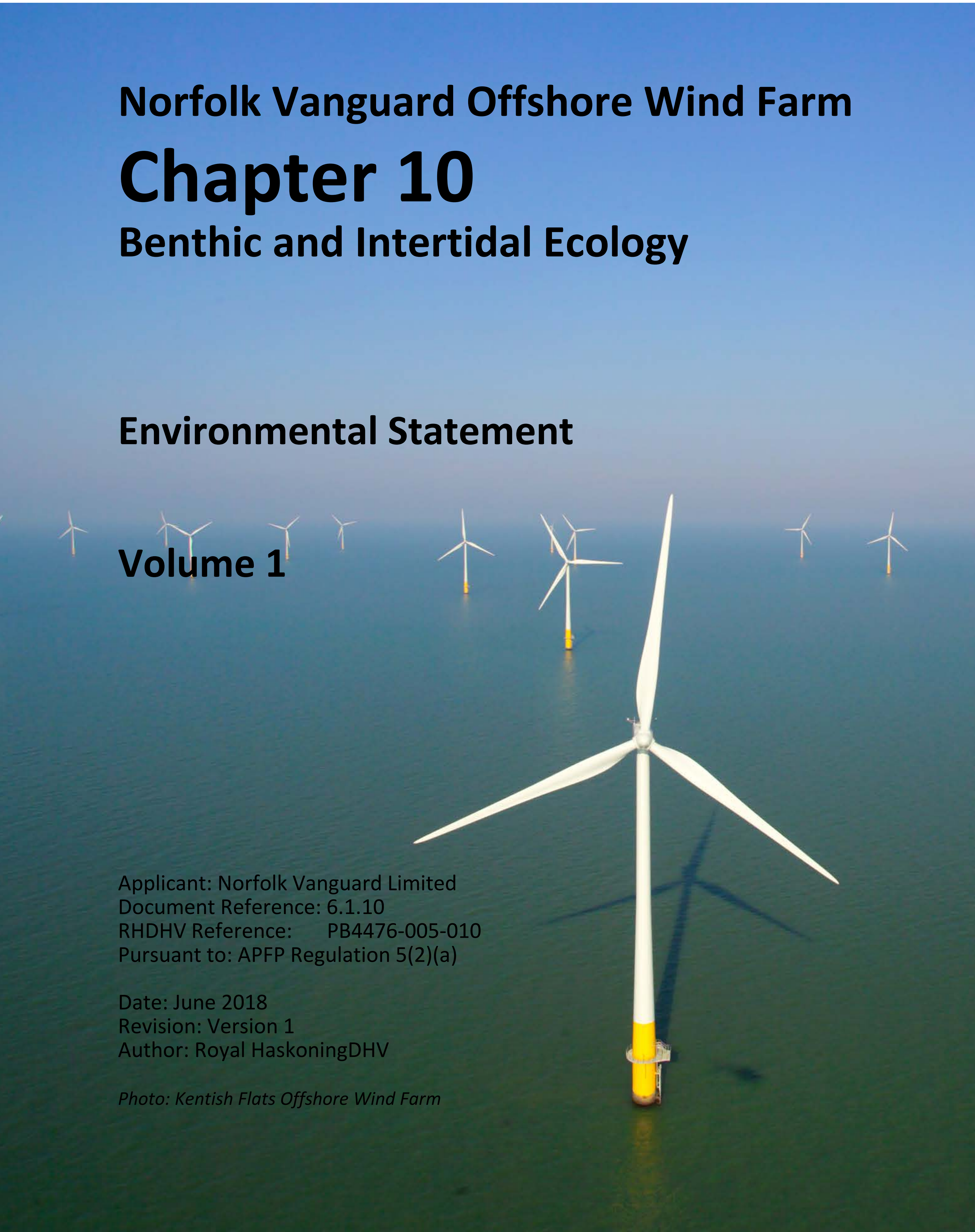
Norfolk Vanguard Offshore Wind Farm

Chapter 10

Benthic and Intertidal Ecology

Environmental Statement

Volume 1



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Environmental Impact Assessment
Environmental Statement

Document Reference: PB4476-005-010

June 2018

For and on behalf of Norfolk Vanguard Limited

Approved by: Ruari Lean, Rebecca Sherwood

Signed: [redacted]

Date: 8th June 2018

For and on behalf of Royal HaskoningDHV

Drafted by: Courtney Clemence; David Tarrant & Gemma Keenan

Approved by: Alistair Davison

Signed: [redacted]

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Glossary

AFDW	Ash-Free Dry Weight
BGS	British Geological Survey
BTO	British Trust for Ornithology
BWMP	Ballast Water Management Plan
CIA	Cumulative Impact Assessment
CoCP	Code of Construction Practice
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
EPP	Evidence Plan Process
ES	Environmental Statement
FEPA	Food and Environment Protection Agency
FERA	Food and Environment Research Agency
GBS	Gravity Based Structure
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
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
PEI	Preliminary Environmental Information
pSPA	possible Special Protection Area
REC	Regional Environmental Characterisation

RSBL	Reference Seabed Level
SAC	Special Area of Conservation
SMRU	Sea Mammal Research Unit
SNCB	Statutory Nature Conservation Body
SPI	Species Of Principal Importance
UXO	Unexploded Ordnance
WT	Wildlife Trust
WCS	Worst Case Scenario
ZEA	Zonal Environmental Appraisal

Terminology

Array cables	Cables which link the wind turbines and the offshore electrical platform.
Interconnector cables	Buried offshore cables which link the offshore electrical platforms
Landfall	Where the offshore cables come ashore at Happisburgh South.
Offshore accommodation platform	A fixed structure (if required) providing accommodation for offshore personnel. An accommodation vessel may be used instead.
Offshore cable corridor	The corridor of seabed from the Norfolk Vanguard OWF sites to the landfall site within which the offshore export cables would be located.
Offshore electrical platform	A fixed structure located within the wind farm area, containing electrical equipment to aggregate the power from the wind turbines and convert it into a more 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 overall area of Norfolk Vanguard East, Norfolk Vanguard West and the offshore cable corridor.
Safety zones	A marine zone outlined for the purposes of safety around a possibly hazardous installation or works / construction area under the Energy Act 2004.
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 Vanguard Limited
The OWF sites	The two distinct offshore wind farm areas, Norfolk Vanguard East and Norfolk Vanguard West
The project	Norfolk Vanguard Offshore 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 Vanguard project area and the wider southern North Sea. Potential impacts are assessed and mitigation measures provided where appropriate.

2. It should be noted that impacts upon shellfish are assessed in Chapter 12 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 11 Fish and Shellfish Ecology;
- Chapter 12 Marine Mammals;
- Chapter 13 Offshore Ornithology; and
- Chapter 14 Commercial Fisheries.

4. This chapter is supported by the following Appendices:

- Appendix 10.1: Fugro (2016) Benthic Characterisation Report; and
- Appendix 10.2: Analysis of benthic data.

5. This chapter of the ES was written by Royal HaskoningDHV, and incorporates survey results from Fugro EMU Ltd and Marine Ecological Surveys Limited (MESL). Technical reports from Fugro EMU's 2016 Norfolk Vanguard Benthic Characterisation Report (herein referred to as the Fugro survey), are included in Appendix 10.1 in Volume 3. In addition, technical survey reports of MESL's Zonal Environmental Appraisal (ZEA) survey for the former East Anglia Zone are available on the Planning Inspectorate website[1].

6. Further reports on sand wave recovery (Appendix 7.1 of the Information to Support HRA report (document reference 5.3)) and the extent of *Sabellaria* reef (Appendix 7.2 of the Information to Support HRA report) support the impact assessment in this chapter.

[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

10.2 Legislation, Guidance and Policy

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

8. 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 long HDD as embedded mitigation (section 10.7.1).
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.

NPS requirements	Section Reference
Section 2.6.113 of NPS EN-3: 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 inter-array 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.	1. Section 10.7.5.1; 2. The impacts associated with cable installation are assessed throughout Section 10.7. An overview of the worst case parameters is provided in Section10.7.3; 3. Sections 10.7.3.6 and 10.7.4.1; 4. Increase suspended sediment Is assessed in section 10.7.4.4. 5. Recoverability is a component of each impact assessment throughout section 10.7.
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.

9. 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.

10. 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 Vanguard 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'.

11. 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.

12. 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;
- MMO *et al.* (2010) Guidance on the Assessment of Effects on the Environmental and Cultural Heritage from Marine Renewable Developments;
- 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;
- The British Standards Institution (2015) Environmental impact assessment for offshore renewable energy projects – Guide. PD 6900:2015; and
- MMO (2014) Review of environmental data associated with post-consent monitoring of licence conditions of offshore wind farms.

10.3 Consultation

13. Consultation is a key part of the Development Consent Order (DCO) application process. Consultation regarding benthic ecology has been conducted through Expert Topic Group meetings, the Scoping Report (Royal HaskoningDHV, 2016), section 42 consultation on the Preliminary Environmental Information Report (PEIR) (Norfolk Vanguard Limited, 2017) and consultation on the draft HRA report. Full details of the project consultation process are presented within Chapter 7 Technical Consultation.

14. Detailed minutes of the Evidence Plan Process (EPP) meetings are provided in Appendices 9.16 and 25.6of the Consultation Report.

Table 10.2 Consultation Responses

Consultee	Date /Document	Comment	Response / where addressed in the PEI
Natural England	March 2016/ EPP meeting minutes	NE advised Norfolk Vanguard Limited to complete full coverage geophysical survey in Norfolk Vanguard West as well as the proposed full coverage in the cable corridor [Norfolk Vanguard East already has full coverage].	The survey campaign included full coverage of NV West and the offshore cable corridor.
Natural England	March 2016/ EPP meeting minutes	NE advised Norfolk Vanguard Limited to undertake geophysical analysis to inform a grab sampling and drop-down video campaign. Where potential for *Sabellaria* reef, only one grab required to minimise potential impacts on *Sabellaria*.	Annex C of Appendix 10.1 provides the rationale for the drop down video and grab sample locations following review of the geophysical data available at that time.
Secretary of State	November 2016	There is a large amount of existing survey data to draw upon, a lot of which comes from East Anglia THREE and East Anglia FOUR surveys. Where existing survey data is relied upon, their suitability for Norfolk Vanguard OWF should be agreed with relevant consultees; in particular the spatial and temporal scope of the surveys should be considered. The Secretary of State expects and recognises that this is likely to be a key objective of the Evidence Plan Process.	The data used (and its suitability) in this assessment has been agreed through the Evidence Plan Process.

Consultee	Date /Document	Comment	Response / where addressed in the PEI
Secretary of State	November 2016	Figures 2.5 and 2.6 of the Scoping Report show a lower coverage of survey effort within NV West compared to NV East, therefore the Secretary of State welcomes that further surveys were undertaken in summer 2016 and that the methodology was agreed with the MMO and Natural England. The methodology has not been provided within the Scoping Report for further comment; however, the Secretary of State expects this detail to be provided within the ES.	The survey methodology is provided in Appendix 10.1. The level of survey effort and validity of data was agreed at the Evidence Plan meeting held on the 16th February 2017.
Secretary of State	November 2016	The Scoping Report notes there is no epibenthic trawl data available for the offshore cable corridor, although grab surveys indicate it is broadly comparable with the benthic ecology in NV West. The Applicant should agree with relevant consultees whether or not there is a need for epibenthic trawls within the cable corridor and document any agreement within the ES.	The scope of the offshore surveys was agreed (March 2016) with Natural England and the MMO prior to their commencement (October 2016).
Secretary of State	November 2016	An assessment of the potential impacts on Annex I sandbank habitat should be presented within the ES.	Assessment of the specific impacts to Annex I sandbank habitat is provided within Sections 10.7 and 10.8.
Secretary of State	November 2016	The Scoping Report identifies the presence of *Sabellaria spinulosa* reef within NV West and the offshore cable corridor. The ES should consider not only potential direct impacts from construction, but also the potential impacts from maintenance activities on reef that may colonise the cables during the operational phase.	Impacts during O&M are assessed based on the baseline sensitivity of the benthic ecology. This therefore takes into account recolonisation, including the potential for *Sabellaria* colonisation of cable protection.
Secretary of State	November 2016	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.	The footprint of scour protection is included in the worst case scenario for habitat loss (Table 10.12).
Norfolk County Council	November 2016	The ES/EIA will need to address the potential impact on ecology, including in particular, impact on the following interests:	Designated sites are considered throughout the impact assessment in Section 10.7

Consultee	Date /Document	Comment	Response / where addressed in the PEI
		• designated sites; • marine benthos; The need to consider cumulative impact is a requirement of the EIA process. Projects to be incorporated in such an assessment must include those in the past, present and foreseeable future. Projects to be incorporated in such an assessment must include not only other potential wind farms but also other types of project taking place in the marine environment or onshore so that all elements of the infrastructure are assessed.	Cumulative impacts are considered in Section 10.8.
MMO	November 2016	Overall the approach to assessing the benthic impact appears appropriate. However, a lot of emphasis has been placed on the use of Zone Environmental Assessment (ZEA) data; more emphasis should be placed on the information within the proposed order limits. Expansion on this information will be required in the ES, however, the MMO notes that the use of other sources of data has been proposed and a list of appropriate sources is given in table 2.9.	Site specific data is provided in Section 10.6.
Natural England	November 2016	Natural England welcomes the commissioning of a number of detailed surveys to address gaps in the existing survey coverage and to provide up-to-date data with which to inform the ES.	Noted.
Natural England	November 2016	An assessment of the amount of potential maintenance work likely to be required across the lifetime of the development should be presented within the Environmental Statement. This should also include the likely maintenance requirements associated with all project cabling, including inter-array cabling.	An estimate of the likely amount of maintenance activity is provided in Table 10.12 which is used to inform the assessment in Section 10.7.5.
Wildlife Trust	November 2016	The WT outlined concerns with routing cables through the Cromer Shoal Chalk Beds MCZ.	Following consultation with nature conservation bodies and site selection work the offshore cable corridor has been amended to avoid the Cromer Shoal Chalk Beds MCZ, therefore removing any direct impacts of the project on the MCZ.

Consultee	Date /Document	Comment	Response / where addressed in the PEI
Stiffkey Parish Council	November 2016	"To be included in the ES: Identification of the area over which biological effects may occur to inform baseline data collection and determining the connectivity between key wildlife (and specifically marine) populations and proposed wind energy sites."	The study area is defined in Section 10.5.1.
Stiffkey Parish Council	November 2016	"To be included in the ES: The methodology proposed to monitor impacts into a wildlife (and specifically marine) population level context and the actions to be taken to determine whether they are biologically significant."	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).
Cefas	February 2017/ EPP meeting minutes	Assessment should cover the benthic impacts outside of the wind farm site.	This assessment uses many regional studies (Table 10.8) to assess all possible impacts to benthic ecology.
Natural England	February 2017/ EPP meeting minutes	NE has concerns over the potential *Sabellaria* habitat across the cable corridor.	Impacts to the Haisborough, Hammond and Winterton SAC are considered throughout the impact assessment (Section 10.7).
Natural England	February 2017/ EPP meeting minutes	Seabed levelling and cable protection (especially rock dump) in the SCI are very undesirable. Key issues if these are required are: • Any dredged material must be fed back into the same sand bank. • NE request that cable protection be recoverable at decommissioning, and evidence be provided that this will be the case. • Cable protection must have a small impact area.	Materials arising from the Haisborough, Hammond and Winterton SAC during installation of cables would be disposed of at a site within the offshore cable corridor which overlaps with the SAC (see Section 10.7.1). This is assessed further within the Information to Support HRA Report. It is not possible to commit to lifting cable protection during decommissioning and therefore cable protection is detailed in Chapter 5, Section 5.4.14. Norfolk Vanguard Limited is committed to minimising protection where possible.
Natural England	February 2017/ EPP	The applicant will need to be specific on the nature of cable protection they are	Details of the cable crossings are provided in

Consultee	Date /Document	Comment	Response / where addressed in the PEI
	meeting minutes	proposing at the cable and pipeline crossing points.	Chapter 5 Project Description, Section 5.4.14 and summarised in Section 10.7.2.
Natural England, Cefas, The Wildlife Trust. Eastern IFCA	February 2017/ EPP meeting minutes	Concerns were raised regarding the installation of export cables within the Cromer Shoal Chalk Beds MCZ (Specific concerns area detailed in Appendix 10.2).	Norfolk Vanguard Limited has made the decision to avoid the MCZ and route the offshore export cables to the south of this designation (see Chapter 4 Site Selection).
MMO	February 2017/ EPP meeting minutes	Need to consider unplanned repairs.	Estimations of unplanned maintenance and repair have been included in Table 10.12 and impacts of these assessed in Section 10.7.5).
Natural England	February 2017/ EPP meeting minutes	Habitat loss should now be considered as long term temporary as the foundations are likely to be cut off below seabed level.	Subsequent advice recommended impacts should be considered permanent
Eastern IFCA	February 2017/ EPP meeting minutes	Aggregate operations to the south of the SCI must be included in cumulative assessment.	Consideration of all other relevant activity within the area is given in Section 10.8.
Cefas	February 2017/ EPP meeting minutes	The Bacton Sandscaping Scheme needs to be included [within the cumulative impact assessment]	Consideration of all other relevant activity within the area is given in Section 10.8
Natural England	July 2016/EPP meeting minutes	[*Sabellaria*] Reef can re-establish in 12 months. Will need to do a new survey prior to each phase. If installed in one phase then it would be less of an impact.	Section 10.7.1.5 describes preconstruction surveys. *Sabellaria* is considered in section 10.6.3 and is assessed further in the Information to Support HRA Report submitted with the DCO application.
Natural England	July 2017/EPP meeting minutes	Avoiding the potential for cable burial during O&M (by pre-sweeping the offshore export cables where necessary) seems to be favourable both from impacts point of view and risk point of view as long as the sediment is put back as close as possible to where it was removed from. Will need to do pre- consent modelling to show this.	The project description assumes pre-sweeping to a Reference Seabed Level to ensure cables remain buried throughout the lifetime of the project. Pre-sweeping volumes have been assessed using the site bathymetry data by CWind (CWind, 2017, unpublished).

Consultee	Date /Document	Comment	Response / where addressed in the PEI
Cefas	July 2017/EPP meeting minutes	Would like to understand which sample groups [from the PRIMER analysis] shown on the map come from which survey year.	Two figures are presented in Appendix 10.2 to show this.
Natural England	11/12/2017 PEIR Response	It is unclear how the separate data sets (i.e. zonal, EA4 and Norfolk Vanguard) have been used. It is difficult to understand what has been done and when. We advise that it would be clearer to state what has been agreed and where gaps have subsequently been filled in.	Further clarity has been provided, on what samples were included in the statistical analysis in Appendix 10.2.
Natural England	11/12/2017 PEIR Response	Figures must be provided to show the location of the designated features of the Haisborough, Hammond and Winterton SAC, plus the site boundary against the anticipated impact.	The Information to Support HRA Report provides an assessment of the impact on designated features within the Haisborough Hammond and Winterton SAC. Figures 7.1 and 7.2 of the Information to Support HRA report show Annex 1 Sandbanks and Annex 1 reef, respectively.
Natural England	11/12/2017 PEIR Response	The consultee cautions the use of EIA matrices when assessing impacts for Annex I habitats as it is not directly relatable to conservation objectives. A clearer conclusion is required at the end of each consideration, culminating in a conclusion of the remaining key issues where a LSE remains and will be carried through to a HRA.	The Information to Support HRA Report (document reference 5.3) assesses the impacts of the project against the achievement of the conservation objectives for the site. _
Natural England	11/12/2017 PEIR Response	Natural England advises that an indicative scour protection and cable management plan/s is provided as part of the application. Further information on the locations of the cable crossings or areas where protection will be needed would be helpful in order to provide more specific advice on the significance of impacts.	A Scour Protection and Cable Protection Plan is submitted as part of this DCO application (document reference 8.16)
Natural England	11/12/2017 PEIR Response	It was stated that cable protection will likely to left in situ following decommissioning. This would therefore have a permanent effect in the form of habitat loss and change in habitat, therefore affecting the form and function of the SAC. This should be acknowledged.	This is recognised within the chapter in sections 10.7.5.1 and 10.7.5.2 and within the Information to Support HRA Report, where the impacts of "permanent Habitat loss" on the conservation objectives is assessed.

Consultee	Date /Document	Comment	Response / where addressed in the PEI
Natural England	11/12/2017 PEIR Response	Clarification is required regarding the quantity/frequency of the reburial of the 10km of cable within the SAC and whether the two occurrences of cable repair are the WCS. Consideration is needed for the repeated nature of the impacts impeding recovery of the site.	Clarity on the predicated quantity/frequency of the cable reburial within the SAC is provided in Section 7.3.2.3.1
Natural England	11/12/2017 PEIR Response	Full details should be provided on the disposal of dredged material. In particular, further justification and information is required regarding the proposed sand wave clearance and the potential impacts within the SAC. There is currently insufficient information on the impacts on and recovery of sand waves to support implementation within designated sites. A requirement for a sand wave levelling plan should be included in the Deemed Marine License.	In support of the Information to Support HRA Report (document reference 5.3) further work has been undertaken assess the impacts and recovery of sand waves within the SAC (Appendix 7.1 of the Information to Support HRA report (document reference 5.3))
Natural England	11/12/2017 PEIR Response	We advise that Conservation Objectives should be considered when determining the level of impact of designated features and advise that evidence is provided to support the predicted 'rapid recover'. It is our view that the removal/relocation of material at such a large scale may have an impact on the Annex I sandbank, the HHW SAC, sediment budget and dynamics.	The conservation objectives are considered within the Section 7 of the Information to Support HRA Report (document reference 5.3)
Natural England	11/12/2017 PEIR Response	Natural England advises that it would be helpful if the Rochdale Envelope can be refined further to inform a realistic WCS, particularly within the SAC in order to provide a more accurate assessment.	A detailed realistic WCS is provided in Section 7.3.2 of the Information to Support HRA Report (document reference 5.3)
Natural England	11/12/2017 PEIR Response	The three phase construction is of concern given that the installation of the export cable is then spread over nearly double the duration three years from July 2024 – Jan 2027 during 15 months (as opposed to the Single Phase (14 months July 2024 – Jan 2026) and two phase construction (16 months from July 2024 – Dec 2025). We would expect further details to be provided in order to determine the impacts to designated features i.e. would the SAC portion of cable be completed in one phase therefore minimising disturbance.	The Norfolk Vanguard project would be constructed in a maximum of two phases (Section 10.7.3.3)
Natural England	11/12/2017 PEIR Response	Consideration should be given to prey resource for red throated diver in the Greater Wash SPA.	Consideration of this is provided in section 10.6.6.

Consultee	Date /Document	Comment	Response / where addressed in the PEI
			The Information to Support HRA Report considers impacts to red-throated diver including consideration of impacts to their prey species.
Natural England	11/12/2017 PEIR Response	It should be noted that Haisborough, Hammond and Winterton SCI was awarded full designation status in Nov 2017 and is now an SAC, this should be updated throughout.	This has been updated throughout the chapter.
Natural England	11/12/2017 PEIR Response	While we agree that understanding value is important, we do not agree that economic value should be included in assessment of nature conservation interest. It would seem more appropriate to include it within the socio-economic chapter.	Economic value has now been removed from the methodology Section 10.4.1.2
Natural England	11/12/2017 PEIR Response	NE query whether the definitions for medium and low value are always appropriate. Nationally rare species and habitats designated within a protected site warrant more than a 'low' value.	Value definitions have been amended in Table 10.4.
Natural England	11/12/2017 PEIR Response	It is noted that one area of medium *Sabellaria spinulosa* reef was found in the offshore cable corridor and one station in NV East array area was classified as low/medium reef. We advise the applicant that we would expect low, medium and high reef to be treated as Annex I reef in impact assessment.	Within this chapter and the Information to Support HRA Report all identified reef is treated as potential Annex 1 reef.
Natural England	11/12/2017 PEIR Response	We agree with the need for a pre-construction survey to be undertaken not more than a year before start of construction to allow accurate micro siting of works away from areas of *Sabellaria* reef.	Noted
Natural England	11/12/2017 PEIR Response	It is acknowledged that there is ongoing analysis of NV geophysical data by Envision Mapping Ltd to determine the further presence of *Sabellaria spinulosa* reef. We welcome this further analysis given the high presence/potential of/for *Sabellaria* within the project boundaries.	This study was presented to Natural England at a meeting on the 31st January 2018 and has been revised to take account of further advice provided by Natural England. The results are presented in Figure 10.12 and Appendix 7.2 of the Information to Support HRA Report (document reference 5.3).

Consultee	Date /Document	Comment	Response / where addressed in the PEI
Natural England	11/12/2017 PEIR Response	Paragraph 87 of the PEIR should be changed to reflect the presence of *Sabellaria* reef in the cable corridor.	This has been amended within this document
Natural England	11/12/2017 PEIR Response	We note that definitions of major and minor include reference to impact on the decision making process, moderate does not. We suggest that these definitions are standardised to all include understanding of impact of regulatory processes.	The moderate definition has been updated (Section 10.4.1.4)
Natural England	11/12/2017 PEIR Response	The embedded mitigation is welcomed by Natural England including the commitment to pre- construction surveys to inform the requirement for micro siting around Annex I habitat; commitment to bury cables to minimise the need to use cable protection and the disposal material remaining within the Haisborough, Hammond and Winterton SAC in order to replenish the sandbank features.	These mitigation measures are discussed in Section 10.7.1 and outlined in the Schedule of Mitigation (document reference 6.5).
Natural England	11/12/2017 PEIR Response	We have concerns regarding the potential use of rock protection used within the SAC and in particular note the exception of cables buried at cable crossing locations. This remains a major concern for Natural England due to the introduction of hard substrata into a predominantly soft sediment environment designated for its Annex I Habitat in the forms of sandbank and reef habitat.	The impacts of cable protection on the conservation objectives of the SAC are included within the Information to Support HRA report (document reference 5.3).
Natural England	11/12/2017 PEIR Response	We question whether paragraph 102 of the PEIR is suggesting that material will be actually removed from the site during operations, or whether it is simply suggesting that material will be displaced during trenching / jetting operations.	Text has been amended to make clear that no sediment would be removed from the SAC. Appendix 7.1 of the Information to Support HRA report (document reference 5.3) demonstrates that sediment deposited back in the Haisborough Hammond and Winterton SAC would be incorporated back into the system
Natural England	11/12/2017 PEIR Response	The WCS for cable protection allows for 4km of rock protection within the Haisborough, Hammond and Winterton SAC should cable burial not be possible. It is unclear whether any other options have	One of the design principles when siting the offshore cable corridor was to avoid existing infrastructure to minimise the amount of

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		been considered, i.e. different techniques for reburial, can the cable corridor be altered in order to allow the cable crossings to be made out with the SAC. From chapter 4 of the PEIR (Site selection and assessment of alternatives) it is clear that the determining factor of site selection has been the landfall, however additional information on the alternatives would be helpful including the following: location and feasibility of cable corridor in relation to geological features and seabed; location of cable crossings; and location of sensitive habitats. To provide these details where possible on one habitat map would help to inform the assessment.	cable protection required (see Chapter 4 site selection). The commitment to an HVDC transmission solution has reduced the WCS for cable protection within the SAC.
Natural England	11/12/2017 PEIR Response	We suggest that paragraph 142 in the PEIR is reworded. Impact compared to available habitat in the southern North Sea is not a comparison that proves useful.	This has been amended within this chapter.
Natural England	11/12/2017 PEIR Response	We are unsure as to why NBN, MarLIN, UKSeaMap and EMODnet have been given low confidence, given their well- audited quality assurance procedures.	The confidence levels in these data sources has been reassessed (section 10.5.2).
Natural England	11/12/2017 PEIR Response	Other than the ABPmer (2012) modelling for East Anglia ONE regarding sediment plumes of 15 foundation installations, has any modelling of sediment plumes and disposal mounds been undertaken? It is acknowledged that effects are expected to be similar to that for the EA ONE modelling, but further detail is required in relation to impacts from smothering and sediment dispersion from installation techniques including the following: changes in sediment composition, and on current installation and cumulative impacts from suspended sediment. Figures demonstrating the range of impact and/ or a table displaying the changes in sediment composition would be helpful. This is particularly important in the Haisborough, Hammond and Winterton SAC.	As agreed through the EPP no site specific sediment plume modelling has been undertaken. A conceptual approach has been taken to predicting the likely deposition of material as a result of sediment plumes (Chapter 8 Marine Geology, Oceanography and Physical Processes)
Natural England	11/12/2017 PEIR Response	We note a maximum potential export cable length within HHW SAC of approximately 40km per cable (240km based on six HVAC cables) with a maximum potential disturbance width of 30m along all 240km of export cables. This leads to a maximum	Both Norfolk Vanguard and Norfolk Boreas have taken the decision to use HVDC technology. This has reduced the magnitude of impact by approximately

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		area of disturbance of 7.2km^2. We also note that a similar level of impact will occur in the same area with later Norfolk Boreas operations, and this should be included in in-combination analysis to allow a full worst case scenario to be assessed. Further impact to the site is also likely to occur from maintenance activities on the cable route during operation.	two thirds. Furthermore, both projects will now be constructed in a maximum of 2 phases each thereby reducing the duration of impacts. This is shown in section 10.8.1
Natural England	11/12/2017 PEIR Response	We advise that the operational impact of long term loss of seabed habitat in the OWF cable corridor should be classed as long term temporary loss of habitat with the commitment to remove cable protection at the time of decommissioning. However, it is acknowledged that removal at the time of decommissioning might not be anticipated in which case the impact should be considered long term permanent.	Operation impacts 1a and 1b have now been classified as permanent as it is recognised that it may not be possible to remove all cable protection during decommissioning and are defined in Table 10.12 Worst Case Scenarios
Natural England	11/12/2017 PEIR Response	We expect Vattenfall to consider the overall impact on the designated features of the site in deciding which methods to use to lay and stabilise cables, and encourage the operator to minimise the amount of hard substrate material used within the SAC. We note that the long-term effect of the introduction of hard substratum into naturally sandy or muddy sea beds is not fully understood at present, and should therefore be carefully considered by the regulators.	Norfolk Vanguard Limited has taken this into consideration and has taken the decision to use HVDC transmission technology for both Norfolk Vanguard and Norfolk Boreas. This has reduced the project WCS number of export cable trenches from 6 to 2 and the cumulative WCS from 12 to 4 cables, thereby reducing the possible introduced hard substrate by approximately two thirds.
Natural England	11/12/2017 PEIR Response	We would expect further detailed commentary on stabilisation operations to allow further understanding of their actual nature conservation impact. This would include: • Location of deposit sites in HHW SAC • Size / grade of rock to be used in HHW SAC • Tonnage / volume to be used in HHW SAC • Contingency tonnage / volume to be used in HHW SAC • Method of delivery to the seabed in HHW SAC	Further detail is provided within section 7.3.2 of the Information to Support HRA Report (document reference 5.3); the Site Characterisation Report (document reference 8.15) and the Scour Protection and Cable Management Plan (document reference 8.16).

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		• Footprint and structure of any other protection structure, e.g. mattresses / frond mattresses in HHW SAC. We also expect some commentary on how precautionary the estimate of 4km of cable protection in HHW is.	
Natural England	11/12/2017 PEIR Response	It is stated under the NV West WCS that there will be no cable protection used within the Haisborough Hammond and Winterton SAC. However, throughout the PEIR project description chapter it is stated that 4km of rock protection has been included within the Rochdale envelope for use within the SAC should cable burial fail. Clarification needs to be provided.	The WCS Scenario (section 10.7.2 has been updated to make clear exactly what the WCS is within the SAC.
Natural England	11/12/2017 PEIR Response	We suggest that sensitivity analyses are reconsidered using the most up-to-date scientific evidence. This includes reports found in the following two links (e.g. Tillin and Tyler-Walters, 2014 a, b): - http://jncc.defra.gov.uk/page-6929 - http://jncc.defra.gov.uk/page-6790	These reports have been used where possible however they assess the sensitivity of level 5 biotopes based on the species that define that level 5 classifications. Biotopes within the Norfolk Vanguard offshore project area have been defined to level 3 across the majority of the site as is appropriate for a characterisation survey and proportionate to the level of impacts likely to occur. Where level 5 biotopes have been identified these reports have been used to help determine sensitivity.
Natural England	11/12/2017 PEIR Response	We have concerns about impacts to potential areas of *Sabellaria spinulosa* reef. One area of *Sabellaria spinulosa* reef (of medium reefiness) and other small aggregations of the species (not reef) were found to occur within the SAC within the boundaries of the cable corridor. We note that it is concluded as a minor adverse impact and highlight that the Conservation Objectives of the designated features should be considered when assessing the sensitivity and vulnerability and thus drawing conclusions on significance. The use of the EIA matrices is helpful, but	The Conservation Objectives of the designated features of the SAC are considered in terms of their sensitivity and vulnerability within the Information to Support HRA Report (document reference 5.3)

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		additional consideration is required to consider the sensitivity from a HRA perspective. We wish to highlight that as an Annex I habitat of a designated site, all impacts should be avoided where possible and therefore we would advise micro-routing the cable around confirmed areas of reef.	
Natural England	11/12/2017 PEIR Response	We do not believe that using percentage of site impacted is a meaningful way to assess level of impact to the SAC. Please see Chapman and Tyldesley (2015) for further discussion of this. As such we do not necessarily agree with the applicant's conclusion of low magnitude. Comparing the impact to that of another industry does not provide a meaningful assessment of impact and we advise that further consideration of impact and recoverability is included once the applicant adjusts their magnitude scales.	The advice provided here is considered within the Information to Support HRA Report (document reference 5.3).
Natural England	11/12/2017 PEIR Response	Paragraph 153 of the PEIR suggests that there is only a small area of Annex I sandbanks at the edge of the offshore cable route. We disagree with this conclusion as, from images provided, the cable route crosses at least two major sandbanks within HHW. We agree that the sandbanks are mobile, but we also disagree with the applicant's consideration that that seems to remove Annex I sandbanks from the need for impact assessment, only including the benthic communities of the Annex I sandbank habitat. We expect full consideration of impact to Annex I sandbanks within future documentation. We further disagree that having a feature with low diversity correlates with a conclusion of low sensitivity.	Impacts to Annex 1 sandbanks within the SAC are assessed against the conservation objectives in the Information to Support HRA Report (document reference 5.3). This includes an assessment of the potential impacts to the benthic communities associated with the sand banks (Section 7.4.1.1.1 of the Information to Support HRA Report). The relevant paragraph within this chapter has been updated to reflect the advice provided.
Natural England	11/12/2017 PEIR Response	It is noted that cable protection within the Haisborough, Hammond and Winterton SAC will be minimised. We advise that the use of cable protection is avoided and where it isn't possible the impacts to *Sabellaria spinulosa* should be minimised and the cable protection removed at the time of decommissioning. We are currently uncertain as to the protected status of *Sabellaria* reef on artificial substrates / infrastructure, and thus are uncertain of the potential impact associated with	The advice provided here is considered within the Information to Support HRA Report (document referenece 5.3).

Consultee	Date /Document	Comment	Response / where addressed in the PEI
		micro siting as described in paragraph 225 of the PEIR.	
Natural England	11/12/2017 PEIR Response	Assessment of the operation and maintenance activities should also consider the impact from recurring temporary habitat loss and disturbance as a result of remedial cable works and repair as well as the use of jack up vessels. The repeated activities will hinder the further establishment or recovery of *Sabellaria spinulosa*. We advise that a survey prior to any works in areas of suitable *Sabellaria spinulosa* habitat both within and out with the SAC should be undertaken to help inform the works and ensure any necessary mitigation is implemented where possible.	The potential impacts of maintenance activities on the recovery of *Sabellaria* reef within the SAC is considered in Section 7.4.1.1.2 of the Information to Support HRA Report (document reference 5.3) and outside of the SAC in section 10.7.5 of this chapter.
Natural England	11/12/2017 PEIR Response	It is reported that the cable corridor footprint overlaps with the Cromer Shoal Chalk Beds MCZ – however according to chapter 5 and chapter 10 of the PEIR the latest site selection avoided overlap with the MCZ. It is advised that clarification be provided.	The offshore cable corridor is approximately 60m to the south of the MCZ (Figure 10.13)
Natural England	11/12/2017 PEIR Response	We query whether the inclusion of Annex B (correspondence between ourselves and Vattenfall regarding the review of geophysical and grab sampling impact assessment) is necessary and request that it is removed from the application.	This correspondence has been removed from the DCO application.
Natural England	11/12/2017 PEIR Response	In addition to provision of a pre-construction installation method final report, there would need to be a survey, mitigation plan and reinstatement plan associated with this.	An In Principle Monitoring Plan (document reference 8.12) is submitted with the DCO application. The details of monitoring would be determined based on the final design of the project in consultation with relevant Regulators and stakeholders.
Natural England	11/12/2017 PEIR Response	With regard to HRA Screening; overall NE agrees with the sites that have been screened in. However, we can't provide any further advice until the impacts have been assessed. The assessment of the impacts need to be undertaken in the specific thematic chapters and then pulled together in the RIAA for additive impacts to each interest feature from the project as a whole.	A draft HRA report was provided to Natural England in March 2018. The final Information to Support HRA Report is submitted as part of this DCO application.

Consultee	Date /Document	Comment	Response / where addressed in the PEI
Natural England	11/12/2017 PEIR Response	Should be referred to as "to seek advice from the relevant SNCB ~~Natural England~~". This applies throughout all documents.	This has been amended throughout this chapter
Natural England	11/12/2017 PEIR Response	Natural England advises that the conservation advice packages for the sites should be taken into consideration at the screening stage to ensure that no impact pathways have been missed.	The conservation objectives of relevant sites are taken into consideration in the Information to Support HRA Report (document reference 5.3)
Natural England	11/12/2017 PEIR Response	English Nature and subsequently Natural England's advice is that foreseeable plans or projects for which there is relevant information in the public domain in order to undertake an impact assessment should also be included in the in-combination assessment.	Consultation, undertaken through the EPP has been used to identify all foreseeable projects which may interact with Norfolk Vanguard (Section 10.8 within this chapter and section 7.4.1.2 in the Information to Support HRA report, document reference 5.3)
Natural England	11/12/2017 PEIR Response	Natural England challenges the assumption that the impacts will be small scale to designated features as there is no evidence to support such an assumption. In addition it is worth highlighting that in the past case law has challenged the consideration of extent only.	The advice provided here is considered within the Information to Support HRA Report (document reference 5.3).
The Wildlife Trusts	08/12/2017 PEIR Response	TWT has concerns regarding the cumulative impacts of repeated cable installation and suggest further work is required on the cumulative impacts of Norfolk Vanguard and Norfolk Boreas. There is an opportunity to reduce cumulative impacts by considering embedded mitigation such as planning the cabling infrastructure in advance for both projects.	Following the commitment of both projects to HVDC transmission technology the cumulative impacts have been greatly reduced. Further work has been undertaken to understand the cumulative impacts especially within the SAC Appendix 7.1 and Appendix 7.2 of Information to inform HRA (document reference 5.3).
The Wildlife Trusts	08/12/2017 PEIR Response	We do not agree with some of the assessment conclusions for Haisborough, Hammond and Winterton SAC. However, we appreciate that a Habitats Regulations Assessment (HRA) will be undertaken against the conservation objectives for this site using the conservation advice.	The advice provided here is considered within the Information to Support HRA Report (document reference 5.3).

Consultee	Date /Document	Comment	Response / where addressed in the PEI
The Wildlife Trusts	08/12/2017 PEIR Response	TWT disputes paragraph 152 of the PEIR *"The seabed is likely to rapidly recover from the temporary disturbance with the impacts likely to be akin to those which are perpetrated by bottom towed fishing gear which is known to operate within the area".*	Acknowledged
The Wildlife Trusts	08/12/2017 PEIR Response	TWT disputes Paragraph 156 of the PEIR *"Given that the benthic communities within the export cable corridor are habituated to regular disturbance from bottom trawled fishing gear, the sensitivity of benthic communities to the increased temporal nature of the impact would not differ from those assessed in Section 10.7.3.2 above".*	Acknowledged
The Wildlife Trusts	08/12/2017 PEIR Response	The conservation advice for Haisborough, Hammond and Winterton SAC states "fisheries using bottom towed gear are active in the site. This may impact biological communities through habitat modification and/or catching of both target and non-target species", highlighting that the SAC may be already disturbed from fishing activity rather than habituated to this activity. For information, Eastern IFCA is currently reviewing the management of fisheries within the SAC. Further consideration of the recovery from temporary disturbance should be undertaken as part of the HRA assessment.	This has been further discussed through the Norfolk Vanguard EPP and is considered within the Information to Support HRA Report (Document reference 5.3)
The Wildlife Trusts	08/12/2017 PEIR Response	Please could Vattenfall confirm if modelling has been undertaken to confirm the prediction made in paragraph 164 of the PEIR on the impacts of distance and thickness of deposit from the sediment plume?	No site specific modelling has been undertaken. As agreed through the EPP modelling undertaken for East Anglia ONE has been used to develop a conceptual understanding of the potential sediment plumes.
Eastern IFCA	11/12/2017 PEIR Response	The Eastern IFCA would encourage further assessment on an ongoing basis of the cumulative impacts of all Southern North Sea wind farm activity, as well as other activities including aggregate extraction activities. The impacts of these projects on the marine environment and fisheries should be assessed in-combination, highlighting any potential cumulative effects associated with the licence application.	This is understood; however, this is not within the remit of a single project and would need to be undertaken at a strategic level and under the guidance of Regulators.

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Eastern IFCA	11/12/2017 PEIR Response	Every effort should be made to maximise the length of cables that are buried and maintain burial over time. Using cable armouring instead of cable burial increases the likelihood of adverse environmental and fishery impacts.	Norfolk Vanguard Limited will seek to bury cables wherever possible.
MMO	11/12/2017 PEIR Response	Further consideration needs to be given as to how the impact of such a long construction window is to be assessed as this increases the impact. The MMO considers that an impact lasting 3 years is not equivalent to an impact last 7-10 years. Also consideration needs to be given as to how the DCO is to be structured to ensure interim monitoring between stages is conducted which takes into consideration any changes either in designation, conservation statuses, fishing practices, navigational issues or benthic habitat changes. For instance Saballeria reef is ephemeral and can establish in 12 months, therefore intermittent surveys will need to be undertaken between phases to assess the impacts of the next construction phase and monitoring will need to be agreed to monitor impacts on wildlife. This factors will need to be captured in the DCO and Deemed Marine Licence.	The indicative construction window is now expected to be 4 years. Therefore, the difference between the maximum duration of impact between single phased and two phase has been reduced. Potential monitoring is outlined in the In Principle Monitoring Plan (document reference 8.12) submitted with the DCO application. Post-construction monitoring is secured by the DCO Schedule 9 and 10 Part 4Condition [20(1)] and Schedule 11 and 12 Part 4 Condition [15(1)].
MMO	11/12/2017 PEIR Response	There is scarce information regarding assessed impacts regarding activities relating to the windfarm that is not construction and to a lesser extent operation. Related activities such as UXO clearance and boulder clearance and cable repair will inevitably be part of the impact of the whole project and should be given further consideration	Impacts of underwater noise are assessed Section 10.7.4.8. This includes consideration of UXO.
MMO	11/12/2017 PEIR Response	The MMO require a more detailed assessment of the potential impacts of the Project as required under the Conservation of Habitats and Species Regulations (2017) taking into account the conservation status and conservation objects of the site. The assessment must consider the proposed activities and either conclude with absolute certainty that there will be no Likely Significant Effects or assess the impacts through an Appropriate Assessment.	The Information to Support HRA Report, a draft of which has been reviewed by Natural England, is provided with the DCO application (document reference 5.3)

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MMO	11/12/2017 PEIR Response	The MMO welcomes that the cable corridor has been rerouted to avoid the Cromer MCZ, however special consideration need to be given to the fact that the route still crosses the SCI and therefore poses a risk to the conservation objectives of the site. Since decommissioning may leave structures on the seabed, habitat loss should be considered as permanent.	The Information to Support HRA Report, a draft of which has been reviewed by Natural England is provided with the DCO application. (document reference 5.3)
MMO	11/12/2017 PEIR Response	Vattenfall has correctly identified species/features of concern. Annex I sandbanks and *Sabellaria spinulosa* Reefs were identified. *Mytilus edulis* was also observed but not in great numbers. The MMO notes no other species or habitats of concern were observed.	Impacts upon these features are assessed throughout this chapter and in the Information to Support HRA Report (Document reference 5.3)
MMO	11/12/2017 PEIR Response	The analysis undertaken to determine benthic community groups was based on a similarity level of ~20% (information from Appendix 10.2). The PEIR concluded from this analysis that there has been little change in benthic communities in the past 7 years. Whilst 20% similarity is often used to characterise benthic communities across a large area, it is an extremely low similarity level to establish whether benthic communities are comparable between the surveys within a smaller area. The MMO recommend that further investigation of how similar the communities really are within each site by removing all data not relevant to Vanguard East and Vanguard West and reanalysing the data from each site. This will increase the confidence in data comparability.	Further analysis is provided in Appendix 10.2
MMO	11/12/2017 PEIR Response	Results presented in Chapter 10: 10.6.2.2 of the PEIR is brief for the cable corridor communities. The presented results describing the faunal communities in this area should be expanded upon, as has been done for NV East and West.	A greater level of detail was provided for NV East and NV West as the data within the OWF come from a greater variety of sources. However further detail on the benthic communities found within the offshore cable corridor have been provided in Appendix 10.2 and further referencing has been added to the impact assessment.
MMO	11/12/2017 PEIR Response	The information presented for the epi-fauna from trawls highlights that, although there are no trawls from the cable corridor, grab survey results indicate the area of the offshore cable corridor that overlaps with the former Zone is broadly comparable within the benthic ecology in NV West. Whilst this may be true, additional habitats are	

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		present along the cable corridor (based on the grab results) that was not present in the former Zone. Further describing the grab results along the cable corridor and combining the information with results from the video survey will enable a more thorough characterisation of the cable corridor fauna.	
MMO	11/12/2017 PEIR Response	It would be beneficial to provide either cross referencing to the various appendices for the results or, better still, provide more detailed information within the PEIR to reduce the amount of cross referencing needed.	
MMO	11/12/2017 PEIR Response	With reference to P19-22, Plates 10.1 – 10.5 of the PEIR. Please ensure that legends are comparable between figures depicting number of individuals and number of species of the former Zone (plates 10.1 and 10.2), at each site NV East and NV West, and for the cable corridor. For example, *Platyhelminthes* and *Asteroidea* are depicted as separate groups in the legend for 'NV West: number of species' but are not shown in the legend for 'NV West: number of individuals'.	Plates 10.1 to 10.5 (now in Appendix 10.2 summarise the most dominant taxonomic groups by species and by individuals. It is not possible to show all taxonomic groups in all of the plates in a manner that could be easily interpreted and therefore a sensible cut off point was established in the data behind each plate.
MMO	11/12/2017 PEIR Response	P38 of the PEIR states that during operation of the windfarm there will be long term loss of seabed habitat. This should be changed to 'permanent loss' as there is no intention to fully remove all elements introduced onto the seabed at the decommissioning stage (according to P42 of the PEIR).	Operation impacts 1a and 1b have now been classified as permanent as it is recognised that it may not be possible to remove all cable protection during decommissioning and are defined in Table 10.12 Worst Case Scenarios.
MMO	11/12/2017 PEIR Response	The Chapter, 'Impacts to the benthic ecology' has considered all benthic communities together, including potential *S.spinulosa* reef. Different habitats will have different sensitivities to the impacts associated with construction and operation of the windfarm and should be assessed as such, not be combined into one overall assessment.	The assessment takes into account the most sensitive communities and species identified and therefore a conservative conclusion is made.
MMO	11/12/2017 PEIR Response	Paragraph 125 of the PEIR: *Nephtys hombergii* prefers different habitat conditions to *Nephtys cirrosa* therefore it may not be appropriate to use this species sensitivity as a proxy. *N. cirrosa*	The assessment has been updated to reflect the level of caution that should be applied when using this

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		is characteristic of mobile sandy sediments (and therefore tolerant of dynamic conditions) however; the species could be impacted if sediments are altered.	proxy, however in the absence of species specific data the use of proxy species is the best approach available.
MMO	11/12/2017 PEIR Response	Given that the sensitivities of many of the characteristic species are not known, the applicant should detail how the confidence rating (high = robust evidence – low = extrapolation and use of proxies) has been used to provide the overall significance assessment for each habitat.	The impact assessment has a confidence rating in the conclusion of each impact.
MMO	11/12/2017 PEIR Response	An assessment of the sensitivity of the Annex I sandbanks must consider infauna, epi-fauna and fish communities together. Although infaunal diversity may be low, the sandbanks may be important habitat (nursery/feeding) for epi-fauna and fish species (e.g. Sand eel (*Ammodytes spp*), Lesser weever (*Echichthys vipera*) etc). An overall assessment of significance, considering all these trophic groups, should be undertaken for protected habitats within the SAC.	An assessment of the sensitivity of Annex I sandbanks with the HHW SAC is undertaken within the Information to Support HRA Report (Document reference 5.3). This includes consideration of the benthic communities which exist on and between the sandbanks. The assessment of impacts on fish is assessed in Chapter 11 Fish and Shellfish Ecology.
MMO	11/12/2017 PEIR Response	As well as embedded mitigation to avoid the Cromer shoal chalk reef, the possibility of micro-siting following pre-construction survey should be incorporated to avoid areas of Annex I reef.	Norfolk Vanguard Limited has committed to micro-siting where possible to avoid sensitive features. This has been made more achievable given Norfolk Vanguard Limited's decision to use to HVDC technology which reduces the number of export cables from 6 to 2.
MMO	11/12/2017 PEIR Response	The MMO would welcome a commitment to ensure that the burial of offshore export cables reduces the effects of EMF and the need for surface cable protection.	Norfolk Vanguard Limited has made the decision to bury cables wherever possible.
MMO	11/12/2017 PEIR Response	Where sandbanks are a feature, material removed to allow for cable burial should be used to replenish the sandbank.	Norfolk Vanguard Limited has committed to ensuring that all sediment removed from sandbanks will remain within the SAC, thereby replenishing the sand banks

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			(further information is provided in Appendix 7.1 of the Information to Support HRA report (document reference 5.3)
MMO	11/12/2017 PEIR Response	Commitment to adhere to the use of best practice techniques to minimise the risk of spreading non-native invasive species is requested.	Outlined in Section 10.7.1.10. These commitments would be secured in the Project Environmental Management Plan in accordance with the Outline Project Environmental Management Plan (document 8.14) provided with the DCO application.
MMO	11/12/2017 PEIR Response	Commitment to further monitor habitats of principle importance (UK BAP habitats) and Annex I reef identified in the pre-construction survey, to ensure that any impacts due to placement of the turbines do not exceed those predicted in the Environmental Statement, is required.	An Offshore In Principle Monitoring Plan forms part of the DCO application (Document 8.12). This document identifies relevant offshore monitoring as required by the deemed marine licence conditions, establishes the objectives of such monitoring and sets out the guiding principles for delivering any monitoring measures as required.
MMO	11/12/2017 PEIR Response	Commitment to monitoring the effects of cable protection on sandbank and reef communities as any barrier to sediment movement could be detrimental to maintaining these features, is required.	
Natural England	31/01/2018 EPP meeting + Written feedback 22/02/18	Further information required in relation to sand wave levelling in the SAC in relation to: • Confirm that the sediment would remain within the SAC • What difference it would make if the sediment is disposed of at the water surface or near the seabed • Consider the effects of phasing • Incorporate evidence from other projects where possible	These are addressed in Appendix 7.1 of the Information to Support HRA report (document reference 5.3)
Natural England	31/01/2018 EPP meeting + Written feedback 22/02/18	Additional survey data is available that should be incorporated into the Sabellaria reef mapping	This data was provided by Natural England and is presented in Appendix 7.2 of the Information to Support HRA report (document reference 5.3).

10.4 Assessment Methodology

10.4.1 Impact Assessment Methodology

15. A matrix approach has been used to assess impacts following best practice, EIA guidance and the approach outlined in the Norfolk Vanguard Scoping Report (Royal HaskoningDHV, 2016).

16. 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 judgment 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.

17. The general approach to the assessment of the significance of each impact is detailed in Chapter 6 EIA Methodology and an explanation of how this is applied to benthic and intertidal ecology within the Norfolk Vanguard project assessment is described below.

10.4.1.1 Sensitivity

18. The sensitivity of biotopes has been reviewed based on expert judgement and informed by available 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; in particular the nature of the impact described by MarLIN has been compared with the nature of the impact for Norfolk Vanguard to determine whether the information is applicable. Where information is unavailable for the key species present at Norfolk Vanguard, consideration has been given to potential proxies that are closely related and have similar habitat preferences.

19. 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.

10.4.1.2 Value

20. 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 has been 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

21. The magnitude of effect has been considered in terms of the spatial extent, duration and timing (seasonality and / or frequency of occurrence) of the effect in question. Expert judgment 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

22. 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.

23. 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 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 as they could contribute to achieving regional or local objectives.
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.

24. For the purposes of this ES and specifically the benthic and intertidal ecology assessment, it is suggested that 'major' and 'moderate' impacts are deemed to be significant. However, whilst 'minor' impacts would not be deemed significant in their own right, they may contribute to significant impacts cumulatively (Section 10.8) or through inter-relationships (Section 10.9).

25. 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

26. The potential for projects to act cumulatively on benthic ecology is considered in the context of the likely spatial and temporal extent of impacts as well as the combined impact on a sensitive or important habitat or species in the wider region.

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

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

29. Each potential impact described for the construction and operation and maintenance (O&M) phases of Norfolk Vanguard is considered in the CIA (Section 10.8).

10.4.3 Transboundary Impact Assessment

30. 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, 2016) and Scoping Opinion (the Planning Inspectorate, 2016), transboundary impacts have been screened out of the EIA for this topic.

10.5 Scope

10.5.1 Study Area

31. The Norfolk Vanguard offshore project area (Norfolk Vanguard East (NV East), Norfolk Vanguard West (NV West) and the offshore cable corridor; see Chapter 5, Figure 5.1)) are located in the southern North Sea, encompassing a total seabed area of approximately 829km^2.

32. Norfolk Vanguard comprises two distinct areas, NV West and NV East ("the Offshore Wind Farm (OWF) sites"), which at their nearest points are located approximately, 47km and 70km from the coast of Norfolk, respectively. An offshore cable corridor joins the OWF sites to the landfall at Happisburgh South. The offshore infrastructure required for Norfolk Vanguard is outlined in Chapter 5 Project Description.

33. It should be noted that the survey areas shown in Appendix 10.1 were based on the project area during earlier stages of the project development. The offshore cable corridor has since been refined and the assessment provided in this chapter is based on the Norfolk Vanguard offshore project area and the landfall area shown in Chapter 5 Figures 5.1 to 5.3.

34. 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 Vanguard 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

35. 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); and

- Site specific surveys of the Norfolk Vanguard offshore project area.

36. Benthic sampling of the former East Anglia Zone was conducted from September 2010 to January 2011 and included the Norfolk Vanguard OWF sites and part of the offshore cable corridor. Further surveys were undertaken in the NV East site in 2013 when that area was part of the East Anglia FOUR site. These surveys included a combination of benthic grabs, trawls and seabed imagery. In total across the three surveys 30 grab samples were collected from NV West and 42 from NV East, as well as five epibenthic trawls in both NV East and NV West. In addition to this, a survey was undertaken of NV East, NV West and the offshore cable corridor in 2016 which comprised 68 drop-down video stations and 65 grab sample stations as well as sediment and contaminant sampling. No epibenthic trawls were undertaken as part of this survey. The methodology for the Norfolk Vanguard survey was agreed with Natural England and the MMO. In addition to the benthic survey (Appendix 10.1), geophysical surveys also informed baseline habitat mapping. The surveys undertaken are summarised in Table 10.8 and sample locations are shown in Figure 10.1.

Table 10.8 Available relevant benthic datasets

Data	Year	Coverage	Confidence
Benthic survey (grabs, trawls and video) by Marine Ecological Surveys Ltd reported in the ZEA (EAOW, 2012a)	2010 - 2011	East Anglia Zone	Site specific surveys provide high confidence; however, data is seven years old so medium
Geophysical survey by Gardline Geophysical Ltd reported in the ZEA (EAOW, 2012a)	2010	East Anglia Zone	Site specific surveys provide high confidence; however, data is seven years old so medium
Benthic survey (grabs, trawls and video) by Fugro EMU Ltd reported in Appendix 10.4 of the East Anglia THREE ES (EATL, 2015)	2013	East Anglia THREE and East Anglia FOUR and associated cable route options	Not site specific and now four years old so medium confidence
Geophysical survey by Fugro EMU Ltd	2016	Norfolk Vanguard offshore project area	Site specific and recent so high confidence
Benthic survey (grabs and video) by Fugro EMU Ltd (Appendix 10.1)	2016	Norfolk Vanguard offshore project area	Site specific and recent so high confidence
Intertidal survey by Royal HaskoningDHV	2017	Happisburgh South Landfall search zone	Site specific and recent so high confidence
Regional Environmental Characterisation (REC) studies (Limpenny *et al.* 2011)	2011	East Coast	Data is seven years old so medium confidence
National Biodiversity Network (NBN) gateway	Collation of various data sources	East Anglia coast	Well- audited quality assurance procedures however not all sources can be verified so medium confidence

Data	Year	Coverage	Confidence
Marine Life Information Network (MarLIN)	Collation of various data sources	UK species information	Well- audited quality assurance procedures so high confidence
UKSeamap 2010 Interactive Map	Collation of various data sources up to 2010	UK	Well- audited quality assurance procedures however not all sources can be verified so medium confidence
European Marine Observation and Data Network (EMODnet) Seabed Habitats	2004-2014	Europe	Well- audited quality assurance procedures however not all sources can be verified so medium confidence

37. In addition, a detailed export cable installation study (CWind, 2017, unpublished) was commissioned by Norfolk Vanguard Limited (summarised in Chapter 5 Project Description) to assess the Fugro (2016) survey data and confirm the potential for cable burial. This study informed the identification of the worst case scenarios (section 10.7.2) and embedded mitigation (section 10.7.1). This 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;
- 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; and
- Explanation of how offshore export cable route adjustments/micrositing can be undertaken due to contingency in the offshore cable corridor width, specifically for bedforms and biogenic reefs.

10.5.3 Assumptions and Limitations

38. Due to the large amount of data that has been collected during 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) there is a good understanding of the existing benthic and intertidal environment.

39. There are however some limitations to the benthic data which has been collected. Firstly, the original ZEA data were acquired nearly seven years ago. There is no

recommended duration of validity for benthic samples and the fact that new survey data collected in 2016 is comparable with that collected in 2011 (Appendix 10.2) indicates that there has been little change in the benthic communities in the past seven years. Therefore, it can be inferred that the ZEA data is still valid for this assessment.

40. Secondly as the different surveys were carried out by different survey contractors and analysed in different laboratories, consistency across all samples cannot be guaranteed. However statistical comparison of the ZEA and Norfolk Vanguard datasets (Appendix 10.2) shows the data are suitably consistent for the purposes of site characterisation.

41. As part of the benthic survey data analysis, Fugro EMU Ltd used signatures from the sidescan sonar data and the benthic grab data to create a biotope map (Figure 10.10). The biotope map can only be used to indicate the 'potential presence' of biotopes where grab and drop down video samples are not available.

10.6 Existing Environment

42. The environmental baseline, including descriptions of sediment type, infauna and epifauna, is presented for NV East and NV West 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

43. Seabed sediment distribution is described in full in Chapter 8 Marine Geology, Oceanography and Physical Processes and shown in Figure 10.2. In summary, in both NV East and NV West the dominant sediment type is medium-grained sand with some samples containing more mud or gravel. Sediment distribution in the offshore cable corridor is variable depending on location. The dominant sediment is sand with slightly gravelly rippled sand and rippled sand on the eastern end of the offshore cable corridor, moving to a mixture of slightly gravelly sand, gravelly sand and sand along the central region. Closer to shore the sediment is composed of coarser sediment.

44. During the ZEA surveys, a total of 564 benthic grab samples within the former Zone were analysed for sediment type. The western side of the NV West sites is generally comprised of relatively coarser sediments than the eastern side, which is comprised of sand with patches of fine sediment (EAOW, 2012a). The majority of NV East mainly comprises of sand dominated samples with some samples in the north east of the site containing relatively higher levels of gravel and mud (Figure 10.1). Detailed

analysis of the sediment showed both sites to be relatively homogeneous across the offshore project area.

45. British Geological Survey (BGS) data is largely comparable with the site specific survey data, showing the sediments in NV West to be predominately slightly gravelly sand with a small area of slightly gravelly mud in the south west of the site, and sediments in NV East to be predominantly slightly gravelly sand.

10.6.2 Infauna

46. In order to provide a comparison of the benthic ecology in the Norfolk Vanguard offshore project area with the wider area, data has been analysed in the context of the former East Anglia Zone as well as in the context of each of the sites (NV East and NV west) and the offshore cable corridor separately.

47. Abundance, as defined by the number of individual organisms per grab, was on average higher in the west of the former zone than in the east. NV East and NV West both support communities with relatively low abundance with the exception of the western edge of NV West (Figure 10.3). Abundance in the offshore cable corridor is typically greatest to the south of NV West and close to the shore.

48. The samples which contained the highest species diversity were located in the north west area of NV West, the offshore cable corridor to the south of NV West, and close to the coast (Figure 10.4).

49. The samples which contained the highest biomass were located in the offshore cable corridor to the south of NV West (Figure 10.5).

50. The infaunal analyses (which are provided in Appendix 10.2) have two components: firstly, a taxonomic comparison between the offshore project area and the former East Anglia Zone and secondly statistical analysis to identify the infaunal communities which exist within the offshore project area and former East Anglia Zone. The results are summarised below.

51. The infaunal communities within NV East and NV West are dominated by many of the same taxonomic groups as the former East Anglia Zone (see Plate 10.1 and Plate 10.3 of Appendix 10.2). Polychaete worms are the most numerous class in terms of individuals followed by Malacostraca (a class of Crustacea).

52. As agreed through the benthic ecology method statement and EPP meetings, infaunal benthic data sets from the ZEA survey, and the Norfolk Vanguard 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 Zone as well as the Norfolk Vanguard offshore cable corridor.

53. 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 Vanguard offshore project area are typical of those within the region or if there are any which are distinctly different or rare.

54. Eighteen distinct faunal groups across the former Zone and Norfolk Vanguard offshore cable corridor were identified and these are presented within section 10.3.2.4 of Appendix 10.2 and displayed in Figure 10.6.

55. Five groups were found within NV West (Figure 10.6) all of which were common across the former Zone. Six groups were found within NV East (Figure 10.6). Four groups were common across the former zone however three groups (d, h and m) were not. Group d was found at three locations (the other two locations were one in the cable corridor and one in the south of the former zone), h was collected during the ZEA surveys and is an outlier due to the fact that it was completely dominated by the polychaete *Capitella* (48 of the 54 individuals within the sample) and m was found at three locations (the other two locations were one in the cable corridor and one just to the south of cable corridor (Figure 10.6). Further information on the faunal groups is provided in Appendix 10.2.

56. The offshore cable corridor contains 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 different communities on the offshore cable corridor are explained further within Appendix 10.2 Section 10.3.2.4.3.

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

10.6.3 Epifauna

58. A total of 78 epibenthic (seabed surface) trawls were taken during the survey of the former East Anglia Zone, five trawl samples fall within NV East and five within NV West. The zonal surveys identified 95 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).

59. 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). Epibenthic abundance ranges from approximately 110 to 4666 within NV West and from 110 to 2740 within NV East (based on abundance categories in EAOW, 2012a).

60. As agreed through the EPP, no epibenthic trawls were undertaken as part of the Norfolk Vanguard 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 NV West.

61. Multivariate analysis of the ZEA epifaunal data which was completed for the East Anglia THREE ES (EATL, 2015) identified four faunal groups (Figure 10.9). The Norfolk Vanguard 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.

62. 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).

63. Analysis of the Norfolk Vanguard video footage showed the presence of two major habitats within the survey area, one featuring predominantly sandy sediments, characteristic of the offshore stations, and one comprising a mix of coarse sand and gravel, including pebbles and cobbles which was mainly located within the offshore cable corridor approaching the shore. The epibenthic communities were found to reflect the sediment complexity.

64. The offshore sandier sediments hosted lower faunal diversity represented mainly by fish, echinoderms, crustaceans and molluscs. As shown in Annex E.1 of Appendix 10.1 sessile epifauna were often either absent or scarce. Although this is likely to be a function of the sediment type it may also be a result of the high levels of bottom trawled fishing activity which occurs within the offshore part of the project area (Chapter 14 Commercial Fisheries). There is evidence that widespread, intensive bottom-fishing disturbance over a prolonged period, results in significant and far reaching changes in the structure of benthic assemblages and habitats in UK waters

(Queirós *et al.* 2006, Kaiser 1998, Kaiser *et al.,* 2000; Hinz *et al.*, 2009 and Hinz *et al.*, 2011).

65. The nearshore coarser sediments comprised more rich and diverse epibenthic communities, which included a variety of sessile epifauna. Characteristic epibenthic species included crustaceans, such as *Pagurus bernhardus*, *Necora puber* and species of *Liocarcinus,* together with echinoderms such as *Ophiura ophiura* and *Ophiura albida*, *Asterias rubens* and *Crossaster papposus*. Sessile colonial epifauna comprised bryozoans, notably, *Flustra foliacea* together with the sea anemone of the genus *Urticina* (Appendix 10.1).

10.6.4 Biotopes across the Offshore Project Area

66. As part of the benthic survey, Fugro EMU 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.

67. The biotope complex 'Circalittoral coarse sediment' (SS.SCS.CCS) was the most common in the survey area, particularly within NV West and NV East (Figure 10.10).

68. Within NV East, the biotope complex SS.SCS.CCS was assigned as characterising the site. Physical and biological data also identified biotope complex 'Circalittoral fine sand' (SS.SSa.CFiSa) at three stations; and 'Circalittoral fine/muddy sand' (SS.SSa.CFiSa / SS.SSa.CMuSa) at one station (Figure 10.10).

69. In NV West, the biotope SS.SCS.CCS was assigned to the majority of the site. In addition, areas of potential '*Sabellaria spinulosa* on stable circalittoral mixed sediment' (SS.SBR.PoR.SspiMx) were assigned along the western edge, with three sample stations being characterised as SS.SBR.PoR.SspiMx.

70. The offshore section of the offshore cable corridor is characterised as predominantly SS.SCS.CCS, with the middle section predominantly SS.SSa.CFiSa and 'Circalittoral mixed sediment' (SS.SMx.CMx) assigned to the section of the offshore cable corridor approaching the shore. 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

- '*Sabellaria spinulosa* on stable circalittoral mixed sediment' (SS.SBR.PoR.SspiMx).

10.6.5 Intertidal

71. 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.

72. Norfolk Vanguard 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

73. There are two habitat types listed in Annex I of the Habitats Directive that occur in the former East Anglia Zone and therefore have potential to occur within the Norfolk Vanguard offshore project area: sandbanks and biogenic reefs. Information to Support HRA is submitted as part of the DCO application (Document reference 5.3) which assesses the impact on Natura 2000 sites. HRA Screening is provided in Appendix 5.1 of the Information to Support HRA report (Document reference 5.3) which was discussed and agreed with stakeholders in July 2017.

74. The Haisborough, Hammond and Winterton SAC to the west of NV West is designated for Annex I sandbanks and *Sabellaria* reefs (JNCC, 2016a). The offshore cable corridor runs through this site. Impacts to the designated features of this site are assessed in Section 7.4 of the HRA within the context of the conservation objectives of the site.

75. 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 (Figure 5.2 within Appendix 10.1). These are predominantly in the middle section of the offshore cable corridor and are known as Hearty Knoll and Newarp Banks. They form part of the Annex I Sandbanks which occur within the Haisborough, Hammond and Winterton SAC.

76. Potential reef structures identified during the benthic surveys within the former East Anglia Zone were biogenic aggregations made by *S. spinulosa*. *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 Vanguard benthic survey were specifically targeted to areas deemed likely to support *S. spinulosa* based on the analysis of the previously collected survey data. As discussed in Section 10.6.4, *Sabellaria* biotopes were recorded in NV West and the offshore cable corridor. Areas identified during the Norfolk Vanguard and Zonal surveys correspond well with Regional Environmental Characterisation (REC) data (Limpenny *et al.* 2011) collected in 2011 (see Figure 10.12).

77. Drop down video images containing *S. spinulosa* were categorised using a scoring system for "reefiness" (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). During the Norfolk Vanguard site specific surveys 20 of the 68 drop down video samples showed *Sabellaria* aggregations, however the "reefiness" of the majority of these was assessed as "not reef" or "low reef". Only one station in the offshore cable corridor was classified as being "medium reef" and one station in NV East was classified as "low/medium reef" (Figure 10.12). Biotope classification by Fugro (2016) shown in Appendix 10.1 identified areas of potential *S. spinulosa* on stable circalittoral mixed sediment (SS.SBR.PoR.SspiMx) in the offshore cable corridor and in NV West (see Figure 10.10).

78. 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 *Sabellaria* reef within the Norfolk Vanguard offshore cable corridor and NV West. 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. Further information on the methodology used is provided in Appendix 7.2 of the Information to Support HRA Report (Document reference 5.3).

79. The mapping process focused on assessing the potential for reef in or near the SAC and showed that there was low confidence in potential *Sabellaria* reef to the east of the SAC (Figure 20 of Appendix 7.2 of the Information to Support HRA Report) and indeed samples taken from that area did not indicate that reef was present. The dog-leg section of the offshore cable corridor and the eastern approach to NV West

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).

80. The presence and extent of *Sabellaria* reef on the north western edge of NV West and section of offshore cable corridor west of the SAC is less certain with not all maps agreeing (Figures 21 and 22 of Appendix 7.2 of the Information to Support HRA Report). 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 Sabellaria biotope SS.SBR.PoR.SspiMx.

81. Horse mussel *Modiolus modiolus* and common or blue mussel *Mytilus edulis* (both in the family Mytilidae) also have the ability to form aggregations which can be classed as reef. No mussel beds were recorded in or around the Norfolk Vanguard offshore project area. Three individual *M. edulis* were recorded at one station in NV West during the Fugro (2016) survey. This is in keeping with the MESL (2011) survey, during which five *M. edulis* were recorded at one station in NV West. No mussels were recorded in the offshore cable corridor or NV East during either survey.

82. The offshore cable corridor overlaps with the proposed Greater Wash possible special Protection Area (pSPA). If designated the site would be designed to primarily protect red-throated diver *Gavia stellata* 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.

83. Only three individuals of *M. edulis* were found within the most nearshore sample of the Norfolk Vanguard survey (Appendix 10.1). Such low numbers of a highly opportunistic and abundant species suggest that these are unlikely to form part of the birds' diet; therefore, potential impact on diet and food availability for diving birds from the proposed Greater Wash possible Special Protection Area (pSPA) is discounted from any further assessment.

84. The impacts to the conservation objectives of The Greater Wash SPA are considered further in Section 6.3.3 of the Information to Support HRA Report (Document reference 5.3).

10.6.6.2 UK Post-2010 Biodiversity Framework

85. The UK Post-2010 Biodiversity Framework, published in July 2012, succeeded the UK Biodiversity Action Plan (BAP) and 'Conserving Biodiversity – the UK Approach'. The Biodiversity Framework is now focussed at country-level rather than a UK-level to demonstrate how the work of the four countries and the UK contributes to achieving those targets (JNCC, 2015). Priority species and habitats that were identified under the UK BAP remain important and are now referred to as habitats of principal importance (HPI) and species of principal importance (SPI).

86. The following habitats of principal importance are present within the former East Anglia Zone and of these, those shown in bold are also found within the Norfolk Vanguard offshore project area:

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

87. Habitat mapping during the ZEA identified small areas of potential mud habitats in deep water in the north west of the former Zone, with none being identified within either NV West or NV East (EAOW, 2012a).

88. As discussed above potential for *S. spinulosa* reef has been identified within NV East, NV West and the offshore cable corridor (Figure 10.12).

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

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

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

10.6.6.3 Marine Conservation Zone features

92. 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 (Defra, 2016) 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.

93. The Norfolk Vanguard benthic survey which overlapped with the MCZ (Appendix 10.1) 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.

10.6.7 Context and Summary

94. The benthic species and biotopes found within the Norfolk Vanguard 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.

95. 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 Vanguard 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

96. The habitats and species found within the Norfolk Vanguard offshore project area are analogous to findings of other surveys that have been conducted within the region. Examples include the East Anglia ONE and THREE surveys, 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).

97. 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 Vanguard surveys such as *N. cirrosa, U. brevicornis* and *B. elegans* (Emu and University of Southampton, 2009).

98. No biogenic or rocky reef areas were confirmed in the combined survey and data analysis for the Norfolk Vanguard project area. However, areas of potential *S. spinulosa* biotope were identified in the offshore cable corridor and NV West. One station in the offshore cable corridor was recorded as having a medium score on the “reefiness” scale (Figure 10.12).

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

10.6.8 Anticipated Trends in Baseline Conditions

100. 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 surveys conducted across the ZEA in 2010 and 2011 are very similar to the findings of the Norfolk Vanguard site specific surveys conducted in 2016.

101. 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 exist across the study area (Chapter 14 Commercial Fisheries).

102. Seabed areas within the Haisborough Hammond and Winterton SAC are currently being considered by regulators (EIFCA, NE and MMO) as potential "closed areas" to fishing. Some of these potential areas 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 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.

103. 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

104. Norfolk Vanguard 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 a number of impacts or reduce 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.

105. 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

106. Careful site selection of the OWF sites 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). 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.

107. The offshore cable corridor takes the shortest, most direct route possible from the OWF sites to landfall, thereby minimising the potential areas of disturbance and potential for cable protection.

10.7.1.2 Intertidal

108. Norfolk Vanguard Limited has made a decision to use long Horizontal Directional Drilling (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 so impacts on the intertidal zone are not considered further.

10.7.1.3 Reduction of turbine numbers

109. Norfolk Vanguard Limited has reduced the maximum number of turbines from 257 to 200, while maintaining the maximum generating capacity of 1800MW by taking the decision to use 9MW to 20MW turbines.

10.7.1.4 Minimising export cabling

110. Norfolk Vanguard Limited has made the decision to use an HVDC solution in order to reduce the number of export cables and volume of cable protection. This results in the following mitigating features:

- There would be two cable trenches instead of six for Norfolk Vanguard (and two cable trenches for Norfolk Boreas, considered in the CIA);
- 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;
- The potential requirement for cable protection in the unlikely event that cables cannot be buried is reduced; and
- The number of export cables required to cross existing cables and pipelines and the associated cable protection is reduced.

10.7.1.5 Pre-construction survey

111. A pre-construction survey (as required under DCO Schedule 9 and 10 Part 4 condition [18] and Schedule 11 and 12 Part 4 condition[13] 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 routing of all Norfolk Vanguard cables, including micrositing where possible. The

locations and cable routes would then be discussed and agreed with the MMO in consultation with the relevant SNCBs.

112. 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

113. As discussed above, should seabed obstacles (e.g. Annex 1 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.

114. Norfolk Vanguard Limited commissioned a Cable Constructability Assessment by Global Marine Systems Ltd (GMSL, 2016 unpublished) to determine an appropriate cable corridor (a combined corridor for Norfolk Vanguard and Norfolk Boreas). This includes a 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 Plate 10.1; source: GMSL, 2016 unpublished, provided in Volume 3 Appendix 4.2):

- A total width of approximately 1.35km is required for Norfolk Vanguard and Norfolk Boreas[2]; which includes
  - Up to two export cable trenches per project with spacing between Norfolk Vanguard and Norfolk Boreas 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 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.

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

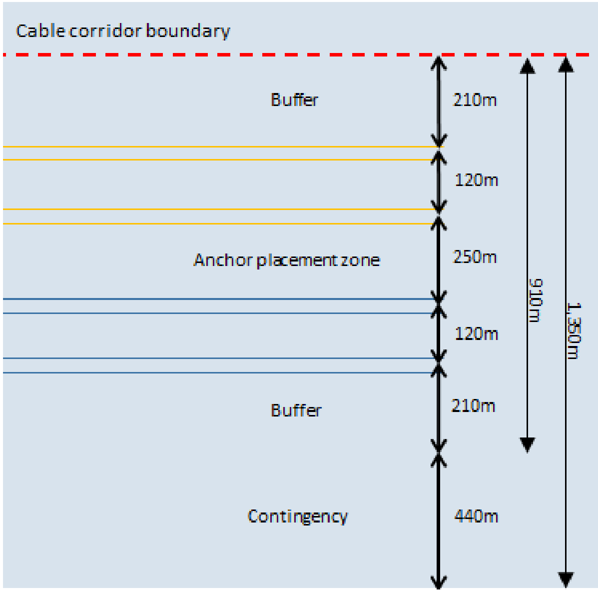

Plate 10.1 Export cables layout (two pairs of cables for Norfolk Vanguard (yellow) and two pairs of cables for Norfolk Boreas (blue)) based on 48m water depth[3]

10.7.1.7 Minimising cable protection

115. Norfolk Vanguard Limited is committed to burying offshore export cables where possible, therefore reducing the need for surface cable protection. A detailed export cable installation study (CWind, 2017, unpublished[4]) was commissioned by Norfolk Vanguard Limited which confirmed that cable burial is expected to be possible throughout the offshore cable corridor, with the exception of cable and pipeline crossing locations.

116. An Outline Scour Protection and Cable Protection Plan (document reference 8.16) is provided with the Norfolk Vanguard DCO Application. A cable burial risk assessment would be undertaken post consent, in consultation with the MMO and relevant SNCBs.

117. The exact method for cable crossings will be subject to crossing agreements; however, the worst case scenario for cable protection is described in section 10.7.3.5.4.

10.7.1.7.1 Sand wave levelling

118. 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. CWind (2017 unpublished) analysed geophysical survey data of the

[3] 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

[4] CWind (2017). Norfolk Vanguard Offshore Windfarm Export Cable Installation Study

offshore cable corridor 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 10.7.3.5.1).

10.7.1.7.2 Cable protection contingency

119. 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 10.7.3.5.4 in order to provide a conservative and future-proofed assessment.

120. 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

121. All seabed material arising from the Haisborough, Hammond and Winterton SAC during cable installation would be placed back within the SAC (Figure 7.3) 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 (see ABPmer, 2018[5]).

122. Sediment would not be disposed of within 50m of known *Sabellaria* reef identified during pre-construction surveys (in accordance with advice from Natural England in January 2018).

10.7.1.9 Electromagnetic Fields (EMF)

123. Norfolk Vanguard 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 (CWind 2017 unpublished) was commissioned by Norfolk Vanguard Limited. This study confirmed that cable burial is expected to be possible throughout the offshore cable corridor with the exception of cable crossing locations.

10.7.1.10 Non-native species

124. The risk of spreading non-native invasive species would be mitigated through use of best-practice techniques, including appropriate vessel maintenance following guidance from the International Convention for the Prevention of Pollution from Ships (MARPOL). These commitments would be secured in the Project Environmental

[5] ABPmer (2018) Norfolk Vanguard and Norfolk Boreas Export Cable Route Sand wave bed levelling

Management Plan (PEMP) in accordance with the Outline PEMP (document reference 8.14) provided with the DCO application.

10.7.2 Monitoring

125. An In Principle Monitoring Plan (document reference 8.12) and outline PEMP (document reference 8.14) is submitted with the DCO application. The development of the detailed design and final PEMP will refine the worst case impacts assessed in this EIA. 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

126. The offshore project area consists of:

- The offshore cable corridor with landfall at Happisburgh South;
- Norfolk Vanguard West (NV West); and
- Norfolk Vanguard East (NV East).

127. The detailed design of Norfolk Vanguard (including numbers of wind turbines, layout configuration, requirement for scour protection etc.) will not be determined until after the DCO has been determined. Therefore, realistic worst case scenarios in relation to impacts/effects on benthic ecology are adopted which have been informed by a number of engineering studies undertaken or commissioned by Norfolk Vanguard Limited (see Section 10.5.2).

10.7.3.1 Foundations

128. Within Norfolk Vanguard, several different sizes of wind turbine are being considered in the range of 9MW and 20MW. In order to achieve the maximum 1,800MW export capacity, there would be between 90 (20MW) and 200 (9MW) wind turbines.

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

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

- Wind turbines – jacket (pin-pile or suction caisson), gravity base structure (GBS), monopile (piled or suction caisson) and tension leg floating platforms;
- Offshore electrical platform – GBS, pin-pile or suction caisson;
- Accommodation platforms – GBS, pin-pile or suction caisson;
- Met masts - GBS, monopile or pin-pile; and

- Lidar - floating with anchors or monopile.

131. The largest seabed footprints are associated with gravity anchors for floating foundations or GBS, where applicable.

10.7.3.2 Layout

132. The layout of the wind turbines would be defined post consent but would be based on the following maxima:

- 1800MW in NV East, 0MW in NV West; or
- 0MW in NV East, 1800MW in NV West.

133. Any other potential layouts that are considered up to a maximum of 1800MW (e.g. 1,200MW in NV West and 600MW in NV East, 600MW in NV West and 1,200MW in NV East or 900MW in NV West and 900MW in NV East) lie within the envelope of these scenarios. Therefore, the maximum parameters outlined in Table 10.12, could all be located in NV East; all in NV West; or split between in each site.

10.7.3.3 Phasing

134. Norfolk Vanguard Limited is currently considering constructing the project in one of the following phase options.

- A single phase of up to 1800MW; or
- Two phases, up to a combined 1800MW capacity.

135. 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.

10.7.3.4 Programme

136. The indicative construction window is expected to be up to four years for the full 1800MW capacity. Table 10.9 and Table 10.10 provide indicative construction programmes for the single phase and two phase options, respectively.

Table 10.9 Indicative Norfolk Vanguard 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
Foundation installation	20 months																				
Array & interconnector cable installation	19 months																				
Export cable installation	6 months																				
Wind turbine installation	20 months																				
Total construction works	23 months																				

Table 10.10 Indicative Norfolk Vanguard construction programme – two 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
Foundation installation	2 x 8 months																				
Array & interconnector cable installation	2 x 7 months																				
Export cable installation	2 x 3 months																				
Wind turbine installation	2 x 8 months																				
Total construction works	2 x 12 months																				

10.7.3.5 Cable installation footprints

10.7.3.5.1 Pre-installation works

Boulder clearance

137. Pre-construction surveys would identify any requirement for boulder clearance within the offshore project area. Norfolk Vanguard Limited has reviewed the Fugro 2016 geophysical survey data and, given the low proportion of boulders in the area, it is likely that micrositing around boulders would be possible however an allowance for clearing up to 75 boulders (53 in the OWF sites and 22 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.

Pre-lay grapnel run

138. A pre-lay grapnel run would be undertaken to clear any debris in advance of each 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

139. The potential for sand wave levelling (pre-sweeping) has been assessed as a potential 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 the DCO application has been determined, in the Cable Specification, Installation and Monitoring Plan (required under DCO Schedule 9 and 10 Part 4 condition [14(1)(g)] and Schedule 11 and 12 Part 4 condition [9(1)(g)])) following pre-construction surveys.

140. Indicative pre-sweeping volumes and areas for the offshore cable corridor 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, resulting in 50,000m^2 pre-sweeping footprint to be added to the trenching footprint

[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

in the SAC or 72,000m^2 for the whole offshore cable corridor when calculating the total disturbance footprint for cable installation (see Table 10.12).

Table 10.11 Parameters for pre-sweeping activity for the offshore export cables

Parameter	Maximum for the section of offshore cable corridor within the Haisborough, Hammond and Winterton SAC	Maximum for the entire offshore export cables (including the SAC volume and area)
Volume of material to be moved		
Per trench (pair of export cables) (m^3)	250,000	1,200,000
Total for two trenches (m^3)	500,000	2,400,000
Area of pre-sweeping		
Per trench (pair of export cables) (m^2)	125,000	480,000
Total for two trenches (m^2)	250,000	960,000

141. Sediment arising from pre-sweeping in the Haisborough, Hammond and Winterton SAC would be disposed 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. Sediment arising from pre-sweeping in the offshore cable corridor to the east of the SAC would be deposited in this section of the offshore cable corridor or in the OWF sites. Figure 2 of Chapter 5 Project Description displays the disposal sites. No pre-sweeping or disposal is anticipated in the nearshore section of the offshore cable corridor.

142. The area and depth of deposited sediment is therefore not known at this stage and will vary depending on the approach to disposal as well as a range of environmental conditions. ABPmer (Appendix 7.1 of the Information to Support HRA report (document reference 5.3)) provide a range of estimated depths of disposed material within an indicative disposal site. The range is between 4.2m if all material is deposited in a cone over an area of 161,209m^2 and 0.25m if the deposition was spread over an area of 900,000m^2.

143. The worst case scenario for the volume of sediment arising from foundation preparation in the OWF sites would be associated with levelling for 90 20MW floating tension leg platforms with gravity anchors. The levelling area per turbine foundation would be up to 8,100m^2, resulting in a total footprint of 729,000m^2 and sediment volume of 3,645,000m^3 (based on a levelling depth of 5m). In addition, levelling of 7,500m^2 per offshore accommodation and electrical platforms and 1,257m^2 per met-mast may be required resulting in a footprint of 32,513m^2 and sediment volume of 162,566m^3. Sediment arising within the OWF sites would be deposited back into the OWF sites (Figure 2 of Chapter 5 Project Description).

Removal of existing disused cables

144. There are seven out-of-service cables in the offshore cable corridor (all in the Haisborough Hammond and Winterton SAC). Four are intact and span the offshore cable corridor; it is assumed that these would 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 would be further cut subject to agreement with the cable owners and suitably sized clump weights would be placed on the cut ends. Finally, one enters and exits the southern edge of the cable corridor which would be avoided, where possible.

10.7.3.5.2 Cable burial

145. Following the cable pre-installation works as described in section 10.7.3.5.1, 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.

146. The maximum length of export cable trenches is 200km from the offshore electrical platforms in NV East to landfall, based on an average length of 100km per trench for a total of two trenches, each containing a pair of cables. The maximum volume of sediment arising from cable burial (using ploughing as the worst case method) would therefore be 3,000,000m^3 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 3,000,000m^3 would result in sediment plumes during cable installation.

10.7.3.5.3 Landfall

147. 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.

10.7.3.5.4 Cable protection

Unburied cable

148. 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). The assessment includes 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. 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

149. There are nine existing cables and two pipelines, including the four disused cables described in paragraph 144, which the Norfolk Vanguard export cables would need to cross (five cables and one pipeline within the SAC). Each crossing would require a carefully agreed procedure between the cable/pipeline owners.

150. 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.

151. 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

152. 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.

153. 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 (see section 10.7.5.1 and 10.7.5.2).

10.7.3.6 Vessel footprints

154. 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).

155. 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 six legs per vessel.

10.7.3.7 Maintenance

10.7.3.7.1 Turbines

156. Regular maintenance of the wind turbines would 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.

10.7.3.7.2 Cable repairs

157. 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 would be undertaken.

158. 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 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.

159. 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.

10.7.3.7.3 Cable reburial

160. As previously discussed, cables could become exposed due to migrating sand waves, although this is unlikely if pre-sweeping is used to bury the cables below the reference seabed level. An In Principle Monitoring Plan (document 8.12) is submitted with the DCO application which outlines 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.

161. 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.

162. 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 OWF sites	Disturbance footprints in the OWF sites due to cable laying operations, jack-up operations and seabed preparation works for turbine foundations	Worst case scenario for an individual foundation would be 20MW floating tension leg platforms with gravity anchors. Preparation area per 20MW platform = 8,100m^2 (based on approximately 90 x 90m). Total turbine seabed preparation area for 1800MW (all in NV East, all in NV West or split between both OWF sites): • 90 x 20MW floating turbines on gravity anchors (with a preparation area of approximately 90 x 90m) = 729,000m^2. • Two offshore electrical platforms seabed preparation = 15,000m^2 (approximately 75m x 100m per platform) • Two accommodation platforms seabed preparation = 15,000m^2 (approximately 75m x 100m per platform) • Two met masts seabed preparation = 2,513m^2 (based on 40m diameter) • Array cable trench – 600km length with average 20m pre-sweeping width = 12,000,000m^2 • Interconnector cable trench - 150km with 20m pre-sweeping width = 3,000,000m^2 (in the OWF sites and/or in the offshore cable corridor between NV East and NV West depending on the location of electrical platforms) • Jack up vessel footprints assuming 2 vessel movements per turbine = 316,800m^2 (based on 200 turbines x 2 movements x vessel footprint of 792m^2) • Vessel anchor footprints (one vessel anchoring per turbine) = 30,000m^2 • Jack up vessel footprints assuming 2 vessel movements per offshore platform = 9,504m^2 • Boulder clearance – 53 boulders of up to 5m diameter = 1,041m^2 Worst case scenario total disturbance footprint = **16.1km^2** Any other works associated with cable installation would be encompassed by the footprints outlined above.	The temporary disturbance relates to seabed preparation and cable installation. The footprint of infrastructure is assessed as a 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.

Impact	Parameter	Worst Case	Rationale

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 = 432m^2 (up to 22 boulders of 5m diameter)
		• 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 section 10.7.3.5.1)
		• Maximum temporary disturbance for cable installation by ploughing = 6,000,000m^2 based on:
		  o Maximum total export cable trench length of 200km.
		  o 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 6 anchors per vessel)
		• Total disturbance footprint – 6.1km^2.
		
		Disturbance footprints within the Haisborough Hammond and Winterton SAC. Note these areas are included in the calculations above:
		
		• Boulder clearance = 432m^2 (up to 22 boulders of 5m diameter)
		• Pre-sweeping area which could be outside the ploughing area – 50,000m^2 (section 10.7.3.5.1)
		• Maximum temporary disturbance for cable installation by ploughing = 2,400,000m^2 based on:
		  o Maximum total export cable trench length of 80km (40km per cable pair in the SAC).
		  o 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
		• 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
			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 2A: Temporary increases in suspended sediment concentrations and associated sediment deposition in the OWF sites	Suspended sediment concentrations and associated sediment deposition from cable and foundation installation and seabed preparation in the OWF sites	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 50m depth x 15m diameter) = 397,608m^3 • Meteorological masts - 2 x pin-pile quadropod = 1,131m^3 (based on 3m diameter piles x 4 piles x 2 metmasts x 20m depth) • Accommodation platforms - 2 x six legged pin-pile = 1,696m^3 (based on 3m diameter piles x 6 piles x 2 platforms x 20m depth) • Offshore electrical platforms - 2 x six legged pin-pile = 1,696m^3 (based on 3m diameter piles x 6 piles x 2 platforms x 20m depth) • Lidar - 2 x monopiles = 189m^3 Total = 402,320m^3 **Seabed preparation/ disposal** • 90 x 20MW turbines on floating tension leg platforms with gravity anchors (based on area described in Impact 1 and levelling depth of up to 5m) = 3,645,000m^3. • Two offshore electrical platforms based on area described in Impact 1 and 5m depth = 75,000m^3 • Two accommodation platforms based on area described in Impact 1 and 5m depth = 75,000m^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 and 3m depth = 36,000,000m^3 • Interconnector cable trench 150km with average 20m pre-sweeping width and 3m depth = 9,000,000m^3 (in the OWF sites and/or in the offshore cable corridor between NV East and NV West depending on the location of the offshore electrical platforms) • Export cable pre-sweeping sediment disposal in the OWF sites = 1,800,000m^3 Total = 50,607,566m^3	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 gravity anchors would not be required

Impact	Parameter	Worst Case	Rationale
		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 in 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) and the remainder would be within the OWF sites (see impact 2A above). Following pre-sweeping, the sediment released 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 at the seabed surface with a V shaped trench profile. This would be back filled naturally or manually. ***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 Sabellaria 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	Parameter	Worst Case	Rationale
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% would be used for 10 minutes. Ramp up will then be undertaken for the next 20 minutes up to the maximum hammer energy.	
Operation			
Impact 1A: Permanent loss of seabed habitat in the OWF sites	The presence of wind turbine and platform foundations, scour protection, array cables, inter-connector cables, and cable protection	Turbines Total worst case turbine footprint (1800MW) with scour protection, based on 90 x 20MW tension floating platform with a gravity anchor of 70 x 70m (350 x 350m with scour protection) = 11,025,000m^2. Array cable protection 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 200 turbines = 100,000m^2 Array cable crossings protection 10 crossings x 100m x 10m = 10,000m^2 Interconnector cable protection Interconnector cable protection approaching platforms 100m cable length x 5m width x 2 platforms = 1,000m^2 Surface laid interconnector cable protection 5m width x 15,000m (10% of the length) = 75,000m^2	

Impact	Parameter	Worst Case	Rationale
		Interconnector cable crossings protection crossings – captured within export cable/array cable crossing total <u>Platforms and other infrastructure</u> Two offshore electrical platforms with scour protection 35,000m^2 Two accommodation platforms with scour protection 35,000m^2 Two met masts with scour protection 15,708m^2 Two wave buoys 300m^2 Two LiDAR monopiles with scour protection 157m^2 **Total WCS footprint = 11.6km^2**	

Impact	Parameter	Worst Case	Rationale
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 eleven crossings (nine cables and two pipelines) are required for each cable pair (i.e. up to 22 crossings in total) resulting in a total footprint of 22,000m^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 36m^2 • Unburied cables In the unlikely event that cable burial is not possible due to hard substrate being encountered, up to 10km per cable pair outside the SAC and 4km inside the SAC per cable pair (28km in total) could require additional protection resulting in a footprint of 140,000m^2 (based on protection width of 5m). **<u>Total</u> WCS footprint = 0.16km^2** Of this total, 0.05km^2 could be within the Haisborough, Hammond and Winterton SAC based on: • Six crossings for each of the two cable pairs within the SAC with a total footprint of 12,000m^2 (0.012km^2) (100m length and 10m width of protection); and • A contingency of up to 4km of cable protection per cable pair, resulting in a footprint of 40,000m^2 (0.04km^2) based on 5m wide cable protection.	

Impact	Parameter	Worst Case	Rationale
Impact 2A: Temporary seabed disturbances from maintenance operations in the OWF sites	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 = 450,000m^2 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 = 36,360m^2. • One interconnector repair per year is estimated – 3m disturbance width x 300m repair length =900m^2. Maintenance of wind turbine generators would 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 792m^2 which would lead to a total area of up to 0.58km^2 per year (assumes large jack up with six legs). 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 (10km in the Haisborough, Hammond and Winterton SAC and 10km outside the SAC) = 120,000m^2 based on two cable pairs and a disturbance width of 3m. 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 5 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 5 years Anchor placement associated with repair works – 150m^2 based on 6 anchors per vessel	

Impact	Parameter	Worst Case	Rationale
		Reburial of up to up to 10km per export cable pair may be required should pre-sweeping not be undertaken. The disturbance width would be approximately 3m and therefore the total disturbance would be 60,000m^2. If reburial is required, it is likely that this would be in relatively short sections (e.g. 1km) at any one time.	
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 and export cables	The presence of array cables, inter-connector cables, and export cables	The following lengths of unburied cables may be required: <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 - 100m (50m cable length x 2 cables) At cable crossings - 600m (10 crossings x 100m cable length) <u>Interconnector cable</u> Interconnector cable protection approaching platforms 150m (50m cable length x 3 cables) Surface laid interconnector cable protection in the unlikely event that cables cannot be buried - 15,000m <u>Export cables</u> At cable crossings – 2,200m (22 crossings (11 per cable pair) x length of 100m 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.	
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 would be less than during the construction phase. Scour protection would likely be left *in situ*.	

Impact	Parameter	Worst Case	Rationale
	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 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 5: Underwater noise and vibration	Decommissioning noise e.g. from cutting foundation	Cutting of up to 200 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 due to cable laying operations, jack-up operations and seabed preparation works for turbine foundations in the OWF sites.

163. Activities associated with the offshore construction works will result in direct temporary loss/disturbance to subtidal habitats within the project area. 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 a temporary disturbance during the construction phase.

164. 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.

165. The maximum potential seabed preparation area has a total disturbance footprint of 16.8km^2 which could be either completely within NE East of NV West (see Table 10.12).

166. The disturbance would be temporary during 23 months of construction activity based on the single phased construction approach, and temporary over a period of four years based on a two phased approach (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 Vanguard as well as the wider former East Anglia Zone and southern North Sea.

10.7.4.1.1 Assessment of impacts in NV West – single phase

167. NV West 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). The maximum percentage of seabed likely to be disturbed within the NV West site totals 5.55%, based on a maximum of 1800MW being located in NV West.

168. The majority of NV West is composed of coarse sediment communities with some areas of potential *Sabellaria* reef identified (Figure 10.12).

169. 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 deemed to have high recoverability and low sensitivity (Tyler-Walters, Lear and Allen, 2004).

170. In terms of the PRIMER analysis, the NV West site is mainly comprised of group of infauna (polychaete worms *N. cirrosa* and *S. bombyx* and the gastropod *Polinices pulchellus,* see Appendix 10.2). Other groups recorded in NV West include:

- Group j – characterised by Nemertea (ribbon worms), *S. spinulosa, S. bombyx*;
- Group m - characterised by the polychaete worms *S. armiger* and *N. cirrosa* and *S. bombyx* and the bivalve *A. alba*;
- Group n - characterised by *N. cirrosa*; and
- Group p - characterised by *N. cirrosa, S. bombyx* and Nemertea.

171. On the whole, the species present are representative of the dynamic sediment environment expected within Norfolk Vanguard. *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 deemed to be low. No information is available for the sensitivity of *N. cirrosa*, however *Nephtys hombergii* represents a potential proxy species, being closely related. 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). No sensitivity information is available for *P. pulchellus, S. armiger,* or appropriate proxy species.

172. It is considered that whether looking at the biotope or species level, the coarse sediment communities will generally be of low sensitivity to disturbance as would be expected of a dynamic environment. However, it is noted that sensitivity information is not available for all species and therefore there is medium confidence in the low sensitivity classification for these species.

173. One station in NV West was found to have potential *S. spinulosa* reef, however this was characterised as 'low reefiness' using the method described in Gubbay (2007) (see Appendix 10.1). This station is located in the northwest corner of the site, where the previous ZEA survey also identified small aggregations of the polychaete. Two further stations were identified as potential '*Sabellaria spinulosa* on stable circalittoral mixed sediment' SS.SBR.PoR.SspiMx but these were classified as 'not reef'. *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).

174. As described in Section 10.6.6.1, mapping undertaken by Envision Limited (2018) shows that of the data sources included in that study only a small number agree that reef is present in this area (see Appendix 7.2 of the Information to Support HRA report (document reference 5.3), Figure 22) and therefore it is likely that the reef identified in the site specific survey is small in extent and localised.

175. 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).

176. As the conditions across the Norfolk Vanguard OWF sites 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 monitoring surveys following cessation of dredging activities and recorded large numbers of *S. spinulosa* in one area the following summer, and found another area to be recolonised within 1.5 years, suggesting annual recruitment in this area. Evidence suggests 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 NV West has low or no reef characteristics, the sensitivity to disturbance would be low on the basis that recovery to this status, in the form of recolonisation of individuals, is expected in approximately 1 year. However, taking a conservative approach that there is potential for *Sabellaria* reef to be present in the area, the sensitivity is classified as medium.

177. The impact of physical disturbance during the construction phase to the benthic ecology at NV West 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 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 in NV East – single phase

178. The maximum percentage of seabed likely to be disturbed within the NV East site totals 5.52% of NV East, based on a maximum of 1800MW being located in NV East (Table 10.12).

179. As with NV West, the disturbance would be temporary during 23 months of construction activity based on the single phased construction approach (Table 10.9). This represents a low magnitude of effect.

180. NV East does not overlap with any designated sites or Annex 1 habitats.

181. 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. The following biotopes have been identified within NV East:

- Circalittoral coarse sediment - SS.SCS.CCS;
- Circalittoral fine sand - SS.SSa.CFiSa; and
- Circalittoral muddy sand - SS.SSa.MuSa.

182. No information is available on the sensitivity of circalittoral fine and muddy sand. As discussed previously, circalittoral coarse sediment is deemed to have high recoverability and low sensitivity (Tyler-Walters, Lear and Allen, 2004).

183. As with NV West, the NV East site is mainly comprised of group of infauna (polychaete worms *N. cirrosa* and *S. bombyx* and the gastropod *P. pulchellus*). Receptor sensitivity is deemed to be low, as described above.

184. Other groups recorded in NV East include:

- Group c – outlier with sparse or no infauna;
- Group d - characterised by the amphipod *Urothoe brevicornis* and bivalve *Goodallia triangularis*;
- Group j – Also found in NV West, characterised by Nemertea (ribbon worms), *S. spinulosa, S.bombyx*;
- Group p - Also found in NV West, characterised by *N. cirrosa, S. bombyx* and Nemertea; and
- Group r - characterised by the bivalves *Tellina pygmaea* (formerly *Moerella pygmaea*) and *Spisula* sp., and brittlestar *Ophiocten affinis*.

185. *T. pygmaea* and *Spisula* are robust bivalves, however no recoverability information is available (Tillin, 2016). No sensitivity information is available for *U. brevicornis, G. triangularis, O. affinis,* or appropriate proxy species.

186. Potential *Sabellaria* reef has been identified in NV East, *Sabellaria* crust was identified during the East Anglia FOUR survey and an area of “low reefiness” was identified during the Norfolk Vanguard surveys (Figure 10.11) and therefore in line with the assessment for NV West (section 10.7.4.1.1) the sensitivity of this feature is deemed to be medium (see section 10.7.4.1.1).

187. Due to a low magnitude of effect, combined with low to medium receptor sensitivity, the impact of temporary disturbance and substratum loss on benthic ecology in the NV East site is assessed as **minor adverse**. As described above in section 10.7.4.1.1, there is a medium to high confidence associated with this assessment.

10.7.4.1.3 Assessment of impacts in NV East or NV West – two phase

188. The maximum infrastructure requirements are the same for each phasing scenario and the impact of disturbance would be localised to the footprint of each activity. The phased approach to construction would aim to build out two arrays and therefore there would be no recurring impact on the same area of seabed as a result of phasing. As a result, while the overall indicative programme is longer under the two phased approach (up to four years, 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 impact 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.

10.7.4.2 Impact 1B: Temporary habitat loss/disturbance due to cable laying operations in the offshore cable corridor

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

189. Boulder clearance, pre-lay grapnel runs, sand wave levelling (e.g. dredging), and cable installation (e.g. ploughing) would lead to temporary disturbance in the offshore cable corridor. The area of that may be affected by these works (6.2km^2, see Table 10.12) constitutes a small proportion (2.62%) of the offshore cable corridor, resulting in the impact of temporary habitat loss or disturbance being assigned a low magnitude.

190. The effect of direct disturbance and temporary loss of seabed habitat during cable installation activities has the potential to cause disturbance to the biotopes shown in Table 10.13, 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.

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

Table 10.13 Biotope sensitivities 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.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	*Sabellaria spinulosa* on stable circalittoral mixed sediment	Low - None	Medium	Medium
SS.SCS.CCS.Pkef	*Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand	Medium	High	*Not sensitive - Low
SS.SSa.CFiSa	Circalittoral fine sand	No available information		
SS.SSa.MuSa	Circalittoral muddy sand	No available information		

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

192. No sensitivity information is available for *Mediomastus fragilis, Lumbrineris* spp., *Protodorvillea kefersteini*, or appropriate proxy species.

193. The Norfolk Vanguard benthic survey (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 (see Appendix 10.1).

194. As discussed in section 10.6.6.1 work completed by Envision Mapping Ltd (2018) (provided in Appendix 7.2 of the Information to Support HRA report (document reference 5.3)) identified potential areas of *Sabellaria* reef within the offshore cable corridor, some of which had relatively low confidence in their prediction and included samples which did not show any reef at all (e.g. areas to the east and west of the SAC). Some areas were identified where there was relatively high confidence in the detection of reef (Figure 10.12). In the dog-leg section of the offshore cable corridor where areas of high confidence were identified which have been confirmed by physical samples (video and grab), these are shown to be relatively discrete patches of reef that do not extend across the 4 to 4.7km width of the cable corridor in this area, leaving adequate space for two pairs of HVDC cables to be installed for Norfolk Vanguard. To the west of the SAC an area of medium confidence reef was identified which includes one sample location where *Sabellaria* biotope was identified and multiple locations where it was not and therefore it is likely that there

would be space available for the export cables. At the eastern approach to NV West there is a thin band of potential reef that stretches across the entire cable corridor. However, this is very narrow (less than 100m in width) and therefore would only be impacted by a very short section of interconnector cable (if required, subject to the location of the offshore electrical platforms).

195. Any export cable installation and potential disposal sites would be located to avoid suspected sensitive habitats such as *Sabellaria* reef, where possible.

196. As discussed above in section 10.7.4.1.1 the sensitivity of *Sabellaria* reef to temporary habitat loss is considered to be medium.

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

Haisborough, Hammond and Winterton SAC

198. 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).

199. 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 6.2km^2 (see Table 10.12).

200. As previously discussed, areas of Annex 1 sandbank are present 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). The Haisborough, Hammond and Winterton SAC site selection assessment concluded that 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 Vanguard Limited has made a commitment that sediment arising from the SAC would be disposed of at a site within the offshore cable corridor 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 to the designated site (Appendix 7.1 of the Information to Support HRA report (document reference 5.3)).

201. The potential impacts of temporary habitat loss/disturbance are considered against the conservation objectives of the SAC within section 7.4 of the Information to Support HRA Report (document reference 5.3).

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

202. Under the scenario where export cable installation would occur in two phases the duration of the impact would increase from one single event lasting six months (Table 10.9) to two separate events lasting 3 months occurring over a period of approximately four years (Table 10.10); however with spacing of approximately 120m between cables pairs, the footprint of disturbance as a result of installing cables in phases would be on separate 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, in accordance with Table 10.5 would be classed as low magnitude.

203. Therefore, impacts would be as follows:

- Impacts to Benthic ecology – **Minor adverse** significance; and
- Impact to Haisborough, Hammond and Winterton SAC – **Minor adverse** significance.

10.7.4.3 Impact 1 Summary: Temporary habitat loss/disturbance in the Norfolk Vanguard offshore project area

204. The magnitude of physical disturbance on benthic ecology in the OWF sites and offshore cable corridor is low and the greatest sensitivity is medium, regardless of the division of capacity between NV East and NV West or the phased approach to construction and therefore the overall worst case impact of physical disturbance is considered to be of **minor adverse** significance.

205. The total worst case footprint for all temporary disturbance is 22.6km^2 which represents 2.73% of the Norfolk Vanguard 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.

206. The overall confidence in this assessment is high. While there is a lack of available information on the sensitivity of some species recorded in the offshore project area, it is deemed 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 deemed to be conservative.

10.7.4.4 Impact 2A: Temporary increase in suspended sediment concentrations and associated sediment deposition in the OWF sites.

207. 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.

208. 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.

209. As described in Chapter 8 Marine Geology, Oceanography and Physical Processes, the majority of the sediment released during construction would be coarse material. 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 resulting mound would be 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 6 hours). Sediment would settle to the seabed within approximately 1km along the axis of tidal flow from the location at which it was released. These deposits would be very thin (millimetres). Chapter 8 Marine Geology, Oceanography and Physical Processes, describes a similar effect for both NV East and NV West using the one or two phase construction scenarios. Taking into account the spatial and temporal extents of increased suspended sediments, this is deemed to have a low impact magnitude on benthos.

10.7.4.4.1 Assessment of impacts in NV West

210. The sensitivity of the receptors in NV West to increases in suspended sediments and smothering are shown below in Table 10.14. The majority of receptors in NV West 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. This type of impact could occur within a few meters of the disposal location for Norfolk Vanguard and is discussed above, this represents a low

magnitude. The worst case scenario is therefore an impact of **minor adverse** significance.

Table 10.14 Sensitivities to increased suspended sediment and smothering by deposited sediment (source: Tyler-Walters, Lear and Allen, 2004; Tillin *et al.,* 2015; Jackson & Hiscock, 2008; Ager, 2005)

Receptor	Tolerance	Recoverability	Overall sensitivity
Light smothering – up to 5cm			
Circalittoral coarse sediment biotopes	Moderate	High	Low
***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
Heavy smothering – up to 30cm			
Circalittoral coarse sediment biotopes	Not available		
***S. spinulosa* on stable circalittoral mixed sediment**	None	Medium	Medium
S. spinulosa	Not available		
S. bombyx	Not available		
A. alba	Not available		
Increased Suspended Sediment Concentrations			
Circalittoral coarse sediment biotopes	High	High	Not sensitive
***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

10.7.4.4.2 Assessment of impacts in NV East

211. The sensitivity of the receptors in NV East to increases in suspended sediments and smothering are shown below in Table 10.15. Sensitivity to increased suspended sediments and light smothering is shown to be low or 'not sensitive'. No information is available on the sensitivity to heavy smothering (around 30cm or greater), a conservative medium sensitivity is assumed for the assessment. As discussed above, this level of impact could occur within a few metres of the disposal location for Norfolk Vanguard and is deemed to have low magnitude. The worst case scenario is an impact of **minor adverse** significance.

Table 10.15 Sensitivities to increased suspended sediment and smothering by deposited sediment (source: Tyler-Walters, Lear and Allen, 2004; Ager, 2005)

Receptor	Tolerance	Recoverability	Overall sensitivity
Light smothering – up to 5cm			
Circalittoral coarse sediment biotopes	Moderate	High	Low
***N. cirrosa* (using *N. hombergii* as a proxy)**	Tolerant	N/A	Not sensitive
S. spinulosa	Low	Immediate	Not sensitive
S. bombyx	Low	High	Low
Heavy smothering – up to 30cm			
Circalittoral coarse sediment biotopes	Not available		
***N. cirrosa* (using *N. hombergii* as a proxy)**	Not available		
S. spinulosa	Not available		
S. bombyx	Not available		
Increased Suspended Sediment Concentrations			
Circalittoral coarse sediment biotopes	High	High	Not sensitive
***N. cirrosa* (using *N. hombergii* as a proxy)**	Tolerant	N/A	Not sensitive
S. spinulosa	Low	Immediate	Not sensitive
S. bombyx	Tolerant	N/A	Not sensitive

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

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

212. As described in Chapter 8 Marine Geology, Oceanography and Physical Processes**,** pre-sweep activities associated with the export cable would result in the removal and disposal of up to 500,000m^3 within the SAC and 100,000m^3 in the offshore cable corridor outside the SAC. A further 1,800,000m^3 of sediment may arise from pre-sweeping export cables within the OWF sites (assessed in section 10.7.4.4). In addition, trenching activity could result in the release of up to 3,000,000m^3 (Table 10.12) of a material from within the offshore cable corridor.

213. Although a large quantity of material could be released, this would occur over a large area 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.

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

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

216. The spoil from the pre-sweep activities would be deposited within a disposal site within the Norfolk Vanguard 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 10.7.3.5.1 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 of the Information to Support HRA report (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 depending on the environmental conditions and nature of disposal (Table 8 of Appendix 7.1 of the Information to Support HRA report), however as described in the Appendix 7.1 of the Information to Support HRA report, 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).

217. 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.

218. Chapter 8 Marine Geology, Oceanography and Physical Processes concludes the magnitude of increase in suspended sediment concentrations to be low in the near field (likely to be of the order of several hundred metres but worst case of up to a kilometre from the offshore cable corridor) and negligible in the far field.

219. 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.

220. 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 of the Information to Support HRA report (document reference 5.3). Therefore, some or all of the sediment (depending on the duration between phases) would have migrated away from the disposal site by the time disposal occurred for the second trench.

221. 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.

222. 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.

223. 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.

224. 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 deemed to be low.

225. As discussed in Impact 1, 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;

- *Sabellaria 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).

226. 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 to increased suspended sediment and smothering by deposited sediment (source: Tillin, 2016; Tillin & Marshall, 2015; Tillin, 2016b)

Receptor	Tolerance	Recoverability	Overall sensitivity
Light smothering – up to 5cm			
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	Not Sensitive* - Low
Sabellaria 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		
Circalittoral mixed sediment	Not available		
***Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel**	Medium	Medium	Medium
***Sabellaria 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

Receptor	Tolerance	Recoverability	Overall sensitivity
Sabellaria 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

227. 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.

228. Any disposal would be located to avoid sensitive habitats such as *Sabellaria* reef and therefore the sensitivity of receptors is considered to be at worst medium.

229. In accordance with Table 10.6 a medium sensitivity, high value and low magnitude of impact for the offshore cable corridor mean that this impact would likely be of **minor adverse** significance.

Haisborough, Hammond and Winterton SAC

230. As mentioned in previous sections, 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 the offshore cable corridor. Any disposal sites would be located to avoid likely *Sabellaria* reef and where possible the biotope (SS.SBR.PoR.SspiMx) and locations where grab samples showed *Sabellaria* reef to be present.

231. 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 is actively influenced by ongoing hydrodynamic processes and changes over time (Section 8.5.10 in Chapter 8).

232. The potential impacts of increase in suspended sediment concentrations 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 reference 5.3).

Cromer Shoal Chalk Beds MCZ

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

234. 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 impacts from suspended sediment and deposition within the MCZ are expected to be negligible.

235. 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 its designation the value of the designated features must be considered high, however during the benthic surveys which included a small section of the southern part of the MCZ (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. 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.

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

236. Under the two phased construction programme the installation of export cables will take approximately three months per phase over approximately four years (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 impact 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.

237. Under a two phased approach 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. Due to the fact that the cables installed under different phases would be approximately 120m apart a different area of seabed would be affected.

238. 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 impact for a two phased would be similar to that of a single phase. The magnitude of the impact is therefore considered to be low.

239. 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.

10.7.4.6 Impact 2 Summary: Temporary increase in suspended sediment concentrations and associated sediment deposition in the- Norfolk Vanguard offshore project area

240. The magnitude of physical disturbance on benthic ecology in the OWF sites is low and the greatest sensitivity is medium, regardless of the division of capacity between NV East and NV West or the phased approach to construction and therefore the overall worst case impact of physical disturbance is considered to be of **minor adverse** significance.

241. The overall impact of suspended sediments in the OWF sites and offshore cable corridor would have minimal spatial overlap. In the context of the wider study area this overall impact is deemed to remain of low magnitude and therefore of **minor adverse** significance.

242. The confidence in this assessment is high. 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 deemed to be conservative.

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

243. Given the low level of contaminants present in the sediments within the offshore wind farm sites and offshore cable corridor (Table 9.10 in Chapter 9 Marine Water and Sediment Quality), changes in water and sediment quality throughout the study area due to re-suspension of contaminants during construction have been assessed as negligible. One sample station in the NV West was found to have slightly elevated levels of Arsenic above that of 'Cefas Action Level 1' but well within 'Level 2'[8] (see Chapter 9 Marine Water and Sediment Quality).

244. 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.

245. All relevant construction activities would be covered by the PEMP (in accordance with the outline PEMP, document 8.14) as well as emergency plans in the case of an

[8] Based on Cefas (2000) in relation to dredging and disposal at sea:
Action Level 1 - not considered to be of concern
Action Level 2 - generally considered to be unsuitable for disposal at sea.
Between Action Levels 1 and 2 - would require further consideration of additional evidence.

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.

246. As a result of the absence of significant existing contamination[9] and the application of mitigation to avoid release of contaminants, there would be **no impact** to the benthic ecology.

10.7.4.8 Impact 4: Underwater noise and vibration

247. Underwater noise and vibration from UXO clearance and pile driving for the installation of monopiles, pin-piles for jackets or piled anchors for tension leg floating platforms (as described in Chapter 5 Description of the Development) has potential to impact on benthos.

248. The maximum hammer energy for piling would be 5,000kJ for 20MW monopile foundations, of which there would be up to 90 turbines. The maximum number of piling operations would be associated with quadropod jackets or piled anchors which would have four piles per turbine (800 piles in total) and a 2,700kJ hammer would be used. In addition, piling may also be required for the two met masts, two accommodation platforms and three offshore electrical platforms.

249. 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.

250. 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 vulgaris* 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 Vanguard, has shown behavioural changes at frequencies around 170Hz (Heinisch and Weise, 1987).

251. 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

[9] elevated levels of arsenic were recorded however these are typical of the region; in the offshore environment these are associated with geological inputs and seabed rock weathering (see Chapter 9 Marine Water and Sediment Quality)

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.

252. The spatial extent of underwater noise and vibration impacts on benthic receptors is unknown; however, foundation installation activities would be temporary, occurring over 20 months under the single phase contraction scenario. Active piling activity would take up to 1,260 hours within this period for the maximum of 200 quadropod foundations and six offshore platforms (i.e. active piling for 9% of the time during the foundation installation period). The maximum duration per foundation would be 12 hours (for the largest 20MW foundations allowing contingency, e.g. for refusals). The magnitude of this impact is therefore deemed to be negligible.

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

10.7.5 Potential Impacts during Operation

10.7.5.1 Impact 1A: Permanent loss of seabed habitat through the presence of seabed infrastructure in the OWF sites

254. 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.

255. Table 10.12 outlines the project infrastructure that would be placed on the seabed for the duration of the project. The total footprint in either NV West or NV East could be up to 11.6km^2 based on the full 1800MW capacity and associated infrastructure being located in either site.

256. Several wind farm developments have had post-construction monitoring requirements, in particular relating to *S. spinulosa.* During post-construction monitoring at the Greater Gabbard wind farm *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 the London Array offshore wind farm *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 individuals were found (MarineSpace, 2015).

257. 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). In year 1 (2010) benthic sampling, *S. spinulosa* were found to

be the 8th most abundant species, with 120 individuals recorded. Individuals were recorded at 3 sites along the export route with up to 6 individuals in a grab sample.

258. In year 2 (2011), *S. spinulosa* had increased in number to be the 5th most abundant species at Gunfleet Sands 1 and 2 with 285 individuals. At one of the export cable sample locations, 71 individuals were recorded from the three grabs taken, with the average number per grab being 23.67. This location had the largest number of *S. spinulosa* recorded out of all the sample locations within the wind farm boundary (CMACS, 2012).

10.7.5.1.1 Assessment of impacts in NV West

259. 11.6km^2 equates to 3.93% loss of habitat within NV West. 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 Vanguard offshore project area and the wider former East Anglia Zone.

260. As previously discussed, NV West does not overlap with any designated sites however potential *Sabellaria* reef was recorded with no or 'low' reef characteristics (see Appendix 10.1). The remaining habitat within NV West is characterised as 'Circalittoral coarse sediment' biotope.

261. 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, however in the context of community level impacts for habitats and species in the Norfolk Vanguard area the overall magnitude is deemed to be low. The resulting impact would be of **minor adverse** significance.

262. 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 10.7.5.3) in relation to the potential impact of colonisation of the new artificial substrate created by the project infrastructure.

10.7.5.1.2 Assessment of impacts in NV East

263. If all turbines were placed in NV East the total footprint would represent 3.9% of the site. The magnitude of impact in NV East is also deemed to be low.

264. The biotopes within the NV East site are circalittoral fine, muddy or coarse sand (SS.SCS.CCS, SS.SSa.CFiSa or SS.SSa.CFiSa/ SS.SSa.CMuSa). As discussed above, within the footprint of habitat loss there would be a removal of these biotopes and associated fauna, however in the context of these biotopes in the surrounding area, the sensitivity to this loss is deemed to be low.

265. As previously discussed, NV East also does not overlap with any designated sites but contains potential *Sabellaria* crust and reef with a “low reefiness score” (Figure 10.11) and therefore a medium sensitivity is assigned.

266. As such, the significant of this impact within NV West would be **minor adverse**.

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

10.7.5.2.1 Assessment of impacts in the offshore cable corridor

267. 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. The maximum footprint of cable protection would be 0.16km^2 which represents 0.07% of the offshore cable corridor. The need for reburial and/or protection would be significantly less where pre-sweeping is used (see section 10.7.3.5.1). The installation of cable protection is deemed to be an impact of negligible magnitude.

268. 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;
- *Sabellaria 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.

269. 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 biotopes in the surrounding area, the sensitivity to this loss is deemed to be low or medium in the case of SS.SBR.PoR.SspiMx**.** The resulting impact is therefore of **minor adverse** significance in relation to potential loss of *Sabellaria* biotope or **negligible** for the wider offshore cable corridor.

Haisborough, Hammond and Winterton SAC

270. 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).

271. Micrositing will be undertaken where possible around sensitive features; however there remains the potential for small areas of *Sabellaria* 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 Vanguard cable protection, see section 10.7.5.5.

272. The potential impact of permanent loss of seabed habitat is considered with respect to achieving the conservation objectives of the SAC within Section 7.4 of the Information to Support HRA Report (document reference 5.3).

10.7.5.2.2 Impact 1 Summary: Norfolk Vanguard offshore project area

273. The magnitude of habitat loss on benthic ecology in the OWF sites is low and the greatest sensitivity is medium, regardless of the division of capacity between NV East and NV West or the phased approach to construction and therefore the overall worst case impact of physical disturbance is considered to be of **minor adverse** significance.

274. The overall impact of habitat loss in the OWF sites and offshore cable corridor would have no spatial overlap; however, consideration should be given to the combined impact in the context of the wider area. The total footprint of all habitat loss is 11.75km^2 which represents 1.42% of the offshore project area and remains of low magnitude in the context of the offshore project area as well as the wider study area.

275. The confidence in this assessment is high. 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 deemed to be conservative.

10.7.5.3 Impact 2A: Temporary seabed disturbances from maintenance operations in the OWF sites

276. There is potential for physical disturbance to benthic organisms and habitats during operation where maintenance activities require the use of jack-up vessels and 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.

277. The worst case scenario for jack-up vessel footprint during O&M activities in either site will be 0.52km^2 per year. In addition, reburial of an estimated 25% of array cable would result in an impact footprint of 0.09km^2 per year and two array cable repairs per year would result in a footprint of 0.04km^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.

278. Whilst there is potential for recurring disturbance during maintenance, the initial micro-siting where possible would avoid any sensitive features therefore the potential for recurring impacts during O&M is also minimised. With regard to maintenance of cables it is highly unlikely that the same stretch of cable would repeatedly fail and therefore recurring disturbance in the same location is considered highly unlikely.

10.7.5.3.1 Assessment of impacts in NV West

279. A physical disturbance footprint as detailed above within NV West is considered to be low magnitude. The sensitivity of species and habitats within the NV West site to physical disturbance have been discussed under Construction Impact 1, with sensitivities being classed as low to medium (taking medium as a precaution).

280. A low magnitude of impact combined with medium sensitivities leads the overall impact in the NV West site to be assessed as **minor adverse**.

10.7.5.3.2 Assessment of impacts in NV East

281. A physical disturbance footprint as detailed above within NV East is considered to be low magnitude. The sensitivity of species and habitats within the NV East site to physical disturbance has been discussed under Construction Impact 1, with sensitivities being classed as low to medium.

282. A low magnitude of impact combined with low to medium sensitivity leads the overall impact in the NV East site to be assessed as **minor adverse**.

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

10.7.5.4.1 Assessment of impacts in the offshore cable corridor

283. 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 1.2km^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 10km per cable (up to 20km in total) is estimated to require reburial within the SAC with a total disturbance footprint of 0.6km^2 over the operational period.

284. 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.

285. The potential impacts of temporary disturbance from operation and maintenance activities is considered with respect to achieving the conservation objectives of the SAC within Section 7.4 of the Information to Support HRA Report (Document reference 5.3).

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

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

287. Boulders and mattresses used in cable protection have been found to add habitat complexity in otherwise barren muddy seafloors, increasing the heterogeneity of the environment in and around offshore wind farms (Lindeboom *et al*., 2011; Goriup, 2017).

288. Table 10.16 below shows the sensitivities of the aforementioned biotopes to habitat change to hard or artificial habitat.

Table 10.17 Biotope sensitivity 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	*Sabellaria spinulosa* on stable circalittoral mixed sediment	None	Very low	High
SS.SCS.CCS.Pkef	*Protodorvillea kefersteini* and other polychaetes in	None	Very low	Medium* - High

Biotope code	Biotope description	Tolerance	Recoverability	Overall sensitivity
	impoverished circalittoral mixed gravelly sand			

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

289. *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. So 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.

290. *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.

291. 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 (if not from sandy to hard, then at least from natural to artificial) and therefore the impact to any ecological receptors cannot be considered beneficial in ecological terms.

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

293. Hard substrates introduced by the project would include foundations and scour protection for wind turbines, electrical platforms, accommodation platforms, meteorological masts and cable protection. The area of introduced substrate is difficult to calculate, however it would be in excess of the 11.6km^2 area calculated across the OWF sites.

294. 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 Offshore Wind Farm in Dutch waters, new hard substrate led to the establishment of new faunal communities and new 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).

295. 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.

296. *S. spinulosa* was recorded on the newly introduced artificial hard substrate at Horns Rev wind farm, suggesting that artificial hard bottoms created by the construction of offshore wind farms offer suitable substrates for *S. spinulosa* colonisation. There was also 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).

297. Several wind farm developments have had post-construction monitoring requirements relating to *S. spinulosa.* During post-construction monitoring at the Greater Gabbard wind farm *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 the London Array offshore wind farm; *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).

298. Foundations with scour protection represent the maximum surface area for recolonisation.

299. 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 0.7km^2 of cable protection may be required (e.g. rock armour, mattresses or sand-filled geotextile bags) across the entire offshore project area.

300. 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 impact is considered to be low.

301. 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 moderate, taking a precautionary principle.

302. Alterations to existing communities allowing colonisation of new substrate within the offshore project area are likely to result in an impact of **minor adverse** significance. Confidence in the accuracy of this assessment is low due to the difficulty predicting exactly what species may colonise the structures; therefore, a precautionary approach has been used to assess the impact.

10.7.5.6 Impact 4: Electromagnetic Fields (EMF) from installed array and export cables

303. EMFs as a result of the presence of array, platform link, 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. Therefore, the magnitude of such an impact is considered negligible.

304. 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).

305. 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.

10.7.6 Potential Impacts during Decommissioning

306. 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 licencing 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.*

307. 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, cable scour and protection 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: Introduction of invasive species from decommissioning vessels.

308. The magnitude of effects would be 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.

10.8 Cumulative Impacts

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

310. 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 OWF sites	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 Boreas sharing the same offshore cable corridor as Norfolk Vanguard.
3	Temporary habitat loss/disturbance in the intertidal zone	No	There is no impact from Norfolk Vanguard and therefore no potential cumulative impact.
4	Temporary increases in suspended sediment concentrations and associated sediment deposition in the OWF sites	Yes	Norfolk Boreas and East Anglia THREE are 1km and 0km from NV East, respectively. There is therefore potential for cumulative impacts associated with suspended sediments and deposition towards the perimeter of each wind farm if construction is undertaken at the same time.
5	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 Boreas, sharing the same offshore cable corridor, as well as impacts from aggregate dredging.
6	Changes to water quality	No	There is no impact from Norfolk Vanguard and therefore no potential cumulative impact.
7	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			
6	Permanent loss of seabed habitat in the OWF sites	Yes	Additive habitat loss/disturbance across the region
7	Permanent loss of seabed habitat in the offshore cable corridor	Yes	Additive habitat loss/disturbance of Norfolk Boreas sharing the same offshore cable corridor as Norfolk Vanguard
8	Temporary seabed disturbances from maintenance operations in the OWF sites	Yes	Additive habitat loss/disturbance across the region
9	Temporary seabed disturbances from maintenance operations	Yes	Additive habitat loss/disturbance of Norfolk Boreas sharing the same offshore cable corridor as Norfolk Vanguard

Impact		Potential for cumulative impact	Rationale
	in the offshore cable corridor		
10	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 Vanguard to avoid the spread of non-native invasive species and it is expected that other projects would follow best practice.
11	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 the same as those identified during the construction stage.			

10.8.1 Cumulative Impacts for the Norfolk Vanguard OWF sites

10.8.1.1 Habitat loss/ disturbance associated with the OWF sites during construction and operation

311. 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.

312. In cases where sensitive habitats are present (e.g. *Sabellaria* 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 OWF sites

10.8.1.2.1 During Construction

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

314. There is potential for the construction phase of NV East to overlap with Norfolk Boreas and East Anglia THREE due to having shared boundaries. As discussed in Section 10.7.4.4, the majority of suspended sediment from Norfolk Vanguard 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) provides similar estimates and it is assumed that the Norfolk Boreas impacts will be comparable. 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 project's turbine spacing at least equivalent to the minimum spacing (680m) required within Norfolk Vanguard. This will be few in number 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 Vanguard offshore cable corridor

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

315. As discussed in Chapter 8, theoretical bed level changes of up to 2mm are estimated as a result of cumulative impacts of Norfolk Vanguard cable installation and dredging at nearby aggregate sites. The sensitivity of benthic receptors to this level of change would be as described in Section 10.7.4.4 and the magnitude of this level of change is negligible and therefore the cumulative impact significance will be **negligible.**

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

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

317. It is likely that installation of the Norfolk Boreas export cables will follow after the Norfolk Vanguard export cables with no temporal overlap. The spatial footprint of installation works for both Norfolk Vanguard and Norfolk Boreas is likely to be double that of Norfolk Vanguard as a worst case scenario, although some elements of the seabed preparation may overlap and therefore reduce the overall combined footprint. As discussed in Table 10.12, the temporary footprint disturbance from export cable installation for Norfolk Vanguard would be up to 13km^2, of which up to 9.45km^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. Assuming Norfolk Boreas also requires up to two export cables, the additional footprint for Norfolk Boreas would be 13km^2, of which 9.45km^2 would be within the Haisborough, Hammond and Winterton SAC. The combined footprint of 26km^2 represents 11% of the shared offshore cable corridor which is deemed to be a low impact magnitude in the context of the wider available habitat.

318. As discussed in Section 10.7.1, Norfolk Vanguard Limited commission a detailed export cable installation study by CWind (2017 unpublished) 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 *Sabellaria* reef.

319. Micrositing will be undertaken for Norfolk Vanguard and Norfolk Boreas, where possible, to minimise potential impacts on sensitive habitats and therefore the cumulative impact is deemed to be **minor adverse.**

10.9 Inter-relationships

320. The construction, operation and decommissioning phases of the proposed Norfolk Vanguard project 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.

321. 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 10.19.

Table 10.19 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	Impacts as a result of suspended sediments and deposition are assessed in	Changes in suspended sediment concentrations are identified in Chapter 8 and, as a measure of

Topic and description	Related Chapter	Where addressed in this Chapter	Rationale
	and Physical Processes and Chapter 9 Marine Water and Sediment Quality	Sections 10.7.4.4, 10.7.4.5 and 10.7.6.	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 10.7.4.7	Chapter 9 provides assessment of the potential for contaminants to be present in the study area.

10.10 Interactions

322. 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 10.20, along with an indication as to whether the interaction may give rise to synergistic impacts.

Table 10.20 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 Increases in suspended	4 Colonisation	5 Electromagnetic Fields (EMF)

Potential interaction between impacts					
			sediment and deposition	of structures	
1 Permanent loss of seabed habitat	-	Yes	Yes	Yes	Yes
2 Temporary seabed disturbances	Yes	-	Yes	No	Yes
3 Increases in suspended sediment	Yes	Yes	-	No	Yes
4 Colonisation of structures	Yes	No	No	-	No
5 Electromagnetic Fields (EMF)	Yes	Yes	Yes	No	-
Decommissioning					
It is anticipated that the decommissioning impacts will be similar in nature to those of construction.					

10.11 Summary

323. 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 offshore project area has a characteristic low diversity sandy habitat. Surveys within NV West and the offshore cable corridors show potential areas of the biotope '*S. spinulosa* on stable circalittoral mixed sediment'.

324. The construction, operation and decommissioning phases of Norfolk Vanguard would cause a range of effects on the benthic ecology which are summarised in Table 10.21. 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.

325. 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.

326. 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 10.21 is relevant to all scenarios described in Section 10.7.2.

Table 10.21 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 NV West and NV East	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	Nothing further to embedded mitigation	**Minor Adverse**
	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 NV West and NV East	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**
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 and species within NV West and NV East	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 and species within NV West	Medium	Low	Minor Adverse	Nothing further to embedded mitigation	**Minor Adverse**
	Habitats and species within NV East	Medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor Adverse**
	Habitats and species within the offshore cable corridor	Low or medium	Negligible	Negligible	Nothing further to embedded mitigation	**Negligible**
	Haisborough, Hammond and Winterton SAC	Medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
Temporary seabed disturbances from maintenance operations	Habitats and species within NV West	Medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
	Habitats and species within NV East	Low	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
	Habitats and species within the offshore cable corridor	Medium	Negligible	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
Increases in suspended sediment concentrations and associated sediment deposition	Habitats and species within the offshore project area	Low	low to negligible	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		Negligible	Negligible	Negligible	Nothing further to embedded mitigation	**Negligible**

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