exposures were identified (although the survey report did not rule out the presence of these features) and it is believed that these features are more prevalent further north within the MCZ. As shown in Figure 10.10 the habitat recorded in the small section of MCZ surveyed was SS.SMx.CMx, which dominated the near shore cable corridor, and one area of potential SS.SCS.CCS.MedLumVen. Therefore, the sensitivity of Cromer Shoal Chalk Beds MCZ in this area has been assessed as being low. A low sensitivity and negligible magnitude of effect result in a predicted impact of **negligible** significance.

The outcome of this assessment was supported by EIFCA during consultation on the PEIR (Table 10.2).

10.7.4.7 Impact 2C: Temporary increase in suspended sediment concentrations and associated sediment deposition in the project interconnector search area.

272. For the worst-case scenario, it is assumed that pre-sweeping and trenching may be required for 100% of the project interconnector cables to an average depth of 3m and with an average width of 20m (Table 10.12). This equates to a total excavation of 2,760,000m^3 of sediment.

273. Any excavated sediment from pre-sweeping for the project interconnector cables would be disposed of within the nearest section of the disposal site (Figure 5.2). This means there will be no net loss of sand from any part of the project interconnector search area. It is likely that some of this sand could be disposed on the upstream side of the cable where tidal currents would, over time, re-distribute the sand back over the levelled area (as re-formed sand waves). Also, in many parts of project interconnector search area there would not be the need for release of sediment volumes as considered under this worst-case scenario as optimisation of cable alignment, depth and installation methods during detailed design would ensure that effects are minimised.

274. The worst-case scenario cable-laying technique is considered to be jetting. The plume modelling simulations undertaken for East Anglia ONE (ABPmer, 2012b) described in section 8.7.6.5 of Chapter 8 Marine Geology, Oceanography and Physical Processes are used as a basis for the expert-based assessment described here. It is anticipated that the changes in suspended sediment concentration due to array and interconnector cable installation (including any sand wave levelling) would be minimal.

275. The predominance of medium-grained sand (which represents most of the disturbed sediment) means that most of the sediment would settle out of suspension within a few tens of metres along the axis of tidal flow from the point of installation along the cable and persist in the water column for less than a few tens of minutes.

276. The sensitivity of the receptors in the project interconnector search area to increases in suspended sediments and smothering are shown below in Table 10.16. Most receptors are not sensitive to increased suspended sediments and smothering. *S. spinulosa* and *S. bombyx* use sediment to build tubes and can therefore thrive in environments with increased suspended sediments. There is no sensitivity assessment available for the *Capitella* genus, however *Capitella capitata* is commonly found in the UK and has been used as a proxy for the *Capita* genus. The maximum sensitivity is shown for *S. spinulosa,* where smothering reaches a level at which there is low tolerance, in which case the recoverability would be medium

when the deposited sediments disperse resulting in medium sensitivity. The worst case scenario is therefore an impact of **minor adverse** significance.

Table 10.16 Sensitivities of receptors within the project interconnector search area to increased suspended sediment and smothering by deposited sediment (source: Tyler-Walters 2004, Lear and Allen, 2004; Tillin et al., 2015; Jackson & Hiscock, 2008; Ager, 2005, Tillin 2016d)

Receptor	Tolerance	Recoverability	Overall sensitivity
Light smothering – up to 5cm			
Circalittoral coarse sediment	Not available		
***S. spinulosa* on stable circalittoral mixed sediment**	High	High	Not sensitive
S. spinulosa	Low	Immediate	Not sensitive
S. bombyx	Low	High	Low
N.Cirrosa	Not available		
P. Pulchellus	Not available		
Capitella	Low	High	Low
Heavy smothering – up to 30cm			
Circalittoral coarse sediment	Not available		
***S. spinulosa* on stable circalittoral mixed sediment**	None	Medium	Medium
S. spinulosa	Medium*		
S. bombyx	Not available		
N. Cirrosa	Not available		
P. Pulchellus	Not available		
Capitella	Low	High	Low
Increased Suspended Sediment Concentrations			
Circalittoral coarse sediment	Not available		
***S. spinulosa* on stable circalittoral mixed sediment**	High	High	Not sensitive
S. spinulosa	Low	Immediate	Not sensitive
S. bombyx	Tolerant	N/A	Not sensitive
N. Cirrosa	Not available		
P. Pulchellus	Not available		
Capitella	Medium	Low	High

* Based on Natural England's advice during relevant representation for Norfolk Vanguard (Table 10.2).

277. As set out in section 10.5.3 the project interconnector search area was extended to allow for cables to be installed across the gap between the Norfolk Boreas site and Norfolk Vanguard East. Although the extended area has not been subject to dedicated bathymetric surveys the majority (over 80%) of the site has been surveyed during existing site specific surveys (see appendix 27.7 of the consultation report (document reference 5.1)). Therefore, the assumption is made that the benthic communities within the additional area will be consistent with those surrounding it and the worst case scenario for sensitivity of benthic species to smothering and SSC would be the same as set out in Table 10.16, which is medium. It should be noted that any area that has not currently been surveyed will be surveyed during pre- and post-construction surveys. More details are provided in the In Principle Monitoring Plan (document reference 8.12).

278. Under the two-phase approach, the principal difference compared to the single-phase assessment is that installation of the cables would occur over two distinct phases however these would also last a total of 24 months which is the same as the single phased approach. Therefore due to the remaining low near-field and negligible far-field magnitude of effect, this would not materially change the assessment of significance compared with a single-phase approach.

10.7.4.8 Impact 2 Summary: Temporary increase in suspended sediment concentrations and associated sediment deposition in the offshore project area

279. The magnitude of physical disturbance on benthic ecology in the Norfolk Boreas offshore project area is low and the greatest sensitivity is medium, regardless of the two phased approach to construction and therefore the overall worst case impact of physical disturbance is considered to be of **minor adverse** significance.

280. The overall impact of suspended sediments in the Norfolk Boreas site, the offshore cable corridor and the project interconnector search area would have minimal spatial overlap. In the context of the wider study area this overall impact is considered to remain of low magnitude and therefore of **minor adverse** significance.

281. The confidence in this assessment is high, except for the areas that have not been surveyed within the extended interconnector search area, where the confidence is medium. The impact significance has been determined on the basis of the most sensitive receptor and the magnitude represents the maximum volume of suspended sediments as assessed in Chapter 8, Marine Geology, Oceanography and Physical Processes. Therefore, the resulting impact significance is considered to be conservative.

10.7.4.9 Impact 3: Impacts of changes to water quality due to re-mobilisation of contaminated sediments

282. Given the low level of contaminants present in the sediments within the Norfolk Boreas offshore project area, changes in water and sediment quality from re-suspension of contaminants during construction have been assessed as negligible (Chapter 9 Marine Water and Sediment Quality).

283. The data summarised in Chapter 9 Marine Water and Sediment Quality illustrate that sediment contamination within the Norfolk Boreas site is low. Only two sample locations exceeded the lower Cefas Action Level 1 and this was for concentrations of arsenic at ST03 and ST10. These exceedances are considered to be marginal as they are only just over the Action Level 1 concentration. Additionally, elevated levels of arsenic are typical of this region of the southern North Sea (Chapter 9 Marine Water and Sediment Quality). These are associated with estuarine and geological inputs and seabed rock weathering therefore they are in line with sample results for metals at East Anglia THREE and Norfolk Vanguard (Chapter 9 Marine Water and Sediment Quality, Table 9.10). There were no Action Level 2 exceedances within the Norfolk Boreas samples.

284. Marine Evidence based Sensitivity Assessment (MarESA) (MarLIN, 2017) shows that, where contaminants levels are within environmental protection standards, marine species and habitats are not sensitive to changes that remain within these standards.

285. All relevant construction activities will be covered by a Project Environmental Management Plan (PEMP) (document Reference 8.14) as well as emergency plans in the case of an accidental spillage or leak to ensure no release of contaminants as a result of the project. In addition to this, all vessels must adhere to the requirements of the MARPOL Convention Regulations with appropriate preventative and control measures.

286. As a result of the absence of significant existing contamination and the application of mitigation to avoid release of contaminants, there would be **no impact** to the benthic ecology.

10.7.4.10 Impact 4: Underwater noise and vibration

287. Underwater noise and vibration from UXO clearance and pile driving for the installation of some foundation types (as described in Chapter 5 Project Description) has potential to impact on benthos.

288. Other noise sources, including vessel activity and placement of cable protection are unlikely to have a significant effect on benthic ecology as the benthos in this area is likely to be habituated to ambient noise such as that created by shipping.

289. The sensitivity of benthic species to noise and vibration is poorly understood, however studies have shown that some species are able to detect sound. Horridge (1966) found the hair-fan organ of the common lobster *Homarus gammarus* to act as an underwater vibration receptor. Lovell et al. (2005) showed that the common prawn *Palaemon serratus* is capable of hearing sounds within a range of 100 to 3,000Hz, and the brown shrimp *Crangon crangon*, which was identified as present within Norfolk Boreas, has shown behavioural changes at frequencies around 170Hz (Heinisch and Weise, 1987).

290. It is therefore possible that the noise created by certain construction activities would be audible to certain benthic species. Although the benthos is likely to be habituated to ambient noise such as that created by shipping or wave action, the noise created by UXO clearance and piling may cause disturbance response. This has been found to be the case during seismic explorations involving noise up to 250dB at 10 to 120Hz (Richardson et al., 1995) whereby polychaetes tended to retreat into the bottom of their burrows or retracted their palps, and bivalve species withdrew their siphons. Furthermore, the air-filled cavities within certain invertebrate species may alter the transmission of sound waves through their bodies, which could potentially cause physiological damage. Therefore, taking a conservative approach, the sensitivity of benthic species is considered medium.

10.7.4.10.1 Assessment of impacts - single phase

291. The worst case scenario for pilling represents the maximum hammer energy required which would be 5,000kJ hammer energy for 20MW monopile foundations, of which there would be up to 90 turbines.

292. The spatial extent of underwater noise and vibration impacts on benthic receptors is unknown; however, foundation installation activities would be temporary, occurring over 18 months under the single phase construction scenario. The maximum piling duration of 1,080 hours for the foundations associated with 10MW monopile or 10MW to 20MW quadropod represents the temporal worst-case scenario (i.e. 9% of the time during foundation installation period). The maximum duration per foundation would be 87 hours.

293. The magnitude of this impact is therefore considered to be negligible.

294. Given that the sensitivity of the benthos is considered to be medium, the significance of the impact would be of **minor adverse** significance.

10.7.4.10.2 Assessment of impacts – two phase

295. The maximum piling parameters would be the same regardless of the construction phasing; however, the piling programme would be slightly different. The overall duration of active piling would remain the same however this could be completed

during up to two separate nine month foundation installation phases undertaken over a two year period (Table 10.10). The maximum piling duration of 1,080 hours for the foundations associated with 10MW monopile and or 10MW to 20MW quadropod . The magnitude of this impact is therefore considered to remain negligible on benthic species.

296. The combined magnitude of underwater noise and vibration from all installation activities is considered to be low. As previously discussed, the sensitivity of benthic species in the Norfolk Boreas site is medium and therefore the impact is considered to be of **minor adverse** significance.

10.7.5 Potential Impacts during Operation

10.7.5.1 Impact 1A: Permanent loss of seabed habitat in the Norfolk Boreas site

297. Habitat loss during the wind farm life would occur from placement of structures on the seabed and scour protection associated with the structures and cables. As indicated by Table 10.12 the worst case scenario for permanent loss of seabed habitat within the Norfolk Boreas site is 6.18km^2. This is considered to be a low magnitude in relation to the site and the wider region due to the presence of comparable subtidal sands and gravel habitats identified throughout the Norfolk Boreas offshore project area and the wider former East Anglia Zone.

298. The Norfolk Boreas site does not overlap with any designated sites however potential *S. spinulosa* reef was recorded with no or 'low' reef characteristics (see Appendix 10.1). The remaining habitat within the Norfolk Boreas site is characterised as sublittoral sands and muddy sands.

299. As the biotope classification is dependent on substratum type, removal and a change to a hard or artificial substratum would ultimately result in a different biotope classification in isolated locations within the footprint of foundations and cable protection. Likewise, individuals of the benthic community associated with the area of seabed taken would be lost and therefore sensitivity of these receptors would be medium. The sensitivity of SS.SBR.PoR.SspiMx to habitat change is high (Tillin *et al.*, 2018) however, as the biotope is only present in discrete areas which would be avoided then the overall sensitivity is considered medium. In the context of community level impacts for habitats and species in the Norfolk Boreas site the overall magnitude is considered to be low. The resulting impact would be of **minor adverse** significance.

300. It is likely that the new infrastructure will become colonised by some of the receptors affected by a loss of habitat and this is assessed in Impact 2 (section 10.7.5.9) in relation to the potential impact of colonisation of the new artificial substrate created by the project infrastructure.

10.7.5.2 Impact 1B: Permanent loss of seabed habitat in the offshore cable corridor

301. Within the offshore cable corridor direct habitat loss would occur where cable protection is placed. This would be where cable burial is not possible and around cable crossings and the breakout point at landfall. As a worst case scenario placement of cable protection has been considered as permanent habitat loss. Due to the patterns of erosion and accretion naturally occurring within the offshore cable corridor (discussed in Appendix 7.1 to the Information to inform HRA (document reference 5.3)) it is expected that the cable protection will undergo periodic burial and uncovering meaning the impact of habitat loss would be persistent rather than permanent. However, for the purposes of this assessment the impact of habitat loss is considered permanent as a precautionary worst case scenario.

302. The maximum footprint of cable protection would be 0.23km^2 which represents 0.096% of the offshore cable corridor. The need for reburial and/or protection would be significantly less where pre-sweeping is used (see section 10.7.3.4.4). The installation of cable protection is considered to be an impact of negligible magnitude.

303. The effect of habitat loss associated with placement of cable protection has the potential to cause disturbance to the following biotopes which have been found within the offshore cable corridor:

- Circalittoral coarse sediment - SS.SCS.CCS;
- Circalittoral mixed sediment - SS.SMx.CMx (nearshore);
- *Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel - SS.SCS.CCS.MedLumVen;
- *S. spinulosa* on stable circalittoral mixed sediment - SS.SBR.PoR.SspiMx;
- *Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand - SS.SCS.CCS.Pkef (nearshore);
- Circalittoral fine sand - SS.SSa.CFiSa; and
- Circalittoral muddy sand - SS.SSa.MuSa.

304. As previously discussed, within the footprint of habitat loss there would be a removal of these biotopes and associated fauna, however in the context of the surrounding area these biotopes frequently occur, therefore sensitivity to this loss is considered to be low or high in the case of SS.SBR.PoR.SspiMx, SS.SCS.CCS and, SS.SCS.CCS.MedLumVem (Tillin *et al.*, 2016c) **.** The resulting impact is therefore of **minor adverse** significance in relation to potential loss of *S. spinulosa* biotope, SS.SCS,CCS and SS.SCS.CCS.MedLumVen or **negligible** for the wider offshore cable corridor.

Haisborough, Hammond and Winterton SAC

305. The project has been designed to minimise the use of cable protection, particularly within the Haisborough Hammond and Winterton SAC (as discussed in section 10.7.1). In the unlikely event that hard substrate (i.e. not an Annex 1 feature) is encountered cable burial may not be possible, resulting in additional cable protection. The worst case scenario for cable protection placement within the SAC is $0.05km^2$ (Table 10.12).

306. Micrositing will be undertaken where possible around sensitive features; however there remains the potential for small areas of *S. spinulosa* biotope and potential reef to be impacted. If this is the case it is highly likely that the *S. spinulosa* would recover to colonise the Norfolk Boreas cable protection, see section 10.7.3.4. The installation of cable protection is considered to be an impact of negligible magnitude.

307. The effect of habitat loss associated with placement of cable protection in the SAC has the potential to cause disturbance to the biotopes which have been found within the offshore cable corridor set out above. At this stage, it is unknown exactly where the cable protection would be required within the SAC if at all, so the exact habitats with the potential to be disturbed is unknown.

308. As previously discussed, within the worst case footprint of habitat loss there would be a removal of these biotopes and associated fauna, however in the context of the frequent presence of these biotopes in the surrounding area, the sensitivity to this loss is considered to be low or high in the case of SS.SBR.PoR.SspiMx, SS.SCS.CCS and SS.SCS.CCS.MedLumVem**.** The resulting impact is therefore of **minor adverse** significance in relation to potential loss of *S. spinulosa* biotope or the coarse sediment biotopes or **negligible** significance for the benthic ecology of the wider offshore cable corridor.

309. Norfolk Boreas Limited have committed to the production of a SIP for the SAC and this is secured through the DCO. The SIP will be the framework for developing and agreeing mitigation and monitoring measures as is necessary to avoid adversely affecting the integrity of the sandbanks and *S.spinulosa* reef features of the site. An In Principle version of the SIP is submitted as part of the DCO application (document reference 8.20).

310. The potential impact of permanent loss of seabed habitat is considered within the Information to Support HRA Report (document reference 5.3) submitted as part of the DCO application.

10.7.5.3 Impact 1C: Permanent loss of seabed habitat in the project interconnector search area

311. Within the project interconnector search area the worst case scenario for permanent loss of seabed habitat is 0.061km^2 (see Table 10.12). This is considered to be a negligible magnitude of effect in relation to the site and the wider region due to the presence of comparable subtidal sands and gravel habitats identified throughout the Norfolk Boreas offshore project area and the wider former East Anglia Zone.

312. The project interconnector does not overlap with any designated sites however potential *S. spinulosa* reef was recorded with 'low' reef characteristics (Norfolk Vanguard Limited, 2018 Appendix 10.1) in the western part of the search area (Figure 10.12). The remaining habitat within the project interconnector search area is characterised as circalittoral coarse sediment.

313. As the biotope classification is dependent on substratum type, removal and a change to a hard or artificial substratum would ultimately result in a different biotope classification in isolated locations within the footprint of foundations and cable protection. Likewise, individuals of the benthic community associated with the area of seabed taken would be lost and therefore sensitivity of these receptors would be medium, or high for SS.SCS.CCS and SS.SBR.PoR.SspiMX. Given the negligible magnitude of effect, the resulting impact would be of **minor adverse** significance.

314. Although the project interconnector search area has not been subject to dedicated bathymetric surveys the majority of the area has been surveyed during existing site specific surveys. Therefore, the assumption is made that the benthic communities within the additional area will be similar to those surrounding it. Therefore, the worst case scenario for sensitivity of benthic species to habitat loss would be the same as those in the surveyed interconnector search area and the impact significance would still be **minor** adverse. It should be noted that any area that has not currently been surveyed will be surveyed during pre- and post-construction surveys. More details are provided in the In Principle Monitoring Plan (document reference 8.12).

315. It is likely that the new infrastructure will become colonised by some of the receptors affected by a loss of habitat and this is assessed in Impact 2 (section 10.7.5.9) in relation to the potential impact of colonisation of the new artificial substrate created by the project infrastructure.

10.7.5.4 Impact 1: Summary: Permanent loss of seabed habitat through the presence of seabed infrastructure in the Norfolk Boreas offshore project area

316. The total footprint of all habitat loss resulting from the project is 6.471km^2 over the project area of nearly 1,170km^2. The magnitude of effect is therefore considered to be low. The greatest sensitivity receptor is medium therefore the overall worst case impact of physical disturbance is considered to be of **minor adverse** significance.

317. The confidence in this assessment is high except for the small area (equating to approximately 20% of the total area) in the interconnector search area which has not been surveyed, where the confidence is medium. The impact significance has been determined on the basis of the maximum footprint and although sensitivity assessments for all biotopes and species present are not available a conservative approach has been applied where these are missing and therefore the resulting impact significance is considered to be conservative.

10.7.5.5 Impact 2A: Temporary seabed disturbances from maintenance operations in the Norfolk Boreas site

318. There is potential for physical disturbance to the benthos during operation where maintenance activities require the use of jack-up vessels. Jack- up vessels will be required for regular maintenance of wind turbines. As outlined in Table 10.12 the maximum average of two turbine locations per day, visited by a jack-up vessel is expected. Jack up vessels will also be used where cable maintenance, replacement or repair is required. As outlined in Table 10.12, the following unplanned repairs of cables are assumed as a worst case scenario, assuming no pre-sweeping prior to installation (pre-sweeping would minimise the potential requirement for reburial):

- Reburial of 25% of array cable every 5 years;
- Two array cable repairs per year;
- One interconnector repair per year;
- Two wind turbines visited per day during O&M using a jack up vessel; and
- Anchored vessels placed temporarily on site to maintain the wind turbines.

319. The worst case scenario for jack-up vessel footprint during O&M activities will be 0.58km^2 per year. In addition, reburial of an estimated 25% of array cable would result in an impact footprint of 0.45km^2 every five years and two array cable repairs per year would result in a footprint of 0.036km^2. One interconnector repair per year would result in a footprint of 0.001km^2. Each footprint would be temporary (days to months) and would then recover, as such, the magnitude of this impact is considered to be low.

320. The sensitivity of species and habitats within the Norfolk Boreas site to physical disturbance has been discussed under Construction Impact 1, with sensitivities being classed as medium. A low magnitude of effect combined with medium sensitivity

leads to an impact of **minor adverse** significance in the Norfolk Boreas site. There is medium to high confidence in this assessment as site specific data is available and MarLIN/MarESA assessments of sensitivity have been completed for many species identified as defining the communities within the site.

10.7.5.6 Impact 2B: Temporary seabed disturbances from maintenance operations in the offshore cable corridor

321. An estimated worst case scenario for unplanned export cable repairs is that one 300m section per year would be removed and replaced resulting in a footprint of 900m^2 per year. In addition, the estimated worst case required reburial is 20km per cable (up to 120km in total) over the project life which would result in up to 0.12km^2 of temporary disturbance (based on a 10m disturbance width), with significantly smaller areas disturbed at any one time. These relatively small areas of seabed disturbance represent a negligible impact magnitude to benthic ecology. Of this total area, up to 4km per cable (up to 8km in total) is estimated to require reburial within the SAC with a total disturbance footprint of 0.08km^2 over the operational period.

322. Using the worst case scenario that this disturbance temporarily affects *S. spinulosa,* the receptor sensitivity is classified as medium**.** The resulting impact significance would be **minor adverse** on the basis that each disturbance activity would be localised and temporary, and the benthic ecology would recover rapidly. There is medium to high confidence in this assessment as site specific data is available and MarLIN/MarESA assessments of sensitivity have been completed for many species identified as defining the communities within the site.

323. The potential impacts of temporary disturbance from operation and maintenance activities are considered within the Information to Support HRA Report (document reference 5.3) submitted in support of the DCO application.

10.7.5.7 Impact 2C: Temporary seabed disturbances from maintenance operations in the project interconnector search area

324. The worst case scenario for the project interconnector search area during O&M activities is estimated to be one repair per year equating to 900m^2 of disturbance. The worst case scenario for the project interconnector search area during O&M activities every five years equates to 69,000m^2. The footprint would be temporary (days to months) and would then recover. Therefore, the magnitude of effect is considered to be low.

325. The sensitivity of species and habitats within the project interconnector site to physical disturbance has been discussed under Construction Impact 1, with sensitivities being classed as medium. A low magnitude of effect combined with medium sensitivity leads to an impact of **minor adverse** significance in the project interconnector search area.

10.7.5.8 Impact 2 Summary: Temporary seabed disturbances from maintenance operations in the offshore project area

326. The magnitude of effect of temporary seabed disturbances from maintenance operations on benthic ecology in the Norfolk Boreas offshore project area is low and the greatest sensitivity is medium therefore the impact is considered to be of **minor adverse** significance.

327. The impacts of temporary seabed disturbance in each of the Norfolk Boreas site, offshore cable corridor and project interconnector search area would have no spatial overlap and unlikely to have a temporal overlap, however as the maintenance activities are unplanned the temporal overlap cannot be quantified.

328. The confidence in this assessment is high. The impact significance has been determined on the basis of the maximum footprint per activity and although sensitivity assessments for all biotopes and species present are not available a conservative approach has been applied where these are missing and therefore the resulting impact significance is considered to be precautionary.

10.7.5.9 Impact 3: Colonisation of turbines/cable protection/scour protection

329. As discussed above, where existing sediment habitat would be lost (Construction impact 1), this would be replaced by new habitat (foundations, scour protection and cable protection).

330. Boulders and mattresses used in cable protection have been found to add habitat complexity in otherwise homogenous, fine sand and coarse sediment, increasing the heterogeneity of the environment in and around offshore wind farms (Lindeboom et al., 2011; Goriup, 2017).

331. Table 10.17 below shows the sensitivities of dominant biotopes to habitat change to hard or artificial habitat, where information available.

Table 10.17 Sensitivity of biotopes with the Norfolk Boreas site to habitat change to hard or artificial habitat. (source: Tyler-Walters, Lear and Allen, 2004; Tillin, 2014b; Tillin, 2016)

Biotope code	Biotope description	Tolerance	Recoverability	Overall sensitivity
SS.SSa.CFiSa	Circalittoral fine sand	Intermediate	Very high	Low
SS.SCS.CCS	Circalittoral coarse sediment	Low	High to very high	Low to moderate
SS.SCS.CCS.MedLumVen	*Mediomastus fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel	None	Very low	Medium* - High
SS.SBR.PoR.SspiMx	*S. spinulosa* on stable circalittoral mixed sediment	None	Very low	High

* based on assessments in Tillin (2014b) which focus on the species which define the biotope

332. *S. bombyx* lives within the sediment so a loss of substratum will cause a loss of individuals. However, recoverability is high due to the widespread distribution of the Group 'n' infaunal group within the site as well as high dispersal potential and reproductive rate of the species (Ager, 2005). The larval dispersal of the species allows it to colonise more remote habitats, and as such the sensitivity of *S. bombyx* to substrate loss/habitat change is moderate.

333. *S. spinulosa* is known to be able to colonise hard substratum and artificial structures, therefore an increase in the availability of hard substratum may be beneficial to this species. Therefore, although the biotope classification may change, the key faunal species may not be as sensitive to change. Based on this, S. spinulosa is considered to have low sensitivity to habitat loss/replacement, as although reefs may be impacted, the resultant habitat will be suitable for recolonisation.

334. Although there is little information available on the growth and development of *S. spinulosa* reefs on subsea cables and cable protection, there has been some monitoring of growth on artificial hard substrates, which may be compared to the artificial hard substrate created by cable protection. *S. spinulosa* was recorded on the newly introduced artificial hard substrate at Horns Rev, suggesting that artificial hard substrate created by the construction of offshore wind farms offer suitable substrates for *S. spinulosa* colonisation (Lindeboom et al. 2011).

335. Several wind farm developments have had post-construction monitoring requirements relating to *S. spinulosa*. During post-construction monitoring at Greater Gabbard *S. spinulosa* was the second most numerous benthic species identified in the benthic drop down video survey, although not in reef form (CMACS, 2014). In the first year of monitoring following construction of London Array; *S. spinulosa* was in the top ten most abundant taxa, and there was an area along the export cable round where a large number of the worms were found (MarineSpace, 2015). In the two years of post-construction monitoring at Gunfleet Sands 1 and 2, the number of *S. spinulosa* individuals more than doubled, and numbers of S. spinulosa found in the export cable route samples were much higher in the second year (CMACS 2010; 2012).

336. All project infrastructure that has a sub-sea surface element would represent a potential substrate for colonisation by marine fauna and flora, including species that may not currently be found within the existing environment. Therefore, the assessment of this impact does not make a distinction between sources of impact in the different study areas as is the case with most other impacts. As any new introduced substrate would be a change from the existing environment the impact to any ecological receptors cannot be considered beneficial in ecological terms.

337. The addition of hard substrate is of particular importance given the otherwise mostly sedimentary environments found across the Norfolk Boreas offshore project area where substrates for colonisation by encrusting epifauna are very limited.

338. Hard substrates introduced by the project would include foundations and scour protection for wind turbines, electrical platforms, service platform, meteorological masts and cable protection. The area of introduced substrate is difficult to calculate as it would be three dimensional and would depend on the foundation design, however it would be in excess of the 11.53km^2 area of permanent habitat loss calculated across the Norfolk Boreas site (Table 10.12).

339. Studies of operational wind farms in the North Sea have found that widespread colonisation of sub-sea surfaces occurs. Lindeboom et al*.* (2011) demonstrated that at the Egmond aan Zee, new hard substrate led to the establishment of new faunal communities and species. During surveys, 33 species were found to have colonised the monopiles and 17 species on the scour protection after two years of monitoring (Lindeboom et al*.* 2011). At Horns Rev there was colonisation by 11 species of algae and 65 invertebrate taxa within two years of the completion of the project. In addition, mobile invertebrates (decapods and molluscs) were found on the scour protection and sessile species had settled on the monopiles (Lindeboom et al*.* 2011).

340. Foundations with scour protection represent the maximum surface area for recolonisation. Cable protection used to protect the array, interconnector and export cables would also be likely to be colonised by the species and communities discussed above. In the worst case scenario, an area of up to 0.64km^2 of cable protection may be required (e.g. rock armour, mattresses or sand-filled geotextile bags) across the entire offshore project area.

341. The change of habitat from a sedimentary substrate to hard substrate would result in potential increases in the diversity and biomass of the marine community of the area through colonisation of the structures. However, there is likely to be only a small interaction between the remaining available seabed and the introduced hard substrate and any interactions would be highly localised. The magnitude of this effect is considered to be low.

342. Due to the widespread nature of the receptors in the region, it is unlikely that there will be any significant community or biodiversity changes. As discussed in section 10.7.1, embedded mitigation will be in place to avoid any potential spreading of non-native invasive species. The sensitivity of the benthic ecology is considered to be medium taking a precautionary approach.

343. Confidence in the accuracy of this assessment is low due to the difficulty of predicting exactly what species may colonise the structures. Therefore, a precautionary approach has been used to assess the impacts.

344. Alterations to existing communities allowing colonisation of new substrate within the offshore project area are considered to result in an impact of **minor adverse** significance.

10.7.5.10 Impact 4: Electromagnetic Fields (EMF) from installed array, interconnector or project interconnector and export cables

345. EMFs as a result of the presence of array, interconnector, project interconnector and export cables may be detected by some benthic species. EMFs are strongly attenuated and decrease as an inverse square of distance from the cable (Gill and Bartlett, 2010), therefore any effects would be highly localised. Furthermore, the aim is to bury as much of the cable as possible, reducing the effect of EMF, although it is recognised that cable may, in some locations, be buried to a lesser extent. Norfolk Boreas have also committed to a HVDC electrical solution thereby reducing the maximum number of export cables from six to two thus limiting the area of seabed over which EMF could be detected. Therefore, the magnitude of such an impact is considered negligible.

346. Evidence for sensitivity to EMFs comes from physiological and behavioural studies on a small number of marine invertebrates and no direct evidence of impacts to invertebrates from undersea cable EMFs exists. Biological effects studies have demonstrated small responses to magnetic fields in the development of echinoderm embryos and in cellular processes in a marine mussel, however at intensity fields far greater than those expected from undersea cables (Normandeau et al*.* 2011). Hutchison et.al (2018) demonstrated that small behavioural responses can occur in American lobster *Homarus americanus* when exposed to the EMF from a subsea HVDC cables. Exposure to cable EMF was associated with changes to the movement and distribution within an enclosure space, however the EMF did not represent a barrier to movement. Love et al. (2016) found no significant differences among fish and invertebrate communities between energized cables, pipe and natural habitat. Statistical differences were found between three fish species however differences were attributed to structures and depth rather than EMF.

347. There is little evidence to suggest that benthic species would be adversely impacted by EMF, therefore the sensitivity of the benthic ecology receptors is considered to be negligible and a **negligible** significance is therefore predicted.

10.7.5.11 Impact 5: Underwater noise from maintenance operations in the Norfolk Boreas site

348. Underwater noise and vibration from operational activities, including vessels required for inspections, vessel anchor placement, cable repairs and cable reburial.

349. As stated in section 10.7.4.10, the sensitivity of benthic species to noise and vibration is poorly understood, however some studies have shown that certain species are able to detect sound. Horridge (1966) found the hair-fan organ of the common lobster *Homarus gammarus* to act as an underwater vibration receptor. Lovell et al. (2005) showed that the common prawn *Palaemon serratus* is capable of detecting sounds within a range of 100 to 3,000Hz, and the brown shrimp *Crangon crangon*, which was identified as present within Norfolk Boreas, has shown behavioural changes at frequencies around 170Hz (Heinisch and Weise, 1987).

350. It is therefore possible that the noise created by certain activities would be audible to certain benthic species. The operational noise generated includes vessel movement, placement of temporary objects on the seabed such as anchors and the operational wind turbines. In relation to operational wind turbines, the underwater noise report (Appendix 5.4) states that noise levels generated above the water surface are low enough that no significant airborne sound will pass from the air to the water and determined that impact piling is the much greater noise source.

351. As the operational noise would be limited to, for example noise from vessel movements operational wind turbine noise, the magnitude of this impact is considered to be negligible.

352. The benthos in this area is likely to be habituated to ambient noise such as that created by shipping. However, as stated in section 10.7.4.10 a conservative approach has been taken with regards to sensitivity of benthic species to underwater noise due to the lack of available information, therefore, sensitivity is considered medium.

353. As the sensitivity of the benthos is considered to be medium, the significance of the impact would be of **minor** adverse significance.

10.7.6 Potential Impacts during Decommissioning

354. The scope of the decommissioning works would most likely involve removal of the accessible installed components. This is outlined in Chapter 5 Project Description and the detail will be agreed with the relevant authorities at the time of decommissioning and be subject to separate licensing based on best available information at that time. Offshore, this is likely to include removal of all of the wind turbine components and part of the foundations (those above seabed level). Some

or all of the array cables, interconnector cables, and offshore export cables may be removed. Scour and cable protection would likely be left in-situ.

355. During the decommissioning phase, there is potential for wind turbine foundation and cable removal activities to cause physical disturbance to the substratum and changes in suspended sediment concentrations. The types of effect would be comparable to those identified for the construction phase:

- Impact 1: Temporary habitat loss/disturbance due to wind turbine foundation, and cable removal operations;
- Impact 2: Changes in suspended sediment concentrations and associated sediment deposition due to removal of wind turbine foundations and parts of the cables;
- Impact 3: Changes to water quality due to the release or spill of decommissioning materials or chemicals; and
- Impact 4: Underwater noise and vibration.

356. As the scour protection, cable protection and foundations at seabed level could remain in situ the magnitude of effects would be either comparable to or less than those identified for the construction phase. Accordingly, given that impacts were assessed to be of **minor adverse** significance for the identified benthic ecology receptors during the construction phase, it is anticipated that the same would be true for the decommissioning phase.

357. It is recognised that there will be colonisation of Norfolk Boreas infrastructure by benthic species. There is, to date, limited data available which could be used to define the nature of colonisation by species and therefore what biotopes would be impacted during the decommissioning phase.

358. The first UK offshore wind farm to be decommissioned will be the Blyth offshore wind farm. An environmental assessment conducted in support of the marine licence for the proposed decommissioning determined that decommissioning would remove any species that have colonised the infrastructure (Natural Power, 2018). However, the surface area to be lost would be small in comparison to the surrounding environment and eventually the site is predicted to return to a state similar to that prior to the construction of the wind farm (Natural Power, 2018). No site specific surveys were undertaken for benthic ecology to support the assessment therefore, the level of colonisation is not known (Natural Power, 2018).

359. It is recognised that the size of the Blyth offshore wind farm is significantly smaller than Norfolk Boreas. However, it is expected that the effects would be similar in that they would be of limited magnitude due to highly localised disturbance and it is likely that conditions would eventually return to the pre-construction state. Therefore, as

stated above, a **minor** impact significance is predicted for habitat loss during decommissioning, this would include the removal of colonised species.

10.8 Cumulative Impacts

360. As discussed in Chapter 8 Marine Geology, Oceanography and Physical Processes, potential cumulative effects on the seabed (and therefore on the benthic ecology) may arise due to the interaction of:

- Installation of foundation structures for Norfolk Boreas and installation of East Anglia THREE and Norfolk Vanguard;
- Installation or decommissioning of the offshore export cable (including works at the landfall) for Norfolk Boreas and installation and decommissioning of the proposed Norfolk Vanguard project;
- Installation or decommissioning of the offshore export cable (including works at the landfall) for Norfolk Boreas and marine aggregate dredging activities in adjacent areas of the seabed; and
- Operation and maintenance of Norfolk Boreas with East Anglia THREE and Norfolk Vanguard.

361. A summary of the screening of potential impacts is set out in Table 10.18.

Table 10.18 Potential cumulative impacts

Impact		Potential for cumulative impact	Rationale
Construction			
1	Temporary habitat loss/ disturbance associated with the Norfolk Boreas site	Yes	Additive habitat loss/disturbance across the region
2	Temporary habitat loss/disturbance associated with offshore cable corridor	Yes	Additive habitat loss/disturbance of Norfolk Vanguard sharing the same offshore cable corridor as Norfolk Boreas.
3	Temporary habitat loss/ disturbance in the project interconnector search area	Yes	Additive habitat loss/disturbance of the project interconnector search area overlapping the Norfolk Vanguard site.
4	Temporary habitat loss/disturbance in the intertidal zone	No	There is no impact from Norfolk Boreas and therefore no potential cumulative impact.
5	Temporary increases in suspended sediment concentrations and associated sediment deposition in the Norfolk	Yes	NV East and East Anglia THREE are approximately 1km and 13km from the Norfolk Boreas site. The tidal predicated tidal zone of influence overlap (Figure 8.15). There is therefore potential for cumulative impacts associated with suspended sediments and deposition

Impact		Potential for cumulative impact	Rationale
	Boreas site		towards the perimeter of each wind farm if construction is undertaken at the same time.
6	Temporary increases in suspended sediment concentrations and associated sediment deposition in the offshore cable corridor	Yes	Consideration is given to cumulative impacts of suspended sediment from Norfolk Vanguard sharing the same offshore cable corridor, as well as impacts from aggregate dredging.
7	Temporary increases in suspended sediment in the project interconnector search area	No	There is unlikely to be any temporal overlap in dredging activities between Norfolk Vanguard and Norfolk Boreas within the project interconnector search area.
8	Changes to water quality	No	There is no impact from Norfolk Boreas and therefore no potential cumulative impact.
9	Impacts of underwater noise	No	The impact of underwater noise on benthos is expected to be localised and therefore there would be no cumulative effects with other plans or projects.
Operation			
10	Permanent loss of seabed habitat in the Norfolk Boreas site	Yes	Additive habitat loss/disturbance across the region.
11	Permanent loss of seabed habitat in the offshore cable corridor	Yes	Additive habitat loss/disturbance of Norfolk Vanguard sharing the same offshore cable corridor as Norfolk Boreas.
12	Permanent loss of seabed habitat in the project interconnector search area	Yes	Additive habitat loss/disturbance of the project interconnector search area overlapping the Norfolk Vanguard site.
13	Temporary seabed disturbances from maintenance operations in the Norfolk Boreas site	Yes	Additive habitat loss/disturbance across the region associated with Norfolk Vanguard
14	Temporary seabed disturbances from maintenance operations in the offshore cable corridor	Yes	Additive habitat loss/disturbance of Norfolk Vanguard sharing the same offshore cable corridor as Norfolk Boreas.
15	Temporary seabed disturbances from maintenance operations in the project interconnector search area	Yes	Additive habitat loss/disturbance of the project interconnector search area overlapping the Norfolk Vanguard site.

Impact		Potential for cumulative impact	Rationale
16	Colonisation of turbines/cable protection/scour protection	No	The effects of recolonisation would be highly localised on the introduced structures and therefore there is no potential cumulative impact. Embedded mitigation is proposed for Norfolk Boreas to avoid the spread of non-native invasive species and it is expected that other projects would follow best practice.
17	EMF from installed array, interconnector and export cables	No	The effects of EMF would be highly localised around the cables and therefore there is no potential cumulative impact.
Decommissioning			
The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of decommissioning and agreed with the regulator. A decommissioning plan will be provided. As such, cumulative impacts during the decommissioning stage are assumed to be no worse than those identified during the construction stage.			

10.8.1 Cumulative Impacts for the Norfolk Boreas site

10.8.1.1 Habitat loss/ disturbance associated with the Norfolk Boreas site during construction and operation

362. Whilst it is recognised that across the former East Anglia Zone and wider southern North Sea there would be additive impacts on the benthic ecology, the overall combined magnitude of these would be negligible taking into account the relatively small scale of the habitats affected by each project in relation to the habitat available within the region, given the relative ubiquity of species and habitats across the southern North Sea.

363. In cases where sensitive habitats are present (e.g. *S.spinulosa* reef), effects would be avoided where possible by micro-siting and therefore the potential cumulative impacts would be **negligible.**

10.8.1.2 Temporary increases in suspended sediment concentrations and associated sediment deposition in the Norfolk Boreas site during construction

364. As there is no physical overlap with the Norfolk Boreas site and other projects, the potential cumulative impacts are limited to those associated with increased suspended sediment from the adjacent Norfolk Vanguard and East Anglia THREE projects.

365. There is potential for the construction phase of Norfolk Boreas to overlap with NV East and East Anglia THREE due to having adjacent boundaries. As discussed in section 10.7.4 the majority of suspended sediment from Norfolk Boreas is expected to settle to the seabed within tens of metres of the source location and the small

proportion of fine sand and mud would settle to the seabed within approximately 1km forming a very thin deposit (millimetres) with the sediment travelling with the tidal flow. The East Anglia THREE EIA (EATL, 2015) and Norfolk Vanguard ES (Norfolk Vanguard Limited, 2018) provide similar estimates. Cumulative impacts would only occur at any locations on the edge of each wind farm where installation works are within range of potential overlap of sediment deposition, noting that there will need to be large buffers between adjacent projects' turbine spacing at least equivalent to the minimum spacing (720m) required within Norfolk Boreas. Such locations will be few in number (if they occur at all) and as the cumulative impact of deposition would only be millimetres in sediment depth the cumulative impact would be **negligible** at these locations, with **no impact** for the majority of locations within the OWF sites.

10.8.2 Cumulative Impacts within the Norfolk Boreas offshore cable corridor

10.8.2.1 Marine aggregate dredging - temporary increases in suspended sediment concentrations and associated sediment deposition

366. As discussed in Chapter 8, theoretical bed level changes of up to 2mm are estimated as a result of cumulative impacts of Norfolk Boreas cable installation and dredging at nearby aggregate sites. The sensitivity of benthic receptors to this level of change would be as described in section 10.7.4.5 and the magnitude of this level of change is negligible and therefore the cumulative impact significance will be **negligible.**

10.8.2.2 Norfolk Vanguard offshore wind farm – habitat loss/ disturbance during construction and operation

367. As Norfolk Boreas and Norfolk Vanguard share an offshore cable corridor there is potential for cumulative impacts associated with construction and unplanned maintenance activities.

368. It is likely that installation of the Norfolk Boreas export cables will follow after the Norfolk Vanguard export cables with no temporal overlap. The worst case spatial footprint of installation works for both Norfolk Vanguard and Norfolk Boreas is likely to be approximately double that of the Norfolk Boreas alone, although some elements of the seabed preparation may spatially overlap and therefore reduce the overall combined footprint. As discussed in Table 10.12, the temporary footprint disturbance from export cable installation for Norfolk Boreas would be up to 6.07km^2, of which up to 4.86km^2 would be within the Haisborough, Hammond and Winterton SAC based on a 20m width for preparation works (including pre-lay grapnel run and pre-sweeping). The Norfolk Boreas offshore cable corridor overlaps with the Norfolk Vanguard offshore cable corridor for a length of approximately 95km. Norfolk Vanguard also requires up to two export cables, the additional footprint for Norfolk Vanguard would be 6.1km^2, of which 4.86km^2 would be within the Haisborough, Hammond and Winterton SAC (Norfolk Vanguard Limited, 2018

Chapter 10, Table 10.12). The combined footprint of 12.2km^2 is considered to represent a low magnitude of effect in the context of the wider available habitat.

369. As discussed in section 10.7.1, VWPL commission a detailed export cable installation study (Appendix 5.2) which included investigation of the space required within the offshore cable corridor for installation of Norfolk Vanguard and Norfolk Boreas and the available contingency for micrositing of the export cables to avoid features such as *S. spinulosa* reef.

370. Micrositing will be undertaken for Norfolk Boreas and Norfolk Vanguard, where possible, to minimise potential impacts on sensitive habitats (e.g. *S. spinulosa*) and therefore the cumulative impact is considered to be **minor adverse.**

10.8.3 Cumulative Impacts within the Norfolk Boreas project interconnector search area

10.8.3.1 Norfolk Vanguard offshore wind farm – habitat loss/ disturbance during construction and operation

371. As the project interconnector search area and the Norfolk Vanguard OWF sites and offshore cable corridor partially overlap there is potential for cumulative impacts associated with construction and unplanned maintenance activities.

372. Installation of the Norfolk Boreas interconnector cables will follow after the construction of the Norfolk Vanguard OWF with no temporal overlap. Therefore, there will be an additive spatial footprint of installation works for both Norfolk Vanguard and Norfolk Boreas, although some elements of the seabed preparation may overlap and therefore reduce the overall combined footprint. It is possible that benthic habitats will have started to recover post Norfolk Vanguard construction.

373. As discussed in Table 10.12, the temporary footprint disturbance from the project interconnector cable installation for Norfolk Boreas would be up to 1.86km^2, however only a small proportion of this (less than 20%) would occur within either of the Norfolk Vanguard OWF sites. The Norfolk Vanguard assessment (Norfolk Vanguard Limited, 2018) identified that a maximum area of 16.1km^2 could be impacted by habitat loss / disturbance which was considered to be a low magnitude or effect. The addition 0.37km^2 (which is 20% of 1.87km^2) would not increase the magnitude of effect and therefore the magnitude is low the context of the wider available habitat.

374. The species and habitats within the project interconnector search area have been assessed as being of low sensitivity to habitat loss and disturbance (section 10.7.4.3 and 10.7.5.3). Where possible, micrositing will be undertaken for Norfolk Boreas and Norfolk Vanguard to minimise potential impacts on sensitive habitats and therefore the cumulative impact is considered to be of **minor adverse** significance.

Table 10.19 Summary of Projects considered for the CIA in Relation to the Topic

Project	Status	Development period	[10]Distance from Norfolk Boreas site (km)	Project definition	Project data status	Included in CIA	Rationale
East Anglia THREE Offshore Wind farm	Consented	2022-2026	13	PDS available	Complete/high	Yes	This project would be located approximately 13km to the south of Norfolk Boreas. It has potential for interaction during the construction of foundations and cable array installation.
Norfolk Vanguard Offshore Wind farm	Pre-Application	2024-2028	1	Outline only	Incomplete/low	Yes	This project would be adjacent to Norfolk Boreas and would share the offshore cable corridor. It has potential for interaction during the construction and operation and maintenance phases
Marine aggregate dredging	Licenced	In operation	Nearest 27km		Complete/high	Yes	Export cables for Norfolk Boreas pass north of marine aggregate extraction areas offshore from Great Yarmouth. There is potential for some interaction between their dredging plumes and plumes from cable installation
Bacton and Walcott Coastal Management Scheme	Application submitted	Construction due 2019	Approximately 1	ES available	Complete/high	No	The Norfolk Boreas Long HDD would have no impact on coastal erosion, and the nearshore cable protection would have negligible impact on sediment transport processes at the coast
Coastal defence/protection works, Happisburgh PF/18/0751	Registered Application 24/04/2018	10 year duration	Approximately 1	Outline	Medium	No	Due to the use of a Long HDD there would be no overlap in activities associated with the two schemes

[10] Shortest distance between the considered project and Norfolk Boreas – unless specified otherwise.

10.9 Inter-relationships

375. The construction, operation and decommissioning phases of Norfolk Boreas would cause a range of effects on benthic ecology. The magnitude of these effects has been assessed using expert assessment, drawing from a wide science base that includes project-specific surveys and previous numerical modelling activities.

376. These effects not only have the potential to directly affect the identified benthic ecology receptors but may also manifest as impacts upon receptors other than those considered within the context of marine and intertidal benthic ecology. The assessments of significance of these impacts on other receptors are provided in the chapters listed in Table 10.20.

Table 10.20 Benthic and Intertidal Ecology inter-relationships

Topic and description	Related Chapter	Where addressed in this Chapter	Rationale
Fish and Shellfish – edible crabs, prey resources, nursery and spawning grounds	Chapter 11 Fish and Shellfish Ecology	N/A –this chapter informs the assessment in Chapter 11	The benthic environment provides the habitat and prey species for fish and shellfish ecology. Therefore, impacts on benthic ecology can have subsequent impacts on fish and shellfish.
Suspended sediments and deposition	Chapter 8 Marine Geology, Oceanography and Physical Processes and Chapter 9 Marine Water and Sediment Quality	Impacts as a result of suspended sediments and deposition are assessed in sections 10.7.4.5, 10.7.4.6 and 10.7.4.7.	Changes in suspended sediment concentrations are identified in Chapter 8 and, as a measure of water quality, these changes are further assessed in Chapter 9. Suspended sediment and associated deposition could impact benthic receptors.
Re-mobilisation of contaminated sediments	Chapter 9 Marine Water and Sediment Quality	section 10.7.4.9	Chapter 9 provides assessment of the potential for contaminants to be present in the study area.

10.10 Interactions

377. The impacts identified and assessed in this chapter have the potential to interact with each other, which could give rise to synergistic impacts as a result of that interaction. The worst case impacts assessed within the chapter take these interactions into account and therefore the impact assessments are considered conservative and robust. For clarity, the areas of interaction between impacts are presented in Table 10.21, along with an indication as to whether the interaction may give rise to synergistic impacts.

Table 10.21 Interaction between impacts

Potential interaction between impacts				
Construction				
	1 Temporary habitat loss / disturbance	2 Temporary increase in suspended sediment and deposition.	3 Changes to water quality	4 Underwater noise
1 Temporary habitat loss / disturbance	-	Yes	No	No
2 Temporary increase in suspended sediment	Yes	-	Yes	No
3 Changes to water quality	No	Yes	-	No
4 Underwater noise	No	No	No	-

Operation					
	1 Permanent loss of seabed habitat	2 Temporary seabed disturbances	3 Colonisation of structures	4 Electromagnetic Fields (EMF)	5 Underwater noise
1 Permanent loss of seabed habitat	-	Yes	Yes	Yes	Yes
2 Temporary seabed disturbances	Yes		No	Yes	Yes
3 Colonisation of structures	Yes	No	-	No	No
4 Electromagnetic Fields (EMF)	Yes	Yes	No	-	Yes
5 Underwater noise	Yes	Yes	No	Yes	
Decommissioning					
It is anticipated that the decommissioning impacts will be no worse than those of construction.					

10.11 Summary

378. The benthic ecology receptors were identified using a wide science base that includes project-specific surveys, surveys of the former East Anglia Zone and wider regional surveys. The majority of the Norfolk Boreas offshore project area has a characteristic low diversity sandy habitat. Surveys within the project interconnector search area and offshore cable corridors show potential areas of the biotope '*S. spinulosa* on stable circalittoral mixed sediment'.

379. The construction, operation and decommissioning phases of Norfolk Boreas would cause a range of effects on the benthic ecology which are summarised in Table 10.22. The magnitude of these effects has been assessed using expert judgement, assessments from other chapters of this ES and has drawn on evidence from other offshore wind farms and other projects such as aggregate dredging.

380. The effects that have been assessed are anticipated to result in changes of **negligible** or **minor adverse** significance to the above-mentioned receptors. No additional mitigation measures, other than those which form part of the embedded mitigation (section 10.7.1), are suggested.

381. It should be noted that impacts under a two phased approach have all been assessed as having the same significance as those which would occur under a single phase approach. Therefore, the content of Table 10.22 is relevant to all scenarios described in section 10.7.2.

Table 10.22 Potential impacts identified for benthic and intertidal ecology

Potential Impact	Receptor	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Construction						
Temporary habitat loss / disturbance	Habitats and species within the Norfolk Boreas Site	Low to Medium	Low	Minor Adverse	Nothing further to embedded mitigation	**Minor Adverse**
	Habitats and species within Offshore cable corridor	Low to Medium	Low	Minor Adverse	Nothing further to embedded mitigation	**Minor Adverse**
	The Haisborough, Hammond and Winterton SAC	Medium	Low	Minor Adverse	SIP for the SAC (document reference 8.20)	**Minor Adverse**
	Habitats and species within the Project interconnector search area	Low	Low	Minor Adverse	Nothing further to embedded	**Minor Adverse**

Potential Impact	Receptor	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
	Intertidal benthic ecology	No receptors present	N/A	No impact	None	**No impact**
Temporary increase in suspended sediment concentrations and associated sediment deposition.	Habitats and species within the Norfolk Boreas site	Medium	low	Minor Adverse	Nothing further to embedded mitigation	**Minor Adverse**
	Habitats and species within Offshore cable corridor	Medium	Low	Minor Adverse	Nothing further to embedded mitigation	**Minor Adverse**
	Haisborough, Hammond and Winterton SAC	Medium	Low	Minor Adverse	Nothing further to embedded mitigation	**Minor Adverse**
	Cromer Shoal Chalk Beds MCZ	Low	Negligible	Negligible significance	Nothing further to embedded mitigation	**Minor Adverse**
	Habitats and species within the project interconnector search area	Medium	Low	Minor Adverse	Nothing further to embedded mitigation	**Minor Adverse**
Changes to water quality due to re-mobilisation of contaminated sediments	Habitats and species within the offshore project area			No impact	None	**No impact**
Underwater noise and vibration	Habitats within the Norfolk Boreas offshore project area	Medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor Adverse**

Potential Impact	Receptor	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Operation						
Permanent loss of seabed habitat through the presence of seabed infrastructure	Habitats within the Norfolk Boreas site	Medium	Low	Minor Adverse	Nothing further to embedded mitigation	**Minor Adverse**
	Habitats and species within the offshore cable corridor	Medium to High	Negligible	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
	Haisborough, Hammond and Winterton SAC	Medium to High	Negligible	Minor Adverse	SIP for the SAC (document reference 8.20)	**Minor adverse**
	Habitats within the project interconnector search area	Medium to High	Negligible	Minor Adverse	Nothing further to embedded mitigation	**Minor adverse**
Temporary seabed disturbances from maintenance operations	Habitats and species within the Norfolk Boreas site	Medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
	Habitats and species within the offshore cable corridor	Medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
	Habitats and species within the project interconnector search area	Medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
Colonisation of turbines/cable protection/scour protection	Habitats and species within the offshore project area	Medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
Electromagnetic Fields (EMF) from installed array and export cables	Habitats and species within the offshore project area	Negligible	Negligible	Negligible	Nothing further to embedded mitigation	**Negligible**
Underwater noise and vibration	Habitats within the Norfolk Boreas offshore project area	Medium	Negligible	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**

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