East Anglia TWO Offshore Windfarm

Chapter 9

Benthic Ecology

Environmental Statement Volume 1

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Glossary of Acronyms

BGS	British Geological Society
BTO	British Trust for Ornithology
CIA	Cumulative Impact Assessment
CMACS	Centre for Marine and Coastal Studies
cSAC	Candidate Special Area of Conservation
DCO	Development Consent Order
DDV	Drop Down Video
DECC	Department of Energy and Climate Change
EAOW	East Anglia Offshore Wind
EC	European Commission
EEC	European Economic Community
EIA	Environmental Impact Assessment
EMF	Electromagnetic Field
EMODNET	European Marine Observation and Data Network
EPP	Evidence Plan Process
ES	Environmental Statement
ETG	Expert Topic Group
EU	European Union
FEPA	Food and Environmental Protection Act
FERA	Food and Environment Research Agency
HDD	Horizontal Directional Drilling
HM	Her Majesty‘s
HRA	Habitats Regulations Assessment
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
IEEM	Institute of Ecology and Environmental Management
IPC	Infrastructure Planning Commission
JNCC	Join Nature Conservation Committee
LAT	Lowest Astronomical Tide
MarESA	Marine Evidence Based Sensitivity Assessment
MarLIN	Marine Life Information Network
MARPOL	International Convention for the Prevention of Pollution from Ships
MCZ	Marine Conservation Zone
MESH	Mapping European Seabed Habitat Project
MMO	Marine Management Organisation
MNNS	Marine Non-Native Species
MPS	Marine Policy Statement
NBN	National Biodiversity Network
NPL	National Physical Laboratory
NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project
ODPM	Office of the Deputy Prime Minister
OES	Ocean Energy Systems
O&M	Operation and Maintenance
oOOMP	Outline Offshore Operations and Maintenance Plan
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
PEIR	Preliminary Environmental Information Report
PEMP	Project Environmental Management Plan
PID	Public Information Days

REC	Regional Environmental Characterisation
rMCZ	Recommended Marine Conservation Zone
SAC	Special Area of Conservation
SMRU	Sea Mammal Research Unit
SNCB	Statutory Nature Conservation Body
SPA	Special Protection Area
SPR	ScottishPower Renewables
SSSI	Site of Special Scientific Interest
UK BAP	United Kingdom Biodiversity Action Plan
UXO	Unexploded Ordnance
ZEA	Zonal Environmental Appraisal

Glossary of Terminology

Applicant	East Anglia TWO Limited
East Anglia TWO project	The proposed project consisting of up to 75 wind turbines, up to four offshore electrical platforms, up to one construction, operation and maintenance platform, inter-array cables, platform link cables, up to one operational meteorological mast, up to two offshore export cables, fibre optic cables, landfall infrastructure, onshore cables and ducts, onshore substation, and National Grid infrastructure.
East Anglia TWO windfarm site	The offshore area within which wind turbines and offshore platforms will be located.
Horizontal directional drilling (HDD)	A method of cable installation where the cable is drilled beneath a feature without the need for trenching.
Inter-array cables	Offshore cables which link the wind turbines to each other and the offshore electrical platforms, these cables will include fibre optic cables.
Landfall	The area (from Mean Low Water Springs) where the offshore export cables would make contact with land, and connect to the onshore cables.
Meteorological mast	An offshore structure which contains metrological instruments used for wind data acquisition.
Marking buoys	Buoys to delineate spatial features / restrictions within the offshore development area.
Natura 2000 site	A site forming part of the network of sites made up of Special Areas of Conservation and Special Protection Areas designated respectively under the Habitats Directive and Birds Directive.
Offshore cable corridor	This is the area which will contain the offshore export cables between offshore electrical platforms and landfall.
Offshore development area	The East Anglia TWO windfarm site and offshore cable corridor (up to Mean High Water Springs).
Offshore electrical platform	A fixed structure located within the windfarm 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 would bring electricity from the offshore electrical platforms to the landfall. These cables will include fibre optic cables.
Offshore construction, operation and maintenance platform	A fixed structure required for construction operation and maintenance personnel and activities.
Offshore platform	A collective term for the construction, operation and maintenance platform and the offshore electrical platforms.
Platform link cable	Electrical cable which links one or more offshore platforms. These cables will include fibre optic cables.
Safety zones	A marine area declared for the purposes of safety around a renewable energy 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.

9 Benthic Ecology

9.1 Introduction

1. This chapter of the Environmental Statement (ES) describes the ecology of the sea bed (benthic ecology) within the East Anglia TWO offshore development area in the context of the wider southern North Sea. Potential impacts are assessed, and mitigation measures identified where appropriate.

2. This chapter has close links to and should be read in conjunction with ***Chapter 10 Fish and Shellfish Ecology*** and ***Chapter 13 Commercial Fisheries***. ***Chapter 10 Fish and Shellfish Ecology*** addresses the ecological impacts on fish and shellfish receptors while ***Chapter 13 Commercial Fisheries*** addresses the potential impacts on commercially important fish and shellfish fisheries.

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

- ***Chapter 7 Marine Geology, Oceanography and Physical Processes***;
- ***Chapter 8 Marine and Sediment Quality***;
- ***Chapter 11 Marine Mammals***; and
- ***Chapter 12 Offshore Ornithology***.

4. This chapter is supported by the following Appendices:

- ***Appendix 9.1 Benthic Ecology Consultation Responses***
- ***Appendix 9.2 Benthic Ecology Sampling Strategy***;
- ***Appendix 9.3 Benthic Survey Factual Data Report***; and
- ***Appendix 9.4 Benthic Statistical Analysis Report***

5. This section of the ES was written by Royal HaskoningDHV and has been prepared in consideration of the relevant National Policy Statements (NPS) guidance (see ***section 9.4.1***). This chapter incorporates survey results and advice from contributors including Bibby HydroMap and Benthic Solutions Limited. Technical information has drawn upon the results of the East Anglia Zonal Environmental Appraisal (ZEA) surveys and Regional Environmental Characterisation (REC) studies, as well as data gathering campaigns, undertaken to inform the East Anglia THREE and East Anglia ONE Environmental Impact Assessments (EIAs).

9.2 Consultation

6. Consultation is a key feature of the EIA process, and continues throughout the lifecycle of a project, from its initial stages through to consent and post-consent. To date, consultation with regards to benthic ecology has been undertaken via Expert Topic Group (ETG) meetings, described within ***Chapter 5 EIA Methodology***, with meetings held in April 2017, March 2018 and June 2019,

through the Scoping Report (ScottishPower Renewables (SPR) 2017) and the Preliminary Environmental Information Report (PEIR) (SPR 2019). Feedback received through this process has been considered in preparing the ES where appropriate and this chapter has been updated for the final assessment submitted with the Development Consent Order (DCO) application.

7. The responses received from stakeholders with regards to the Scoping Report, PEIR, as well as feedback to date from the benthic ecology ETG meetings, are summarised in ***Appendix 9.1***, including details of how these have been taken account of within this chapter.

8. Ongoing public consultation has been conducted through a series of Public Information Days (PIDs) and Public Meetings. PIDs have been held throughout Suffolk in November 2017, March 2018, June / July 2018 and February / March 2019. A series of stakeholder engagement events were also undertaken in October 2018 as part of phase 3.5 consultation. Consultation phases are explained further in ***Chapter 5 EIA Methodology.*** Full details of the proposed East Anglia TWO project consultation process are presented in the Consultation Report (document reference 5.1) which is provided as part of the DCO application. No issues regarding benthic ecology were raised by community consultees during any of the PIDs.

9.3 Scope

9. The East Anglia TWO windfarm site is located in the southern North Sea and is within the former East Anglia Zone. At its nearest point, the East Anglia TWO windfarm site is located approximately 37km from the port of Lowestoft and 33km from Southwold, both settlements being along the East Anglia coast.

10. The offshore cable corridor includes two potential routes from the landfall to the East Anglia TWO windfarm site. The northern route passes to the north of the Southwold Aggregates Area and Southwold Transhipment Area and would allow for a connection to an offshore electrical platform in the north of the East Anglia TWO windfarm site. The southern route passes to the south of the Southwold Aggregates Area and Southwold Transhipment Area and allows for connection to an offshore electrical platform in the centre or south of the East Anglia TWO windfarm site.

11. Detailed site description is provided in ***Chapter 6 Project Description***.

9.3.1 Study Area

12. The benthic ecology assessment for the proposed East Anglia TWO project has, where appropriate, been divided into two study areas:

- The East Anglia TWO windfarm site; and
- The East Anglia TWO offshore cable corridor.

13. Within this chapter, these study areas are also placed within the context of the former East Anglia Zone and wider southern North Sea. The East Anglia TWO windfarm site, the offshore cable corridor and landfall location are shown in context within the former East Anglia Zone in ***Figure 9.2***. Note that where both areas are relevant the term 'offshore development area' is used.

14. The study area for benthic ecology is determined by the range of potential impacts. Direct impacts will be located within the East Anglia TWO windfarm site and offshore cable corridor and indirect impacts will be determined by the extent of and range of potential changes to marine physical processes (see ***Chapter 7 Marine Geology, Oceanography and Physical Processes***). The magnitude of change on marine physical processes in the far-field (beyond approximately 1km) is unlikely to be sufficient to result in a discernible impact on benthic ecology (see ***Appendix 7.2 and 7.3***).

9.3.2 Worst Case

15. The design of the proposed East Anglia TWO project (including number of wind turbines, layout configuration, requirement for scour protection, electrical design, etc.) is not yet fully determined, and may not be known until sometime after the DCO has been granted. Therefore, in accordance with the requirements of the Project Design Envelope (also known as the Rochdale Envelope) approach to EIA (Planning Inspectorate 2018) (as discussed in ***Chapter 5 EIA Methodology***), realistic worst case scenarios in terms of potential effects upon benthic ecology are adopted to undertake a precautionary and robust impact assessment.

16. Definition of the worst case scenarios has been made from consideration of the proposed East Anglia TWO project that is presented in ***Chapter 6 Project Description***, alongside the mitigation measures that have been embedded in the design (***section 9.3.3***).

9.3.2.1 Foundations

17. The worst case scenario is based on wind turbines with a blade tip height of between 250 and 300m, therefore the worst case is based on either 60 x 300m or 75 x 250m wind turbines. In addition, up to four offshore electrical platforms, one construction, operation and maintenance platform, one meteorological mast, up to 20 buoys (LiDAR, wave recording and guard) plus offshore cables are part of the worst case.

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

- Wind turbines and meteorological mast – monopile, four-legged jacket on piles, four-legged jacket on suction caissons, gravity-base structure and suction caisson;

- Offshore electrical and construction, operation and maintenance platforms – eight-legged jacket on piles, eight-legged jacket on suction caissons and gravity-base structure.

9.3.2.2 Boulder Clearance

19. High-resolution, pre-construction geophysical surveys would identify any requirement for boulder clearance within the offshore development area. A review of the geophysical survey data carried out for the site reveals that, given the low proportion of large boulders in the area, it is likely that micrositing around large boulders would be possible.

20. Where smaller boulders are in the path of the cable plough they would be removed either by the pre-lay grapnel run (PLGR) or a dedicated plough or grab. Smaller boulders are anticipated to be removed during the PLGR activity and therefore disturbance associated with their movement is captured within the parameters in ***section 9.3.2.3.1.1***. For boulders up to 1m diameter there would be a temporary disturbance footprint at the source location they are moved from (see construction Impact 1 ***section 9.6.1.1***) and a change in habitat at the location they are moved to (see construction Impact 6 ***section 9.6.1.6***). As a worst case it has been assumed that up to 300 boulders with a maximum diameter of 1m may have to be removed and relocated, this is based on experience from the recently constructed East Anglia ONE project. This results in a total temporary disturbance footprint of 235.5m^2 for 300 boulders and a total change in habitat area at the locations they are moved to, of also 235.5m^2.

21. Superficial boulders will also need to be cleared around wind turbine foundations at the locations where jack-up legs will be placed on the sea bed to ensure a safe jacking up procedure. Whilst the need and extent of this activity will be informed by the detailed pre-construction geophysical information, boulders will only be cleared for the areas over which the jack up legs will be placed. Therefore, the disruption to the sea bed that may occur as a result of this activity would not exceed the disruption already quantified for jacking up. Superficial boulders would be side-cast locally in an area presumed to already host boulders on the basis that there is a need to move them anyway.

9.3.2.3 Cable Installation Footprints

9.3.2.3.1 Pre-installation works

9.3.2.3.1.1 Pre-lay Grapnel Run

22. A pre-lay grapnel run would be carried out to clear any debris (including small boulders) in advance of installation of cables. A conservative maximum width of sea bed disturbance along the pre-lay grapnel run of 20m has been assumed to account for potential future increases in cable laying plough and pre-lay grapnel run requirements. For example, the width of the export cable installation plough being used on East Anglia ONE is 5.5m wide.

9.3.2.3.1.2 Sand Wave Levelling

23. 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 sea bed surface that is unlikely to require reburial throughout the life of the project. A final decision on this would be made post-consent, following acquisition of high-resolution geophysical data to inform final project design.

24. Indicative sand wave levelling (pre-sweeping) volumes removed for export cable, array cable and platform link cables would be up to 1,550,000m^3 (550,000m^3 in the windfarm site and 1,000,000m^3 in the offshore cable corridor). This volume is based on the under construction East Anglia ONE project which is similar in scale and is in a similar geographical area to the proposed East Anglia TWO project. The sediment released at any one time would be subject to the capacity of the dredger. For sand wave levelling in the East Anglia TWO windfarm site, the maximum width of pre-sweeping would be approximately 20m depending on the depth of sand waves and thus the area of temporary disturbance would be encompassed by the parameters in the pre-lay grapnel run (see ***section 9.3.2.3.1.1***) above. For pre-sweeping in the offshore cable corridor, the profile of levelling works along the export cables would be 60m wide, with an average depth of 2.5m and a slope gradient of 1:4. An assumption of 10km of sand wave levelling / pre-sweeping in the offshore cable corridor results in an area of sea bed of up to 800,000m^2 being affected by sand wave levelling / pre-sweeping in the offshore cable corridor. Any required sand wave levelling would be in discrete areas and not along the full length of the corridor. See ***Chapter 6 Project Description section 6.5.10.15*** for further detail on sand wave levelling.

25. Sediment arisings from sand wave clearance in the offshore cable corridor would be deposited back within the offshore cable corridor at locations which avoid any sensitive features such as *Sabellaria spinulosa* reefs (if their presence is determined from pre-construction surveys). Agreement is being sought for a single disposal site encompassing the offshore cable corridor which avoids overlap with existing disposal sites (see the Site Characterisation Report (Offshore Cable Corridor) document reference 8.16). However, the Applicant will consult with the MMO and their advisors post-consent on the results of the pre-construction surveys and any sensitive features that may require avoidance during sediment disposal activity. No sand wave levelling / pre-sweeping or disposal is anticipated in the near shore section of the offshore cable corridor, subject to findings of the detailed pre-construction geophysical survey.

9.3.2.3.2 Cable Burial

26. Following the pre-installation cable works as described in ***section 9.3.2.3.1***, 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 however it is likely that the majority of the cable will be installed using a plough (see ***Chapter 6 Project Description section 6.5.10.3***):

- Ploughing (realistic worst case scenario for benthic receptors);
- Trenching or cutting; and
- Jetting.

9.3.2.3.2.1 Export cables

27. The maximum length of disturbance caused by ploughing during export cable installation would be 160km based on an average plough length of 80km per cable for a total of two cables each requiring separate installation by the worst case of ploughing. The area of disturbance caused during ploughing would be encompassed by the PLGR which takes up a 20m wide swathe. This area is exclusive of that taken up for sand wave levelling in the offshore cable corridor as described in ***section 9.3.2.3.1.2***.

28. This results in a maximum area of sea bed disturbance of 3,200,000m^2 when considering a disturbance width of 20m.

9.3.2.3.2.2 Inter-array and Platform Link Cables

29. The maximum area of disturbance caused by installation of the inter-array and platform link cables would also be encompassed by the PLGR. Assuming that a PLGR is carried out over the whole length of inter-array and platform link cables (up to 200km and 75km respectively), an area of disturbance of up to 4,000,000m^2 and 1,500,000m^2 respectively would occur.

9.3.2.3.2.3 Backhoe Dredging in Offshore Cable Corridor

30. There may also be a requirement for backhoe dredging in the offshore cable corridor, for example, at the HDD pop-out location or in areas of difficult ground, which could result in a V-shaped trench cross section of up to 8.6m wide x 4m deep x 2,000m long per export cable which would result in a maximum area of sea bed disturbance of 34,400m^2 and a maximum volume of 68,800m^3 of sediment displacement for two export cables (see ***Table 9.1***). Again, all sediment material generated would be disposed of in a licensed disposal area as set out in the Site Characterisation Report (Windfarm Site) (document reference 8.15) and the Site Characterisation Report (Offshore Cable Corridor (document reference 8.16).

9.3.2.3.2.4 Volumes of sediment affected

31. The worst case estimates for areas and volumes of sediment affected during cable laying are provided in ***Table 9.1*** and ***Chapter 6 Project Description section 6.5.10.15***. A summary of the cable installation method and subsequent volumes of sediment affected is provided in the following paragraphs, however see the aforementioned sections for greater detail.

32. During cable ploughing there would be material disturbed by the presence of the cable, however this would be minimised as any resulting plough installation corridor (i.e. any trench potentially created by the cable plough) would be backfilled with its own material through natural processes.

33. The installation of subsea cables has the potential to disturb the sea bed up to a depth of 3m. It is difficult to estimate the actual volumes of sediment (and subsequent suspended sediment levels) that would be displaced during installation of cables however the types and magnitudes of effects that could be caused have previously been assessed within an industry best-practice document on cabling techniques (BERR 2008). This document has been used alongside expert judgement and analysis of site conditions to inform the relevant assessments within the ES.

34. It is anticipated that the changes in suspended sediment concentration due to cable installation would be less than those arising from the disturbance of near-surface sediments during foundation installation activities at any one location, including sea bed preparation, with the location of release changing as work progresses along the cable routes. The overall sediment release volumes at any one location would be low and confined to near the sea bed along the alignment of the cable route and the rate at which sediment is released into the water column would be relatively slow. ***Table 9.1*** summarises the estimated maximum sediment disturbance areas and volumes during the installation of export, inter-array and platform link cables. See ***Chapter 6 Project Description section 6.5.10.15*** for further information on the derivation of these maximum disturbance calculations.

Table 9.1 Total Area, Volume and Maximum Daily Sediment Volume Disturbance Calculations during Cable Installation

Activity	Maximum Area of Sea Bed Disturbance (m^2)	Total Volume of Sediment Interaction (m^3)	Worst Case Daily Volume of Sediment Interaction (m^3)
Export cable installation	3,200,000	96,000 (48,000 per cable)	2,160
Inter-Array cable installation	4,000,000	458,000	2,198.4
Platform link cable installation	1,500,000	171,750	2,198.4
Sand wave levelling for export cables	800,000	1,000,000	n/a*
Sand wave levelling inter array cables	320,000	400,000	n/a*

Activity	Maximum Area of Sea Bed Disturbance (m^2)	Total Volume of Sediment Interaction (m^3)	Worst Case Daily Volume of Sediment Interaction (m^3)
Sand wave levelling for platform link cables	120,000	150,000	n/a*
Backhoe dredging in the offshore cable corridor e.g. at the HDD pop-out location	34,400, but this area is not used in any assessments within the ES as it is already incorporated within the areas affected for export cable installation and sand wave levelling.	68,800	n/a*

** It is not believed to be practical to calculate daily sediment interaction volumes for these activities. Disposal methods and volumes would be as set out in the Site Characterisation Report (Windfarm Site) (document reference 8.15) and Site Characterisation Report (Offshore Cable Corridor) (document reference 8.16). Maximum volumes of disposed sediment during single disposal events would be subject to the capacity of the dredger.*

35. Modelling simulations undertaken for the East Anglia ONE export cable installation (ABPmer 2012b) provide the following quantification with regard to the fate of suspended sediment:

- Sand-sized sediment (which represents most of the disturbed sediment) would settle out of suspension within less than 1km from the point of installation within the offshore cable corridor and persist in the water column for less than a few tens of minutes.
- Mud-sized material (which represents only a very small proportion of the disturbed sediment) would be advected a greater distance and persist in the water column for hours to days.
- In water depths greater than 20m lowest astronomical tide (LAT), 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 depths nearer to the coast (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.
- After 180 hours following cessation of installation activities any plume would have been fully dispersed.

36. There are similarities in water depth, sediment types and metocean conditions between the offshore cable corridor for East Anglia ONE and for the proposed East Anglia TWO project making the earlier modelling studies a suitable analogue for the present assessments. Additionally, the above quantifications, particularly

those relating to deeper waters, would be relevant to sediment affected in the windfarm site during inter-array and platform link cable installation.

9.3.2.3.2.5 Export Cable Laying Vessel Anchor Footprints

37. Another potential source of sea bed disturbance during cable burial is from the anchoring of the cable laying vessel in shallow waters. A maximum estimate of sea bed disturbance from anchoring of the cable laying vessel is 15,500m^2. This is based on a maximum of 620 anchor points (based on experience from East Anglia ONE) with each anchor having an area of 25m^2. Following best practice, anchoring points would avoid agreed sensitive features.

9.3.2.3.3 Landfall

38. The export cable landfall would be made to the north of Thorpeness using HDD. There will be no works in, or access required to, the intertidal zone that could result in an impact, therefore intertidal impacts are not assessed further.

9.3.2.3.4 Cable Protection

9.3.2.3.4.1 Unburied Cable

39. Due to the largely sandy nature of the offshore development area (see ***Figure 9.3***), cable burial through ploughing is expected to be possible throughout with the exception of cable crossing locations. The areas which would be occupied by cable protection are based on calculations stated in ***Chapter 6 Project Description Table 6.19*** and are outlined below in ***Table 9.2***. It is expected that any requirement for cable protection would be considerably reduced following further detailed design studies.

9.3.2.3.4.2 Cable Crossing

40. A worst case scenario of up to 55 cable crossings within the East Anglia TWO windfarm site (i.e. East Anglia TWO cables crossing with Atlantic Crossing and the East Anglia ONE and East Anglia THREE offshore export cables) and up to 30 crossings in the offshore cable corridor has been used in the assessment. This number could be reduced if it is possible to cut the Atlantic Crossing cable.

41. The worst case for total number of cable crossings are as follows:

- Export cable: 30 crossings;
- Platform link cables: 30 crossings; and
- Inter-array cables: 25 crossings.

42. At each crossing, protection would be installed to prevent damage to existing operational cables. Each East Anglia TWO cable (export, inter-array or platform link) would then be placed on top of the layer of protection with a further layer of cable protection placed on top of that. The worst case form of cable protection would be rock as opposed to concrete mattresses, however based on East Anglia ONE, which is currently being constructed, it is likely that many of the crossings will use concrete mattresses. The worst case dimensions of rock cable protection

for cable crossings would be 8.50m wide and 160m long. The maximum height of crossings would be 2.25m.

9.3.2.3.4.3 Types of cable protection

43. The types of cable protection options that may be used are discussed in ***Chapter 6 Project Description section 6.5.10.4***.

44. The areas of habitat affected by cable protection are outlined in ***Table 9.2***.

9.3.2.3.5 Vessel Footprints

45. Jack-up vessels may be used to install the wind turbines, offshore platforms and meteorological mast, the jack-up legs will be placed on the sea bed causing disturbance for which a worst case footprint of 3,000m^2 per single jack-up operation has been assumed. A conservative assumption estimates that the jack up vessel would need to reposition three times for each installation. A worst case jack-up footprint of 9,000m^2 per foundation has therefore been assumed as a worst case.

9.3.2.4 Maintenance

9.3.2.4.1 Wind Turbines and Offshore Platforms

46. Periodic maintenance throughout the East Anglia TWO windfarm site would be required during operation. These works will have minimal impact on benthic ecology however the placement of jack up vessel legs during maintenance activity has been considered to provide a comprehensive assessment.

47. It has been assumed that there may be a requirement for a jack-up vessel to visit each wind turbine once every two years to carry out maintenance. It has been assumed that, for maintenance purposes, the vessel would jack-up once at each wind turbine location resulting in a disturbance footprint of 3,000m^2 (based on the spud-can footprint of the jack-up vessel) per wind turbine. Therefore, as a worst case, a temporary disturbance footprint from jack-up vessels during maintenance activities of 112,500m^2 per annum has been assumed.

48. While the worst case scenario assumes that up to 687 vessel trips per annum to the East Anglia TWO windfarm site would be required, these trips relate primarily to the movements of Crew Transfer Vessels (CTVs) which do not routinely anchor. The above disturbance estimates for jack-up vessels have sufficient redundancy to accommodate any rare occasions when a CTV would need to anchor. Therefore, no assessment of these vessels anchoring has been undertaken.

9.3.2.4.2 Cable Repairs

49. During the life of the proposed East Anglia TWO 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.

50. 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 five maintenance activities requiring the use of a cable laying vessel per year has been assessed.

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

- Vessel anchor placement;
- Exposing / digging up the damaged part of the cable using jetting (3m disturbance width);
- Cutting the cable – assumed to be approximately 300m of export cable and platform link cable although length subject to the nature of the repair, or the whole length of an array cable (up to 4km although in reality, individual inter-array cables would be much shorter);
- 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 sea bed; and
- Cable burial, where possible.

9.3.2.4.3 Percentage Sea Bed Areas Affected

52. The definitions of the worst case scenarios have been made from consideration of ***Chapter 6 Project Description***.

53. ***Table 9.2*** outlines the worst case scenarios for each identified impact. Where percentage areas affected have been calculated, these are based on a total windfarm site area of 218.4km^2 and an offshore cable corridor area of 137.6km^2 which results in a total offshore development area for the assessment of 356km^2. As a worst case, the offshore cable corridor area has been calculated based on the northern route (see ***Figure 9.2***) which has the largest area of the two routes and from which the worst case export cable length was calculated. This has been done in consideration of the ecological sensitivity of the fauna and biotopes, for which there was deemed to be no discernible difference between the northern and southern cable route options (based on the current available information (see ***section 9.5***)) to warrant one cable route option being the worst case. Therefore, it has been based on area. It would not be realistic to combine the areas for both route options as in reality only one of these routes will be used following final design of the project.

Table 9.2 Realistic Worst Case Scenarios

Impact	Parameter	Justification / Rationale
Construction		
Impact 1: Temporary physical disturbance	Worst case scenario is associated with 250m wind turbines with four-legged jacket suction caisson foundations. Worst case preparation area per 250m wind turbine = 6,947.63m^2 Sea bed preparation area for offshore development area: Sea bed preparation for 75 x 250m wind turbine on four-legged jackets with suction caissons = 521,071.88m^2. Four offshore electrical platforms and one construction, operation and maintenance platform each with a sea bed preparation area of 37,312m^2 = 186,560m^2. One operational meteorological mast assumed to be the same as sea bed preparation for one 250m wind turbine with four-legged jacket on suction caissons foundation which is conservative = 6,947.63m^2 Pre-lay grapnel run with a 20m wide swathe along the whole length of cable routes would disturb the following areas: • 160km export cable = 3,200,000m^2 • 200km of inter-array cable = 4,000,000m^2 • 75km of platform link cable = 1,500,000m^2 Sand wave levelling: • Offshore cable corridor = 800,000m^2; • Platform link cables = 120,000m^2 • Inter-array cables = 320,000m^2	The temporary disturbance relates to sea bed preparation and cable installation. The footprint of infrastructure including cable protection is assessed as a permanent impact in Operation and Maintenance (O&M) impact 1. It should be noted that the sea bed preparation area for foundations is less than the footprint of the foundation scour protection. The area affected by sand wave levelling in the windfarm site would be encompassed by the pre-lay grapnel run while the area affected in the offshore cable corridor would differ at up to 800,000m^2 due to a wider (60m) dredge being required.

Impact	Parameter	Justification / Rationale
	Jack up barge sea bed footprint for 75 foundations (based on a jack up barge footprint of 3,000m^2 and three movements per foundation) the maximum disturbance would be 675,000m^2. Boulder clearance in the offshore development area – 300 boulders with a maximum diameter of 1m = 235.5m^2 Anchoring of the export able laying vessel – 15,500m^2. Worst case scenario total temporary disturbance footprint = **11,345,315.m^2** which constitutes 3.19% of the maximum offshore development area. Any other works associated with cable installation would be encompassed by the footprints outlined above.	
Impact 2: Increased suspended sediment concentrations and associated potential smothering of benthic receptors	The worst case scenario would involve the maximum volume of sediment disturbed through preparation of the sea bed, including: <u>Sea bed preparation</u> 75 x 250m four-legged jacket suction caisson foundations 23,731.9m^3 per wind turbine totalling 1,779,890.63m^3. Eight-legged jacket suction caisson foundations for up to four offshore electrical and one construction, operation and maintenance platform would result in a maximum sediment release into the water column of 668,800m^3. Four-legged jacket suction caisson foundation for one meteorological mast. The maximum possible amount of sediment released into the water column would be up to 23,731.9m^3.	Sea bed preparation (dredging using a trailer suction hopper dredger and levelling layer) may be required up to a sediment depth of 5m. The worst case considers the maximum volumes for the project. The worst case would be defined by 75 250m wind turbines mounted on four-legged jacket suction caisson foundations. The meteorological mast would be installed on foundations which, in the worst case for sediment disturbance, would be four-legged jacket suction caisson foundations. As a worst case, the figure for sea bed preparation for a 250m wind turbine four-legged jacket on suction caissons has been used and is considered

	<u>Sand wave levelling</u> The total volume of sediment excavated during sand wave levelling would not exceed the following: • Export cable – 1,000,000m^3 • Platform link cable – 150,000m^3 • Inter-array cables – 400,000m^3 <u>Backhoe dredging requirements</u> There may also be a requirement for dredging along the export cable route, e.g. around the HDD punch-out location during the installation of export cables. Based on East Anglia ONE values, although with adequate redundancy built in, it is assumed that up to 2.5% (2km) of each cable corridor will require dredging to a max width of 8.6m and a depth of 4m. Based on a v-shaped trench cross section the worst case volume of sediment would therefore = 68,800m^3 for both export cables. Therefore, the total volume of sediment displacement / re-suspension (i.e. from the use of a dredger) in the offshore development area requiring to be disposed of would be: **4,091,222.50m^3** <u>Cable ploughing sediment disturbance</u> • Export cable – 96,000m^3 • Inter array cables – 458,000m^3 • Platform link cables – 171,750m^3 However, temporally, the maximum volumes of sediment affected would be up to 2,198.4m^3 per day (see ***Table 9.1***).	conservative. For drill arisings the worst case for meteorological mast is based on a 300m wind turbine. The worst case with regard to sediment displacement during installation of offshore platform foundations (including four electrical and one construction operation and maintenance) would be from installation of eight-legged jacket suction caissons which would require the excavation of up to 668,000m^3. Cable ploughing and sand wave levelling – see ***Chapter 6 Project Description section 6.5.10.15*** for detail on how these numbers have been derived.

Impact	Parameter	Justification / Rationale
	<u>Drill Arisings</u> Should the installation of monopiles or jackets using pin piles be required, drilling may also be undertaken which would release subsurface materials into the water column. Wind turbine foundations based on worst case volume associated with 10% of 60 300m wind turbines with monopile foundations requiring installation by drilling (45m depth 15m diameter) = 47,713m^3 Meteorological mast based on arisings from a 300m wind turbine monopile foundation which is conservative = 7,952.16m^3 Offshore electrical and construction, operation and maintenance platforms – 43,210m^3 Total drill arisings = 98,874.56m^3 Sub-surface sediments have a different physical composition to near-surface sediments and may therefore be more widely dispersed by tidal currents. However, the volumes involved are far smaller than sea bed preparation for jacket suction caisson foundations (***Chapter 7 Marine Geology, Oceanography and Physical Processes***) and therefore it is considered that installation of jacket suction caisson foundations is the worst case scenario for re-suspension of sediments. It should be noted that sea bed 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 sea bed preparation outlined above are not aggregated.	

Impact	Parameter	Justification / Rationale
Impact 3: Re-mobilisation of contaminated sediments	As above	The worst case would involve the maximum amount of suspended sediment released into the water column. This is calculated in the row above.
Impact 4: Underwater noise and vibration	Hammer Energies The maximum amount of hammer energy for monopile installation is 4,000kJ. There would be no concurrent piling activity in the East Anglia TWO windfarm site. Piling Time Periods 325 minutes (5.42hrs) x 60 monopiles = 325 hours (300m wind turbine monopile) Unexploded Ordnance (UXO) clearance operations Up to 80 UXO devices with an up to 700kg (net explosive quantities (NEQ)) for a single UXO device.	The greatest contribution to underwater noise, which may affect benthic species, would be from installation of monopile foundations. The greater the hammer energies used the greater the amount of underwater noise produced. The maximum hammer piling duration of 325 hours (13.5 days) represents the temporal worst-case scenario for the installation of monopiles for the 300m wind turbines (this includes 10 minute soft-start and 20 minute ramp-up). This is greater than the maximum hammer piling duration of 137.5 hours for the installation of monopiles for the 250m wind turbines.
Impact 5: Potential impacts on sites of marine conservation importance	No direct impacts due to proximity of designated sites. Indirect impacts related to an increase in suspended sediments, movement of sediment in tidal currents and subsequent smothering therefore the worst case would be as above in construction impact 2.	
Impact 6: Habitat Change Resulting from Sea bed Preparation / Sediment Disposal	Worst case scenario is associated with 250m wind turbines with four-legged jacket suction caisson foundations. Preparation area per 250m wind turbine = 6,947.63m^2	It should be noted that, while the area affected by sea bed preparation for cable installation (e.g. PLGR) could potentially result in a permanent change to the already dynamic baseline habitat, the resultant sea bed conditions are likely to be very similar and would support a similar species diversity.

Impact	Parameter	Justification / Rationale
	<u>Total sea bed preparation area for offshore development area:</u> Area affected during sea bed preparation for 75 x 250m wind turbines on four-legged jackets with suction caissons = 521,072m^{2}m^2. Four offshore electrical platforms and one construction, operation and maintenance platform each with a sea bed preparation area of 37,312m^2 = 186,560m^2. One operational meteorological mast sea bed preparation for four-legged jacket on suction caisson = 6,947.63m^2 Boulder relocation by grab = 235.5m^2 Pre-lay grapnel run area for cable installation: • 160km export cable = 3,200,000m^2 • 200km of inter-array cable = 4,000,000m^2 • 75km of platform link cable = 1,500,000m^2 Sand wave levelling: • offshore cable corridor = 800,000m^2; • Platform link cables = 120,000m^2 • Inter-array cables = 320,000m^2 A total sea bed area of up to **10,654,815m^2** could therefore be subject to permanent habitat change. In terms of habitat change from the disposal of sediment the worst case would be associated with: • Backhoe dredging in the offshore cable corridor – 68,800m^3	Area of sea bed preparation for one meteorological mast on four legged jacket with suction caisson assumed to be the same as one 250m wind turbine foundation which is conservative.

Impact	Parameter	Justification / Rationale
	• Inter-array sand wave levelling – 400,000m^3 • Platform link sand wave levelling – 150,000m^3 • Export cable sand wave levelling – 1,000,000m^3 • Drill arisings for wind turbine monopiles and offshore platform pin-piles – 98,874.56m^3 This totals up to **1,717,674.56m^3** of disposed sediment in the offshore development area that could potentially result in habitat change.	
Operation		
Impact 1: Loss of habitat	The maximum possible sea bed footprint of the project including scour protection. The maximum size of the project footprint is based on the following: <u>Windfarm Site Infrastructure</u> 60m diameter gravity-based foundation and scour protection footprints together are calculated as 25,446.9m^2 per foundation (see ***Chapter 6 Project Description Table 5.7***). Therefore, for 60 foundations (see adjacent notes column) the maximum area of baseline habitat lost would be 1,526,814.03m^2 which is considered the worst case. The maximum area of baseline habitat lost due to installation of offshore electrical and construction, operation and maintenance platforms on eight-legged jackets with suction caissons with associated scour protection would amount to 15,276m^2 per platform. There would be up to five such structures totalling 76,380m^2. The gravity-base foundation and scour protection for one meteorological mast would be 2,827.43m^2.	The scenario described gives rise to the greatest area of permanent sea bed habitat loss. Areas impacted by scour would be changed irreversibly and would therefore count as habitat loss.

Impact	Parameter	Justification / Rationale
	Cable Protection in the Windfarm Site Cable protection for up to 7.5km of platform link cable due to ground conditions of up to 63,750m^2. Additionally, up to 40,800m^2 of cable protection would be required for unburied platform link cables at cable crossings. Cable protection for up to 20km of inter-array cables due to ground conditions of up to 170,000m^2. Additionally, up to 34,000m^2 would be required for unburied inter-array cables at cable crossings. Therefore, a total area of up to 308,550m^2 of cable protection would be required in the windfarm site. Total footprint during operation within the East Anglia TWO windfarm site which could be subject to permanent habitat loss is therefore 1,914,571.46m^2 which constitutes 0.89% of the windfarm site. Export Cable Cable protection due to an inability to bury export cables would result in a footprint of up to 68,000m^2 (5% of the length of each export cable). Protection associated with cable crossing for export cables would result in a footprint of up to 40,800m^2. Total footprint which could be subject to permanent habitat loss during operation of the export cables is therefore 108,800m^2 (0.08% of the northern offshore cable corridor area). **Total** The overall total footprint which could be subject to permanent habitat loss would therefore be **2,023,371.46m^2** (0.57% of the offshore development area).	

Impact	Parameter	Justification / Rationale
Impact 2: Physical disturbance	The maximum area of disturbance during operation is difficult to predict at this stage however estimates have been given based upon industry experience (also see ***section 9.3.2.4***). It has been assumed that there may be a requirement for a jack-up vessel to visit each wind turbine once every two years to carry out maintenance. It has been assumed that, for maintenance purposes, the vessel would jack-up once at each wind turbine location resulting in a disturbance footprint of 3,000m^2 per wind turbine. Therefore, for 75 250m wind turbines = 112,500m^2 per annum. There may be a need to perform maintenance operations on electrical cables during the lifetime of the project. It has been estimated that cable maintenance / replacement activities would be carried out up to five times per year (see ***Chapter 6 Project Description, section 6.5.15.1***). Work vessel anchors used for maintenance operations The majority of the 687 vessel trips involved in the maintenance of the proposed East Anglia TWO project would be from Crew Transfer Vessels (CTVs) which do not routinely anchor to the sea bed. Therefore, an assessment of these vessels anchoring has not been undertaken. The disturbance estimates for jack-up vessel maintenance have sufficient redundancy to accommodate any rare occasions when a CTV would need to anchor.	An accurate estimate of the maximum area to experience physical disturbance during operation is difficult to calculate. However, any area would only be temporarily disturbed and would be expected to rapidly recover.
Impact 3: Increased suspended sediment concentrations and associated potential	The maximum amount of suspended sediment that would be released into the water column due to changes in tidal regime around infrastructure has been calculated based on findings verified by field measurements (see ***Chapter 7 Marine Geology, Oceanography and Physical Processes section 7.6.2.4***). This has been calculated as a	The need for and type of scour protection would not be determined until the wind turbine location and associated foundation types are known.

Impact	Parameter	Justification / Rationale
smothering of benthic receptors	worst case scour volume under a 50-year return period event of about 5,000m³ for an individual foundation of similar type and size to a worst case 53m gravity-based foundation. Therefore, for 75 wind turbine foundations the maximum amount of scour material released into the water column would be 375,000m³.	Of all the foundation options under consideration 75 53m diameter gravity-base structures would cause the greatest amount of scour because the estimated volume of sediment arisings is on a per wind turbine basis. Assumptions for scour produced from ***Chapter 7 Marine Geology, Oceanography and Physical Processes***).
Impact 4: Colonisation of foundations and cable protection	The introduction of new hard structures with a maximum surface area provided by the project infrastructure outlined in operation impact 1 above.	Gravity base structures will provide the largest surface area for potential colonisation and therefore are considered to be the worst case scenario. It is not possible to accurately calculate the surface area that would be available for colonisation. It would however be greater than the figure presented for "footprint" in operation impact 1 (above) as operation impact 1 is a 2-D metric, whilst this impact is a 3-D metric.
Impact 5: Interactions of EMF with Benthic Invertebrates	The greatest impact from EMF would occur if cables are unburied or buried to the shallowest depth of 1m, and the maximum amount of cable of the maximum cable rating is utilised, based on: The maximum length of inter-array (up to 75kV of alternating current) cables would be up to 200km, with up to 24km unburied The maximum length of platform link cables would be up to 75km of 400kV High Voltage Alternating Current (HVAC) cable, with up to 12.3km unburied The maximum length of export cable (up to 600kV) would be 160km, with up to 12.8km unburied	The scenario described would pertain to the largest possible area that could be impacted by EMF. Although it should be noted that where cables are unable to be buried they would be protected which would provide some degree of attenuation of EMF.

Impact	Parameter	Justification / Rationale
Impact 6: Underwater Noise and Vibration	It is difficult to estimate the noise produced during operational activities although it will be much less than that produced during construction due to the absence of piling. Noise will primarily be associated with vessel movements for which the annual number of vessel round trips is anticipated to be 687 with the additional use of a jack-up vessel to each wind turbine every two years and five uses of a cable laying vessel every year. The level of underwater noise from operational wind turbines is also difficult to estimate however noise levels would be low and would likely reach ambient levels 100m from wind turbines (MMO 2014).	The exact vessels to be used for maintenance activities are yet to be defined so the likely levels of noise produced cannot be determined at this stage.
Impact 7: Introduction of marine non-native (MNNS) species	Based on permanent infrastructure outlined for operation impact 1.	Permanent infrastructure available for colonisation by MNNS.
Decommissioning		
Impact 1: Temporary physical disturbance	The maximum area of disturbance during decommissioning would be equal to or less than that during construction (see construction impact 1).	The maximum area of disturbance caused by decommissioning of the proposed East Anglia TWO project would result from the removal of foundations and scour protection. It has been assumed that cable protection would be left *in-situ*. See construction impact 1 for rationale on the worst case number and size of foundations that would be removed. All buried cables would simply be cut at the ends and left *in-situ*.

Impact	Parameter	Justification / Rationale
Impact 2: Increased suspended sediment concentrations and associated potential smothering of benthic receptors	As per details in construction impact 2 (above) for increased suspended sediment concentration and sediment deposition (although predicted to be much less in reality – see adjacent notes column).	Any impacts produced during decommissioning would be less than those described during the construction phase (see construction impact 2) due to absence of sea bed preparation, which is the main source of increased suspended sediment concentration during the construction phase.
Impact 3: Re-mobilisation of contaminated sediments	As above in construction impact 3.	The worst case would involve the maximum amount of suspended sediment released into the water column. This is described in the row above.
Impact 4: Underwater noise and vibration	Noise created by the removal of foundations using cutting machinery.	The removal of monopiles or piles for jacket foundations to 1-2m below sea bed level is likely to involve the use of cutting machinery. This would create underwater noise and vibration which is estimated as substantially less than that created during the installation of piles.
Impact 5: Potential impacts on sites of marine conservation importance	As above in construction impact 5.	At the time of decommissioning a further assessment of designated sites will be carried out to ensure that there is still no overlap with decommissioning activities.
Impact 6: Loss of habitats and species colonising hard structures	As per details in operation impact 4 above. It is assumed that all colonised hard substrate would be removed see ***Chapter 6 Project Description***.	Assumed that all project infrastructure above sea bed level (with the exception of cable protection which would be left *in situ*) would be removed during decommissioning, resulting in the loss of colonised substrate.

9.3.3 Mitigation and Best Practice

54. The Applicant is committed to minimising impacts on benthic communities by employing a number of techniques and engineering designs / modifications inherent in the project. These have been considered during the pre-application stage, in order to reduce, avoid or offset 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.

55. 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 6 Project Description*** and ***Chapter 4 Site Selection and Assessment of Alternatives***) including engineering requirements, ongoing discussions with stakeholders and regulators, commercial considerations and environmental best practice.

9.3.3.1 Embedded Mitigation

9.3.3.1.1 Site Selection

56. The offshore development area avoids, as far as possible, designated sites, including the Alde, Ore and Butley Estuaries Special Area of Conservation (SAC) (3.6km south east and Orfordness – Shingle Street SAC (5.09km south east) both of which have benthic features as part of their designations. The offshore cable corridor was routed to avoid direct impacts upon nearshore features such as Sizewell Bank and Aldeburgh Napes.

57. The offshore cable corridor has been designed to avoid cable crossings where possible. Where there are cable crossings these have, as far as possible, been aligned at a 90° angle. This is primarily for technical reasons but also serves to minimise the requirement for cable protection.

9.3.3.1.2 Intertidal

58. The Applicant is committed to using HDD from the intertidal zone from an onshore location to the subtidal zone. Therefore, there will be no impacts on the intertidal zone.

9.3.3.1.3 Minimising Scour Protection

59. Following industry best-practice the Applicant will seek to minimise the use of scour protection. This will be secured through a Scour Protection and Cable Protection Plan that will be submitted post consent.

9.3.3.1.4 Electromagnetic Fields (EMF)

60. The Applicant is committed to burying offshore export cables where possible which reduces the effects of EMFs.

9.3.3.2 Best Practice

61. Pre-construction survey methodology would be agreed with the MMO in consultation with Natural England. The survey design would be based on best

practice and in consultation with the relevant authorities at the time and is anticipated to consist of a mixture of geophysical, drop-down video (DDV) and grab surveys (as applicable) to ensure a comprehensive ground-truthing of the proposed final cable route design. The results of the surveys would be used to inform the location of wind turbines and the routeing of all East Anglia TWO cables, including micrositing where possible. The locations and cable routes would then be discussed and agreed with the MMO in consultation with Natural England.

9.3.3.2.1 Micrositing

62. As discussed above, should sea bed obstacles (e.g. *Sabellaria* reef not in an SAC for which reef is a qualifying feature[1]) 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. Areas of Coralline Crag in the nearshore area will also be avoided by routeing of the export cable to the south of the formation (see ***Chapter 6 Project Description***).

63. Micrositing mitigation would be agreed through consultation with the MMO and Natural England on the identified sensitive features which are required to be avoided (e.g. *Sabellaria* reef) and secured within the DCO through the In Principle Monitoring Plan (document reference 8.13), and post consent through the design plan.

9.3.3.2.2 Cable Protection

64. Burying cables is the best form of cable protection therefore surface laying with protection (e.g. rock dump) will only be undertaken where physically necessary. A detailed export cable installation study will be carried out pre-construction to inform on the potential for export cable burial throughout the offshore cable corridor however given the sandy nature of the sediment this is considered likely.

65. A Scour Protection and Cable Protection Plan will be produced post consent that will detail the scour protection and cable protection requirements for the proposed East Anglia TWO project. A cable burial risk assessment would be undertaken post consent, in consultation with the MMO and Natural England.

66. The exact method for cable crossings will be subject to crossing agreements however the worst case scenario for cable protection is discussed in ***section 9.6.2.1***.

9.3.3.2.3 Sediment Disposal

67. Sediment would not be disposed of within 50m of known *Sabellaria* reef identified during pre-construction surveys (in accordance with the latest published advice from Natural England which is, at present, that provided for the Norfolk Vanguard

[1] Note that any *Sabellaria* reef encountered would fit this description as the offshore development area does not overlap with any SAC designated for reef

project (Norfolk Vanguard Limited 2018). This requirement would be secured through the Project Environmental Management Plan (PEMP).

9.3.3.2.4 Marine Non-Native Species

68. The risk of spreading MNNS 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 PEMP which will be submitted post consent.

9.3.4 Monitoring

69. Post-consent, the final detailed design of the proposed East Anglia TWO project will refine the worst-case parameters assessed in this ES. It is recognised that monitoring is an important element in the management and verification of the actual proposed East Anglia TWO project impacts.

70. As stated in the In-Principle Monitoring Plan (document reference 8.13), no monitoring is currently planned for benthic ecology, subject to agreement with the MMO and relevant Statutory Nature Conservation Bodies (SNCBs).

71. The requirement for and final design and scope of monitoringwill be agreed with the regulator and relevant stakeholders and included within the relevant Management Plan, submitted for approval, prior to construction works commencing.

9.4 Assessment Methodology

9.4.1 Guidance

72. The characterisation of the benthic ecology baseline and the assessment of potential impacts has been made with specific consideration of the relevant NPS which are the principle decision making guidance documents for Nationally Significant Infrastructure Projects (NSIP).

73. Those relevant to benthic ecology within the proposed East Anglia TWO project are:

- Overarching NPS for Energy (EN-1) (Department of Energy and Climate Change (DECC 2011); and
- NPS for Renewable Energy Infrastructure (EN-3) (DECC 2011).

74. ***Table 9.3*** summarises the relevant NPS text and provides references to sections in this ES where each is addressed.

Table 9.3 NPS Assessment Requirements

NPS Requirements	NPS Reference	Section Reference
An assessment of the effects of installing cable across the intertidal zone should include information, where relevant, about: Any alternative landfall sites that have been considered by the Applicant during the design phase and an explanation for the final choice; Any alternative cable installation methods that have been considered by the Applicant during the design phase and an explanation for the final choice; Potential loss of habitat; Disturbance during cable installation and removal (decommissioning); Increased suspended sediment loads in the intertidal zone during installation; and Predicted rates at which the intertidal zone might recover from temporary effects.	***Section 2.6.81*** of ***NPS EN-3***	There will be no impact on the intertidal zone due to the use of HDD as embedded mitigation (*see* ***section 9.3.3.1.2***).
Applicants are expected to have regard to guidance issued in respect of Food and Environmental Protection Act (FEPA) [now Marine Licence] requirements.	Section ***2.6.83 NPS EN-3***	Other relevant guidance, including in respect of the Marine Licence, is outlined further below.
Where necessary, assessment of the effects on the subtidal environment should include: Loss of habitat due to foundation type including associated sea bed preparation, predicted scour, scour protection and altered sedimentary processes; Environmental appraisal of inter-array and cable routes and installation methods; Habitat disturbance from construction vessels' extendible legs and anchors; Increased suspended sediment loads during construction; and Predicted rates at which the subtidal zone might recover from temporary effects.	Section ***2.6.113*** of ***NPS EN-3***	***Section 9.6.1.6** and **9.6.2.1;*** The impacts associated with cable installation are assessed throughout ***section 9.6***. An overview of the worst case parameters is provided in ***section 9.3.1.*** ***Sections 9.6.1.1*** and ***9.6.2.2;*** ***Section 9.6.1.2;*** Recoverability is a component of each impact assessment throughout ***section 9.6***

NPS Requirements	NPS Reference	Section Reference
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 sea bed 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.	Section ***2.6.119*** of ***NPS EN-3***	Mitigation measures embedded in the project design are outlined in ***section 9.3.3.***
Where cumulative effects on subtidal habitats are predicted as a result of the cumulative effects of multiple cable routes, it may be appropriate for applicants for various schemes to work together to ensure that the number of cables crossing the subtidal zone is minimised and installation / decommissioning phases are coordinated to ensure that disturbance is reasonably minimised.	Section ***2.6.120*** of ***NPS EN-3***	During detailed project design cable crossings would be minimised as far as possible. Where they are required the East Anglia TWO export cables would be as far as possible oriented perpendicular to the cable being crossed in order to minimise the requirement for cable protection (see ***section 9.6.2.1***).

75. 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.

76. 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 the proposed East Anglia TWO project are The East Inshore and The East Offshore Marine Plans (Her Majesty's (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'.

77. Other guidance on the requirements for windfarm studies are provided in the documents listed below:

- Cefas (2004) Offshore Wind Farms: Guidance Note for EIA 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 EIA in Relation to Dredging Applications; and
- Defra (2005) Nature Conservation Guidance on Offshore Windfarm Development. A guidance note on the implications of the European Commission (EC) Wild Birds and Habitats Directives for developers undertaking offshore windfarm developments.

78. 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 and 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) EIA 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.

9.4.2 Data Sources

9.4.2.1 Available Literature

79. A desk study of available information was undertaken both to inform the initial survey design and to provide regional characterisation information for the assessment. Available literature was also used to inform the sensitivity of habitat types, based on the abundance of the habitat and its resilience to impacts. Sources include, but are not limited to:

- East Anglia Offshore Wind (EAOW) ZEA: Benthic Biological Characterisation Report (MESL 2011);
- REC studies (Emu 2009 and the University of Southampton and Limpenny et al. 2011);
- Other relevant published literature;
- Marine Life Information Network (MarLIN);
- The Mapping European Seabed Habitat (MESH) project (JNCC 2008); and
- Consultation responses (see ***section 9.2***).

9.4.2.2 Existing Data Sources

80. The relatively homogenous nature of the benthos within the East Anglia TWO windfarm site and the scale of the existing survey data allows for the appropriate characterisation of the existing benthic environment in the East Anglia TWO windfarm site to be described primarily by using existing data. The existing data drawn upon was gathered for the ZEA (MESL 2011) and relevant data from the East Anglia ONE windfarm site, East Anglia ONE and East Anglia THREE cable

corridor surveys. In addition, contextual information from the Norfolk Vanguard EIA and Norfolk Boreas ES have been considered.

81. Spatial coverage of the data within the East Anglia TWO windfarm site is comprehensive with only minor gaps in coverage. The ZEA for the former East Anglia Zone commenced in 2010 with the purpose of identifying the suitable locations for individual windfarms within the zone. The survey data collected across the former East Anglia Zone includes coverage of the East Anglia TWO windfarm site. During the ZEA benthic survey, 643 benthic grabs samples were analysed and 428 taxa were identified. Of these grabs, 38 were taken within the East Anglia TWO windfarm site.

82. ***Table 9.4*** gives a summary of the existing data used to inform the assessment of the existing benthic environment in the East Anglia TWO windfarm site and offshore cable corridor.

Table 9.4 Summary of Existing Survey Data and Relevant Sampling Sites

Survey	Year	Total Number of Samples	Samples within the East Anglia TWO windfarm site	Samples within the East Anglia TWO Export Cable Corridor
Zone grab survey	2010	643	38	0
Zone beam trawl survey	2010	78	3	0
East Anglia ONE offshore cable corridor grab sample survey	2011	41	1	4
East Anglia ONE Offshore Windfarm Survey	2010	133	0	2
East Anglia THREE/FOUR grab sample survey	2013	49	1	5
East Anglia THREE/FOUR Beam Trawl	2013	12	0	0

83. The samples collected across the multiple survey campaigns described above, in general, characterise the East Anglia TWO windfarm site and wider former East Anglia Zone as being relatively homogenous in sediment and benthic

community characteristics. Benthic communities are characterised by those which favour circalittoral coarse sediment.

9.4.2.3 Primary Data Collection

84. The consultation process (see ***section 9.2***) resulted in agreement that the benthic ecology data coverage from the ZEA survey was sufficient to inform the impact assessment for the East Anglia TWO windfarm site. In addition, new side scan sonar and multi-beam echo sound data was collected for the East Anglia TWO windfarm site (June/July 2017) and these data are used to inform physical processes and benthic ecology assessments.

85. It was agreed through consultation with the relevant stakeholders that additional data to inform the assessment of benthic ecology receptors would be collected in each of the offshore cable corridors. The following data have been collected:

- Side scan sonar and multi-beam echo sound (including backscatter) data for all areas of the offshore cable corridors. These data will be used to identify potential areas of reef and provide a conservative estimate of reef presence; and
- Physical benthic sampling has been undertaken in all areas of the offshore cable corridor which were not sampled as part of the ZEA. The sampling strategy also took into consideration sample data available from East Anglia ONE and East Anglia THREE surveys. The survey collected faunal, sediment and contaminant samples. Intrusive sampling was not undertaken in areas where geophysical survey indicated the potential presence of *Sabellaria* reef (or any other Annex I habitat) or potential cultural heritage assets.

86. Detailed survey methodologies are presented in ***Appendix 9.2***.

87. ***Table 9.5*** summarises the number of samples that have been acquired from the campaigns across the East Anglia TWO windfarm site and offshore cable corridor route options.

Table 9.5 Summary of Survey Data and Relevant Sampling Sites

Survey	Year	Total Number of Samples	Samples within the East Anglia TWO windfarm site	Samples within the offshore cable corridor
East Anglia TWO windfarm site sidescan sonar survey (for identifying potential areas of *Sabellaria* reef)	2017	n/a	Complete coverage	Complete coverage
East Anglia TWO offshore cable corridor sidescan sonar	2018	n/a	n/a	Complete coverage of offshore cable corridor

Survey	Year	Total Number of Samples	Samples within the East Anglia TWO windfarm site	Samples within the offshore cable corridor
survey (for identifying potential areas of *Sabellaria* reef)				
East Anglia TWO offshore cable corridor grab samples	2018	65	0	65
East Anglia TWO contaminant samples	2018	15	4	11

9.4.2.4 Data Assumptions and Limitations

88. Due to the large amount of data that has been collected during ZEA and site specific surveys as well as other available data which provide a wider context within the region there is a good understanding of the existing benthic and intertidal environment. There are however some potential limitations to the benthic data which have been collected. Firstly, the ZEA data were acquired eight 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 indicates that there has been little change in the benthic communities in the past eight years. Therefore, it can be inferred that the ZEA data is still valid for this assessment.

89. 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 different datasets shows the data are suitably consistent for the purposes of site characterisation.

90. ***Table 9.6*** summarises the sources used to inform the assessment and associated levels of confidence in the source.

Table 9.6 Data Sources Features

Data	Year	Coverage	Confidence
Benthic survey (grab samples (faunal and sediment)) by Bibby Hydromap (see ***Appendix 9.3***)	2018	East Anglia TWO and East Anglia ONE North offshore cable corridors	High
Benthic survey (grabs, trawls and video) by Marine Ecological Surveys Ltd reported in the ZEA (EAOW 2012)	2010 - 2011	East Anglia Zone	Site specific, however data is eight years old, so medium

Data	Year	Coverage	Confidence
Geophysical survey by Gardline Geophysical Ltd reported in the ZEA (EAOW 2012)	2010	East Anglia Zone	Site specific, however data is eight 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, East Anglia FOUR and associated cable route options	Some site overlap, so medium
Benthic survey (grabs) by Marine Ecological Surveys Limited (MESL 2012)	2010	East Anglia ONE offshore development area	Slight overlap with the offshore cable corridor so medium.
REC studies (Limpenny et al. 2011)	2011	East Coast	Overlap with site, however data is seven years old so medium
National Biodiversity Network (NBN) gateway	Collation of various data sources	East Anglia coast	Not all sources can be verified so low
MarLIN	Collation of various data sources	UK species information	Not all sources can be verified so low
UKSeamap 2010 Interactive Map	Collation of various data sources up to 2010	UK	Not all sources can be verified so low
European Marine Observation and Data Network (EMODnet) Seabed Habitats	2004-2014	Europe	Not all sources can be verified so low

9.4.3 Impact Assessment Methodology

91. A matrix approach has been used to assess impacts following best practice, EIA guidance and the approach outlined in the in the East Anglia TWO Scoping Report (SPR 2017).

92. The data sources discussed in ***section 9.4.2*** were used to characterise the existing benthic environment (see ***section 9.5***). Each impact has been identified using expert judgement and confirmed through the ETG process and is subsequently assessed using the following methodology.

93. The overarching approach to the assessment of the significance of each impact is detailed in ***Chapter 5 EIA Methodology***.

9.4.3.1 Sensitivity

94. For the benthic EIA it was agreed through the ETG to use the following sensitivity definitions. The sensitivity of a receptor is determined through its ability to accommodate change and reflects on its ability to recover if it is affected and is dependent upon adaptability, tolerance and recoverability characteristics. The sensitivity of biotopes has been assessed using the Marine Evidence based Sensitivity Assessment (MarESA) and through the examination of online resources or through published research (Tyler-Walters et al. 2018; 2011 and 2004). Regarding the sensitivity of species, similarities between impacts caused by windfarms and the aggregates industry have been assumed.

95. The sensitivity definitions are presented below in ***Table 9.7***.

Table 9.7 Definitions of the Different Sensitivity Levels for Benthic Ecology Receptors

Sensitivity	Definition
High	Individual receptor (species or habitat) has very limited or no capacity to accommodate, adapt or recover from the anticipated impact.
Medium	Individual receptor (species or habitat) has limited capacity to accommodate, adapt or recover from the anticipated impact.
Low	Individual receptor (species or habitat) has some tolerance to accommodate, adapt or recover from the anticipated impact.
Negligible	Individual receptor (species or habitat) is generally tolerant to and can accommodate or recover from the anticipated impact.

9.4.3.2 Value

96. For some assessments, the 'value' of a receptor may also be an element to add to the assessment where relevant – for instance if a receptor is designated or has an economic value. Example definitions of the value levels for a generic receptor are given in ***Table 9.8***.

Table 9.8 Definitions of the Value Levels for Benthic Ecology Receptors

Value	Definition
High	Internationally or nationally important
Medium	Regionally important or internationally rare
Low	Locally important or nationally rare
Negligible	Not considered to be particularly important or rare

97. It should be noted that high value and high sensitivity are not necessarily linked within a particular impact. A receptor could be of high value (e.g. an Annex 1 habitat) but have a low or negligible physical / ecological sensitivity to an effect – it is important not to inflate impact significance just because a feature is 'valued'.

This is where the narrative behind the assessment is important; the value can be used where relevant as a modifier for the sensitivity assigned to the receptor.

9.4.3.3 Magnitude

98. For the benthic EIA, it was agreed through the ETG to use the following definitions of magnitude of effect. 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.

99. The magnitude definitions are presented below in Table 9.9.

Table 9.9 Definitions of the Magnitude Levels for Benthic Ecology Receptors

Value	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.

9.4.3.4 Impact Significance

100. Following the identification of receptor value and sensitivity and magnitude of the effect, it is possible to determine the significance of the impact. A matrix as presented in ***Table 9.10*** will be used.

101. It is important to note that the matrix (and indeed the definitions of sensitivity, value and magnitude) is a framework to aid understanding of how an expert judgement has been reached from the narrative of each impact assessment and it is not a prescriptive formulaic method.

Table 9.10 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

102. Through the use of this matrix, an assessment of the significance of an impact can be made in accordance with the definitions in ***Table 9.11***.

Table 9.11 Impact Significance Definitions

Value	Definition
Major	Very large or large changes in receptor condition, both negative 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 changes in receptor condition, which are likely to be important considerations at a local level.
Minor	Small changes in receptor condition, which may be raised as local issues but which are unlikely to be important in the decision making process.
Negligible	No discernible change in receptor condition.
No change	No impact, therefore no change in receptor condition.

103. For the purposes of the EIA, ‘major’ and ‘moderate’ impacts are deemed to be significant. In addition, whilst ‘minor’ impacts are not significant in their own right, they may contribute to significant impacts cumulatively or through interactions.

104. Following initial assessment, if the impact does not require additional mitigation (or none is possible) the residual impact will remain the same. If however, additional mitigation is proposed there will be an assessment of the post-mitigation residual impact.

9.4.4 Cumulative Impact Assessment

105. 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 arising from the proposed East Anglia TWO project and those arising from other projects either already constructed (where applicable), consented or in the planning process.

106. The potential for cumulative impacts to manifest is considered in terms of the East Anglia TWO windfarm site and the offshore cable corridor separately and

together (as per the East Anglia THREE EIA). This is undertaken because the export cables and windfarm impacts will be different and have different potential for cumulative interaction, particularly cumulative effects of cables on the Outer Thames Estuary SPA.

107. The potential cumulative impacts on benthic receptors caused by interactions of activities within the offshore development area and other relevant windfarm sites are:

- Temporary physical disturbance;
- Loss of habitat; and
- Increased suspended sediment concentrations and associated smothering of benthic receptors.

108. There is potential for cumulative impacts to occur through the interactions between activities associated with the installation and decommissioning of the East Anglia TWO export cable and export cables from other windfarms as well as interactions with aggregate extraction sites. The impacts proposed for assessment are:

- Temporary physical disturbance associated with activities in the offshore cable corridor;
- Loss of habitat;
- Increased suspended sediment concentrations and associated potential smothering of benthic receptors;
- Interactions of EMF with benthic invertebrates; and
- Impacts upon the Outer Thames Estuary SPA.

109. ***Chapter 6 EIA Methodology*** provides greater detail to the general method of the Cumulative Impact Assessment (CIA).

9.4.5 Transboundary Impact Assessment

110. Transboundary impacts have been considered with regard to the extent of influence of changes or effects and their potential to impact upon benthic ecology receptor groups that are located within other European Union (EU) member states.

111. The localised nature of the potential impacts on the benthos means that significant transboundary impacts are unlikely. In accordance with the Scoping Report (SPR 2017) and subsequent ETG meetings (see ***Appendix 9.1***), transboundary impacts have been screened out of the EIA for this topic. This approach is in line with that agreed for benthic assessments for previous projects such as East Anglia THREE and Norfolk Vanguard.

9.5 Existing Environment

112. The environmental benthic baseline presented below includes descriptions of the sediment type, infauna and epifauna with respect to the offshore development area. This baseline is based upon the data sources discussed in ***section 9.4.2***.

113. A description of protected areas and important species in the vicinity of the offshore development area is also given.

9.5.1 Sediment Types

114. A summary of the sediment types of the offshore development area is given in this section. Sea bed sediment type distribution is described in full in ***Chapter 7 Marine Geology, Oceanography and Physical Processes***.

9.5.1.1 East Anglia TWO Windfarm Site

115. Data collected during the ZEA surveys indicate that the sediment throughout East Anglia TWO windfarm site is predominantly sandy with some areas of sandy gravel (see ***Figure 9.3a*** and ***Figure 9.3b***). Sample locations with greater proportions of gravel tend to be in the north and south east of the East Anglia TWO windfarm site. Silt was generally absent or non-significant (less than 5%) from sampling locations within the East Anglia TWO windfarm site.

116. Multivariate analysis of the samples collected during the ZEA found that there was a significant relationship between biological communities and sediment type with the strongest correlation found between faunal communities and gravel (2-8mm), sand and fine silt substrata (MESL 2011).

117. Sandbanks, sand waves and mega-ripples are typical sediment formations within the former East Anglia Zone and are present within the East Anglia TWO windfarm site.

9.5.1.2 East Anglia TWO Offshore Cable Corridor

118. British Geological Society (BGS) data for the offshore cable corridor indicates that sediments will be predominantly coarse sediments, mainly sand with some muddy sand (McBreen et al. 2011). This is consistent with the site specific survey data which shows sediments in both the northern and southern offshore cable corridor options primarily consisting of sand and gravel however with differing conditions closer to shore as indicated by the results of nine samples within the 10 to 20m depth contour which were predominantly silty (see ***Appendix 9.3*** and ***Figure 9.3***).

119. The East Coast REC (Marine Aggregate Levy Sustainability Fund 2009), which covers a portion of the offshore cable corridor, and data from the ZEA suggest that areas inshore of the East Anglia TWO windfarm site are predominantly sand and gravel, with isolated pockets of fine material in sheltered areas, or areas where irregular sea bed topography encourages deposition. ZEA samples indicate that sediments in the northern offshore cable corridor have a higher

proportion of gravel than those samples which were taken from the southern offshore cable corridor.

9.5.2 Faunal Communities

120. In the following sections, infauna (as sampled by grabs) is taken to mean species that live in, are partially buried within, or below the sediment. Epifauna (sampled by benthic trawls) is taken to mean species that live on the surface. Fish (including sandeels) and cephalopods (squid and cuttlefish) species have been removed from the benthic and epibenthic dataset as they are not considered to be benthic species. These data are incorporated into ***Chapter 10 Fish and Shellfish Ecology***.

121. As agreed through the benthic ecology method statement and Evidence Plan Process (EPP) meetings, data have been analysed in the context of the former East Anglia Zone, the East Anglia TWO windfarm site and the offshore cable corridor separately.

9.5.2.1 Infaunal and Epifaunal Communities in the Former East Anglia Zone and the Offshore Development Area

122. A total of 643 faunal grabs were taken as part of the ZEA surveys. A total of 428 taxa were recorded with mean per sample values of 70 individuals, 16 taxa and 0.26g ash free dry weight (gAFDW). These values are representative of the mobile sandy substrata that comprises the former East Anglia Zone, which supports relatively low abundances of small fauna drawn from a limited range of taxa. This suggests that parts of the former East Anglia Zone are areas of limited ecological importance.

123. Of the samples taken from the ZEA, Annelida made up the greatest contribution to abundance and taxonomic richness whereas Echinodermata made the greatest contribution to total biomass (gAFDW). Abundance, taxonomic richness and faunal diversity were not evenly spread across the former East Anglia Zone and faunal abundance was shown to be on average higher in the west of the former zone than the east.

124. Subsequent sampling campaigns to inform East Anglia THREE, East Anglia ONE and the former East Anglia FOUR EIAs have added significantly to the data set produced by the ZEA. In order to characterise infaunal communities across all of these datasets, the data were combined and subsequently analysed for assessment using PRIMER V7. The following analyses of the infaunal communities of the former East Anglia Zone uses 852 samples; 566 from the ZEA surveys, 49 from the East Anglia THREE and former East Anglia FOUR surveys, 133 samples from the East Anglia ONE windfarm site survey, 39 samples from the East Anglia ONE offshore cable corridor survey and 65 samples from the East Anglia ONE North and TWO offshore cable corridor surveys (see ***Appendix 9.4***).

125. By far the most numerate class were the polychaetes accounting for greater than 50% of all individuals identified. They were also the most numerate class in terms of species identified with approximately 40% of all species identified as polychaetes.

126. The most numerous polychaete in the combined data set was *S. spinulosa* with a total of 10,661 individuals present across 139 sample stations. The greatest number found in a single sample was 1,741 and in total 13 station samples contained more than 100 individuals. *Spiophanes bombyx* was also very numerous with 4,508 individuals identified. This species was less numerous overall than *S. spinulosa,* however, it was identified at almost four times as many sample stations (518). Other species of polychaete, which were not as abundant at individual sample stations as *S. spinulosa*, but were identified at a greater number of sample stations include:

- *Nephtys cirrosa* (1,266 individuals found at 537 stations);
- *Nephtys species* which could only be identified to genus (414 individuals found at 246 sample stations);
- *Glycera sp.* (691 individuals found at 247 sample stations);
- *Ophelia borealis* (1,108 individuals found at 326 sample stations);
- *Ophelia sp.* which could not be identified to species level (837 individuals found at 167 sample stations); and
- *Scoloplos armiger* (645 individuals found at 203 sample stations).

127. Malacostracan crustaceans were the next most numerate class both in terms of individuals and number of species. The most numerous was the long clawed porcelain crab *Pisidia longicornis* with 1,299 individuals identified at 33 sample stations. This high abundance was mainly due to an aggregation at ZEA station 420. Many other species within the class were more evenly distributed across the surveyed areas, these included:

- *Abludomelita obtusata* (1,178 individuals found at 70 sample stations);
- *Bathyporeia elegans* (586 found at 181 sample stations); and
- *Urothoe brevicornis* (882 individuals at 228 sample stations).

128. Bivalve molluscs made up approximately 10% of all the individuals identified. The most common bivalve species was *Abra alba* (1,832 found across 121 sample stations). Other species of bivalve such as *Fabulina fabula* (810 individuals at 145 sample locations) and unidentified species within the genus *Spisula* (258 found across 136 sample stations) were also numerous.

129. To characterise the benthic communities cluster analysis was conducted using PRIMER V7 which identified 31 different faunal groups within the former East Anglia Zone (see ***Appendix 9.4***). Of these, four samples failed to group with any

other samples and were thus recorded as outliers. The biotope[2] codes displayed in ***Table A9.4.3*** of ***Appendix 9.4*** were assigned to each faunal group using the current UK Marine Classification System v4.05 (Connor et al. 2004). Biotopes were allocated to the groups identified by the cluster analysis and a summary of the codes assigned to each is displayed in ***Table A9.4.3*** of ***Appendix 9.4***. It should be recognised that the assignment of biotope codes is subjective; groupings identified do not always fit easily into the defined categories. Where available, the biotope allocations have been taken from the survey reports (***Appendix 9.3,*** MESL 2011 and EATL 2015).

130. The assignment of biotopes allows the assessment of the sensitivity described in ***section 9.4.3.1*** by using the sensitivities to physical disturbance defined by MarESA; Tyler-Walters, Lear and Allen 2004; Tillin 2013; Tillin 2016 which are also defined for reference in ***Table 9.12*** for the biotopes identified as being present in the offshore development area. Figures 9.4a and 9.4b also show the biotope classifications of faunal groups and their geographic distribution throughout the offshore development area and former East Anglia Zone.

9.5.2.2 Infaunal Communities in the East Anglia TWO Windfarm Site

131. The infaunal communities within the East Anglia TWO windfarm site are dominated by many of the same species groups as the former East Anglia Zone (***Table A9.4.3*** of ***Appendix 9.4*** and ***Figure 9.4b***). Abundance in the East Anglia TWO windfarm site, as defined by the number of individual organisms per grab and as taken from the ZEA data, can be seen to be broadly similar to the wider former East Anglia Zone, exhibiting communities with relatively low abundance and diversity (see ***Figures 9.5a, b*** and ***9.6a, b***).

132. Infaunal communities within the East Anglia TWO windfarm site are dominated by the polychaete worms *Nephtys cirrosa* and *Spiophanes bombyx*. Three communities were identified within the East Anglia TWO windfarm site *(see* ***Figure 9.8a, b****)*:

- Group ab - Characterised by *Nephtys cirrosa, Spiophanes bombyx,* Nemertea, *Polycirrus sp.* and *Glycera sp.* (25 locations);
- Group q - Characterised by Nemertea, *Ophiuroidea* and *S. bombyx* (two locations); and
- Group ac - Characterised by *N. cirrosa* and *Ophelia borealis* (one location).

133. Infaunal abundance within the East Anglia TWO windfarm site is low to moderate relative to adjacent areas of the former East Anglia Zone, with abundance generally increasing in the north of the site. Some sample locations in the south west of the East Anglia TWO windfarm site also suggest higher abundance, relative to the rest of the site (see ***Figure 9.5a, b***).

[2] Biotope is defined as the combination of an abiotic habitat and its associated community of species.

9.5.2.3 Infaunal Communities in the Offshore Cable Corridor

134. The infaunal communities within the offshore cable corridor vary with depth and sediment type, with the deeper, sandier areas further offshore characterised, predominantly, by the same faunal groups as the East Anglia TWO windfarm site (predominantly Groups ab and q) while the areas further inshore are represented by communities associated with siltier sediments, as follows:

- Group b – Characterised by a mud shrimp *Corophium volutator* (four locations)
- Group c – Characterised by *Sertularia cupressina and Vesicularia spinosa* (four locations)
- Group e – Characterised by *Notomastus* and *Eunereis longissima* (three locations)
- Group d – Characterised by *Scalibregma inflatum* (three locations)

135. There are also 18 incidences of Group p spread throughout the offshore cable corridor although with the exception of the nearshore area (see ***Figure 9.8a***). Group p is characterised by *Kurtiella bidentate and Abra alba*.

136. Infaunal abundance and diversity in both the offshore cable corridor northern and southern options broadly matches that of the wider East Anglia zone (see ***Figures 9.5a, b*** and ***9.6a, b*** respectively). In terms of infaunal biomass a greater mass of organisms can be seen to be present within the offshore cable corridor compared to the windfarm site and wider former East Anglia Zone. The larger biomass of samples is generally down to the presence of mollusc or echnioderm species which can add significantly to the weight of samples. For example, in the case of sample B37 in ***Appendix 9.3*** (the sample with the greatest weight) six pea urchins *Echinocyamus pusillus* had a large bearing on the infaunal biomass.

9.5.3 Epifaunal Communities

137. As noted in ***section 9.5.2***, epifauna is sampled by benthic trawls and is taken to mean species that live on the surface of the sea bed. As discussed in ***section 9.4.2***, several surveys have been undertaken across the former East Anglia Zone which have been combined to characterise epibenthic communities.

138. The epibenthic data are semi-quantitative therefore in terms of comparing samples across the survey area it has less meaning than using the infaunal grab data as described in ***section 9.5.2***. However, a semi-quantitative comparison still gives an indication of the relative abundance of the different species. Many fish species (including sandeels) were recorded within the epifaunal data; these have been removed from this analysis, as fish are not considered part of the benthic community for the purposes of this assessment. These are considered in ***Chapter 10 Fish and Shellfish Ecology***.

139. As agreed through ETGs (see ***Appendix 9.1***), no epibenthic trawls were undertaken as part of the East Anglia TWO and East Anglia ONE North offshore cable corridor surveys and therefore this type of survey data is not available for a large section of the cable corridor options. However, the results of the grab survey indicate the area of the offshore cable corridor which overlaps with the former East Anglia Zone is broadly comparable with the benthic ecology in the East Anglia TWO windfarm site.

9.5.3.1 Epifaunal Communities in the former East Anglia Zone

140. Epifaunal abundance varies across the former East Anglia Zone with relatively high abundances occurring in the north-west with lower abundances apparent in the south east, i.e. the area of the East Anglia TWO windfarm site. Species diversity (identified as the number of different species found within a sample) was more evenly distributed over the former East Anglia Zone with no defined distribution pattern.

141. A total of 78 epibenthic (sea bed surface) trawls were taken during the ZEA survey, three of which fall within the East Anglia TWO windfarm site (see ***Table 9.4***). The zonal surveys identified 95 taxa of macrofauna, with an average of 956 individuals and 24 taxa per trawl sample (MESL 2011). The distribution of abundance and taxonomic richness across the former East Anglia Zone varies, with abundance generally higher in the north and diversity showing no defined pattern (see ***Figures 9.9a, b*** and ***9.10a, b*** respectively).

142. 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.

143. Epibenthic abundance ranges from approximately 41 to 400 within the East Anglia TWO windfarm site (based on abundance categories in EAOW 2012) (see ***Figure 9.9a***).

144. By far the most dominant class of organism within the epifauna were the Malacostraca which include crabs, lobsters, shrimp, krill, and amphipods. Within this group the brown shrimps *Crangon allmanni* (35,354 individuals identified across 83 sample stations) and *Crangon Crangon* (1,773 individuals identified across 43 sample stations) were numerous. These two species play an important ecosystem function role within the southern North Sea and are a key food source for flatfish. Also abundant were the hermit crabs *Paguridae* (1,897 individuals identified across 88 sample stations) and the crab *Liocarcinus holsatus* (1,946 individuals identified across 81 Sample stations).

145. The next most abundant class in terms of number of individuals identified were the brittlestars (*Ophiuroidea*). However, in terms of species, this class constituted only 3.49%. Brittlestars often show aggregation behaviour and this was reflected in the fact that up to 1,700 *Ophiura albida* were identified in a single sample.

146. The class Hydrozoa constituted over 15% of the species identified within the former East Anglia Zone with *Hydractinia echinata* (found at 69 sample stations) and *Tubularia* sp. (identified at 30 sample stations) the most widely distributed.

147. ***Figure 9.10b*** displays the epifaunal diversity in the East Anglia TWO windfarm site in the context of the former East Anglia Zone. Diversity (measured in terms of number of species) ranges from 7 to 20 species per sample.

148. Multivariate analysis of the ZEA epifaunal data which was completed for the East Anglia THREE EIA identified four faunal groups (***Figure 9.11a, b***). The East Anglia TWO windfarm site is dominated by epifaunal group D with one sample in the northern offshore cable corridor being characterised by group B. These groups are characterised by the following key taxa:

- The hermit crab family Paguridae (groups D and B);
- The common starfish *Asteria Rubens* (group D); and
- The shrimp *C. Almani*.

149. 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 (MESL 2011).

9.5.4 Landfall and Intertidal Habitats

150. The landfall location for up to two export cables for the proposed East Anglia TWO project is in the vicinity of Sizewell and Thorpeness in Suffolk. Landfall will be made using HDD and therefore, there will be no direct or indirect impacts on the intertidal zone and so impacts on the intertidal zone are not considered further.

9.5.5 Protected Habitats and Species

151. The following section discusses protected sites and the potential for designation of habitats in the vicinity of the offshore development area. These include Special Protection Areas (SPAs), Marine Conservation Zones (MCZs), candidate Special Areas of Conservation (cSAC) and associated Annex I Habitats, Sites of Special Scientific Interest (SSSI), and species and habitats listed on the United Kingdom Biodiversity Action Plan (UK BAP).

9.5.5.1 Potential Annex 1 Habitat

152. Two potential Annex I Habitats were identified within the offshore development area:

- *Sabellaria spinulosa* reef (also referred to as *Sabellaria* reef); and
- Vegetated shingle.

9.5.5.1.1 Sabellaria reef

153. *Sabellaria spinulosa* has the potential to form dense aggregations and reef-like structures in certain conditions. This biogenic reef habitat is listed in Annex I of the Habitats Directive (92/43/European Economic Community (EEC)) due to the diversity of species it can support.

154. The ZEA surveys indicate that *S. spinulosa* individuals are present within the offshore cable corridor (see ***Figure 9.12a, b***) with the potential for aggregations and potentially reef. Data collected from both the ZEA and East Coast REC (Limpenny et al*.* 2011) indicate *Sabellaria* reef could be present in the offshore development area, particularly the northern arm of the offshore cable corridor. During the ZEA grab surveys, *S. Spinulosa* was found to be present at 108 of the 566 characterisation sample stations with abundances at these stations ranging from 1 to 1,660 individuals.

155. During ZEA analysis an exercise was conducted to determine likely presence of *Sabellaria* reef across the former East Anglia Zone. This exercise assigned a value of between 1 and 5 depending on the 'reefiness' of suspected areas of *Sabellaria* reef (where a score of 5 is highly likely to be reef, (Gubbay 2007)). The results showed that there were two potential areas of *Sabellaria* reef in the East Anglia TWO windfarm site, one with a 'reefiness' index of 2 and one with an index of 3. There are also four potential areas in the northern offshore cable corridor ranging from a 'reefiness' scale of 2 to 4 (see MESL 2011; ***Figure 12*** and ***Figure 9.13***).

156. Results from the side scan sonar survey carried out in 2018 (Bibby HydroMap 2018) show that there is no evidence of *Sabellaria* reef in the offshore cable corridor. Minor or relict patches of *Sabellaria* were found at a number sample locations (10) (see ***Appendix 9.3***) however nothing which constitutes a reef was identified. However, it is acknowledged that side scan sonar data would need to be ground-truthed with drop-down video in order to accurately determine the presence or absence of *Sabellaria* reef. As noted in ***section 9.3.3.1.4*** a detailed pre-construction geophysical survey will identify any areas of Sabellaria reef which are required to be avoided, as agreed with the MMO in consultation with Natural England and secured through the Design Plan which is submitted with the DCO application.

9.5.5.1.2 Vegetated Shingle

157. Coastal vegetated shingle is considered rare globally and is listed on Annex I of the EU Habitats Directive ('perennial vegetation of stony banks'). It supports a unique range of flora and fauna that are adapted to the harsh conditions that are present at such locations. This is a feature of the Leiston - Aldeburgh SSSI at the landfall. Landfall will be made using HDD and therefore, there will be no direct or indirect impacts on the intertidal zone and so impacts on the intertidal zone are not considered further.

9.5.5.2 Marine Protected Areas

158. The East Anglia TWO windfarm site does not overlap with any internationally, nationally or locally important sites designated for benthic ecology receptors.

159. There are areas of sandbank habitat inshore of the offshore cable corridor which are supporting features of the Outer Thames Estuary SPA (see ***Figure 9.14***). This SPA is designated for wintering populations of red-throated diver *Gavia stellata* that it supports. The primary prey of the red-throated diver is fish species although they are also considered to occasionally consume crustaceans and molluscs. Direct impacts on this habitat have been largely avoided through the site selection process however an assessment of construction and decommissioning impacts on benthic habitats and receptors associated with the site is presented in ***sections 9.6.1.5*** and ***9.6.3***.

160. The offshore cable corridor is 2.1km from the Orford Inshore MCZ. It is predicted that there would be no potential for the proposed East Anglia TWO project activities to adversely impact upon the sites' designated features of subtidal mixed sand and gravels. This is due to a lack of physical overlap and negligible impact in the far-field as a result of an increase in suspended sediment concentrations during construction (see ***section 7.6.1.5*** of ***Chapter 7 Marine Geology Oceanography and Physical Processes***). This conclusion is supported by an assessment (EATL 2016) that was carried out for the East Anglia THREE project which is closer to the MCZ at only 300m away. This assessment was carried out when the MCZ was a recommended MCZ (rMCZ). The East Anglia THREE assessment concluded that there would be, at worst, negligible impact from indirect effects and concluded no adverse effect on the site should it be designated. Therefore, the MCZ is not considered further.

161. As discussed above, the landfall overlaps with the Leiston - Aldeburgh SSSI at the landfall. Landfall will be made using HDD and therefore, there will be no direct or indirect impacts on the intertidal zone.

9.5.5.3 Protected Species

162. Species and habitats recorded during the infaunal and epifaunal surveys were compared against the current information, relevant to UK waters, for those identified as of conservation interest. This included, but was not restricted to, the following legislative drivers and conventions:

- The Wildlife and Countryside Act 1981 (WCA81);
- Habitats Directive (Annex I Habitats and Annex II Species) as expressed in UK legislation (The Conservation of Habitats and Species Regulations 2017);
- Conservation of Offshore Marine Habitats and Species Regulations 2017
- Marine and Coastal Access Act 2009;
- The UK Biodiversity Framework; and

- The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) Threatened and/or Declining Species and Habitats.

163. The amphipod *Apherusa ovalipes* was identified in the ZEA report (MESL 2011) as a species of conservation concern present within the former East Anglia Zone. However, of the three records identified none were within the offshore development area. The species is included in the JNCCs list of "Rare marine benthic flora and fauna in Great Britain" (Sanderson 1996a).

164. Mussels, particularly blue mussel *Mytilus edulis* and northern horse mussel *Modiolus modiolus* are considered important as they are a good prey source and, where found in high densities, they have potential to create biogenic reefs which are Annex I habitats (see ***section 9.5.5.1.1***). Although there was no evidence from any of the benthic survey campaign of mussels forming biogenic reefs, individuals of these species were recorded at various locations across the former East Anglia zone. None of these species were present in any of the samples collected for the site specific surveys.

9.5.5.4 Other Important Species

165. The brown shrimp *Crangon allmani* was found within many of the epifaunal surveys. Brown shrimp are not protected in the UK but are important commercial species and play an important role in ecosystem function and energy flow within the southern North Sea. *Crangon* spp. are an important prey source for many commercially important fish species such as cod *Gadus morhua*, plaice *Pleuronectes platessa* and juvenile bass *Dicentrarchus labrax* (Steenbergen et al. 2011) and are also predated by some sea birds (See ***Chapter 10 Fish and Shellfish Ecology*** for an assessment of the impacts on these species).

166. The edible crab *Cancer pagurus*, whilst not a protected species in the UK, is a key predator of a variety of crustaceans and molluscs and therefore has an important ecosystem function. Edible crab is also an important commercial shellfish species throughout the North Sea, but was only found at one station in the various benthic surveys, with additional individuals being captured during the beam trawls.

9.5.6 Context and Summary

167. The benthic species and biotopes found within the offshore development area are considered broadly typical of those that exist within the former East Anglia Zone and wider southern North Sea. Species abundance and diversity are broadly in keeping with that of the former East Anglia Zone.

168. 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 East Anglia Zone and the communities found within the offshore development area are generally consistent with those found across the wider former East Anglia Zone. These are generally

of low diversity, containing species which recover rapidly and are typical of physically disturbed habitats.

9.5.7 Anticipated Trends in Baseline Conditions

169. The baseline conditions for benthic ecology are considered to be relatively stable within the offshore development 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 (located 56km north east from the East Anglia TWO windfarm site) conducted in 2016.

170. 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 7 Marine Geology Oceanography and Physical Processes***) and anthropogenic impacts such as fishing, particularly from beam trawling within the study area (***Chapter 13 Commercial Fisheries***).

171. Warming sea temperatures may result in large scale changes to the marine ecosystem (Brierley and Kingsford 2009) with the northerly migration of benthic species likely to occur. At the macro scale, this would result in changes to the benthic community structure. Hiddink, Burrows and Molinos (2014) conducted a study which aimed to evaluate the changes in distribution of 65 common and widespread (including *S. bombyx* and *N. cirrosa*) North Sea benthic invertebrate species between 1986 and 2000 through examination of their geographic, bathymetric and thermal niche shifts. The study confirmed the anticipated northerly migration of species with many benthic invertebrates showing north-westerly range shifts and a movement towards deeper and cooler waters. Distribution shifts were found not to keep pace with increases in surface and sea bed temperatures and therefore many species experienced an increase in temperatures. The authors noted that, ultimately, a reduction in benthic biodiversity could occur if the studied species are unable to adapt to or withstand an increase in temperature in the North Sea.

172. The timescale over which any discernible change in benthic community may occur as a result of increasing sea temperatures is largely unknown and requires further study.

9.6 Potential Impacts

173. The potential impacts that may occur during construction, operation and decommissioning of the proposed East Anglia TWO project are presented in this section. They correspond with those impacts listed in ***Table 9.2*** which has a description of the worst case scenario for each impact.

174. The receptors for each impact are described within the text of each assessment. All the receptors have been identified through the compilation of the existing environment in ***section 9.5***. Benthic species or habitats which are not considered

to have any potential to be impacted by the proposed East Anglia TWO project have not been presented within the baseline.

175. Many of the impacts assessed within this section take a study area based approach whereby impacts in the East Anglia TWO windfarm site are assessed separately to the impacts within the offshore cable corridor.

176. The rationale behind this approach is that in many cases the mechanism for the impact (or source) is very different i.e. within the East Anglia TWO windfarm site, permanent foundations would be installed however within the offshore cable corridor most impacts would be temporary in nature. Furthermore, the receptors themselves are different, i.e. the East Anglia TWO windfarm site only contains communities found in deeper water whereas the offshore cable corridor contains shallow water. When this approach is taken, a summary section is provided which combines the two study areas to assess the overall impact for the offshore development area as a whole.

177. For some of the impacts this summary section is not required, for example, when the source of impact and the receptor are similar across the two study areas or when the impacts are seen across only one of the study areas.

9.6.1 Potential Impacts During Construction

9.6.1.1 Impact 1: Temporary Physical Disturbance

178. There is potential for direct physical disturbance of subtidal habitats during foundation and cable installation from jack-up vessel legs, construction vessel anchors, sea bed preparation for foundations (sand wave levelling / pre-sweeping / dredging and drilling) and cable trenching. The disposal of dredged or drilled material on the sea bed also has potential to smother benthic receptors potentially resulting in injury or mortality (see ***section 9.6.1.2*** for and assessment of this impact).

179. 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 temporarily disturbed, thus aiding recovery of benthic communities in the area. Where disturbed sediments (e.g. from foundation and cable protection installation) are subsequently covered with infrastructure, the permanent loss of habitat is assessed as an operational impact in ***section 9.6.2.1***. Where permanent habitat loss may result from sea bed preparation (e.g. sand wave levelling), this is considered as a construction impact in ***section 9.6.1.6***.

180. The maximum potential sea bed preparation area in the offshore development area has a total disturbance footprint of 11.3km^2 (see ***Table 9.2***).

181. The disturbance would be temporary during the approximate 27 months of construction activity with the majority of disturbance occurring during installation of foundations and cables. Some elements of disturbance, such as that caused

by jack-up vessel legs, will be highly localised and only occur over a period of a few days (see ***Chapter 6 Project Description***). This represents a low magnitude impact in relation to the offshore development area and the wider region due to the temporary nature of the impact and presence of comparable subtidal sands and gravel habitats throughout the East Anglia TWO windfarm site, the majority of the offshore cable corridor and the wider former East Anglia Zone and southern North Sea.

182. The East Anglia TWO windfarm site does not overlap with any designated sites protected for their benthic habitats or features however the offshore cable corridor bisects the Outer Thames Estuary SPA (see ***Figure 9.13***).

9.6.1.1.1 Temporary Physical Disturbance in the Windfarm Site

183. The majority of the East Anglia TWO windfarm site is composed of coarse sediment communities with some evidence of areas of *Sabellaria* reef identified from previous surveys (MESL 2011).

184. In terms of sensitivity to the effect of direct disturbance and loss of sea bed habitat (see ***section 9.6.2.1***) 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, ‘Infralittoral Fine Sand’ SS.SSa.IFiSa of which the majority of the East Anglia TWO windfarm site is comprised (see ***Figure 9.4***), is deemed to have a high recoverability and low sensitivity (Tyler-Walters, Lear and Allen 2004).

185. In terms of the PRIMER analysis, the East Anglia TWO windfarm site is mainly comprised of groups of infauna consisting of polychaete worms (*Nephytys cirrosa* and *Spiophanes bombyx*). Groups recorded in the East Anglia TWO windfarm site are shown in ***Figure 9.8a*** and are characterised as follows:

- Group ab - Characterised by *Nephtys cirrosa, Spiophanes bombyx, Nemertea*, *Polycirrus sp.* and *Glycera sp.* (25 locations);
- Group q - Characterised by Nemertea, *Ophiuroidea* and *S. bombyx* (two locations).
- Group ac - Characterised by *N. cirrosa* and *Ophelia borealis* (one location); and

186. Group ab was the dominant group with other groups generally being recorded in isolated samples.

187. On the whole, biotopes and species present are representative of the dynamic sediment environment expected within the East Anglia TWO windfarm site. *S. bombyx* is an opportunistic polychaete and likely to recolonise disturbed areas after cessation of disturbance causing activities and before most other species. 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.

188. *N. cirrosa* lives infaunally in sandy sediment in the intertidal and shallow sublittoral area. 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 and Hughes 2005).

189. It is considered that, whether looking at the biotope or species level, the coarse sediment communities will generally be of low sensitivity to disturbance which is expected of a dynamic sedimentary environment (see ***Table 9.12***). However, it is noted that sensitivity information is not available for all species and therefore there is medium confidence in this classification.

Table 9.12 Biotope Sensitivities to Physical Disturbance (source: Tyler-Walters, Lear and Allen 2004; Tillin 2013; Tillin 2016)

Biotope code	Biotope description	Tolerance	Recoverability	Overall sensitivity
SS.SSa.IFiSa	Infralittoral fine sand	Intermediate	High	Low
SS.SCS.CCS	Circalittoral coarse sediment	Intermediate	High	Low
SS.SMx.CMx	Circalittoral mixed sediment	Intermediate	Medium	Medium
SS.SSa.CFiSa	Circalittoral fine sand	No available information		
SS.SCS.ICS	Infralittoral coarse sediment	Not available		
SS.SMU.CSaMu	Circalittoral cohesive sandy mud	Intermediate	High	Low

190. The ZEA surveys identified an area in the south east of the East Anglia TWO offshore windfarm site that has potential *Sabellaria* reef which was found to be of 'low reefiness' using the Gubbay (2007) method (see MESL 2011). Two other stations with potential *Sabellaria* reef were identified in the north east of the site during the East Coast REC studies (Limpenny et al. 2011) (see ***Figure 9.13***). *S. spinulosa* is most frequently found in disturbed conditions and has a high rate of reproduction suited to life in unstable environments (Jackson and Hiscock 2008).

191. 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). This is supported by post construction surveys at operational windfarms (i.e. Greater Gabbard,

London Array and Gunfleet Sands) which have indicated rapid recovery of *Sabellaria*. The species was found to be one of the most abundant and it reached pre-construction abundance levels one to two years after construction (CMACS 2010; 2012; MMO 2014 and Marine Space 2015).

192. As the conditions across the East Anglia TWO windfarm site are largely homogenous and given that surveys reveal areas with potential to support reefs within the site, it is likely that suitable conditions will occur to allow *S. spinulosa* to re-establish in disturbed areas. 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 three to five years with successful annual larval recruitment (Pearce et al. 2007). As the *S. spinulosa* in the East Anglia TWO windfarm site 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 one 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.

193. While sea bed preparation for the worst case wind turbine, offshore platform and meteorological mast foundation option (jacket with suction caissons) and for inter-array and platform link cable installation covers a relatively large area (6.2km^2) any direct effects such as injury or mortality to benthic individuals from project construction activities would be restricted to those individuals in the immediate vicinity of the works which would be temporary in nature. Therefore, direct impacts would be limited and the magnitude of effect is considered to be low.

194. Taking account of embedded mitigation, which includes micrositing around *Sabellaria* reef, the impact of physical disturbance during the construction phase on benthic ecology receptors within the East Anglia TWO windfarm site is assessed as **minor adverse**. 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 representative of communities within the site.

9.6.1.1.2 Temporary Physical Disturbance in the Offshore Cable Corridor

195. Boulder clearance, pre-lay grapnel runs, sand wave levelling (i.e. dredging), and cable installation (i.e. ploughing) would lead to temporary physical disturbance in the offshore cable corridor. The area that may be affected by these works (3.6km^2, see ***Table 9.2***) constitutes a small proportion (2.6%) of the offshore cable corridor, resulting in the impact of temporary physical disturbance being assigned a low magnitude.

196. The effect of direct disturbance and temporary loss of sea bed habitat during cable installation activities has the potential to cause disturbance to the biotopes present (i.e. those in ***Table 9.12***). The sensitivities of these biotopes based on the tolerance and recoverability from physical disturbance are provided in ***Table 9.12***.

197. Areas of Coralline Crag (a geological formation native to the Suffolk coast consisting of a series of marine deposits characterised by bryozoan and mollusc debris – see ***Chapter 7 Marine Geology, Oceanography and Physical Processes***) and sandbanks, are located in the nearshore area of the coast between Lowestoft and Southwold (see ***Figure 9.14***). ***Figures 9.14*** and ***Figure 7.7*** shows how the offshore cable corridor has been routed to avoid sandbanks and the Crag. Therefore, there will be no direct adverse impacts on sandbanks or Coralline Crag and therefore there would be **no change** to these habitats from the construction activities in the offshore cable corridor. Any areas of *Sabellaria* reef in the offshore cable corridor (or East Anglia TWO windfarm site) identified via a detailed pre-construction geophysical survey which are required to be avoided (i.e. by micrositing of cable routes and wind turbine foundations) will be agreed with the MMO in consultation with Natural England and secured through the Design Plan and In Principle Monitoring Plan (document reference 8.13).

198. Areas affected will be relatively small in scale, localised and of a temporary nature, the magnitude of effect is therefore considered to be low. Sea bed recovery is expected quickly following cessation of installation activities, sensitive sites will be avoided by micrositing and given the tolerance and recoverability of the communities present, the significance of the impact on benthic receptors in the offshore cable corridor is assessed as **minor adverse**.

9.6.1.1.3 Impact 1 Summary: Temporary Physical Disturbance

199. The total worst case footprint for all temporary disturbance is 11.3km^2 which represents 3.19% of the offshore development 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 development area as well as the wider study area. The magnitude of temporary physical disturbance on benthic ecology receptors in the offshore development area is low and the greatest sensitivity is medium (i.e. *S. spinulosa*). Therefore, the overall worst case impact of temporary physical disturbance is considered to be of **minor adverse** significance.

200. 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 development 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.

9.6.1.2 Impact 2: Increased Suspended Sediment Concentrations and Associated Potential Smothering of Benthic Receptors

201. Increases in suspended sediment concentrations within the water column may occur as a result of sea bed preparation and associated sediment disposal together with sediment disturbed due to installation of offshore infrastructure, including foundations and cables. Activities such as sea bed disturbance 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 on benthic ecology receptors. ***Chapter 7 Marine Geology, Oceanography and Physical Processes*** provides details of potential suspended sediment changes.

202. Sediment disturbance and deposition from construction activities, such as cable and foundation installation could have an adverse and indirect impact on the benthic communities in the offshore development area. 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. However, given the coarse nature of the substrate and dynamic conditions throughout the offshore development area, it is likely that the communities are habituated and tolerant to smothering due to natural conditions. Available evidence suggests that this is indeed the case given the dominant species and communities detailed above in ***section 9.5***.

203. As described in ***Chapter 7 Marine Geology, Oceanography and Physical Processes***, most of the sediment released during construction would be coarse material and would primarily be released during sea bed preparation for wind turbines and offshore platforms which would make up a relatively short period within the full 27 month offshore construction window. As a result of the coarse nature of the sediment, this would fall as a highly turbid dynamic plume upon its discharge, reaching the sea bed 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. A 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. up to 6 hours). Sediment would settle to the sea bed within approximately 1km along the axis of tidal flow from the location at which it was released (see ***Appendix 7.2***). These deposits would be very thin (millimetres). Taking account of the spatial and temporal extents of increased suspended sediments, this is deemed to have a low impact magnitude on benthic receptors.

9.6.1.2.1 Increased Suspended Sediment Concentrations and Associated Potential Smothering of Benthic Receptors in the Windfarm Site

204. The sensitivity of receptors in the East Anglia TWO windfarm site to increases in suspended sediments and smothering are shown below in ***Table 9.13***.

Table 9.13 Sensitivities to Increased Suspended Sediment and Smothering by Deposited Sediment (source: Tyler-Walters et al 2018; Gibb et al 2014; Tyler-Walters, Lear and Allen 2004; Tillin et al. 2015; Jackson and Hiscock 2008; Budd and Hughes 2005)

Receptor	Tolerance / Resistance	Recoverability / Resilience	Overall Sensitivity
Light smothering – up to 5cm of fine materials			
Circalittoral coarse sediment biotopes	Medium	High	Low
S. spinulosa	High	Immediate	Not sensitive
S. bombyx	High	High	Low
N. hombergii (proxy species for *N. cirrosa*)	Tolerant	N/A	Not sensitive
Heavy Smothering – up to 30cm of fine materials			
Circalittoral coarse sediment biotopes	Not available		
S. spinulosa	Not available (Medium*)		
S. bombyx	Not available		
N. hombergii (proxy species for *N. cirrosa*)	Not available		
Increased suspended sediment concentrations			
Circalittoral coarse sediment biotopes	High	High	Not sensitive
S. spinulosa	High	Immediate	Not sensitive
S. bombyx	Tolerant	N/A	Not sensitive
N. hombergii (proxy species for *N. cirrosa*)	Tolerant	N/A	Not sensitive

*A conservative medium sensitivity has been assumed for the assessment.

205. While the overall volume of sediment displacement (i.e. sediment released from a dredger) in the East Anglia TWO windfarm site would be relatively large at approximately 4,090,000m^3, the majority of receptors in the East Anglia TWO windfarm site 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. ***Table 9.13*** shows that, overall, species present within the East Anglia TWO windfarm site are not sensitive to increases in suspended sediment and associated smothering. Any benthic communities in the immediate vicinity (within tens of metres see ***paragraph 203***) of sediment disposal locations e.g. wind turbine sea

bed preparation areas, which were unable to be avoided by micrositing, would potentially experience heavy smothering. While there is a paucity of available information on the sensitivity of the relevant species to heavy smothering (see ***Table 9.13***), it is assumed that, given the existing dynamic environment of the offshore development area, that species present would be of medium tolerance to this heavier smothering which would only occur in discrete areas and which therefore represents a low magnitude. The worst case scenario (heavy smothering) is therefore an impact of **minor adverse** significance.

9.6.1.2.2 Increased Suspended Sediment Concentrations and Associated Potential Smothering of Benthic Receptors in the Offshore Cable Corridor

206. As described in ***Chapter 7 Marine Geology, Oceanography and Physical Processes***, sand wave levelling / pre-sweeping activities associated with the export cable would result in the removal and disposal of sediment which would result in a temporary increase in suspended sediment concentrations. Sediment may also arise from pre-sweeping for export cables within the windfarm site (see ***section 9.6.1.2.1***). In addition, ploughing or jetting activity could result in the increase of suspended sediment in the offshore cable corridor.

207. Sediment transport modelling undertaken for the East Anglia ONE and cumulatively for the former East Anglia Zone (see ***Appendix 7.2***), found that coarse sediment would settle out rapidly (within 1km) where disturbed (or dredged). For finer materials deposition could occur at up to 50km from the source however the deposited sediment layer across the wider sea bed would be generally less than 0.2mm thick and would not exceed 2mm.

208. Sediment displacement in the offshore cable corridor would primarily be related to backhoe dredging e.g. at the HDD pop-out location or in areas of difficult ground conditions. It is estimated that up to 68,800m^3 of sediment could be released into the water column during this activity. For cable ploughing for the export cable the overall release volumes at any one location would be low and confined to near the sea bed along the alignment of the cable route and the rate at which sediment is released into the water column would be relatively slow and would be spread along the entire cable route. It is estimated that up to 96,000m^3 of sediment could be disturbed during export cable ploughing, only a small proportion of which would be suspended into the water column. As detailed in ***Chapter 7 Marine Geology, Oceanography and Physical Processes*** any increases in suspended sediment concentration in the offshore cable corridor arising from the disturbance of near surface sediments would be much less than those arising during foundation installation activities. Any potential smothering impact on benthic receptors would be confined to those within the immediate vicinity of the backhoe dredging activity, disposal site or cable installation location. Backhoe dredging, the export cable route and disposal sites would avoid sensitive features as agreed with the MMO and Natural England and the overall

volumes of sediment release would result in a low magnitude of impact on benthic receptors. When considering the low sensitivity of receptors this would result in an overall impact of **minor adverse** significance.

9.6.1.3 Impact 3: Remobilisation and Disposal of Contaminated Sediments

209. Sediment disturbance could lead to the mobilisation of contaminants which may be lying dormant within sediment and which could be harmful to the benthos. Given the low level of contaminants present in the sediments within the offshore development area (***Table 8.11*** in ***Chapter 8 Marine Water and Sediment Quality***), changes in water and sediment quality throughout the study area due to re-suspension or disposal (e.g. through drilling for foundation installation) of contaminants during construction have been assessed as negligible.

210. MarESA (MarLIN 2017) shows that, where contaminant levels are within environmental protection standards, marine species and habitats are not sensitive to changes that remain within these standards.

211. All relevant construction activities would be covered by the PEMP as well as emergency plans in the case of an accidental spillage or leak to ensure no release of contaminants as a result of the project. In addition to this, all vessels must adhere to the requirements of the MARPOL Convention Regulations with appropriate preventative and control measures.

212. As a result of the absence of significant existing contamination and the application of mitigation to avoid release of contaminants, there would be **negligible** impact with regard to benthic ecology receptors.

9.6.1.4 Impact 4: Underwater Noise and Vibration

213. Underwater noise and vibration from UXO clearance and pile driving for the installation of monopiles or pin-piles (as described in ***Chapter 6 Project Description***) has potential to impact on benthic receptors.

214. The maximum energy for piling would be 4,000kJ for 300m wind turbine monopile foundations, of which there would be up to 60. The maximum amount of piling operations would be associated with four-legged jackets which would have four piles per wind turbine (up to 300 piles for 75 250m wind turbines) using a maximum hammer energy of 1,800kJ however the greatest time periods for piling would be associated with installation of 60 300m wind turbines on four-legged jacket pin-pile foundations. In addition, pin-piling may also be required for one operational met mast, four offshore electrical platforms and one construction, operation and maintenance platform.

215. Other noise sources, including vessel activity and placement of cable protection are unlikely to have a significant effect on benthic ecology as the receptors in this area are likely to be habituated to noise such as that created by shipping due to the high intensity of shipping activity in the southern North Sea.

216. 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 the former East Anglia Zone (MESL 2011), has shown behavioural changes at frequencies around 170Hz (Heinisch and Weise 1987). There may be reactions from some benthic species to episodic noise such as that from pile driving and presence of vessels in an area (Lovell et al. 2005, Wale et al. 2013 and 2013a, Solan et al. 2016). Any impact is likely to be localised and temporary (i.e. occurring only during piling).

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

218. The spatial extent of underwater noise and vibration impacts on benthic receptors is unknown however is likely to be localised to areas in the immediate vicinity of monopile or pin-pile foundation installation. These installation activities would be intermittent.

219. Active piling activity for 325 hours (13.5 days) represents the temporal worst-case scenario for the installation of monopiles for the 300m wind turbines (this includes 10 minute soft-start and 20 minute ramp-up) The magnitude of this effect is therefore deemed to be negligible and therefore the overall significance of the impact would be **negligible**.

9.6.1.5 Impact 5: Potential Impacts on Sites of Marine Conservation Importance

220. As part of the Habitats Regulations Assessment (HRA) screening exercise, 15 designated sites within the southern North Sea which have benthic features as primary reasons for designation or qualifying features were identified (see the Information to Support Appropriate Assessment Report, document 5.3). Only four of these are within 50km (not including those transboundary sites already screened out, see ***Appendix 9.1***). There are no SACs designated for benthic

features within the footprint of the offshore development area and therefore no potential for direct impacts upon them.

221. There are areas of sandbank habitat inshore of the offshore cable corridor which are supporting features of the Outer Thames Estuary SPA (designated for red throated diver) (see ***Figure 9.14***). Direct impacts on the mapped sandbanks have been avoided through the site selection process however there is potential for smaller unmapped sandbanks and sand waves to be encountered during pre-construction surveys which may potentially require to be levelled to ensure the export cable(s) is installed at a depth below the sea bed surface that is unlikely to require its reburial throughout the life of the project. Based on the extent of sand wave levelling required for the East Anglia ONE project, it is anticipated that up to 1,000,000m^3 of sediment could be affected during sand wave levelling for export cable installation. As a worst case it is assumed all of this would be within the Outer Thames Estuary SPA. The sediment arisings from sand wave levelling in the offshore cable corridor would all be deposited within the export cable corridor.

222. Shallow sand banks would be avoided as far as possible by micrositing, however there is potential for portions of these and smaller sand waves to be levelled during export cable installation. This would result in an increase in suspended sediments, the impact of which is discussed below. In terms of direct impact, the removal of sand waves could potentially result in a temporary reduction or change in location of the food sources of red throated diver. This area of the southern North Sea is naturally dynamic, experiencing strong tidal currents and mobile sediments and therefore the fish and crustacean species (i.e. the prey of red-throated diver) present in the area), would be expected to be largely tolerant (i.e. of low sensitivity) to the anticipated levels of disturbance caused by sand wave levelling, see ***Chapter 10 Fish and Shellfish Ecology***. Over time, sand waves would be expected to re-form and the area to return to baseline conditions. Sand wave levelling would only be in discrete areas along the export cable route and the extent of this activity is considered to be small in relation to similar available habitat within the wider Outer Thames Estuary SPA. Therefore, the magnitude of impact is considered to be low.

223. Overall, the direct removal / levelling of sand waves from within the Outer Thames Estuary SPA would therefore result in an impact of **negligible adverse** significance.

224. With regard to indirect effects on protected sites with benthic supporting features these would be primarily related to sediment resuspension, movement in tidal currents and then subsequent deposition. Sediment transport modelling undertaken for East Anglia ONE and cumulatively for the former East Anglia Zone (see ***Chapter 7 Marine Geology, Oceanography and Physical Processes***) found that coarse sediment would settle out rapidly (within 1km) where disturbed

(or dredged). For finer materials deposition could occur at up to 50km from the source however the deposited sediment layer across the wider sea bed would be generally less than 0.2mm thick and would not exceed 2mm.

225. There are no SACs within 1km of the offshore development area and therefore it is unlikely that there is potential for indirect effects from the suspension of coarse sediment and therefore these sites are considered to be of negligible sensitivity. While finer sediment particles could be deposited at sites further away, these would be widely dispersed in low concentrations and within the range of natural variability. Therefore, any effects would be small scale, temporary and the recoverability of the benthic habitats and species throughout the southern North Sea is high, the magnitude of effect would be negligible.

226. There would also be potential for indirect impacts on supporting features of the Outer Thames Estuary SPA. The potential effects of changes in suspended sediments / sediment transport were considered above for all sites. Wave modelling (see ***Appendix 7.2***) determined that under all wave directions modelled, the zone of effects from the proposed East Anglia TWO project are small resulting in changes in baseline wave height of less than ±1% and therefore not significant and would not affect these sandbanks.

227. There remains the potential for impact on non-sandbank areas of the SPA from direct disturbance caused by cable installation and placement of cable protection; and from indirect disturbance caused by increased suspended sediment and subsequent smothering during cable installation. The area of direct disturbance within the SPA (discounting that from sand wave levelling which is assessed above) would be encompassed by the pre-lay grapnel run and would be relatively small at 3,200,000m^2 (which represents 0.09% of the entire SPA (and avoids known sandbanks) and would be of a temporary nature. The communities present within the northern coastal section of the Outer Thames Estuary SPA (see ***Figure 9.14***) that would be directly impacted by cable installation activities, exhibit high recoverability and tolerance to physical disturbance (see ***section 9.5.1.2***) any impact on sites of marine conservation importance would be related to temporary physical disturbance or increases in suspended sediment which have been assessed to be of low magnitude and therefore the effect on sites of marine conservation importance would also be of low magnitude.

228. Therefore, considering a sensitivity of low, an impact of **negligible adverse** significance on benthic ecology receptors associated with sites of marine conservation importance during construction of the project is evaluated.

9.6.1.6 Impact 6: Habitat Change Resulting from Sea Bed Preparation / Sediment Disposal

229. Habitat change may result from construction activities such as sand wave levelling, pre-sweeping and the disposal of sediment from a dredger or spoil

associated with drill arisings. These activities would have a footprint of 10.2km^2 across the entire offshore development area. The sediment types throughout the offshore development area are largely uniform and so there is limited potential for a permanent habitat change from disposal of sediment. Where disturbed sediments (e.g. from foundation or cable protection installation) are subsequently covered with infrastructure, the permanent loss of habitat is assessed as an operational impact in ***section 9.6.2.1***.

230. Schratzberger and Piers (2014) examined the role of sedimentary regime in shaping the distribution of subtidal mobile sandbank environments in the southern North Sea and looked at the benthic communities (with a particular focus on meiofaunal nematodes) that inhabit these environments. This study can be used to infer potential effects resulting from the removal / levelling of smaller sand waves.

231. It is noted that within the southern North Sea the variety of sedimentary transport processes, which operate at different scales and frequencies, create a wide range of sedimentary environments within sandbanks and therefore create a wide range of niches and a dynamic and diverse habitat. Therefore, the species associated with sandbank / sand wave habitats are considered to be able to quickly recover from disturbance such as that during construction of the proposed East Anglia TWO project. Following levelling of sand waves and subsequent installation of infrastructure, mobile sedimentary regimes would be expected to continue to be dynamic and, while the addition of hard infrastructure would result in a different biotope classification (see ***sections 9.6.2.1*** and ***9.6.2.4***), the areas in between the introduced infrastructure would rapidly return to the habitat type that was present prior to sand wave levelling. However, taking a precautionary approach and considering that individual *S. spinulosa* are likely to be present within the habitats with potential to be lost as a result of sea bed preparation and sediment disposal, the sensitivity of these habitats to change is considered to be medium.

232. There is potential for spoil from monopile and to a lesser extent, pin pile drill arisings to be disposed of adjacent to foundation locations. However, the volume would be small at up to 7,952.16m^3 per monopile. As a worst case it has been assumed that only up to 10% of monopile foundations would require drilling. When combined with the maximum potential drill arisings from pin-pile installation for offshore platforms this totals 98,874.56m^3 of potential drill arisings. It is likely that a large proportion of the drill arisings would be released in the water column as suspended sediment and therefore would fall under the assessment in ***section 9.6.1.2.1***. Other spoil generated during drilling is anticipated to be disposed of adjacent to the foundation location. Foundation locations would be microsited where possible to avoid sensitive features therefore avoiding disposal onto or next to sensitive features.

233. Any deposited spoil material from drilling would be likely to persist at the disposal location for longer than sediment from layers closer to the surface of the sea bed. However as discussed above, the total volumes would be relatively small, and the disposed sediment would be likely to mostly winnow away over the course of a few years. This represents an impact of low magnitude which when combined with a sensitivity of medium results in an overall impact of **minor adverse** significance for the impact of the disposal of spoil material from drilling for foundations

234. The disposal of sediment from sand wave levelling would result in habitat change in the areas where sediment is disposed (see the Site Characterisation Reports (Windfarm Site and Offshore Cable Corridor) document references 8.15 and 8.16, respectively). The worst case is associated with a volume of 1,550,000m^3 of sediment disposed episodically within the disposal area, therefore the habitat which experienced a change would be small in the context of the wider southern North Sea.

235. There are areas inshore where there is a higher concentration of silty substrate (see ***Figure 9.3a***) where there is potential for backhoe dredging e.g. at the HDD pop-out location. The disposal of more silty sediment on sediment of a more sandy and gravelly nature would result in a temporary change in habitat type and therefore potentially benthic community, however the volume of sediment associated with backhoe dredging in the nearshore area (up to 96,000m^3) represents a small volume for disposal relative to the disposal area within which it would be disposed (see the Site Characterisation Reports (Windfarm Site and Offshore Cable Corridor) (document references 8.15 and 8.16, respectively). Moreover, over the period of a few years any deposited siltier sediment would be expected to winnow away, and the habitat to return to its original condition and benthic community structure. This would therefore result in a low magnitude of impact. When considering a sensitivity of receptor of medium this results in an overall impact of **minor adverse** significance.

236. Large sandbanks associated with the Outer Thames Estuary SPA have been avoided in the site selection process and therefore direct impacts upon these features would be avoided. Across the wider offshore development area, the overall area affected would be small and sandbanks and sand waves would be avoided where possible by micrositing which results in a low magnitude of impact. Benthic communities associated with any levelled sand waves would be expected to recover rapidly and / or recruit other suitable nearby habitat and therefore their sensitivity would be low resulting in an overall effect of **minor adverse** significance.

237. Disposal locations would be selected to avoid sensitive benthic features (e.g. *S. spinulosa* reef), in consultation with the MMO and Natural England.

9.6.2 Potential Impacts During Operation

9.6.2.1 Impact 1: Loss of Habitat

238. The installation of infrastructure (foundations, scour protection and cable protection) will result in the permanent loss of some sea bed habitat throughout the lifetime of the proposed East Anglia TWO project. Additionally, there may be some loss of habitat over time associated with scour around foundations.

239. ***Table 9.2*** outlines the project infrastructure that would be placed on the sea bed for the duration of the project. Overall, this will have a relatively small footprint (approximately 2.02km^2 which is 0.57% of the offshore development area) and it is not anticipated that it would be considered significant in the context of similar available habitat in the wider area.

9.6.2.1.1 Loss of Habitat in the East Anglia TWO Windfarm Site

240. Within the windfarm site it is estimated that a worst case permanent loss of habitat would represent an area of approximately 1.91km^2 which is 0.89% of the windfarm site. This is considered to be a low magnitude in relation to the site and the wider region due to the presence of comparable subtidal sand and gravel habitats identified throughout the East Anglia TWO windfarm site and the wider former East Anglia Zone.

241. As previously discussed the East Anglia TWO windfarm site does not overlap with any sites designated for benthic habitats or features however potential *Sabellaria* reef was recorded with low-medium reef characteristics (see ***Figure 9.13***) in the south east of the windfarm site. The remaining habitat within the windfarm site is characterised as ‘Circalittoral coarse sediment’ biotope.

242. 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 from the benthic community associated with the area of sea bed take would be lost however in the context of community level impacts for habitats and species in the East Anglia TWO windfarm site the overall magnitude is deemed to be low. The resulting impact would be of **minor adverse** significance.

243. In terms of changes to habitat as a result of scour around foundations, this would again be small in scale and highly localised around the edge of the scour protection (see ***Chapter 7 Marine Geology, Oceanography and Physical Processes***). While the individuals associated with this habitat may be lost, the dynamic nature of sediments throughout the region and the ability of species such as *S. spinulosa* to colonise various habitat types means this impact would be negligible in magnitude and would therefore result in an overall impact significance of **negligible**.

244. This is supported by post construction surveys at operational windfarms (i.e. Greater Gabbard, London Array and Gunfleet Sands) which have indicated rapid recovery of *Sabellaria*. The species was found to be one of the most abundant and it reached pre-construction abundance levels one to two years after construction (CMACS 2010; 2012; Marine Space 2015).

245. 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 operational impact 4 (***section 9.6.2.4***) in relation to the potential impact of colonisation of the new artificial substrate created by the introduced artificial substrate.

9.6.2.1.2 Loss of Habitat in the Offshore Cable Corridor

246. 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 HDD breakout point offshore of the landfall. The maximum footprint of cable protection would be 108,800m^2 which represents 0.08% of the offshore cable corridor.

247. Post construction monitoring reports from various offshore windfarms have concluded no significant impacts on benthic habitats and associated faunal communities (MMO 2014). Moreover, the MMO (2014) report indicates that post construction monitoring has demonstrated a lack of ecological impact on benthic receptors due to cable laying.

248. Only a small percentage of the offshore cable corridor would experience a change of habitat. Individuals from the benthic community associated with the area of sea bed take would be lost. These species represent a medium sensitivity in the context of community level impacts for habitats and species in the offshore cable corridor and the overall magnitude is deemed to be low. Species such as *S. spinulosa* would be able to recolonise the introduced artificial substrate and would be able to recruit in the areas of the offshore cable corridor that did not require cable protection. The resulting impact is therefore assessed as being of **minor adverse** significance.

9.6.2.2 Impact 2: Physical Disturbance

249. There is potential for physical disturbance of the sea bed from jack-up vessel legs and vessel anchors during planned maintenance or, in the case of a cable failure, excavation of cables. In addition, small localised disturbance may occur as a result of changes in physical processes instigated by the positioning of structures on the sea bed. In general, the impacts from planned maintenance and changes in physical processes would be temporary, localised and small scale and overall there would be less impact than during construction.

250. As outlined in ***Table 9.2*** the following planned and unplanned maintenance activities are assumed as worst case scenarios:

- Repair and reburial of one array cable (of less than 4km length) every five years;
- Repair and reburial of 300m of export cable and platform link cable every five years
- Five cable repairs per year requiring the use of a cable laying vessel; and
- One visit to each wind turbine by a jack-up barge every two years (resulting 112,500m^2 of disturbance).

251. The worst case scenario for reburial of an up to 4km length of array cable would result in an impact footprint of 12,000m^2 every five years (average impact footprint of 2,400m^2 per year) (assuming a 3m disturbance width by jetting for repairs). For export cable reburial a disturbance footprint of 1,800m^2 every five years (360m^2 per year) would potentially occur which is calculated from an estimated worst case reburial of 300m of each export cable, based on a 3m disturbance width due to jetting, with smaller areas disturbed at any one time. The same level of disturbance (1,800m^2 every five years and 360m^2 per year) would occur for platform link cables. In addition, jack-up vessel footprint during O&M activities would result in a disturbance footprint of 3,000m^2 every visit to a wind turbine. Each footprint would be temporary (days to weeks in any one location) and would then recover, as such, the magnitude of this impact is considered to be low.

252. Whilst there is potential for recurring disturbance during maintenance, initial micro-siting, where possible, would avoid any sensitive features and therefore the potential for recurring impacts during O&M would be minimised. The worst case would be temporary disturbance to *S. spinulosa* which results in a classification of medium sensitivity. Regarding 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.

253. A low magnitude of impact combined with medium sensitivity leads to the overall impact of physical disturbance within the offshore development area during O&M to be evaluated as **minor adverse**. This has been reached on the basis that each disturbance activity would occur relatively infrequently, would be localised and temporary and that benthic ecology receptors would recover rapidly.

9.6.2.3 Impact 3: Increased Suspended Sediment Concentrations and Associated Potential Smothering of Benthic Receptors

254. Small volumes of sediment could be re-suspended during maintenance activities such as unplanned cable repair or from disturbance caused by jack up vessel legs and work vessel anchors. The volume of sediment arisen would be lower than during construction. Changes in coastal processes in the area caused by the deployment of the windfarm may also lead to increased sediment deposition

on the sea bed however it is not expected that there would be significant smothering effects during operation.

255. ***Chapter 7 Marine Geology, Oceanography and Physical Processes*** assessed the potential for suspended sediment to arise as a result of scour around foundation structures. The assessment found that under a worst case scenario of a 1 in 50 year return period, up to 5,000m^3 per wind turbine could potentially be released.

256. These values are considerably less than the worst case volumes of sediment potentially released following sea bed preparation activities which are around five times greater per wind turbine. Therefore, the impact would be of negligible magnitude. Given the high recoverability and tolerance of benthic habitats and species in the East Anglia TWO windfarm site and offshore cable corridor to increases in suspended sediment, the sensitivity would be low (see ***section 9.6.1.2*** and ***Table 9.13***). Therefore, an overall impact of **negligible** significance would result.

9.6.2.4 Impact 4: Colonisation of Foundations and Cable Protection

257. The sub-sea structures (foundations, scour protection and cable protection) are expected to be colonised by a range of species leading to a localised increase in biodiversity (Lindeboom et al 2011, Goriup 2017). Although potentially viewed as a positive effect, this represents a change from the existing environment ecology and may also increase the potential for colonisation by non-native species (see ***section 9.6.2.7***). Overall, the area available for colonisation would be low and to date there is no evidence of a clear 'reef effect' (Ocean Energy Systems (OES) 2009, Lindeboom et al 2011) or significant changes of sea bed environments beyond the vicinity of the structures themselves.

258. ***Table 9.14*** shows the sensitivity of the biotopes identified as being present throughout the East Anglia TWO windfarm site to a change to hard or artificial habitat.

Table 9.14 Biotope sensitivity to habitat change to hard or artificial habitat (source: Tyler-Walters et al 2018; Gibb et al 2014; Tyler-Walters, Lear and Allen 2004, Tillin 2014; 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.SSa.IFiSa	Infralittoral fine sand	Intermediate	High	Low

Biotope code	Biotope description	Tolerance	Recoverability	Overall sensitivity
SS.SCS.ICS	Infralittoral coarse sediment	Not available		
SS.SMU.CSaMu	Circalittoral cohesive sandy mud	Not available		
SS.SMx.CMx	Circalittoral mixed sediment	Not Available		

259. Confidence in the accuracy of this assessment is low due to the difficulty predicting exactly what species may colonise the structures and therefore a precautionary approach has been used to assess the impact.

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

261. *S. bombyx* lives within the sediment so a loss of substratum will cause a loss of individuals. However, recoverability is high due to widespread distribution of the infaunal Group M (see ***section 9.5.2.2***) within the site as well as high dispersal potential and reproductive rate of the species (Ager 2005). Furthermore, 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.

262. All project infrastructure that has a sub-sea element would represent a potential substrate for colonisation by marine flora and fauna, 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 East Anglia TWO windfarm site and offshore cable corridor as is the case with other impacts. As any newly introduced substrate would be a change from the existing environment (if not from sandy to hard then from natural to artificial) the impact on any ecological receptors cannot be considered beneficial in ecological terms.

263. The area of introduced colonisable substrate is difficult to calculate however it has been estimated as 1.91km^2 in the East Anglia TWO windfarm site and 0.11km^2 in the offshore cable corridor (see ***Table 9.2***).

264. Studies of operational windfarms 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 Windfarm 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).

265. 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 can be broadly compared to the artificial hard substrate created by cable protection.

266. *S. spinulosa* was recorded on the newly introduced artificial hard substrate at Horns Rev windfarm, suggesting that substrates created by the construction of offshore windfarms offer suitable substrates for *S. spinulosa* colonisation. There was also colonisation by eleven 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).

267. Several windfarm developments have had post-construction monitoring requirements relating to *S. spinulosa*. During post-construction monitoring at the Greater Gabbard windfarm *S. spinulosa* was the second most numerous benthic species identified in the benthic drop down video (DDV) 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 around which 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).

268. A change of habitat across an area of up to 356km^2 (i.e. the offshore development area) from a sedimentary substrate to a hard substrate would result in changes to the diversity and biomass of the marine communities present in the area through colonisation of the introduced infrastructure. However, there is likely to be only a small interaction between the remaining available sea bed and the introduced hard substrate and any interactions would be highly localised. Therefore, the magnitude of this impact is considered to be low.

269. Due to the widespread nature of the receptors in the region, it is unlikely that there will be any significant community or biodiversity changes. The sensitivity

of the benthic ecology is considered to be moderate, taking account of the precautionary principle.

270. Taking account of magnitude and sensitivity, alterations to existing communities through the addition of artificial hard substrate in the offshore development area would result in an impact of **minor adverse** significance.

9.6.2.5 Impact 5: Interactions of EMF with Benthic Invertebrates

271. EMF emissions from inter-array and offshore export cables have the potential to result in immunological effects on benthic invertebrates including, for example, delayed reproduction, however there is little evidence of any adverse effects (Schmiedchen et al*.* 2018). Hutchison et al*.* 2018 aimed to assess the potential for biologically significant consequences to occur by consideration of the importance of behavioural effects recorded and their repeatability through time. While the study was around a High Voltage Direct Current (HVDC) cable and therefore not directly comparable to the East Anglia TWO project which is using HVAC cables, it found that for elasmobranchs and American lobsters *Hommarus americanus* there was no evidence of the cable acting as a direct barrier to movement. They found that for a 330MW HVDC power cable, there was deemed to be no significant effect on American lobsters. While they would behave differently when exposed to EMF i.e. increase their turning behaviour and be distributed differently, they would be expected to move freely past the cable.

272. EMFs are strongly attenuated and decrease as an inverse square of distance from the cable (Gill et al. 2012), therefore any effects would be highly localised. Furthermore, it is anticipated that, as far as possible, cables would be buried thus reducing the effect of EMF, although it is recognised that cables may, in some locations, be buried to a lesser extent. Therefore, the magnitude of such an impact is considered negligible.

273. 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).

274. 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 which results in an overall impact of **negligible** significance.

9.6.2.6 Impact 6: Underwater Noise and Vibration

275. Research into the effects of underwater noise upon benthos is on-going however it is likely that there is habituation to noise created by the existing shipping which

occurs in the area. There may be reactions from some benthic species to episodic noise such as that from the presence of vessels in an area (Lovell et al. 2005, Whale et al. 2013a&b, Solan et al. 2016). Noise associated with the operational phase is primarily related to vessel movements on site. The impact of vessel noise on benthic invertebrates will be very localised and of a small scale and temporary nature.

276. In terms of underwater noise from operational wind turbines, measurement data from operational wind turbines at UK windfarms indicated low levels which were broadly comparable to ambient noise at ranges of only a few hundred meters (MMO 2014). It should be noted however that these measurements were taken from smaller wind turbines, often located in shallower water depths, which are likely to produce lower noise levels than those that will be installed for the proposed East Anglia TWO project. However, it is considered that, while the distances over which noise would propagate from the wind turbines would likely increase, they would still likely reach ambient levels within a few hundred metres. Therefore, any impact on benthic receptors would be negligible taking account of the relatively limited hearing ability of benthic receptors and the relatively low levels of underwater noise produced by operational wind turbines.

277. ***Section 9.6.1.4*** provides a review of literature relevant to hearing in and sensitivity of benthic receptors to underwater noise and vibration from shipping (i.e. the main source of noise during the operational phase) and therefore this information is not repeated here.

278. It is likely that benthic receptors throughout the East Anglia TWO offshore development area are habituated to ambient noise and vibration such as that created by shipping. They are therefore considered to be of negligible sensitivity to the noise produced by operational activities.

279. During operation vessel activity (up to 687 trips per annum) is likely to be concentrated within the windfarm site and localised by episodic maintenance requirements. While vessel activity would occur throughout the life of the project, it is likely to be greatest during the first few months and years of operation, tailing off throughout the middle part of the life of the project and then potentially increasing towards the end as wind turbines age and become in need of more frequent repair. As a result, a magnitude of impact of negligible is assigned to underwater noise and vibration during operation.

280. Benthic receptors will likely become increasingly habituated to noise produced by vessel activity. Therefore, taking account of the sensitivity of receptor and magnitude of impact an overall effect of **negligible** significance is assigned to this impact.

9.6.2.7 Impact 7: Introduction of Marine Non-native Species

281. Artificial hard substrates introduced by the proposed East Anglia TWO project including foundations, scour and cable protection could act as potential 'stepping stones' or vectors for MNNS.

282. The primary pathway for the potential introduction of MNNS is from the use of vessels and infrastructure that has originated from outwith the southern North Sea region particularly from regions that are ecologically distinct from the southern North Sea.

283. While the pathway for introduction of MNNS is from the use of foreign vessels and the introduction of infrastructure, both of which will be greatest during the construction phase, the introduction of MNNS has been considered as an operational impact. This is because, the vector capability of introduced artificial hard substrate would be most pronounced during the operational lifetime when the likelihood of MNNS establishing and extending their range would be greatest and therefore when the impact is most likely to be significant. Depending on the species, there is potential for secondary ecological changes to occur where there is competition between the non-native species and the native community.

284. Wilhelmsson and Malm (2008) noted examples of anthropogenic structures that constitute suitable habitats for MNNS. Specifically, the study recorded that numerous specimens of the intertidal giant chironomid *Telmatogeton japonicus*, an Asian invasive species known to have been transported around the world in ship ballast and on ship hulls, were found in the splash zone on several of the wind turbines at Utgrunden on the Swedish Baltic coast and at other sites in Denmark. The species has also been recorded on offshore buoys in Belgium. The authors note that the first recordings in Denmark of two amphipods, *Jassa marmorata* and *Caprella mutica*, were also made at offshore windfarm sites.

285. Potential MNNS impacts are a growing consideration for other proposed offshore developments including aquaculture, tidal and wave energy projects as well as the increasing number of mobile deep water drilling rigs and proposed floating production, storage and offloading facilities. Although ship ballast water appears to be the largest single vector for MNNS, bio-fouling communities on ships and petroleum platforms and the placement of human-made structures that provide new habitat are also identified as contributors (Glasby et al. 2007).

286. Under embedded mitigation (***section 9.3.3***) the Applicant and its contractors are committed to applying best practice techniques including appropriate vessel maintenance as outlined in MARPOL. This would minimise the risk of introduction of MNNS.

287. Given the required minimum distances between wind turbines (800m between wind turbines in a row and 1200m between rows) and potential scour protection infrastructure (see ***Table 9.2***) it is not anticipated that the changes would

constitute any form of linked reef-like feature. Taking account of this and of embedded mitigation, the magnitude of effect is considered to be low. The sensitivity of the existing environment is considered to be medium and therefore the potential adverse impact of introduced substrate acting as a vector for MNNS is considered to be of **minor adverse** significance.

9.6.2.8 Impact 8: Potential Impacts on Sites of Marine Conservation Importance

288. There is potential for impacts upon the benthic ecology receptors associated with the Outer Thames Estuary SPA from the presence of and maintenance activities associated with the export cables. However, given that the areas affected would be highly localised and the magnitude of effects would be less than those of construction, it is considered that the significance of any impact would be **negligible**.

9.6.3 Potential Impacts During Decommissioning

289. No decision has been made regarding the final decommissioning policy, as it is recognised that industry best practice, rules and legislation change over time. The decommissioning methodology and programme would need to be finalised nearer to the end of the lifetime of the proposed East Anglia TWO project so as to be in line with latest and current guidance, policy and legislation at that time. Any such methodology and programme would be agreed with the relevant authorities and statutory consultees. The requirement to submit a written decommissioning programme for approval is secured within the requirements of the DCO. The worst case scenarios for decommissioning activities and associated implications for benthic ecology are considered analogous with those assessed for the construction phase.

290. The scope of decommissioning works would involve removal of the accessible installed components. This is outlined in ***Chapter 6 Project Description*** and the detail will be agreed with the relevant authorities at the time of decommissioning and be subject to separate licensing based on best available information at that time. Offshore, this is likely to include removal of all of the wind turbine components and part of the foundations (those above sea bed level).

291. Unburied sections of the inter-array (and those in close proximity to foundations), platform link and offshore export cables would be cut at the ends and buried sections left *in situ*. Scour and cable protection would also be left *in situ*.

292. During decommissioning, there is potential for wind turbine foundation 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 although due to the absence of cable trenching during decommissioning, the levels of physical disturbance and increases in suspended sediment concentrations are likely to be much less pronounced.

293. The types of effect would be comparable to the following impacts identified for the construction (or in the case of the introduction of MNNS, the operation) phase:

- Impact 1: Temporary physical disturbance;
- Impact 2: Increased suspended sediment concentrations and associated potential smothering of benthic receptors;
- Impact 3: Remobilisation of contaminated sediments;
- Impact 4: Underwater Noise and Vibration; and
- Impact 5: Potential impacts on sites of marine conservation importance.

294. The magnitude of impacts 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.

295. For impacts during decommissioning deemed not to be directly comparable with those during construction, an assessment is carried out in the following sections.

9.6.3.1 Impact 1: Loss of Habitats and Species Colonising Hard Structures

296. During decommissioning, a proportion of the installed infrastructure (foundations, scour protection, cable sections) would be removed. This infrastructure would likely be colonised (see ***section 9.6.2.4***) and its removal would result in the loss of the species associated with it. It should be noted that confidence in the accuracy of this assessment is low due to the difficulty predicting exactly what species may colonise the structures and therefore what species may be removed during decommissioning. As a result, a precautionary approach has been used to assess the impact.

297. Removal of the colonised infrastructure would, over time, and subject to any predicted future trends, promote a return to the benthic conditions which occurred at the site prior to construction. The area of colonised infrastructure would be relatively low and restricted to areas in the immediate vicinity of the wind turbine foundations or cable protection. Lindeboom et al*.* (2011) and OES (2009) note that there is no clear evidence of changes to benthic environments beyond the vicinity of the structures themselves and so the magnitude of impact would be low.

298. As noted in ***section 9.6.2.4*** post construction monitoring surveys at a number of windfarms have found large abundances of *S. spinulosa*, particularly around cable routes but not in reef form (CMACS 2014 and Marine Space 2015). *S. spinulosa* are able to colonise both hard substrata and the mobile sediments present throughout the offshore development area. Therefore, the recoverability of the species to disturbance and removal during decommissioning activities is deemed to be high because, although individuals which have colonised the

introduced hard substrata may be impacted, the resultant habitat will be suitable for recolonization. Additionally, the high recruitment rates and ability of *S. spinulosa* to quickly settle out on recently disturbed sediment / habitat (see ***section 9.6.1.1.2***) means it would be able to quickly recover following its removal.

299. A reverting throughout the offshore development area of up to 1.81km^2 of artificial hard substrate habitat back to the soft substrate habitat present before construction would potentially result in a decrease in biodiversity however any impacts would be highly localised. Therefore, the magnitude of impact would be low.

300. Due to the widespread nature of the receptors in the region, it is unlikely that there will be any significant community or biodiversity changes. The sensitivity of the benthic ecology colonising introduced infrastructure is considered to be medium, taking account of the precautionary principle due to the inability to determine what species will be present (and in what form e.g. *S. spinulosa* reef or individuals).

301. Alterations to communities established throughout the operational phase would therefore result in an impact of **minor adverse** significance.

9.6.3.2 Impact 2: Loss of Habitat Resulting from Foundation or Cable Infrastructure Not Being Fully Removed During Decommissioning

302. It is anticipated that sections of the wind turbine foundations approximately 1m below the sea bed and cables outwith the vicinity of wind turbine foundations would be left *in situ*. This would result in the permanent loss of habitat below the surface layers of the sea bed. Habitat loss from the non-retrieval of foundations would be restricted to piled foundation types and would result in a worst case of approximately 222,327m^2 of habitat being lost. It is difficult to estimate the area of sub-benthic habitat that would be lost due to cables being left buried in the sea bed however an approximate estimate is that up to 373km of buried cable would be left *in situ*. It is considered that leaving cables buried would be less intrusive and result in a lower magnitude of environmental impact than removing them which could lead to further temporary physical disturbance and increases in suspended sediments.

303. Post construction studies at a number of windfarms have shown colonisation of windfarm infrastructure by a number of species, including *S. spinulosa*, to levels above that of the baseline (see ***section 9.6.2.1***) however it is unlikely that infaunal colonisation of foundations and cables between 3 and 65m below the sea bed would occur to a great extent with abundance and biomass of benthic species found to decrease significantly with depth (Frojan et al. 2012; Rees et al. 1999). Therefore, the sensitivity of benthic receptors is considered to be low.

304. Leaving portions of the foundations, cables and cable protection *in situ* reduces the potential for temporary physical disturbance and increases in suspended

sediment concentrations that would otherwise occur. The habitat lost due to this infrastructure would be minimal in the context of the entire maximum offshore development area (356km^2) and the wider southern North Sea and therefore the magnitude of impact would be negligible.

305. An overall significance of impact of **negligible adverse** is therefore evaluated for this impact.

9.7 Cumulative Impacts

306. The CIA considers habitat loss and disturbance in conjunction with adjacent windfarm projects and relevant industrial activities (e.g. aggregate extraction) together with inter-related effects caused by changes in physical processes based on the results of the physical processes assessment (see ***Chapter 7 Marine Geology, Oceanography and Physical Processes***). For the latter, it is anticipated that impacts will be localised and restricted to the zone of influence defined within the physical processes assessment. This zone of influence is based on the tidal and wave regime and has been used as a basis for deciding which projects should be considered in the CIA i.e. projects 50km or greater from the offshore development area are not considered. In addition, all operational projects, or projects which are planned to be constructed before construction of the East Anglia TWO project is due to begin, have also been scoped out of the CIA for cumulative construction effects.

307. Table 9.15 details the impacts assessed in section 9.6 and assesses the potential for there to be an arising cumulative impact.

Table 9.15 Potential Cumulative Impacts

Impact	Potential for cumulative impact	Data confidence	Rationale
Construction			
Impact 1: Temporary physical disturbance	Yes	Medium	Additive disturbance across the region from the sharing with East Anglia ONE North of the inner part of the offshore cable corridor (if the southern offshore cable corridor route option is selected) or the entire offshore cable corridor (if the northern offshore cable corridor route option is selected) (see ***Figure 9.1***).
Impact 2: Increased suspended sediment concentrations	Yes	Medium	East Anglia ONE North is 10km north east of East Anglia TWO windfarm site. The Southwold Aggregates Area is 3.4km from the offshore cable corridor. There is an aggregate extraction area 3km west of the East Anglia TWO windfarm site. There is therefore potential for cumulative impacts

Impact	Potential for cumulative impact	Data confidence	Rationale
			associated with suspended sediments and deposition if there is any overlap in the offshore construction phases of the two projects or aggregate extraction.
Impact 3: Re-mobilisation of contaminated sediments	No	Medium	There is a negligible impact from the proposed East Anglia TWO project and therefore any potential cumulative impact would also be negligible.
Impact 4: Underwater noise and vibration	No	Medium	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.
Impact 5: Potential impacts on sites of marine conservation importance	No	Medium	There is no impact from the proposed East Anglia TWO project and therefore no potential for cumulative impact.
Impact 6: Habitat Change Resulting from Sea Bed Preparation / Sediment Disposal	Yes	Medium	Sea bed preparation required at the East Anglia ONE North project has potential to result in habitat loss and therefore there is potential for cumulative impacts.
Operation			
Impact 1: Loss of habitat	Yes	High	Additive habitat loss across the region.
Impact 2: Physical disturbance	Yes	High	Additive physical disturbance across the region.
Impact 3: Increased suspended sediment concentrations	Yes	Medium	East Anglia ONE North is 10km north east of East Anglia TWO. There is therefore potential for cumulative impacts associated with suspended sediments and deposition if maintenance operations are being conducted simultaneously.
Impact 4: Colonisation of foundations and cable protection	No	Low	The effects of colonisation would be highly localised on the introduced structures and therefore there is no potential cumulative impact.
Impact 5: Interactions of EMF with benthic invertebrates	Yes	Medium	Although EMF effects would be highly localised around the cables, because the East Anglia TWO and East Anglia ONE North projects are sharing part or all of the offshore cable corridor there is potential for

Impact	Potential for cumulative impact	Data confidence	Rationale
			cumulative impact in the offshore cable corridor. Regarding, EMF in each project's windfarm site, effects will be highly localised around the inter-array and platform link cables and therefore there is no potential cumulative impact.
Impact 6: Underwater noise and vibration	No	Medium	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.
Impact 7: Introduction of MNNS	No	Medium	Embedded mitigation is proposed for the East Anglia TWO project to avoid the spread of non-native invasive species and it is expected that other projects would follow best practice.
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, except for the impacts in the below rows, cumulative impacts during the decommissioning stage are assumed to be the same as those identified during the construction stage.			
Impact 1: Loss of habitats and species colonising hard structures	No	Low	The effects of colonisation would be highly localised on the introduced structures and therefore so would any effect resulting from their removal. No potential for cumulative impact.
Impact 2: Loss of habitat resulting from foundation or cable infrastructure not being fully removed during decommissioning	Yes	Low	Although the effects of a loss of habitat would be highly localised and unlikely to affect particularly valuable habitat, there is potential for cumulative impact.

Table 9.16 Summary of Projects Considered for the CIA in Relation to Benthic Ecology

Project	Status	Offshore Construction period	Distance[3] from East Anglia TWO windfarm site (km)	Distance[4] from offshore cable corridor (km)	Included in CIA	Rationale
East Anglia ONE North	Pre-Application	2026-2028	10	0	Yes	Projects share part of an offshore cable corridor, are in a similar geographical area and likely to be constructed at similar times.
East Anglia ONE	Under construction	2018-2020	10	15	Yes	No potential for cumulative construction impacts however due to close proximities of projects there is potential for cumulative operational impacts.
Southwold Aggregates Area	In-planning	Unknown	4	3.4	Yes	Area is in close proximity to the offshore cable corridor.
Sizewell C Nuclear Power Station	Pre-Application	2021-2031	31	2	No	Screened out based on negligible impacts (outlined in ***section 3*** of ***Appendix 4.5***) and cable corridor siting south of Sizewell.

[3] Shortest distance between the considered project and East Anglia TWO
[4] Shortest distance between the considered project and either the northern or southern offshore cable corridor option – whichever is nearest.

9.7.1 Cumulative Impacts within the East Anglia TWO Windfarm Site

9.7.1.1 Temporary Physical Disturbance Associated with the Offshore Windfarm Sites During Construction and Operation

308. Whilst it is recognised that across the former East Anglia Zone and wider southern North Sea there would be additive physical disturbance effects on benthic ecology receptors, the overall combined magnitude of these would be negligible. The East Anglia ONE North site is 10km north east from the East Anglia TWO windfarm site and there may be temporal overlap of the construction period however, relative to the wider environment, the overall area of physical disturbance would be small, localised and of a temporary nature.

309. Regarding East Anglia ONE, this is currently under construction therefore there is no pathway cumulative temporary physical disturbance with the proposed East Anglia TWO project. Moreover, given the recoverability of the habitats and species across the former East Anglia Zone these areas would be expected to rapidly recover from temporary physical disturbance. East Anglia ONE North is 10km away and East Anglia ONE is 11km away from the East Anglia TWO windfarm site. Both projects will be subject to strict protocols to minimise the levels of disturbance during construction and operation activities.

310. The relatively small scale of the habitats affected by each project in relation to the habitat available within the region coupled with the relative ubiquity of species and habitats across the southern North Sea would lead to an effect of negligible magnitude.

311. In cases where sensitive habitats are present (e.g. *Sabellaria* reef), effects would be avoided where possible by micrositing and therefore potential cumulative impacts would be of **negligible** significance.

9.7.1.2 Loss of Habitat During Construction, Operation and Decommissioning

312. Whilst it is recognised that across the former East Anglia Zone and wider southern North Sea there would be an additive loss of habitat (including that from sea bed preparation during construction of the windfarms and from buried sections of piles or cables not being removed during decommissioning), the overall combined magnitude of this would be low taking account of the relatively small scale of the habitats affected by each project in relation to the habitat available within the region and its recoverability following removal of project infrastructure (see ***sections 9.6.1.6, 9.6.2.1*** and ***9.6.3.2***).

313. While the number of existing and planned windfarm projects in the southern North Sea is large, the areas of benthic habitat that would be lost as a result of their infrastructure would be relatively low in the context of the available habitat in the wider area. While a loss of habitat could be expected to result in a loss of the species associated with these habitats (resulting in a sensitivity of medium) recolonisation of the introduced infrastructure by some of the species present at

the windfarm sites prior to construction (e.g. *S. spinulosa* as in CMACS (2014)) would be expected together with the addition of species perhaps not originally there which could lead to a localised increase in biodiversity as has been witnessed at current operational windfarm sites (Lindeboom et al. 2011; MMO 2014; Goriup 2017). Therefore, the impact would be of low magnitude.

314. The amount of project infrastructure that would be left *in situ* following decommissioning would be expected to be similar across the projects included in this CIA. Therefore, taking the proposed East Anglia TWO project as a worst case (it has the greatest proposed capacity out of the three projects and therefore likely the most infrastructure) and multiplying this by three, the area of sea bed infrastructure that would be left *in situ* would be 4.8km^2. Again, the total area of habitat lost cumulatively between the projects would be low in the context of available habitat in the wider North Sea region and it is highly likely that the introduced hard substrate would be colonised by many species native to the region and therefore the impact would be low in magnitude.

315. In cases where sensitive habitats are present (e.g. *Sabellaria* reef), effects would be avoided where possible by micrositing and therefore potential cumulative impacts would be of **minor adverse** significance.

9.7.1.3 Increased Suspended Sediment Concentrations in the Offshore Windfarm Sites During Construction and Operation

316. Cumulative increases in suspended sediment during operational phases would be temporally distinct, of small scale (e.g. from jack-up vessel leg placement or cable repair) and highly localised therefore there would be **no change** in suspended sediment concentrations in terms of cumulative impacts.

317. The East Anglia ONE North project is 10km to the north east and may be constructed at a similar time to the proposed East Anglia TWO project and therefore represents the greatest potential for cumulative impacts in terms of increased suspended sediment in the windfarm sites. In addition, the East Anglia ONE windfarm site is located 11km to the south and therefore there is potential for operational impacts however these would be much less than the potential cumulative construction impacts from proposed East Anglia ONE North and East Anglia TWO projects.

318. As discussed in ***section 9.6.1.2.1***, the majority of suspended sediment from East Anglia TWO activities is expected to settle out on the sea bed within tens of metres of the source location. For a small proportion of finer materials these would settle out over a larger distance however this would form a very thin deposit with sediment travelling within the tidal flow.

319. ***Appendix 7.3*** describes how any plume that does arise would move in the direction of tidal currents which are governed by tidal ellipses. These are presented in ***Figure 7*** of ***Appendix 7.3*** which shows that there is no potential

physical connection, in terms of tidal currents, between the proposed East Anglia TWO and East Anglia ONE North projects. Therefore, there would be **no change** in terms of cumulative impacts from increases in suspended sediment concentrations from construction activities undertaken in the windfarm sites.

9.7.2 Cumulative Impacts Within the Offshore Cable Corridor

9.7.2.1 Temporary Physical Disturbance Associated with Activities in the Offshore Cable Corridor During Construction and Operation

320. The proposed East Anglia Two and East Anglia ONE North projects will share part or all of an offshore cable corridor and therefore there is potential for cumulative impacts associated with construction and unplanned maintenance activities.

321. If the projects do share an offshore cable corridor it is unlikely that cable ploughing for both projects will be carried out at the same or a similar time. Therefore, the potential for cumulative temporary physical disturbance is limited however, as a worst case, if they were to be installed at the same or similar time it is estimated that an area double that of East Anglia TWO could be affected. Although some elements of the sea bed preparation may overlap and therefore reduce the overall combined footprint any impacts would be temporary and limited to within tens of metres of the cable plough and therefore would be of low magnitude.

322. The sensitivity of the habitats and species within the offshore cable corridor to physical disturbance would be medium taking account of the precautionary principle by considering *Sabellaria* as the worst case. However, given the recoverability of habitats and species within the offshore cable corridors and the commitment by both the proposed East Anglia TWO and East Anglia ONE North projects to microsite around sensitive habitats, potential temporary physical disturbance impacts would be minimised. The magnitude of impact would be low resulting in an overall impact of **minor adverse** significance.

9.7.2.2 Loss of Habitat During Construction, Operation and Decommissioning

323. As noted above there is potential for cumulative impacts from the proposed East Anglia TWO and East Anglia ONE North projects sharing an offshore cable corridor. Regarding loss of habitat in the offshore cable corridor, this would be primarily related to sea bed preparation or sand wave levelling (see ***section 9.6.1.6***). If the projects were to use separate offshore cable corridors then the levels of sea bed preparation required could be expected to be double that of the proposed East Anglia TWO project as a worst case scenario. However, by sharing an offshore cable corridor the projects would be able to minimise a loss of habitat by requiring a narrower width of corridor than the combined width of two separate offshore cable corridors.

324. Taking two separate cable corridors and therefore two separate sand wave levelling exercises as the worst case and using an area of 0.8km^2 (assuming a pre-sweeping width of 40m) based on the parameters for the proposed East Anglia TWO project, the area of sand wave habitat potentially lost for both projects would be up to 1.6km^2. This is a relatively small area in the context of available habitat in the wider North Sea region.

325. Taking account of the dynamic nature of sand wave habitats in the southern North Sea (see ***section 9.6.1.6***) and the commitment to microsite around larger sandbanks and *Sabellaria* reef the magnitude of impact would be low.

326. In terms of a loss of habitat during the operational phase this would be primarily related to the installation of cable protection at cable crossings and where cable burial is not possible. If the proposed East Anglia TWO and East Anglia ONE North projects were to share a full offshore cable corridor then it can be expected that the amount of cable protection required would be double that of the East Anglia TWO project and therefore this is considered as the worst case. This total area of habitat loss would be up to 217,600m^2 which is considered small in the context of the wider available habitat in the southern North Sea. While the introduction of this artificial substrate would result in a change of biotope and the likely loss of species from the immediate area, studies have found that recovery of species such as *S. spinulosa* in windfarm export cable routes are rapid following cessation of activities and therefore the magnitude of impact is deemed to be low (CMACS 2010; 2012; MMO 2014).

327. It is likely that export cables for both the proposed East Anglia TWO and East Anglia ONE North projects would be left *in situ* following decommissioning. It is difficult to work out the area of habitat that would be lost as a result of cables being left *in* situ however the area would be small in the context of similar available habitat in the wider region and any loss would be confined to depths of 1-3m below the sea bed. Furthermore, leaving the export cables *in situ* would negate the potential for adverse impacts on benthos associated with an increase in suspended sediment and remobilisation of contaminated sediments. Therefore, the cumulative magnitude of impact of a loss of habitat from cables being left *in situ* following decommissioning would be low.

328. Overall, this would result in an effect of **minor adverse** significance.

9.7.2.3 Increased Suspended Sediment Concentrations During Construction and Decommissioning

329. As described in ***section 9.6.1.2.2*** the volume of sediment that would arise from installation of the offshore export cables would be small in scale compared to that occurring during foundation installation. As described in ***Appendix 7.3***, overall, there would be **no change** in terms of cumulative magnitude of impact for installation of East Anglia TWO and East Anglia ONE North cables.

330. The majority of the southern offshore cable corridor and a portion of the northern offshore cable corridor (a large proportion of which is also the East Anglia ONE North offshore cable corridor) pass through an 'Area Identified as Potential Aggregate Resource'. In addition, the Southwold Aggregates Area lies 3.4km south of the northern offshore cable corridor and 3.6km north of the southern offshore cable corridor (see ***Figure 17.5*** in ***Chapter 17 Infrastructure and Other Users***).

331. Small theoretical bed level changes are estimated as a result of cumulative impacts of East Anglia TWO cable installation and dredging at nearby aggregate sites however any changes would be small in scale, temporary and temporally distinct depending on whether aggregate dredging and construction of the proposed East Anglia TWO and East Anglia ONE North projects were carried out at the same time. The sensitivity of benthic receptors to this level of change would be as described in ***section 9.6.1.2*** (low to negligible). Therefore, an overall impact of **minor adverse** significance would result.

9.7.2.4 Interactions of EMF with Benthic Invertebrates During Operation

332. There is potential for cumulative EMF impacts particularly if the northern offshore cable corridor route option is selected as the final option for the East Anglia TWO project as this will be shared with East Anglia ONE North. A lesser cumulative EMF impact would be expected if the southern route option is chosen as a shorter length of the route, closer to landfall, would be shared.

333. The addition of a further two export cables for the East Anglia ONE North project can be expected to result in a doubling of the levels of EMF within the vicinity of the export cables. While each project's export cables will be buried as far as possible, the areas where burial is not possible are likely to be similar across both projects and therefore it would be in these areas where the greatest potential for impact lies.

334. As described in ***section 9.6.2.5*** there is little evidence of any adverse effects on benthic invertebrates. 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 and the magnitude of impact would be negligible. Furthermore, the substrate found throughout the East Anglia TWO northern offshore cable corridor (i.e. the route that would be shared between the two projects) would largely permit cable burial (see ***Figure 9.3a***) which the Applicant is committed to undertaking as far as possible. This would minimise impacts from EMF. Therefore, a cumulative impact of **negligible adverse** significance would result from sharing of the offshore cable route for East Anglia TWO and East Anglia ONE North.

9.7.2.5 Impacts Upon the Outer Thames Estuary SPA during Construction

335. During the installation of the proposed East Anglia TWO and East Anglia ONE North export cables there is potential for cumulative impacts on benthic receptors associated with the Outer Thames Estuary SPA. Impacts would primarily be related to increases in suspended sediment and associated smothering during ploughing (see ***section 9.6.1.2***). The volume of sediment released would be expected to be double that of the proposed East Anglia TWO project (see ***Table 9.2***) which amounts to 2,600,000m^3 (which includes sediment released due to trenching in the HDD pop-out area for both projects (see ***Table 9.2*** construction impact 2). While this represents a relatively large amount of disturbed sediment, the vast majority of it would settle in mounds on either side of the plough and would result in a low magnitude of impact (see ***section 9.6.1.2***).

336. Benthic species are likely to be habituated to increases in suspended sediments and physical disturbance caused by natural events and are therefore considered to be of low sensitivity. Sensitive habitats (i.e. sandbanks) in the Outer Thames Estuary SPA will be avoided by micrositing in both the proposed East Anglia TWO and East Anglia ONE North projects. The overall impact would be of **minor adverse** significance.

9.8 Transboundary Impacts

337. ***Appendix 7.3*** modelled sediment transport from the proposed East Anglia TWO project and concluded that due to the small scale and localised nature and of effects, transboundary impacts are highly unlikely to occur. It was therefore agreed by the SNCBs, following publication of ***Appendix 7.3*** and subsequent consultation at ETG meetings, that Transboundary Impacts on benthic ecology receptors could be scoped out (see consultation ***Appendix 9.1***).

9.9 Interactions

338. 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 areas of interaction between impacts are presented in ***Table 9.17,*** along with an indication as to whether the interaction may give rise to synergistic impacts. This provides a screening tool for which impacts have the potential to interact.

339. ***Table 9.18*** then provides an assessment for each receptor (or receptor group) related to these impacts in two ways. Firstly, the impacts are considered within a development phase (i.e. construction, operation or decommissioning) to see if, for example, multiple construction impacts could combine. Secondly, a lifetime assessment is undertaken which considers the potential for impacts to affect receptors across development phases. The significance of each individual impact is determined by the sensitivity of the receptor and the magnitude of effect; the sensitivity is constant whereas the magnitude may differ. Therefore, when

considering the potential for impacts to be additive it is the magnitude of effect which is important – the magnitudes of the different effects are combined upon the same sensitivity receptor. If minor impact and minor impact were added this would effectively double count the sensitivity.

340. For the purposes of this 'Interactions' assessment the receptor groups considered are:

- Sites of Marine Conservation Importance; and
- Benthic habitats and species (outside of designated sites).

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Table 9.17 Potential Interactions Between Impacts

Potential Interaction between impacts Construction	Impact 1 Temporary physical disturbance	Impact 2 Increased suspended sediment concentrations and associated potential smothering of benthic receptors	Impact 3 Remobilisation of contaminated sediments	Impact 4 Underwater noise and vibration	Impact 5 Potential impacts on sites of marine conservation importance	Impact 6 Habitat Change Resulting from Sea Bed Preparation / Sediment Disposal
Impact 1 Temporary physical disturbance	-	Yes	Yes	Yes (species dependent)	Yes	Yes
Impact 2 Increased suspended sediment concentrations and associated potential smothering of benthic receptors	Yes	-	Yes	Yes (species dependent)	Yes	No
Impact 3 Remobilisation of contaminated sediments	Yes	Yes	-	Yes (species dependent)	Yes	Yes
Impact 4 Underwater noise and vibration	Yes (species dependent)	Yes (species dependent)	Yes (species dependent)	-	Yes (species dependent)	Yes (species dependent)
Impact 5 Potential impacts on sites of	Yes	Yes	Yes	Yes (species dependent)	-	Yes

Potential Interaction between impacts							
marine conservation importance							
Impact 6 Habitat Change Resulting from Sea Bed Preparation / Sediment Disposal	Yes	No	Yes	Yes (species dependent)	Yes	-	
Operation							
	Impact 1 Loss of habitat	Impact 2 Physical disturbance	Impact 3 Increased suspended sediment concentrations and associated potential smothering of benthic receptors	Impact 4 Colonisation of foundations and cable protection	Impact 5 Interactions of EMF with benthic invertebrates	Impact 6 Underwater noise and vibration	Impact 7 Introduction of MNNS
Impact 1 Loss of habitat	-	Yes	No	No	No	Yes (species dependent)	No
Impact 2 Physical disturbance	Yes	-	Yes	No	No	Yes (species dependent)	No
Impact 3 Increased suspended sediment concentrations and associated potential smothering of benthic receptors	No	Yes	-	No	No	Yes (species dependent)	No
Impact 4 Colonisation of foundations and cable protection	No	No	No	-	No	No	No

Potential Interaction between impacts							
Impact 5 Interactions of EMF with benthic invertebrates	No	No	No	No	-	No	No
Impact 6 Underwater noise and vibration	Yes (species dependent)	Yes (species dependent)	Yes (species dependent)	No	No	-	No
Impact 7 Introduction of MNNS	No	No	No	No	No	No	-

Decommissioning		
With the exception of the two impacts outline below it is anticipated that the remainder of the decommissioning impacts will be similar in nature to those of construction.		
	Loss of habitats and species colonising hard structures	Loss of habitat resulting from foundation or cable infrastructure not being fully removed during decommissioning
Loss of habitats and species colonising hard structures	-	No
Loss of habitat resulting from foundation or cable infrastructure not being fully removed during decommissioning	No	-

Table 9.18 Potential Interactions Between Impacts on Benthic Ecology

	Highest level significance				
Receptor	**Construction**	**Operation**	**Decommissioning**	**Phase Assessment**	**Lifetime Assessment**
Sites of Marine Conservation Importance	Negligible	Negligible	Negligible	**No greater than individually assessed impact** The impact takes into account all of the potential effects that make up the impact on this receptor.	**No greater than individually assessed impact** Spatial impacts will be greatest during construction, and these impacts will be highly localised and temporary. Although there may be a permanent above surface footprint from cable protection this will be in the same locations as the area disturbed during construction (albeit with a smaller footprint). Any maintenance activities will be small scale, localised and again within the original area of disturbance. It is therefore considered that over the project lifetime these impacts would not combine and represent an increase in the significance level.
Benthic habitats and species	Minor adverse	Minor adverse	Minor adverse	**No greater than individually assessed impact** ***Construction*** *Impact 1 Temporary Physical Disturbance, Impact 2 Increased Suspended Sediment, Impact 3 Remobilisation of Contaminated Sediments and Impact 6 Habitat*	**No greater than individually assessed impact** Spatial impacts will be greatest during construction, and these impacts will be highly localised and temporary. Although there will be a permanent above surface footprint from infrastructure this will be in the same locations as the area disturbed during

	Highest level significance				
Receptor	**Construction**	**Operation**	**Decommissioning**	**Phase Assessment**	**Lifetime Assessment**
				Change Resulting from Sea Bed Preparation / Sediment Disposal are separately assessed as having low to negligible impact magnitudes. These impacts are intrinsically linked, with the main impact pathway being from physical disturbance which, depending on the impact, is either related to volume or areas of sediment / habitat affected and whether the impact is direct or indirect. Each impact would manifest through many of the same construction activities and therefore, there is potential for an interaction between the impacts. Only receptors within the direct footprint of plant / infrastructure would be physically disturbed, therefore beyond the immediate footprint of construction there is no pathway for interaction of direct and indirect impacts (e.g. sedimentary impacts). Within the footprint of direct disturbance, the greatest effect will come from the physical disturbance with suspension of sediments etc. being of secondary importance. It is therefore considered that the interaction of these impacts would not	construction (albeit with a smaller footprint). Any maintenance activities will be small scale, localised and again within the original area of disturbance. It is therefore considered that over the project lifetime these impacts would not combine and represent an increase in the significance level. The main source of underwater noise would be from piling and UXO clearance during construction. Operational noise effects and EMF effects would be highly localised during the project lifetime with negligible impacts. Given the scale of effect and ubiquity of receptors across the Southern North Sea region it is considered that over the project lifetime these impacts would not represent an increase in the significance level.

	Highest level significance				
Receptor	**Construction**	**Operation**	**Decommissioning**	**Phase Assessment**	**Lifetime Assessment**
				represent an increase in the significance level. *Impact 4 underwater noise and vibration* from pile driving and UXO clearance would potentially interact with all other impacts with the level of interaction being dependent on the sensitivity of individual species. Any receptors in the immediate footprint of construction would be most affected by the physical disturbance. Therefore, there is no pathway for greater impact through interactions with noise. Given that this will include mortality of individuals in this footprint there is no pathway for a greater impact significance. Beyond the immediate footprint, any interaction would be limited to the localised area where there is potential for noise disturbance within the footprint of any sediment plumes. Given that the magnitude of effect for all these impacts is negligible with limited sensitivity of the receptors, it is not considered that there would be any greater impact significance.	

Receptor	Highest level significance Construction	Operation	Decommissioning	Phase Assessment	Lifetime Assessment
				Operation *Impact 2 Physical Disturbance* and *Impact 3 Increased Suspended Sediment Concentrations* have potential to interact however given the scale of disturbance during operation there would be limited pathways for interaction for these impacts during the operational stage. It is therefore considered that the interaction of these impacts would not represent an increase in the significance level. There would only be potential for interaction with noise or EMF effects where these footprints overlapped with physical disturbance. Given that such overlaps will be highly localised and episodic it is considered that any interaction would not result in any greater impact significance	

9.10 Inter-relationships

341. The construction, operation and decommissioning phases of the East Anglia TWO 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.

342. 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 benthic ecology. The assessment of significance of these impacts on other receptors are provided in the chapters listed in ***Table 9.19***.

Table 9.19 Benthic 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 10 Fish and Shellfish Ecology***	N/A – this chapter informs the assessment in ***Chapter 10 Fish and Shellfish Ecology***.	Potential impacts on shellfish species are not assessed within this chapter, rather these are assessed within ***Chapter 10 Fish and Shellfish Ecology***. Many of the benthic species identified in ***Chapter 9*** are prey for shellfish species identified in ***Chapter 10 Fish and Shellfish Ecology***.
Suspended sediments and deposition.	***Chapter 7 Marine Geology, Oceanography and Physical Processes*** and ***Chapter 8 Marine Water and Sediment Quality***	Impacts as a result of suspended sediment and deposition are assessed in *sections* ***9.6.1.2***, ***9.6.2.3*** and ***9.6.3***.	Calculations for the volume of suspended sediment likely to arise and the associated transport pathways are described in ***Chapter 7 Marine Geology, Oceanography and Physical Processes***
Re-mobilisation of contaminated sediments.	***Chapter 8 Marine Water and Sediment Quality***	***Section 9.6.1.3.***	The potential extent of contaminated sediments is described in ***Chapter 8 Marine Water and Sediment Quality***. Contaminated sediments could adversely affect benthic species.
Impacts on the Outer Thames estuary SPA	***Chapter 10 Fish and Shellfish Ecology***	Potential impacts shellfish associated with the Outer Thames Estuary SPA considered briefly in ***section 9.6.1.5*** but considered in more detail in ***Chapter 10 Fish and Shellfish Ecology***.	Impacts on fish species which are prey for red-throated diver (the main qualifying feature of the SPA) are discussed in ***Chapter 10 Fish and Shellfish Ecology***.

9.11 Summary

343. Benthic ecology receptors were identified using a wide science base that includes project-specific surveys in the offshore cable corridor, surveys of the former East Anglia Zone and wider regional surveys. The majority of the offshore development area has a characteristic low diversity sandy habitat. A project-specific benthic grab survey within prospective offshore cable corridors (see ***Figure 9.1***) found that infaunal abundance and diversity is broadly comparable with the wider East Anglia Zone. Furthermore, no *Sabellaria* reef was identified in these surveys (Bibby HyrdoMap 2018).

344. The construction, operation and decommissioning phases of the East Anglia TWO project would cause a range of effects on benthic ecology. These are summarised in ***Table 9.20***. 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 windfarms and other activities such as aggregate dredging.

345. The effects that have been assessed are anticipated to result in changes of **negligible** or **minor adverse** significance to the above-mentioned receptors. No mitigation measures, other than those which form part of the embedded mitigation (***section 9.3.3***), are suggested.

Table 9.20 Potential Impacts Identified for Benthic Ecology

Potential Impact	Receptor	Value / Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Construction						
Temporary physical disturbance	Habitats and species within the East Anglia TWO windfarm site	Low to medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
Temporary physical disturbance	Habitats and species within the offshore cable corridor	Low to medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
Increased suspended sediment concentrations and associated smothering of benthic receptors	Habitats and species within the East Anglia TWO windfarm site	Low to medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**

Potential Impact	Receptor	Value / Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Increased suspended sediment concentrations and associated smothering of benthic receptors	Habitats and species within the offshore cable corridor	Low / negligible	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
Remobilisation of contaminated sediments	Habitats and species within the offshore development area	Low to medium	Negligible	Negligible	Nothing further to embedded mitigation	**Negligible**
Underwater noise and vibration	Habitats and species within the offshore development area	Medium	Negligible	Negligible	Nothing further to embedded mitigation	**Negligible**
Potential impacts on sites of marine conservation importance	Habitats and species within the offshore development area	Low to negligible	Negligible	Negligible	Nothing further to embedded mitigation	**Negligible**
Habitat change resulting from sea bed preparation / sediment disposal	Habitats and species within the offshore development area	Medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
Operation						
Loss of habitat in the windfarm site	Habitats and species within the East Anglia TWO windfarm site	Medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
Loss of habitat in the offshore cable corridor	Habitats and species within the	Medium	Negligible	Negligible	Nothing further to	**Negligible**

Potential Impact	Receptor	Value / Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
	offshore cable corridor				embedded mitigation	
Physical disturbance	Habitats and species within the offshore development area	Medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
Increased suspended sediment	Habitats and species within the offshore development area	Low	Low to negligible	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
Colonisation of foundations and cable protection	Habitats and species within the offshore development area	Medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
Interactions of EMF with benthic invertebrates	Habitats and species within the offshore development area	Negligible	Negligible	Negligible	Nothing further to embedded mitigation	**Negligible**
Underwater noise and vibration	Habitats and species within the offshore development area	Negligible	Negligible	Negligible	Nothing further to embedded mitigation	**Negligible**
Introduction of MNNS	Habitats and species within the offshore development area	Medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**

Potential Impact	Receptor	Value / Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Sites of Marine Conservation Importance	Habitats and species within the offshore development area	Low to negligible	Negligible	Negligible	Nothing further to embedded mitigation	**Negligible**
Decommissioning						
Loss of habitats and species colonising hard structures	Habitats and species within the offshore development area	Medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
Loss of habitat resulting from foundation or cable infrastructure not being fully removed during decommissioning	Habitats and species within the offshore development area	Low	Negligible	Negligible	Nothing further to embedded mitigation	**Minor adverse**
Impact from the complete removal of piled foundations	Habitats and species within the offshore development area	Low	Negligible	Negligible	Nothing further to embedded mitigation	**Minor adverse**

346. A summary of the potential cumulative impacts and the evaluated sensitivities of receptors, magnitude of impacts and overall significance of impacts is provided in ***Table 9.21***.

Table 9.21 Potential Cumulative Impacts Identified for Benthic Ecology

Potential Impact	Receptor	Value / Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Construction						
Temporary physical disturbance associated with the windfarm sites	Habitats and species within the East Anglia TWO windfarm site	Medium to low	Negligible	Negligible	Nothing further to embedded mitigation	**Negligible**
Loss of habitat	Habitats and species within the offshore development area	Medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
Increased suspended sediment concentrations and associated potential smothering of benthic receptors in the offshore windfarm sites during construction	N/A	N/A	**No change**	N/A	N/A	**N/A**
Increased suspended sediment concentrations within the offshore cable corridor	Habitats and species within the offshore cable corridor	Low	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
Impacts upon the Outer Thames Estuary SPA	Habitats and species within the Outer Thames Estuary SPA	Low	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
Operation						
Temporary physical disturbance associated with the offshore windfarm sites	Habitats and species within the East Anglia TWO windfarm site	Medium	Negligible	Negligible	Nothing further to embedded mitigation	**Negligible**
Temporary physical disturbance associated with activities in the offshore cable corridor	Habitats and species within offshore development area	Medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**

Potential Impact	Receptor	Value / Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Loss of habitat in the windfarm sites	Habitats and species within the East Anglia TWO windfarm site	Medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
Loss of habitat in the offshore cable corridor	Habitats and species within the offshore cable corridor	Medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
Increased suspended sediment concentrations associated potential smothering of benthic receptors in the offshore windfarm sites	Habitats and species within the East Anglia TWO windfarm site	N/A	**No change**	N/A	N/A	**N/A**
Increased suspended sediment concentrations in the offshore cable corridor	Habitats and species within offshore cable corridor	Low	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
Interactions of EMF with benthic invertebrates	Species within the offshore development area	Negligible	Negligible	Negligible	Nothing further to embedded mitigation	**Negligible**
Decommissioning						
Loss of habitat in the windfarm sites	Habitats and species within the East Anglia TWO windfarm site	Medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**
Loss of habitat in the offshore cable corridor	Habitats and species within the offshore cable corridor	Medium	Low	Minor adverse	Nothing further to embedded mitigation	**Minor adverse**

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