Dudgeon and Sheringham Shoal Offshore Wind Farm Extensions

Preliminary Environmental Information Report

Volume 1

Chapter 10 - Benthic and Intertidal Ecology

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Glossary of Acronyms

BAP	Biodiversity Action Plan
BEIS	Department for Business, Energy and Industrial Strategy
BGS	British Geological Survey
BSL	Below Sea Level
BTO	British Trust for Ornithology
CIA	Cumulative Impact Assessment
CIEEM	Chartered Institute of Ecology and Environmental Management
CSCB	Cromer Shoal Chalk Beds
CSIMP	Cable Specification, Installation and Monitoring Plan
CSQC	Canadian Sediment Quality Guidelines
DBT	Dibutyltin
DCO	Development Consent Order
DEP	Dudgeon Extension Project
EAC	Environmental Quality Standards
EEA	European Economic Area
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EQS	Environmental Quality Standard
ER-Ls	Effects Range Lows
ES	Environmental Statement
EPP	Evidence Plan Process
ETG	Expert Topic Group
EUNIS	European Nature Information System
FOCI	Feature of Conservation Interest
FEPA	Food and Environment Protection Act
FERA	Food and Environment Research Agency
HDD	Horizontal Directional Drilling
IEEM	Institute of Ecology and Environmental Management
IPC	Infrastructure Planning Commission
INNS	Invasive Non-Native Species
IPMP	In-Principle Monitoring Plan
JNCC	Joint Nature Conservation Committee

MarESA	Marine Evidence based Sensitivity Assessment
MarLIN	Marine Life Information Network
MBT	Monobutyltin
MCZ	Marine Conservation Zone
MPA	Marine Protected Area
MPS	Marine Policy Statement
MMO	Marine Management Organisation
MW	Megawatts
NE	Natural England
NPL	National Physical Laboratory
NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project
OWF	Offshore Wind Farm
OSP	Offshore Substation Platform
PAH	Polycyclic Aromatic Hydrocarbons
PEIR	Preliminary Environmental Information Report
PEL	Probable Effect Level
PEMP	Project Environmental Management Plan
PLGR	Pre-lay grapnel run
PSD	Particle Size Distribution
SAC	Special Area of Conservation
SEP	Sheringham Shoal Extension Project
SMRU	Sea Mammal Research Unit
SNCB	Statutory Nature Conservation Body
SPA	Special Protection Area
SSC	Suspended Sediment Concentrations
TEL	Threshold Effect Level
TBT	Tributyltin
THC	Total hydrocarbons
TNT	Trinitrotoluene
UK	United Kingdom
UXO	Unexploded Ordnance

Glossary of Terms

The Applicant	Equinor New Energy Limited
Dudgeon Offshore Wind Farm Extension site	The Dudgeon Offshore Wind Farm Extension offshore wind farm boundary.
The Dudgeon Offshore Wind Farm Extension Project (DEP)	The Dudgeon Offshore Wind Farm Extension site as well as all onshore and offshore infrastructure.
DEP offshore survey area	The benthic characterisation survey area covering DEP offshore wind farm area, offshore interlink and DEP export cable.
DEP offshore area	The Dudgeon Offshore Wind Farm Extension offshore wind farm boundary, including all offshore infrastructure
Infield cables	Cables which link the wind turbine generators to the offshore substation platforms.
Interlink cables	Cables linking two separate project areas. This can be cables linking: 1. DEP South and DEP North 2. DEP South and SEP 3. DEP North and SEP 1 is relevant if DEP is constructed alone or first in a phased development. 2 and 3 are relevant in a tandem construction.
Landfall	The point at the coastline at which the offshore export cables are brought onshore, connecting to the onshore cables at the transition joint bay above mean high water.
Offshore cable corridor	An area which will contain cables outside of a wind farm site(s), either interlink cables or offshore export cables.
Offshore export cables	The cables which would bring electricity from the offshore substation platform(s) to the landfall (220 – 230kV).
Offshore substation platform	A fixed structure located within the wind farm area, containing electrical equipment to aggregate the power from the wind turbine generators and convert it into a more suitable form for export to shore.
PEIR boundary	The area subject to survey and preliminary impact assessment to inform the PEIR, including all permanent and temporary works for DEP and SEP. The PEIR boundary will be refined down to the final DCO boundary ahead of the application for development consent.

Study area	Area where potential impacts from the project could occur, as defined for each individual EIA topic.
Sheringham Shoal Offshore Wind Farm Extension site	Sheringham Shoal Offshore Wind Farm Extension offshore wind farm boundary.
SEP offshore survey area	The benthic characterisation survey area covering SEP offshore wind farm area and SEP export cable.
SEP offshore area	Sheringham Shoal Offshore Wind Farm Extension offshore wind farm boundary, including all offshore infrastructure.
The Sheringham Shoal Offshore Wind Farm Extension Project (SEP)	The Sheringham Shoal Offshore Wind Farm Extension site as well as all onshore and offshore infrastructure.

10 BENTHIC ECOLOGY

10.1 Introduction

1. This chapter of the Preliminary Environmental Information Report (PEIR) considers the potential impacts of the proposed Dudgeon Offshore Wind Farm Extension Project (DEP) and Sheringham Shoal Offshore Wind Farm Extension Project (SEP) on benthic ecology. The chapter provides an overview of the existing environment for the proposed offshore development area, followed by an assessment of the potential impacts and associated mitigation for the construction, operation and decommissioning phases of DEP and SEP.
2. This chapter has been written by Royal HaskoningDHV, with the assessment undertaken with specific reference to the relevant legislation and guidance, of which the primary source are the National Policy Statements (NPS). Details of these and the methodology used for the Environmental Impact Assessment (EIA) and Cumulative Impact Assessment (CIA) are presented in **Section 10.4**.
3. The assessment should be read in conjunction with the following linked chapters:
   - **Chapter 8 Marine Geology, Oceanography and Physical Processes;**
   - **Chapter 9 Marine Water and Sediment Quality;**
   - **Chapter 11 Fish and Shellfish Ecology;**
   - **Chapter 12 Marine Mammal Ecology;** and
   - **Chapter 13 Offshore Ornithology.**
4. Additional information to support the benthic ecology assessment includes:
   - **Appendix 10.1 DEP Benthic Characterisation Report;**
   - **Appendix 10.2 SEP Benthic Characterisation Report;**
   - **Appendix 10.3 DEP and SEP Habitat Mapping;** and
   - **Appendix 10.4 Benthic Ecology Sensitivity MarESA.**

10.2 Consultation

5. Consultation with regard to benthic ecology has been undertaken in line with the general process described in **Chapter 6 EIA Methodology**. The key elements to date have included scoping and the ongoing Evidence Plan Process (EPP) via the Seabed Expert Topic Group (ETG). The feedback received has been considered in preparing the PEIR. **Table 10-1** provides a summary of how the consultation responses received to date have influenced the approach that has been taken.
6. Consultation relating to the Marine Conservation Zone Assessment (MCZA) has been included in the MCZA report and has not been repeated here.
7. This chapter will be updated following the consultation on the PEIR in order to produce the final assessment that will be submitted with the Development Consent Order (DCO) application. Full details of the consultation process will also be presented in the Consultation Report alongside the DCO application.

Table 10-1: Consultation responses

Consultee	Date / Document	Comment Received	Project Response
Habitat Loss			
Planning Inspectorate	Scoping Opinion, 19/11/19	The Scoping Report proposes to assess permanent habitat loss during operation and decommissioning only. A number of construction activities have the potential to result in a degree of habitat loss during construction. The Inspectorate considers that 'temporary habitat loss' should be scoped in for all phases of the Proposed Development as any interaction with the seabed may cause loss of habitat for some species. This should include as assessment of likely significant effects from cable protection. The consultation responses from the MMO and NE support this position. The Inspectorate therefore does not agree that construction phase effects can be scoped out of the assessment.	Temporary habitat loss/disturbance is assessed during construction in (**Section 10.6.2.1**) operation (**Section 10.6.3.1**) and decommissioning (**Section 10.6.4**). Long term habitat loss due to cable protection installation is assessed during operation in **Section 10.6.3.3**; and permanent habitat loss is assessed in **Section10.6.3.2** for any infrastructure not removed. The assessment is based on the worst case area of seabed that may be affected for each project (in isolation and together).
Planning Inspectorate	Scoping Opinion, 19/11/19	The ES should assess the significant effects associated with temporary habitat loss which could arise from construction activities that extend beyond the permanent footprint of the infrastructure, for example from construction vessels' extendible legs and anchors.	
Planning Inspectorate	Scoping Opinion, 19/11/19	The ES should assess any likely significant effects resulting from the loss of habitat due to scour, scour protection and altered sedimentary processes.	
MMO	Scoping Opinion, 19/11/19	The potential impact of 'Permanent habitat loss' has been scoped in under the operation phase of the development in Table 2-8. While there is a recognition that the exact nature and design of turbine foundation remains unknown, all available types result in a degree of habitat loss during the construction phase. The MMO recommend including reference to the maximum area of seabed that may be affected (e.g. a total of 61 turbine with gravity base foundations), in relation to the DEP and SEP area for lease, to help justify the scoping decision.	
Sediment deposition			
Natural England	Seabed Expert Topic Group 03/02/2021	How will the project ensure that seabed sediments moved as a result of the works will be deposited in an environment of a similar nature and will avoid sensitive habitats etc. It is recommended that this is considered as part of the assessment. Consideration of sediment deposition on as part of benthic ecology assessment is required.	Embedded mitigation for the project (**Section 10.3.3**) states that any sediment removed from the Cromer Shoal Chalk Beds Marine Conservation zone (CSCB MCZ) will be deposited within the MCZ in areas similar to the habitat removed. **Section 10.6.2.2** (construction), **Section 10.6.3.4** (operation) and **Section 10.6.4** (decommissioning) assesses impacts of sediment deposition on benthic ecology.
Contaminated sediments			

Consultee	Date / Document	Comment Received	Project Response
Planning Inspectorate	Scoping Opinion, 19/11/19	Table 2-8 of the Scoping Report proposes to scope out re- mobilisation of contaminated sediments during operation, however there is no text within the chapter to support this approach. For the reasons given above in Table 4.2 of this Opinion, and as the Scoping Report scopes in this matter for effects to fish and shellfish, the Inspectorate does not consider it has sufficient information to scope this matter out. Any likely significant effects should be assessed within the ES.	Impacts on benthic ecology receptors from re-mobilisation of contaminated sediments are assessed in **Section 10.6.2.3**, in relation to construction. This explains that due to there being no contaminated sediments above levels of concern within DEP and SEP offshore areas there is no pathway for effect to benthic receptors. Therefore, there is no impact for all scenarios and the impact is not considered further in relation to operation or decommissioning due to there being no pathway for impact on benthic receptors.
Underwater noise			
Planning Inspectorate	Scoping Opinion, 19/11/19	The Scoping Report proposes to scope out underwater noise and vibration during the operational phase. This is on the basis that monitoring studies of operational turbines (North Hoyle, Scroby Sands, Kentish Flats and Barrow wind farms) have shown noise levels from wind farms to be only marginally above ambient noise levels and there is no evidence to suggest that this low level of noise and vibration has a significant effect on benthic ecology. The Inspectorate is concerned that the evidence presented within the Scoping Report to support the proposed scope of works may not be comparable to conditions likely to prevail for the SEP and DEP. The Inspectorate is also aware of current evidence gaps supporting the proposed approach in relation to vibration. The consultation responses from the MMO and NE both point to concerns in this regard. The Inspectorate considers that an assessment of the likely significant effects associated with these matters should be included in the ES. The Applicant is encouraged to make effort to agree the extent of any such assessment with relevant statutory consultation bodies including the MMO and NE.	Impacts to benthic ecology due to underwater noise during the operational phase have been assessed in **Section 10.6.3.6**.
Natural England	Scoping Opinion, 19/11/19	Underwater noise: Please be advised that the EIA will need to clearly demonstrate that data from previous R1 and 2 OWF remains fit for purpose for the larger turbines and electrical systems now used across industry. This has not been presented here in order for us to agree to it being scoped out.	Impacts to benthic ecology due to underwater noise during the operational phase has been assessed in **Section 10.6.3.6**.
Planning Inspectorate	Scoping Opinion, 19/11/19	The Inspectorate welcomes the intent to assess effects from underwater noise and vibration during the construction and decommissioning phases. The Applicant should make effort to agree the methodology with the relevant consultation bodies and it should be clearly explained within the ES. The baseline environment should be established and potential noise and vibration impacts assessed against this baseline. The criteria/thresholds used to determine the likely significance of effect should be clearly explained and justified, based on scientific publications, where available.	The baseline for benthic ecology is presented in **Section 10.5**. The methodology for the impact assessment is presented in **Section 10.4.3**.
Invasive Species			

Consultee	Date / Document	Comment Received	Project Response
Planning Inspectorate	Scoping Opinion, 19/11/19	The Scoping Report states that the introduction of artificial hard substrates and the use of vessels during construction could encourage the influx of invasive species, the effect of which will be assessed during operation. The Inspectorate considers the effects of invasive species should be assessed throughout the lifetime of the Proposed Development. The ES should identify and assess any likely significant effects associated with the potential introduction and spread of INNS, including the colonisation of hard substrates, in the marine environment from offshore works. Any measures to prevent or reduce these effects should be described in the ES.	INNS is assessed in the construction phase (**Section 10.6.2.5**) and in the operational phase (**Section 10.6.3.7**).
Marine Management Organisation (MMO)	Scoping Opinion, 19/11/19	The potential impact of 'Invasive species' has been scoped out of the construction phase of the development. The MMO recommend that further justification is included, e.g., mitigation measures for vessels/platforms involved in the construction of the DEP and SEP to ensure they are free from non-native species	
Cable Protection			
Natural England	Scoping Opinion, 19/11/19	Cable protection: Please be advised that a joint position paper between the MMO and Natural England is currently being drafted in relation to the place of cable protection. This position will clearly define the parameters for what is considered a construction impact, maintenance over the life time of the project, additional O&M placement and decommissioning. Currently the impacts from the use of cable protection are considered to be construction/installation and should be assessed as such recognising that this phase can last several years. In addition it is Natural England advice that cable protection is a permanent/long lasting impact not just during the lifetime of the project, but also beyond as there is currently no evidence to support the successful removal. Especially within designated sites where remove is likely to further impact on the interest feature of the site.	Temporary habitat loss/disturbance is assessed during construction (**Section 10.6.2.1**), operation (**Section 10.6.3.1**) and decommissioning (**Section 10.6.4**). Long term habitat loss is assessed in **Section 10.6.3.2**, and permanent habitat loss in **Section 10.6.3.2** for any cable protection not removed.
Natural England	ETG1, 30/10/2019	In principle Natural England is not against a 'no cable protection solution' but stated that they would be concerned of the risk of the OfTO requiring burial post-consent and subsequent risk to the designated site conservation objectives. NE would also be concerned about later exposure of buried cable requiring protection post-consent.	Noted. Cables will be buried where possible, minimising the requirement for external cable protection measures and thus minimising habitat loss impacts to benthic ecology receptors.
Habitat Creation			

Consultee	Date / Document	Comment Received	Project Response
Planning Inspectorate	Scoping Opinion, 19/11/19	The Inspectorate agrees that effects are unlikely to be significant during construction and that this matter can therefore be scoped out. However, any likely significant effects to colonisers of artificial substrates from decommissioning activities should be assessed.	The assessment of permanent habitat loss is assessed during decommissioning as a worst case scenario due to the fact that the artificial structures, where benthic receptors have the potential to colonise, may remain in-situ, therefore in the worst case scenario that is assessed the colonisers will also remain in-situ, therefore this impact has not been assessed. If the artificial structures are removed then an assessment of impacts to colonisers will be undertaken at the point of decommissioning, as stated in **Section 10.6.4**.
Planning Inspectorate	Scoping Opinion, 19/11/19	The Scoping Report states that there may be beneficial impacts such as habitat creation during operation. Any increase and/or change in biodiversity and species abundance as a result of the Proposed Development may not necessarily be beneficial if it is not representative of seabed/designated site features. This should be taken into account in the Applicant's assessment.	Habitat creation during operation as a result of colonisation of foundations and cable protection is assessed in **Section 10.6.3.5**.
Natural England	Scoping Opinion, 19/11/19	Habitat Creation: Please be advised that any increase and/or change in biodiversity and species abundance as a result of the OWF and associated infrastructure may not be beneficial as not representative of seabed/designated site features.	The impacts of change in habitat and associated biodiversity and species abundance as a result of the addition of the new artificial hard substrate are assessed in **Section 10.6.3.3** (for long term habitat loss) and **Section 10.6.3.2** (for permanent habitat loss).
Designated sites and species			
Planning inspectorate	Scoping Opinion, 19/11/19	The Scoping Report identifies the potential for *S. spinulosa* reef to be present in the application site. The ES should assess any impacts occurring during construction and also any potential impacts occurring during maintenance activities on reef that may colonise the cables during the operational phase.	Project surveys did not record any Annex I biogenic reefs. Biogenic reef that develops on artificial substrate such as external cable protection is not considered Annex I habitat as it would not naturally occur at the location. Impacts on *S. spinulosa* reef that may develop on the seabed in the vicinity of buried cables are assessed for operation (**Section 10.6.3**).
MMO	Scoping Opinion, 19/11/19	The data sources presented in Table 2-9 are relevant and the characterisation surveys proposed in Table 2-10 are suitable. However, if the cable route is re-routed to avoid the MCZ, further data will need to be obtained as the area to the west of the MCZ is data poor.	N/A. The cable corridor has not been re-routed to avoid the MCZ.

Consultee	Date / Document	Comment Received	Project Response
Natural England	Scoping Opinion, 19/11/19	For designated site features please determine sensitivity using conservation advice packages and advice on operations.	Conservation advice packages and advise on operations were used to determine sensitivity of designated site features, presented in the baseline in **Appendix 10.4**.
Natural England	Seabed ETG2, 02/06/2020	Subtidal chalk feature does not have to be at the surface to be a feature of the site and therefore she disagrees the chalk feature was only identified near the shore and extends further and covers most of the area – this position is considered necessary so as to be consistent with advice given to fisheries. LB stated that the assessment needs to make a distinction between outcropping and subcropping chalk features.	The distribution of outcropping subtidal chalk is described in **Section 10.5**. Further information is available in the **Draft Information for Marine Conservation Zone Assessment Report**.
Cumulative Impact Assessment			
PINS	Scoping Opinion, 19/11/19	The cumulative effects assessment should assess impacts on fisheries management areas that could potentially interact with the Proposed Development and where significant effects are likely to occur.	Cumulative impacts are assessed in **Section 10.7** which includes consideration of impacts from fisheries management.
MMO	Scoping Opinion, 19/11/19	For the cumulative impact assessment, and especially for the nearshore zone (landfall), the MMO advises that the local Shoreline Management Plan should be included in the considerations of impacts, especially as the minimum expected operational life of the projects will be 30 years and that a full list of nearby developments/schemes should be provided and considered.	Cumulative impacts are assessed in **Section 10.7** and include consideration of the relevant shoreline management plan. The DEP and SEP export cable corridor landfall is located within Policy Unit 6.01 of the Kelling Hard to Lowestoft Ness Shoreline Management Plan (SMP) (AECOM, 2010). The policy in this area is to allow natural processes to take place, i.e. allow coastal retreat through a policy of no active intervention on the open coast. HDD at landfall will avoid direct impact on the coastline. Erosion would continue as a natural phenomenon driven by waves and subaerial processes, which would not be affected by DEP and SEP.
Natural England	Scoping Opinion, 19/11/19	Please be advised that fisheries management areas will need to be considered as a plan or project.	Cumulative impacts are assessed in **Section 10.7** which includes consideration of impacts from fisheries management.
Benthic survey			

Consultee	Date / Document	Comment Received	Project Response
MMO	Scoping Opinion, 19/11/19	The precise benthic survey design to aid site characterisation currently remains unknown. However, the approach presented in the scoping report states that habitat maps will be made following interpretation of geophysical data. The MMO recommend that acoustic data are first interpreted and used to inform the placement of sampling stations for ground truthing, using the methods proposed (sediment samples and seabed imagery), before any habitat maps are created to ensure a more accurate assessment.	The benthic survey design, including the locations of sampling stations, has been informed by a review of geophysical acoustic data. The results of the benthic sampling survey were then used to classify acoustic data to produce habitat maps as described in **Appendix 10.3 DEP and SEP Habitat Mapping**.
MMO	Scoping Opinion, 19/11/19	Furthermore, it is recommended that the location of suitable reference areas is considered at this stage to aid with future monitoring requirements (for the both extension projects and the current Dudgeon and Sheringham OWFs).	A subset of the benthic survey stations were grab sampled in triplicate so that statistically robust assessment of can be over time can be made by future monitoring surveys.
Natural England	Scoping Opinion, 19/11/19	Please be advised that Natural England advises against undertaking benthic surveys during the winter months in this location due to prevailing weather conditions and ability to collect satisfactory data sets. Case example is the Sheringham Shoal pre- construction benthic survey. In addition, the use of sub-bottom profilers along the Bacton export cable route should be avoided in the winter months due to potential impacts to marine mammals within the Southern North Sea SAC. Natural England notes that no geotechnical investigations are included. We advise that as a minimum there would need to be some geotechnical investigations done pre- application to understand the feasibility of cable installation within the MCZ (see also comments on paragraph 204). These would need to be licenced through the MMO and would need to follow after the benthic surveys to demonstrate that there would be a significant impact to the features from the geotechnical surveys themselves. We would therefore expect a Preliminary Trenching Assessment (as done by Hornsea P3) or A cable installation assessment (Vanguard) to be provided as part of the project application.	The project geophysical surveys (using a sub-bottom profiler) where competed between September and December 2019 (offshore cable corridors, including the Bacton corridor) and between March and May 2020 (wind farm sites and interlink cable corridors) and therefore avoided the winter months. The project benthic surveys where competed in August 2020 and therefore avoided the winter months. No pre-application geotechnical surveys are planned. Existing geotechnical information, particularly evidence obtained from installing the nearby Dudgeon Offshore Wind Farm (OWF) export cable, will be used to inform a Cable Specification, Installation and Monitoring Plan (CSIMP) to be submitted with the DCO application.
Cefas	ETG3, 03/02/2021	Cefas noted that mixed and coarse sediment areas usually overlap with each other, this type of habitat with the addition of muddier sediments could provide habitat for different species.	A mosaic of similar subtidal course and mixed sediments was identified by project surveys with the distinction between them based on variations in the low proportion of fine sediment, that were sufficient to influence the macrofaunal communities present (**Section 10.5.5.1.3**).
Interactions with other chapters			

Consultee	Date / Document	Comment Received	Project Response
MMO	Scoping Opinion, 19/11/19	It is clearly stated in the text that "The Marine Geology, Oceanography and Physical Processes assessment is likely to have key inter-relationships with Marine Water and Sediment Quality, Benthic and Intertidal Ecology and Fish and Shellfish Ecology and these will be considered where relevant throughout the EIA process" (Chapter 2.1.2), but there is no further information provided on how this assessment will be done. As the combination of activities within the development project could lead to significant impacts, further explanation should be given accordingly.	Impact interactions are considered in **Section 10.10**, which includes interactions between marine geology, oceanography and physical processes and benthic ecology.
Scoping Report			
MMO	Scoping Opinion, 19/11/19	Section 2.3 'Benthic Ecology', (line 256, page 69) incorrectly summarises the Dudgeon OWF post-construction monitoring report. The MMO recommend that the sentence "The overall conclusion of the Dudgeon post-construction monitoring is that there are no significant differences in the benthic communities due to the construction of the wind farm." is removed from the scoping report. Prior advice on the Dudgeon OWF post-construction monitoring report has highlighted significant differences between the pre- and post-construction benthic assemblage.	A summary of the Dudgeon OWF post-construction monitoring report is provided in **Section 10.4.2**.
MMO	Scoping Opinion, 19/11/19	Not all protected features presented in the designation order of the Cromer Shoal Chalk Beds MCZ are included in the scoping report (line 265, page 70). Please amend the report accordingly.	All features of the Cromer Shoal Chalk Beds MCZ are presented in the baseline in **Section 10.5.5.1**.
Transboundary			
Planning Inspectorate	Scoping Opinion, 19/11/19	The Scoping Report states that effects on Benthic and Intertidal Ecology are likely to be restricted to the Proposed Development boundary and the immediate surrounding area. Having regard to the location of the Proposed Development (a minimum of 100km from any international territory boundary), the nature of potential impacts to benthic and intertidal ecology, the Inspectorate considers that transboundary impacts are unlikely to result in significant effects and therefore can be scoped out of the ES.	Transboundary impacts to benthic ecology have been scoped out. Justification for this is provided in **Section10.8.**
MMO	Scoping Opinion, 19/11/19	Regarding transboundary impacts, the applicant suggests that they are unlikely to occur or if they do, it's unlikely that they will be significant. No information is provided on how they have reached this conclusion. The text should be revised accordingly, and this conclusion should be further explained and better justified.	
EMF			
Planning Inspectorate	Scoping Opinion, 19/11/19	The Scoping Report proposes to scope out the assessment of effects from EMF on benthic species as any impacts are likely to be highly localised and impacts from EMFs are strongly attenuated decreasing as an inverse square of distance from the cable. The Scoping Report references studies which show EMFs do not impact benthic species and habitats. The Inspectorate considers that the evidence presented by in the Scoping Report is sufficient to demonstrate no likely significant effects in this regard and this matter can be scoped out of the ES	EMF has been scoped out in agreement with advice from Natural England and MMO, during the scoping response.

Consultee	Date / Document	Comment Received	Project Response
MMO	Scoping Opinion, 19/11/19	Potential impacts from Electromagnetic Fields (EMF) on benthic invertebrates have also been scoped out with the justification that there is a lack of evidence to suggest impact. The MMO agree with this justification. Note that while Bochert & Zettler (2006) did conclude that the distributions of the brown shrimp Crangon crangon, common starfish Asterias rubens and polychaete worm Hediste diversicolor do not change when exposed to EMF, the experimental conditions were much lower salinity (10 psu) than is typically found in the North Sea (~35 psu).	
Natural England	Scoping Opinion, 19/11/19	EMF should not be completely scoped out of the EIA, but Natural England agrees that it can be for benthic ecology.	

10.3 Scope

10.3.1 Study Area

8. The study area for benthic ecology has been determined by the extent of the potential effects on benthic receptors. Direct effects will occur within the offshore footprint of DEP and SEP infrastructure and construction, maintenance and decommissioning activities. These direct impacts will be entirely within the SEP wind farm site, DEP North and DEP South wind farm sites and offshore cable corridors. Indirect impacts may extend beyond the PEIR boundary, determined by the extent of potential changes to marine physical processes and sediment redeposition, as described in **Chapter 8 Marine Geology, Oceanography and Physical Processes**.

10.3.2 Realistic Worst Case Scenario

10.3.2.1 General Approach

9. The final design of DEP and SEP will be confirmed through detailed engineering design studies that will be undertaken post-consent to enable the commencement of construction. In order to provide a precautionary but robust impact assessment at this stage of the development process, realistic worst case scenarios have been defined in terms of the potential effects that may arise. This approach to EIA, referred to as the Rochdale Envelope, is common practice for developments of this nature, as set out in Planning Inspectorate Advice Note Nine (2018). The Rochdale Envelope for a project outlines the realistic worst case scenario for each individual impact, so that it can be safely assumed that all lesser options will have less impact. Further details are provided in **Chapter 6 EIA Methodology**.
10. The realistic worst case scenarios for benthic ecology assessment are summarised in **Table 10-2**. These are based on the project parameters described in **Chapter 5 Project Description**, which provides further details regarding specific activities and their durations.
11. In addition to the design parameters set out in **Table 10-2**, consideration is also given to how DEP and SEP will be built out as described in **Section 10.3.2.2** below. This accounts for the fact that whilst DEP and SEP are the subject of one DCO application, it is possible that either one or both DEP and SEP will be developed, and if both are developed, that construction may be undertaken either concurrently or sequentially.

Table 10-2: Realistic Worst Case Scenarios

Impact	DEP in Isolation	SEP in Isolation	DEP & SEP Together	Notes and Rationale
Construction				
Impact 1: Temporary habitat loss / disturbance	**Offshore cables:** Up to **267km** of cables comprising: • One HVAC export cable up to **62km** in length • **135km** of infield cables (DEP North: 90km; DEP South: 45km) • Up to 3 parallel interlink cables between DEP South and OSP in DEP North: up to **66km** in length (combined) • Burial depth: 0.5 to 1m (excluding	**Offshore cables:** Up to **130km** of cables comprising: • One HVAC export cable up to **40km** in length • **90km** of infield cables • No interlink cables • Burial depth: Same as DEP in isolation	**Worst case scenario per offshore cables:** Up to **481km**[1]: • 2 HVAC export cables up to **102km** in length • Up to **225km** of infield cables • Up to 7 interlink cables from DEP North to OSP in SEP, up to **154km** total length • Burial depth: Same as DEP and SEP in isolation • Cable trench maximum width of disturbance: Same as	The temporary disturbance relates to seabed preparation and cable installation. It should be noted that the seabed preparation area for foundations is less than the footprint of the foundation scour protection. **DEP and SEP together worst case scenario per cable** **Export:** DEP and SEP are developed with a separated grid option (each having their own

[1] The individual worst case scenarios presented for export, interlink and infield cables would not represent a developable scenario if taken as a total, therefore a 'realistic' worst case scenario for all cables is presented for this and for all other activities that vary depending on the development scenario in question. This includes sandwave clearance, number of OSP and anchoring.

Impact	DEP in Isolation	SEP in Isolation	DEP & SEP Together	Notes and Rationale
	burial in sand waves up to 20m; export cable surface lay possible in Cromer Shoal Chalk Beds MCZ) and up to 1.0m for the export cables. • Cable trench maximum width of disturbance: 3.0m • Maximum area disturbed: **0.789km^2** (Export cable 0.186km^2, Infield cables 0.405km^2, Interlink cables 0.198km^2)	• Cable trench maximum width of disturbance: Same as DEP in isolation • Maximum area disturbed: **0.390km^2** (Export cable 0.12km^2, Infield cables 0.27km^2)	DEP and SEP in isolation	substation and export cable). **Infield:** Assumes SEP, DEP North and DEP South are all built. **Interlink:** Assumes DEP and SEP are developed with an integrated grid option but only DEP North is developed.
			Realistic worst case scenario for all cables Up to **448km** of cables based on realistic scenario: **1.35km^2** (Export cable 0.24km^2, Infield cables 0.68km^2, Interlink cables 0.43km^2)	**Realistic worst case scenario for all cables** The realistic worst case scenario for cables is DEP and SEP are developed with an integrated grid option and both DEP North and DEP South are developed.

Impact	DEP in Isolation	SEP in Isolation	DEP & SEP Together	Notes and Rationale
	Seabed preparation ($0.986km^2$) • Sandwave clearance at north end of corridor between SEP and DEP North and corridor between DEP South and DEP North, in DEP North and DEP South: **$0.93km^2$** • Levelling (dredging) for GBS foundations, max 5m depth: $0.056km^2$ (for 18+MW) • Route clearance: Pre-lay grapnel run (PLGR): included in cable trench area / boulder clearance: **$785m^2$**	**Seabed preparation ($0.043km^2$)** • Levelling (dredging) for GBS foundations, max 5m depth: **$0.042km^2$** (for 18+MW) • Route clearance: PLGR: included in cable trench areas / boulder clearance: **$1,178m^2$**	**Seabed preparation** • Sandwave clearance at north end of corridor between SEP and DEP North and corridor between DEP South and DEP North, in DEP North and DEP South: **$0.93km^2$** • Levelling (dredging) for GBS foundations, max 5m depth: **$0.097km^2$** (for 18+MW) • Route clearance: PLGR: included in cable trench areas / boulder clearance: **$1,963m^2$**	The width of seabed disturbance along the PLGR is estimated to be up to 3m, which would be encompassed by the maximum footprint of cable installation works which has already been accounted for above. Boulders that present an obstacle to installation of infrastructure will be confirmed by the pre-construction surveys. Large boulders (in the order of 5m diameter and 1m height) will be relocated by subsea grab to an adjacent area of seabed within the DEP and SEP boundaries. The footprint of the boulder placement in the new location has been counted in the ‘boulder clearance’ disturbance footprint.

Impact	DEP in Isolation	SEP in Isolation	DEP & SEP Together	Notes and Rationale
				DEP and SEP together worst case scenario The worst case scenario for sandwave levelling when considered on its own is DEP and SEP developed with a separated grid option. However, the realistic worst case scenario is presented below.
			Realistic worst case scenario Realistic worst case scenario for sandwave clearance: **0.76km²** Maximum realistic worst case scenario for seabed preparation for DEP and SEP together: **0.85km²**	**Realistic worst case scenario** The realistic worst case scenario for sandwave clearance is DEP and SEP developed with an integrated grid option and both DEP North and DEP South are developed.
	Vessels (0.134km²) **Jack up vessels**	**Vessels (0.078km²)** **Jack up vessels**	**Vessels** **Jack up vessels**	Worst-case scenario is a jack-up barge with six legs per barge (200m² per leg) equating to a total footprint of 1,200m² per installation.

Impact	DEP in Isolation	SEP in Isolation	DEP & SEP Together	Notes and Rationale
	• Up to two jack-up deployments at each turbine/OSP. (**32 turbines + one OSP: 79,200m^2**) **Anchoring (77,520m^2)** • Turbine/OSP installation vessel anchoring (up to 12 lines per location) = **23,760m^2** • Export cable installation vessel anchoring (seven lines) (62km) = **26,040m^2** • Interlink cable installation vessel anchoring (seven moorings) = **27,720m^2**	• Up to two jack-up deployments at each turbine/OSP. (**24 turbines + one OSP: 60,000m^2**) **Anchoring** (**34,800m^2**) • Turbine/OSP installation vessel anchoring (up to 12 lines per location) = **18,000m^2** • Export cable installation vessel anchoring (seven lines) (40km) = **16,800m^2**	• Up to two jack-up deployments at each turbine/OSP. (**56 turbines + two OSPs: 139,200m^2**) **Anchoring** • Turbine/OSP installation vessel anchoring: (up to 12 lines per location) **41,760m^2**. • Export cable installation vessel anchoring (seven lines) (62km + 40km) = **42,840m^2** • Interlink cable installation vessel anchoring (seven moorings) = **64,680m^2**	**The worst case scenario for DEP and SEP together for anchoring** Turbine/OSP: DEP and SEP developed in an separated grid option. Export: DEP and SEP is developed with a separated grid option. Interlink: DEP and SEP are developed with an integrated grid option but only DEP North
			Realistic worst case scenario Anchoring: **0.135km^2**	**Realistic worst case scenario**

Impact	DEP in Isolation	SEP in Isolation	DEP & SEP Together	Notes and Rationale
			Jack up (1 OSP only): **0.137km²** Maximum realistic worst case scenario for vessels for DEP and SEP together: **0.27km²**	The realistic worst case scenario for vessels is DEP and SEP developed with an integrated grid option and both DEP North and DEP South are developed.
	HDD Exit Point **(978m²)** • Initial trench (600m²) • Transition zone (50m²) • Jack up footprint (128m²) • Deposited material on seabed (200m²)	**HDD Exit Point** **(978m²)** • Initial trench (600m²) • Transition zone (50m²) • Jack up footprint (128m²) • Deposited material on seabed (200m²)	**HDD Exit Point** **(1356m²)** • Initial trench (600m²) • Transition zone (100m²) • Jack up footprint (256m²) • Deposited material on seabed (400m²)	Horizontal Directional Drilling (HDD) beneath intertidal zone with offshore exit point approximately 1,000m offshore. For the DEP and SEP together scenario, the initial trench assumes both export cables are within the same initial trench, meaning the area of disturbance is the same as DEP and SEP in isolation scenarios. However, for the transition zone it assumes two trenches therefore the area of disturbance is double

Impact	DEP in Isolation	SEP in Isolation	DEP & SEP Together	Notes and Rationale
				DEP and SEP in isolation scenarios. Jack up footprint for DEP and SEP together is includes total jack up legs footprint and jack up movements required. Disturbance from the HDD exit point activities are within the CSCB MCZ, therefore footprint of temporary habitat loss/disturbance within the MCZ has been provided (below).
	Total Disturbance Worst case scenario total temporary disturbance footprint for DEP in isolation = **1.91km²** **Disturbance in the MCZ** Worst case scenario total temporary disturbance footprint	**Total Disturbance** Worst case scenario total temporary disturbance footprint for SEP in isolation= **0.53km²** **Disturbance in the MCZ** Worst case scenario total temporary disturbance footprint for	**Total Disturbance** Realistic worst case scenario total temporary disturbance footprint for DEP and SEP together= **2.47km²** **Disturbance in the MCZ** Worst case scenario total temporary disturbance footprint for DEP and SEP together in the	Long term habitat loss in the Cromer Shoal Chalk Beds MCZ is assessed under operational impacts. **Realistic worst case scenario** The realistic worst case scenario for seabed disturbance is DEP and SEP developed with an

<table>
<tr><th>Impact</th><th>DEP in Isolation</th><th>SEP in Isolation</th><th>DEP & SEP Together</th><th>Notes and Rationale</th></tr>
<tr><td></td><td>for DEP in isolation in the CSCB MCZ due to cable installation = 0.035km^2</td><td>SEP in isolation in the CSCB MCZ due to cable installation = 0.035km^2</td><td>CSCB MCZ due to cable installation = 0.069km^2</td><td>integrated grid option and both DEP North and DEP South are developed.</td></tr>
<tr><td rowspan="2">Impact 2: Temporary increases in suspended sediment concentrations (SSC) and deposition</td><td colspan="3">The worst case scenarios for Impact 2 are set out in Chapter 8 Marine Geology, Oceanography and Physical Processes (Table 8.3). The following impacts are relevant to the worst case for benthic ecology:
Impact 1 (a and b): Changes in suspended sediment concentrations due to seabed preparation and foundation installation and OSPs;
Impact 2 (a and b): Changed in seabed level due to seabed preparation and foundation installation and OSPs;
Impact 3: Changes in suspended sediment concentrations due to export cable corridor;
Impact 4: Change in seabed level due to deposition from the suspended sediment plume during export cable installation within the offshore cable corridor;
Impact 5: Changes in suspended sediment concentrations due to offshore cables installation (infield and interlink cables), and
Impact 6: Change in seabed level due to offshore cable installation (infield and interlink cables).</td><td rowspan="2">The worst case scenario represents the greatest potential for increased SSC across the study area as a result of changes to physical processes which could result in impacts to benthic ecology.

The worst case scenario for increased SSC during the construction period assumes sea bed preparation for the maximum number of GBS foundations, drilling for OSPs, jetting for export cable installation, and mechanical cutting for infield and interlink cable installation.</td></tr>
<tr><td>Total increases in SSC
Worst case scenario for total temporary</td><td>Total increases in SSC
Worst case scenario for total temporary increases</td><td>Total increases in SSC
Worst case scenario for total temporary increases in SSC for</td></tr>
</table>

Impact	DEP in Isolation	SEP in Isolation	DEP & SEP Together	Notes and Rationale
	increases in SSC for DEP in isolation= **1,165,529.16m^3** **Total increases in SSC in the MCZ** Worst case scenario for total temporary increases in SSC for DEP in isolation in the CSCB MCZ due to cable installation= **6,148.33m^3**	in SSC for SEP in isolation= **520,521.87m^3** **Total increases in SSC in the MCZ** Worst case scenario for total temporary increases in SSC for SEP in isolation in the CSCB MCZ due to cable installation= **6,148.33m^3**.	DEP and SEP together= **1,744,451.03m^3** **Total increases in SSC in the MCZ** Worst case scenario for total temporary increases in SSC for DEP and SEP together in the CSCB MCZ due to cable installation= **11,696.65m^3**	The realistic worst case scenario for increased SSC is DEP and SEP are developed with an integrated grid option and both DEP North and DEP South are developed.
Impact 3: Re-mobilisation of contaminated sediments	The worst case scenarios for Impact 3 are set out in **Chapter 9 Marine Water and Sediment Quality** (**Table 9.3**). The following impacts are relevant to the worst case scenario for benthic ecology: Impact 5: Deterioration in water quality due to the release of contaminated sediment during construction activities			
Impact 4: Underwater noise and vibration	The worst case scenarios for Impact 4 are set out in **Chapter 12 Marine Mammal Ecology**. They are underwater noise and vibration from UXO (Unexploded Ordnance) clearance and from piling. Noise levels from these sources are summarised in the marine mammals chapter in **Table 12-21** (UXO) and **Table 12-31** (piling). Underwater noise will be generated by other			UXO clearance generates highest noise levels. Hammer piled foundations generate underwater noise at multiple locations over a

Impact	DEP in Isolation	SEP in Isolation	DEP & SEP Together	Notes and Rationale
	construction activities including seabed preparations, cable installation and rock placement, and from vessels. **UXO** Various possible types and sizes of UXO. Worst case identified by Sheringham Shoal OWF and Dudgeon OWF: 2,000lb German air dropped bomb (Trinitrotoluene (TNT) equivalent of 525kg) Possible number of UXO unknown. **Piling** Maximum hammer energy for monopiles • Up to 5,000kJ for 14 MW WTG • Up to 5,500kJ for 18+MW WTG Maximum hammer energy for pin-piles: up to 3,000kJ Further details, including piling durations are set out in **Chapter 12 Marine Mammal Ecology**.			larger area for a longer duration.
Impact 5: Invasive Non-Native Species (INNS)	**Construction vessels** • Maximum number of construction vessels: **16**	**Construction vessels** • Maximum number of construction vessels: **16**	**Construction vessels** • Maximum number of construction vessels: **25**	Impacts from INNS may occur during and after the operation phase if INNS introduced by DEP and SEP activities establish on project infrastructure and in the surrounding marine environment. The risk of introducing INNS during construction is primarily

Impact	DEP in Isolation	SEP in Isolation	DEP & SEP Together	Notes and Rationale
				related to vessel activities should vessels come from other marine bioregions.
Operation				
Impact 1: Temporary habitat loss / disturbance	• Up to 10 jack-up deployments per year. Legs / spudcans footprint up to **12,000m²** per year • Cable repair, replacement and reburial footprint: **1,743m²** per year **Total Disturbance** Worst case scenario total temporary disturbance footprint for DEP in isolation per year = **13,743m²** Approximate total temporary disturbance footprint	• Up to 10 jack-up deployments per year. Legs / spudcans footprint up to **12,000m²** per year • Cable repair, replacement and reburial footprint: **1,170m²** per year **Total Disturbance** Worst case scenario total temporary disturbance footprint for SEP in isolation per year = **13,170m²** Approximate total temporary disturbance footprint for SEP in	• Up to 20 jack-up deployments per year. Legs / spudcans footprint up to **24,000m²** per year • Cable repair, replacement and reburial footprint: **4,737m²** per year. • Realistic cable repair, replacement and reburial footprint: **4,704m²** **Total Disturbance** Realistic worst case scenario total temporary disturbance footprint DEP and SEP together per year = **28,704m²**	Assuming a jack-up vessel with a seabed footprint of 1,200m² (up to four legs / spudcans, each with a footprint of up to 300m²). Disturbance is shown on average per year, however maintenance could vary across years during the operational stage. An approximate total disturbance is also shown for the operational life time, which is expected to be 35 years. The realistic worst case scenario for temporary habitat loss is DEP and SEP developed in integrated grid option

Impact	DEP in Isolation	SEP in Isolation	DEP & SEP Together	Notes and Rationale
	for DEP in isolation per operational lifetime (35 years) = **0.48km²**	isolation per operational lifetime (35 years) = **0.46km²**	Approximate total temporary disturbance footprint for SEP in isolation per operational lifetime (35 years) = **1km²**	and both DEP North and DEP South are developed.
Impact 2: Permanent habitat loss	**Wind turbine foundations:** Maximum footprint of 32 GBS foundations (14MW) including foundation scour protection: **0.46km²** **Substation foundations:** Maximum footprint of substation foundations including scour protection (with suction cans): **1,662m²**	**Wind turbine foundations:** Maximum footprint of 24 GBS foundations (14MW) including foundation scour protection: **0.34km²** **Substation foundations:** Maximum footprint of substation foundations including scour protection (with suction cans): **1,662m²**	**Wind turbine foundations:** Maximum footprint of 56 GBS foundations (14MW) including foundation scour protection: **0.8km²** **Substation foundations:** Maximum footprint of substation foundations including scour protection (with suction cans): **3,324m²**	Infrastructure that may not be removed during decommissioning. For reference, the DEP wind farm sites cover an area of 103.5km². The SEP wind farm site covers an area of 92.6km². Footprint of cable protection does not include cable protection in the MCZ as this is covered in long term habitat loss (Impact 3) below.
	Subsea cable surface protection	**Subsea cable surface protection and pipeline crossings:**	**Subsea cable surface protection and pipeline crossings:**	

Impact	DEP in Isolation	SEP in Isolation	DEP & SEP Together	Notes and Rationale
	and pipeline crossings: Maximum footprint of cable protection (Export, interlink and infield) and cable crossing protection: **0.051km^2** Up to **3.0km of surface protection: 15,400m^2** (0.5km export cables, 1.5km interlink cables, 1km infield cables) Up to **17 crossings** (overtrawlable) each with 2,100m^2 footprint (**35,700m^2**) • Infield cables, up to seven crossings (three in DEP North at Durango-Waveney pipeline,	Maximum footprint of cable protection (Export, interlink and infield) and cable crossing protection: **0.015km^2** Up to **1.5km of surface protection: 6,400m^2** (0.5km export cables, 1.0km infield cables) Up to **four crossings** (overtrawlable) each with 2,100m^2 footprint (**8,400m^2**) • Infield cables, no crossings • Export cable, up to four crossings (two for Dudgeon export cables, 2 for Hornsea Three export cables). One disused subsea cable crosses the export cable but no crossing required.	Maximum footprint of cable protection (Export, interlink and infield) and cable crossing protection: **0.059km^2** Up to **3km of surface protection: 14,800m^2** (0.5km export cables, 1.5km interlink cables, 1km infield cables) Up to **21 crossings** (overtrawlable) each with 2,100m^2 footprint (**44,100m^2**) • Infield cables, up to seven crossings (three in DEP North at Durango-Waveney pipeline, up to four in DEP South) • Interlink cables, up to six crossings (three cables from DEP South crossing 2	

Impact	DEP in Isolation	SEP in Isolation	DEP & SEP Together	Notes and Rationale
	up to four in DEP South) • Interlink cables, up to six crossings (three cables from DEP South crossing two Dudgeon export cables) • Export cable, up to four crossings (two at Dudgeon export cables, two for Hornsea Three export cables). One disused subsea cable crosses the export cable but no crossing required.		Dudgeon export cables) • Export cables, up to eight crossings (four at Dudgeon export cables, four for Hornsea Three export cables). One disused subsea cable crosses the export cable but no crossing required.	
	Total permanent habitat loss: 0.51km^2	**Total permanent habitat loss: 0.36km^2**	**Total permanent habitat loss: 0.86km^2**	
Impact 3: Long term habitat loss (in Cromer	**Cable protection (900m^2):**	**Cable protection (900m^2):**	**Cable protection (1,800m^2):**	Rock bags (designed to be removable on

Impact	DEP in Isolation	SEP in Isolation	DEP & SEP Together	Notes and Rationale
Shoal Chalk Beds MCZ)	• HDD exit transition zone (100m x 3m): **300m²** • External cable protection (100m x 6m): **600m²**	• HDD exit transition zone (100m x 3m): **300m²** • External cable protection (100m x 6m): **600m²**	• HDD exit transition zone (2 cables): **600m²** • External cable protection (2 cables): **1,200m²**	decommissioning) may be placed in the HDD exit transition zone and as cable protection for export cable. The impact assessment is based on removal during decommissioning.
Impact 4: Temporary increases in suspended sediment concentrations (SSC)	See Operation Impact 1: Temporary habitat loss / disturbance. Temporary increases in SSC will result from periodic jack up vessel deployment, and cable repair, replacement and reburial activities.			The volume of sediment that could be suspended has not been calculated but will be a small proportion of the quantity generated by construction and decommissioning activities.
Impact 5: Colonisation of foundations and cable protection	See impacts 2 and 3.	See impacts 2 and 3.	See impacts 2 and 3.	
Impact 6: Underwater noise and vibration	The worst case scenarios for Impact 6 are set out in **Chapter 12 Marine Mammal Ecology** (**Table 12.3**). The following impacts are relevant to the worst case scenario for benthic ecology: • Underwater noise from operational turbines • Underwater noise from maintenance activities • Underwater noise from vessels			

<table>
<tr><th>Impact</th><th>DEP in Isolation</th><th>SEP in Isolation</th><th>DEP & SEP Together</th><th>Notes and Rationale</th></tr>
<tr><td>Impact 7: INNS</td><td>O&M vessels
• Maximum number of construction vessels: 7

See also impacts 2, 3 and 6 for infrastructure that may be colonised.</td><td>O&M vessels
• Maximum number of construction vessels: 7

See also impacts 2, 3 and 6 for infrastructure that may be colonised.</td><td>O&M vessels
• Maximum number of construction vessels: 9

See also impacts 2, 3 and 6 for infrastructure that may be colonised.</td><td></td></tr>
<tr><td colspan="5">Decommissioning</td></tr>
<tr><td>Impact 1: Temporary habitat loss / disturbance</td><td colspan="3" rowspan="4">No final decision has yet been made regarding the final decommissioning policy for the offshore project infrastructure. It is also recognised that legislation and industry best practice change over time. However, the following infrastructure is likely be removed, reused or recycled where practicable:
• Turbines including monopile, steel jacket and GBS foundations;
• OSPs including topsides and steel jacket foundations;
• Offshore cables may be removed or left in situ depending on available information at the time of decommissioning; and
• Cable protection in the Cromer Shoal Chalk Beds MCZ.
The following infrastructure is likely to be decommissioned in situ depending on available information at the time of decommissioning:
• Scour protection;
• Offshore cables may be removed or left in situ; and</td><td rowspan="4">Decommissioning arrangements will be detailed in a Decommissioning Plan, which will be drawn up and agreed with the Department for Business, Energy and Industrial Strategy (BEIS) prior to construction.</td></tr>
<tr><td>Impact 2: Permanent habitat loss</td></tr>
<tr><td>Impact 3: Temporary increases in suspended sediment concentrations</td></tr>
<tr><td>Impact 4: Re-mobilisation of contaminated sediments</td></tr>
</table>

Impact	DEP in Isolation	SEP in Isolation	DEP & SEP Together	Notes and Rationale
Impact 5: Underwater noise and vibration Impact 6: INNS Impact 6: Potential impacts on sites of marine conservation importance	• Crossings and cable protection outside the Cromer Shoal Chalk Beds MCZ. The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of decommissioning and will be agreed with the regulator. For the purposes of the worst case scenario, it is anticipated that the impacts will be no greater than those identified for the construction phase.			

10.3.2.2 Construction Scenarios

12. The following principles set out the framework for how DEP and SEP may be constructed:
    - DEP and SEP may be constructed at the same time, or at different times;
    - If built at the same time both projects could be constructed in four years, with offshore construction being undertaken over two years (likely years three and four) of the overall construction period;
    - If built at different times, either project could be built first;
    - If built at different times the first project would require a four-year period of construction including a two year offshore construction period, the second project a three-year period of construction including a two year offshore construction period;
    - If built at different times, the duration of the gap between start of construction of the first project, and the start of construction of the second project may vary from two to four years;
        - If the gap between the projects is less than two years, the first project would wait for the second project in order to be constructed together;
    - Assuming maximum construction periods, and taking the above into account, the maximum period over which the construction of both projects could take place is seven years; and
    - The earliest construction start date is 2024 and the latest is 2028.
13. In order to determine which construction scenario presents the realistic worst case for each receptor and impact, the assessment considers both maximum duration effects and maximum peak effects, in addition to each project being developed in isolation, drawing out any differences between DEP and SEP.
14. The three construction scenarios considered in the benthic ecology assessment are therefore:
    - Build DEP or build SEP in isolation;
    - Build DEP and SEP concurrently – reflecting the maximum peak effects; and
    - Build one project followed by the other with a gap of up to four years (sequential) – reflecting the maximum duration of effects. This would result in a maximum gap in offshore construction of one year.
15. Any differences between DEP and SEP, or differences that could result from the manner in which the first and the second projects are built (concurrent or sequential and the length of any gap) are identified and discussed where relevant in the impact assessment section of this chapter (**Section 10.6**). For each potential impact only the worst case construction scenario for the two projects is presented, i.e. either concurrent or sequential. The justification for what constitutes the worst case is provided, where necessary, in **Section 10.6**.

10.3.2.3 Operation Scenarios

16. Operation scenarios are described in detail in **Chapter 5 Project Description**. The assessment considers the following three scenarios:
    - Only DEP in operation;
    - Only SEP in operation; and
    - The two projects operating at the same time, with a gap of up to three years between each project commencing operation.
17. The operational lifetime of each project is expected to be 35 years.

10.3.2.4 Decommissioning Scenarios

18. Decommissioning scenarios are described in detail in **Chapter 5 Project Description**. Decommissioning arrangements will be agreed through the submission of a Decommissioning Plan prior to construction, however for the purpose of this assessment it is assumed that decommissioning of DEP and SEP could be conducted separately, or at the same time.

10.3.3 Summary of Mitigation

10.3.3.1 Mitigation Embedded in the Design

19. This section outlines the embedded mitigation relevant to the benthic ecology assessment, which has been incorporated into the design of the projects (**Table 10-3**). Where other mitigation measures are proposed, these are detailed in the impact assessment (**Section 10.6**).

Table 10-3: Embedded Mitigation Measures

Parameter	Mitigation Measures Embedded into the Design of DEP and SEP
General	
Site selection	Careful site selection of the DEP and SEP wind farm areas and offshore cable corridor has been carried out to avoid designated sites as far as possible. It has not been possible to avoid the Cromer Shoal Chalk Beds MCZ (as detailed in **Chapter 4 Site Selection and Assessment of Alternatives**), however use of appropriate cable installation methodologies can help to ensure that impacts from cable installation are short term and reversible. The offshore cable corridor takes the shortest, most direct route possible from the DEP and SEP wind farm areas to landfall, whilst avoiding as many known sensitive benthic habitats as possible therefore reducing impacts to benthic ecology. Additionally, the offshore cable corridor has been sited to avoid cable crossings where possible and there are no cable crossings in the MCZ.
Turbines	Larger turbines have been selected that will reduce the number of turbines (and foundations) required whilst maintaining generating capacity, and therefore reduce impacts to benthic ecology.

Parameter	Mitigation Measures Embedded into the Design of DEP and SEP
Landfall	HDD will be used to install the export cables at the landfall, with the HDD exit point located approximately 1,000m offshore. Therefore, there will be no direct impacts on the intertidal zone. Additionally, **Chapter 8 Marine Geology, Oceanography and Physical Processes** concludes that there will be no significant indirect impacts on the nearshore environment. Therefore, no impacts are predicted on the intertidal zone and it is not considered further in this chapter.
Foundations	The selection of appropriate foundation designs and sizes at each wind turbine location will be made following pre-construction surveys within the offshore project area.
	For piled foundation types, such as monopiles and jackets with pin piles, pile-driving will be used in preference to drilling where it is practicable to do so (i.e. where ground conditions allow). This would minimise the quantity of sub-surface sediment released into the water column from the installation process.
	Micro-siting will be used where possible to minimise the requirements for seabed preparation prior to foundation installation.
Cables	Cables will be buried where possible, minimising the requirement for external cable protection measures and thus minimising habitat loss impacts on benthic ecology receptors. The minimum amount of pre-sweeping that is required to assist with the cable installation process will be undertaken and only in relation to the interlink cables and wind farm sites.
Sediment disposal	All seabed material arising from the Cromer Shoal Chalk Beds MCZ during cable installation (namely at the HDD exit point) would be placed back within the MCZ at or close to the source, using an approach, to be agreed with the MMO in consultation with the relevant Statutory Nature Conservation Bodies (SNCB). Sediment would not be disposed of in or nearby known sensitive benthic habitats and where possible will be redeposited within areas of similar sediment type.

10.3.3.2 Other Mitigation Measures

20. In addition to the embedded mitigation measures as outlined above, the Applicant has also committed to the following mitigation measures summarised in **Table 10-4**.

Table 10-4: Additional Mitigation Measures

Parameter	Mitigation Measures Embedded into the Design of DEP and SEP
Cable protection	The allowance for external cable protection within the Cromer Shoal Chalk Beds MCZ boundary is minimised.
	All external cable protection used within the Cromer Shoal Chalk Beds MCZ will be designed to be removable (i.e. no loose rock) with a commitment to remove, if required, at decommissioning.

10.4 Impact Assessment Methodology

10.4.1 Policy, Legislation and Guidance

10.4.1.1 National Policy Statements

21. The assessment of potential impacts upon benthic ecology has been made with specific reference to the relevant NPS. These are the principal decision making documents for Nationally Significant Infrastructure Projects (NSIPs). The NPS for Renewable Energy Infrastructure (EN-3) (DECC, 2011) is the NPS of most relevance to the benthic and intertidal ecology assessment.

22. The specific assessment requirements for benthic ecology, as detailed in the NPS, are summarised in **Table 10-5** together with an indication of the section of the PEIR chapter where each is addressed.

Table 10-5: NPS Assessment Requirements

NPS Requirement	NPS Reference	Section Reference
NPS for Renewable Energy Infrastructure (EN-3)		
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.	2.6.81	**Chapter 4 Site Selection and Alternatives** provides the rationale for the location of the wind farm sites and offshore cable corridors. HDD will be used at the landfall under the intertidal zone, therefore there will be no impacts to intertidal habitats, as described in **Section 10.3.3**.

NPS Requirement	NPS Reference	Section Reference
Applicants are expected to have regard to guidance issued in respect of FEPA (now Marine Licence) requirements.	2.6.83	Other relevant guidance, including Marine Licensing, are outlined below.
Where necessary, assessment of the effects on the subtidal environment should include: • loss of habitat due to foundation type including associated seabed 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.	2.6.113	An assessment of effects on the subtidal environment is set out in **Section 10.6**.
Construction and decommissioning methods should be designed appropriately to minimise effects on subtidal habitats, taking into account other constraints. Mitigation measures which the IPC 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;	2.6.119	Mitigation measures are set out in **Section 10.3.3**

NPS Requirement	NPS Reference	Section Reference
• burying cables at a sufficient depth, taking into account other constraints, to allow the seabed to recover to its natural state; and • the use of anti-fouling paint might be minimised on subtidal surfaces, to encourage species colonisation on the structures.		

10.4.1.2 Other

23. 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 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.

24. England currently has nine marine plans; those relevant to DEP and SEP are the East Inshore and The East Offshore Marine Plans (HM Government, 2014). These contain the two objectives stated below, which are of relevance to 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'.

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

- Cefas (2004) Offshore Wind Farms: Guidance Note for Environmental Impact Assessment in Respect of FEPA and CPA requirements: Version 2;
- Cefas (2010) Strategic Review of Offshore Wind Farm Monitoring Data Associated with FEPA licence conditions, with input from the Food and Environment Research Agency (FERA) and the Sea Mammal Research Unit (SMRU);

- Marine Management Organisation (MMO) (2014) Review of Post-Consent Offshore Wind Farm Monitoring Data Associated with Licence Conditions, with input from the British Trust for Ornithology (BTO), National Physical Laboratory (NPL) and the SMRU;
- Defra (2005) Nature Conservation Guidance on Offshore Windfarm Development. A guidance note on the implications of the EC Wild Birds and Habitats Directives for developers undertaking offshore windfarm developments. Version R1.9. 13.

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

- Cefas (2012) Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects;
- Wyn & Brazier (2001); Joint Nature Conservation Committee (JNCC) Marine Monitoring Handbook;
- Ware and Kenny (2011) Guidance for the Conduct of Benthic Studies at Marine Aggregate Extraction Sites;
- Institute of Ecology and Environmental Management (IEEM) (2010) Guidelines for Ecological Impact Assessment in Britain and Ireland – Marine and Coastal;
- Chartered Institute of Ecology and Environmental Management (CIEEM) (2016) Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater and Coastal, 2nd Edition; and
- The British Standards Institution (2015) Environmental impact assessment for offshore renewable energy projects – Guide. PD 6900:2015.

27. Further detail is provided in **Chapter 3 Policy and Legislative Context**.

10.4.2 Data and Information Sources

10.4.2.1 Project geophysical surveys

28. Site specific geophysical surveys (using a multibeam echosounder, side scan sonar and sub-bottom profiler) were undertaken prior to the benthic characterisation surveys, to inform the design of the benthic site characterisation surveys and to feed into the habitat mapping process. The surveys were undertaken in accordance with Ware and Kenny (2011) guidelines and agreed in advance with stakeholders including the MMO, Cefas and Natural England as required. The surveys undertaken were:

- Geophysical survey of the offshore export cable corridor options, September to December 2019 (Gardline, 2020a); and
- Geophysical survey of the DEP and SEP wind farm sites and interconnector cable corridors, March to May 2020 (Gardline, 2020b).

10.4.2.2 Project benthic characterisation survey

29. In order to provide site specific and up to date information on which to base the impact assessment, a benthic site characterisation survey was conducted split into separate reports for DEP and SEP. The site characterisation reports are available in **Appendix 10.1 DEP Benthic Characterisation Report** (Fugro, 2020a) and **Appendix 10.2 SEP Benthic Characterisation Report** (Fugro, 2020b).

30. The benthic characterisation survey was conducted in August 2020, and covered the DEP and SEP wind farm sites and the offshore cable corridors. The ‘DEP offshore survey area’ covered the DEP North and DEP South wind farm sites, interlink and offshore export cable corridors (**Appendix 10.1**) and ‘SEP offshore survey area’ covered the SEP wind farm site and the SEP offshore export cable corridor (**Appendix 10.1**). The survey areas and locations of survey stations are shown in **Figure 10.1**.

31. The survey included 26 survey stations within the DEP wind farm sites (with a ‘D’ prefix), 26 stations within the SEP wind farm site (with an ‘SS’ prefix), 19 stations in the two DEP interlink cable corridors (with a ‘CC’ prefix), and 25 stations in the export cable corridor between the SEP wind farm site and landfall (with an ‘EC’ prefix). The sampling consisted of drop down video and still photography at all stations, and grab sampling for macrofaunal and Particle Size Distribution (PSD) analysis at the majority of stations, some with triplicate grabs. At a subset of stations additional sediment grabs were taken for chemical analysis to determine levels of sediment contamination. The distribution of this sampling is illustrated in **Figure 10.1**.

32. The number of stations of each type of sampling method in the project areas were:

- Drop down video: All stations
- Grab samples:
  - 21 of the 26 stations within DEP wind farm sites (‘D’ stations);
  - 17 of the 26 stations within SEP wind farm site (‘SS’ stations);
  - 19 of the 19 stations within the two interlink cable corridors (‘CC’ stations); and
  - 18 of the 25 stations within the offshore export cable corridor (‘EC’ stations).
- Grab for chemical samples:
  - 2 stations within DEP wind farm sites;
  - 1 station within SEP wind farm site;
  - 1 station within the interconnector cable corridors; and
  - 3 stations within the DEP and SEP offshore export cable corridor.

33. The methodology for the benthic characterisation survey and subsequent data analysis was agreed with Natural England and the MMO. Further details of the surveys are available in **Appendix 10.1 DEP Benthic Characterisation Report** and **Appendix 10.2 SEP Benthic Characterisation Report**.

10.4.2.3 Benthic habitat mapping

34. Benthic habitat maps have been produced for the project area by combining the geophysical data sets and benthic sample data (grab and drop down video imagery) using geostatistical processing and spatial statistical analysis. A technical report summarising the benthic habitat mapping method and results is provided in **Appendix 10.3 DEP and SEP Habitat Mapping** (Envision, 2021).

10.4.2.4 Other available sources

35. The data sources that have been used to inform the assessment are listed in **Table 10-6**.

Table 10-6: Other available data and information sources

Data set	Spatial coverage	Year	Notes
Dudgeon OWF Environmental Statement (including 2009 pre-construction survey)	Dudgeon project area including the wind farm site and offshore export cable corridor.	2009	The report covers the Dudgeon project area which is in close proximity to the DEP wind farm sites, DEP South to SEP interlink cable corridor and offshore export cable corridor between the SEP wind farm site and landfall.
Sheringham Shoal OWF Environmental Statement	Sheringham Shoal project area including the wind farm site and offshore export cable corridor.	2006	The report covers the Sheringham Shoal project area which is in close proximity to the SEP wind farm site and offshore export cable corridor close to landfall.
Dudgeon OWF post-construction survey (MMT, 2019)	Dudgeon wind farm site (including outside the boundary) and export cable corridor section within the Cromer Shoal Chalk Beds MCZ.	2018	Recent survey data in close proximity to the DEP and SEP offshore areas, allowing comparison with the pre-construction baseline survey and an assessment of benthic recovery.

Data set	Spatial coverage	Year	Notes
Sheringham Shoal Post Construction Monitoring Benthic Survey (Fugro, 2013)	Sheringham Shoal wind farm site and offshore export cable corridor, plus reference sites including inside the SEP with farm site and in close proximity to the DEP and SEP export cable corridor.	2012	Survey data in close proximity to, and within, the DEP and SEP offshore areas, allowing comparison with the pre-construction baseline survey and an assessment of benthic recovery.
Sheringham Shoal OWF Second Post-Construction Benthic Monitoring Survey (Marine Ecological Surveys, 2014)	Sheringham Shoal wind farm site and offshore export cable corridor, plus reference sites including inside the SEP with farm site and in close proximity to the DEP and SEP export cable corridor.	2014	Survey data in close proximity to, and within, the DEP and SEP offshore areas, allowing comparison with the pre-construction baseline survey and an assessment of benthic recovery.
Sheringham Shoal OWF Export Cable Route Post - Construction Benthic Monitoring Survey (Fugro, 2020c)	Sheringham Shoal offshore export cable corridor within the Cromer Shoal Chalk Beds MCZ.	2020	Recent survey data in close proximity to the DEP and SEP offshore export cable corridor. Ten video transects across the offshore export cable route within the MCZ. Photographic data was analysed and compared with pre-construction survey data.
Marine Life Information Network (MarLIN) Marine evidence and sensitivity assessment (MarESA)	UK waters	Various	The MarLIN 'evidence base' remains the largest review yet undertaken on the effects of human activities and natural events on marine species and habitats, and includes evidence-based sensitivity assessments that have been used in the impact assessment.

10.4.3 Impact Assessment Methodology

36. **Chapter 6 EIA Methodology** provides a summary of the general impact assessment methodology applied to DEP and SEP. The following sections confirm the methodology used to assess the potential impacts on benthic ecology.
37. A matrix approach has been used to assess impacts following best practice, EIA guidance and the approach outlined in the DEP and SEP Scoping Report (Royal HaskoningDHV, 2019). An explanation of how this is applied within the benthic ecology assessment is set out below.
38. The data sources summarised in **Section 10.4.2** were used to characterise the existing environment, the description of which is presented in **Section 10.5.** Each impact, which has been identified using expert judgement and through the Scoping Process, is then assessed in terms of its significance using the methods described below.

10.4.3.1 Definitions

10.4.3.1.1 Sensitivity

39. The assessment identifies receptors for which there is a pathway for effect, and the sensitivity of those receptors to each effect. The definitions of sensitivity are based on MarLIN's Marine Evidence based Sensitivity Assessment (MarESA) (Tyler-Walters et al., 2018) which determines sensitivity based on resistance (tolerance) and resilience (recoverability) which are defined as:
    - **Resistance:** the likelihood of damage (termed intolerance or resistance) due to a pressure; and
    - **Resilience:** the rate of (or time taken for) recovery (termed recoverability, or resilience) once the pressure has abated or been removed.
40. The MarESA assessment of sensitivity is guided by the presence of key structural or functional species/assemblages and/or those that characterize the biotope groups. Physical and chemical characteristics are also considered where they structure the community. MarESA has been used in order to determine sensitivity of specific biotopes and dominant macrofauna recorded during the site specific benthic characterisation surveys. The sensitivity of biotopes taken from MarESA is provided in **Appendix 10.4**.

Table 10-7 Resistance and Resilience Scale Definitions

Level	Description
Resistance (Tolerance)	
None	Key functional, structural, characterizing species severely decline and/or physicochemical parameters are also affected e.g. removal of habitats causing a change in habitats type. A severe decline/reduction relates to the loss of 75% of the extent, density or abundance of the selected species or habitat component e.g. loss of 75% substratum (where this can be sensibly applied).

Level	Description
Low	Significant mortality of key and characterizing species with some effects on the physicochemical character of habitat. A significant decline/reduction relates to the loss of 25-75% of the extent, density, or abundance of the selected species or habitat component e.g. loss of 25-75% of the substratum.
Medium	Some mortality of species (can be significant where these are not keystone structural/functional and characterizing species) without change to habitats relates to the loss <25% of the species or habitat component.
High	No significant effects on the physicochemical character of habitat and no effect on population viability of key/characterizing species but may affect feeding, respiration and reproduction rates.
Resilience (Recovery)	
Very Low	Negligible or prolonged recovery possible; at least 25 years to recover structure and function.
Low	Full recovery within 10-25 years.
Medium	Full recovery within 2-10 years.
High	Full recovery within 2 years.

41. MarESA uses a matrix approach using both recovery and resilience to determine sensitivity. The sensitivity matrix used in this assessment, based on MarESA, is presented in **Table 10-8**.

Table 10-8 Sensitivity Matrix

		Resistance			
		None	**Low**	**Medium**	**High**
Resilience	**Very Low**	High	High	Medium	Low
	Low	High	High	Medium	Low
	Medium	Medium	Medium	Medium	Low
	High	Medium	Low	Low	Negligible

42. MarESA sensitivities are not available at the habitat level (EUNIS[2] level 3). However, the confidence in the data at the habitat level is higher than at the biotope level (EUNIS level 5). Therefore, where sensitivity at the habitat level is assessed it is based on the worst case sensitivity of biotopes identified within the habitat.

[2] The European Nature Information System (EUNIS) habitat classification is a comprehensive pan-European system for habitat identification. More information is available at: https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification

43. It is important to note that where local evidence is available about habitat tolerance and recovery, for example from post construction benthic monitoring surveys at the Dudgeon and/or Sheringham Shoal OWFs, sensitivities are modified accordingly.

10.4.3.1.2 Value

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

Table 10-9 Definitions of Value Levels for Benthic Ecology

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

10.4.3.1.3 Magnitude of Effect

45. The definitions of magnitude for the purpose of the benthic ecology assessment are provided in **Table 10-10**.

Table 10-10: Definition of Magnitude

Magnitude	Definition
High	Fundamental, permanent / irreversible changes, over the whole receptor, and / or fundamental alteration to key characteristics or features of the particular receptors character or distinctiveness.
Medium	Considerable, permanent / irreversible changes, over the majority of the receptor, and / or discernible alteration to key characteristics or features of the particular receptors character or distinctiveness.

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

10.4.3.2 Impact Significance

46. In basic terms, the potential significance of an impact is a function of the sensitivity of the receptor and the magnitude of the effect (see **Chapter 6 EIA Methodology** for further details). The determination of significance is guided by the use of an impact significance matrix, as shown in **Table 10-11**. Definitions of each level of significance are provided in **Table 10-12**.
47. Potential impacts identified within the assessment as major or moderate are regarded as significant in terms of the EIA regulations. Appropriate mitigation has been identified, where possible, in consultation with the regulatory authorities and relevant stakeholders. The aim of mitigation measures is to avoid or reduce the overall impact in order to determine a residual impact upon a given receptor.

Table 10-11: Impact Significance Matrix

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

Table 10-12: Definition of Impact Significance

Significance	Definition
Major	Very large or large change in receptor condition, both adverse or beneficial, which are likely to be important considerations at a regional or district level because they contribute to achieving national, regional or local objectives, or could result in exceedance of statutory objectives and / or breaches of legislation.

Significance	Definition
Moderate	Intermediate change in receptor condition, which are likely to be important considerations at a local level.
Minor	Small change in receptor condition, which may be raised as local issues but are unlikely to be important in the decision-making process.
Negligible	No discernible change in receptor condition.
No change	No impact, therefore, no change in receptor condition.

10.4.4 Cumulative Impact Assessment Methodology

48. The cumulative impact assessment (CIA) (**Section 10.7**) considers other plans, projects and activities that may impact cumulatively with DEP and SEP. As part of this process, the assessment considers which of the residual impacts assessed have the potential to contribute to a cumulative impact, the data and information available to inform the cumulative assessment and the resulting confidence in any assessment that is undertaken. **Chapter 6 EIA Methodology** provides further details of the general framework and approach to the CIA.
49. For benthic ecology, these activities include other OWFs, subsea cables and pipelines, oil and gas exploration and extraction, and fisheries management areas. As a general rule, other activities are only screened into the CIA where there is a spatial and/or temporal overlap in effects such that a cumulative impact would be possible, or where impacts are on a defined receptor group (such as within the boundaries of a designated site).

10.4.5 Transboundary Impact Assessment Methodology

50. The transboundary assessment (**Section 304**) considers the potential for transboundary effects to occur on benthic ecology receptors as a result of DEP and SEP; either those that might arise within the Exclusive Economic Zone (EEZ) of European Economic Area (EEA) states or arising on the interests of EEA states. **Chapter 6 EIA Methodology** provides further details of the general framework and approach to the assessment of transboundary effects.

10.4.6 Assumptions and Limitations

51. A large amount of data has been collected by the site-specific surveys, in addition to that available from the neighbouring Dudgeon and Sheringham Shoal OWFs. Datasets for the latter projects include those from the characterisation (EIA), pre-construction and post-construction stages of development (e.g. DOW, 2009; Scira, 2006; Scira, 2014, Fugro, 2013, 2015, 2020c;, MMT, 2019, Marine Ecological Surveys, 2014). As a result, the benthic ecology of the project areas has been thoroughly characterised and there is a high degree of confidence in the data for the purpose of informing the impact assessment.

52. With regard to the habitat maps (ENUIS level 3) and biotope maps (EUNIS 5), the confidence is provided in **Appendix 10.3** however, in summary, the Level 2-3 habitat maps have a high confidence and the accuracy assessment supports this. Mapping extents of benthic communities at higher EUNIS levels may decrease the accuracy but this is often due to the potential for 'confusion' between biotopes which occupy similar habitats e.g. Sublittoral sands (A5.2) mapped as Infralittoral sands (A5.23). However this is a known characteristic of the habitat mapping process and is not considered to materially affect the overall confidence in it for the purpose of informing the assessment. See **Appendix 10.3** for further details.

10.5 Existing Environment

53. The environmental baseline, including descriptions of sediment type, infauna and epifauna, is presented for the DEP and SEP wind farm sites and the offshore cable corridors. A description of protected areas and important species in the vicinity of the project is also provided. Analysis of the various benthic ecology data sets is provided in **Appendix 10.1**, **Appendix 10.2** and **Appendix 10.3**.

10.5.1 Sediment Characterisation

54. Particle size analysis has been completed for all stations where grab samples were taken. Stations were then classified according to Folk (1954) and the British Geological Survey (BGS) modified Folk classification (Long, 2006) based on the proportion of gravel, sand and mud (fines). **Figure 10.2** shows the sediment fractional composition recorded at each survey station and the BGS modified Folk classification for each sample. Multivariate analysis of sediments was also undertaken.

55. Further information about the sediments recorded is available in **Appendix 10.1** and **Appendix 10.2**.

10.5.1.1 DEP offshore survey area

56. Sand was the dominant fraction of the sediment at the majority of stations ranging from 36.81% (EC_24) to 100% (D_19) with a mean of 73.47%. The gravel content ranged from 0.00% (D_19) to 60.33% (EC_24) with a mean of 23.89%. The proportion of fine sediments was generally low across the survey area ranging from being absent (0.00%) at 22 stations to 22.13% (EC_16) with a mean of 2.65%.

57. Based on the proportions of gravel, sand and mud, five sediment classes have been identified across the DEP survey areas based on the BGS modified Folk classification. The most common sediment type is sandy gravel 'sG' (25 stations), followed by sand 'S' (20 stations), gravelly sand 'gS' (9 stations), muddy sandy gravel 'msG' (3 stations) and 1 station classed as gravelly muddy sand 'gmS'.

58. The geographical distribution of these different sediment types did not appear to have any distinct spatial pattern, however, the stations with the higher sand proportion were primarily within the DEP wind farm sites, particularly in DEP North where the majority of stations were classed as sand (S). The stations with a higher gravel proportion were primarily along the offshore cable corridors (CC and EC stations) where most stations were classed as sandy gravel (sG) or gravelly sand (gS) (**Figure 10.2**).

59. The multivariate analysis of sediments identified five groups (A to E) differentiated by the proportion of medium sand and coarse sand, and also whether a secondary element was present in the sediments, as either coarse pebble, medium pebble and fine pebble. Epifauna associated with these sediment groups are described in **Section 10.5.3.1.2**.

10.5.1.2 SEP offshore survey area

60. Sand was the dominant fraction of the sediment at the majority of stations ranging from 34.19% (SS_26) to 99.98% (EC_19), with a mean of 60.48%. The gravel content was generally higher than in the DEP wind farm sites, present at all stations and ranging from 0.02% in the export cable corridor (EC_19) to 60.51% (SS_08) in the SEP wind farm site, with a mean of 36.17%. The proportion of fine sediments was generally low across the survey area. Eight of the stations were devoid of fines and across the SEP offshore survey area fines content ranged from 0.00% to 22.13% (EC_16) with a mean of 3.35%.

61. Four sediment classes based on the BGS modified Folk classification have been identified across the SEP survey areas. The most common sediment type is sandy gravel 'sG' (22 stations), followed by muddy sandy gravel 'msG' (7 stations), sand 'S' (4 stations), gravelly sand 'gS' (1 station), and 1 station classed as gravelly muddy sand 'gmS'.

62. The geographical distribution of these different sediment types did not appear to have any distinct spatial pattern, however, sandy gravel was present along the majority of the offshore export cable corridor, including within the Cromer Shoal Chalk Beds MCZ, and much of the SEP wind farm site. Sand areas are present along the offshore export cable corridor in the nearshore area (EC_15 and EC_19) and around the Sheringham Shoal sandbank feature (EC_08, EC_09). Although the proportion of fine sediments was generally low, higher proportions were present at EC_16 and in the western part of the SEP wind farm site, resulting in the classification of these stations as 'mixed sediments' (msG and gmS) (**Figure 10.2**).

63. The multivariate analysis of sediments identified four groups (A to D) differentiated primarily by the proportion of medium sand, then coarse sand, and coarse pebble. Epifauna associated with these sediment groups are described in **Section 10.5.3.2.2**.

10.5.2 Sediment Chemistry

64. To inform the baseline for sediment quality, seven grab samples were taken for chemical analysis during benthic surveys of the DEP and SEP offshore survey areas (**Appendix 10.1** and **Appendix 10.2**). Sample locations are shown in **Figure 10.1**. Ten samples were originally planned, however, at three sites, sampling was unsuccessful because of repeated failure of the grab to take a sample due to rocks in the grab jaws and insufficient sediment recovered.

65. Analysis was undertaken for the following contaminants:

- Heavy metals (arsenic, mercury, cadmium, chromium, copper, lead, nickel and zinc);
- Polycyclic Aromatic Hydrocarbons (PAHs);
- Organotins (Monobutyltin (MBT), Dibutyltin (DBT) and Tributyltin (TBT)); and

- Total hydrocarbons (THC).

66. The context of the contaminants found within sediments is established through the use of recognised guidelines and action levels, in this case Cefas Action Levels have been applied because they provide good coverage of contaminants, across a broad range of contaminant types (MMO, 2018). These levels are used to indicate general contaminant levels in the sediments. If, overall, levels do not generally exceed the lower threshold values of these guideline standards, then contamination levels are not considered to be of significant concern and are low risk in terms of potential impacts on the marine environment.

67. The comparison of the sediment quality data against Cefas Action Levels has been undertaken within **Chapter 9 Marine Sediment and Water Quality**, **Section 9.5.4** and is not repeated here. However, the comparison showed that no samples exceed the lower Cefas Action Level 1 and therefore sediment contamination levels are low. Six samples had levels of arsenic marginally exceeding Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (CSQC) Threshold Effect Level (TEL) (7.24mg/kg) concentrations, ranging from 8.73 to 14.3mg/kg. However, these are well below the CSQC arsenic Probably Effect Levels (PEL) (41.6mg/kg). Furthermore, Whalley et al., (1999) state that uncontaminated nearshore marine and estuarine sediments contain from about 5 to about 15mg/kg dry weight total arsenic found primarily in the form of arsenate which is less toxic than in its inorganic forms (Neff, 1997). Therefore, sediment arsenic concentrations are well below any likely biological effects concentrations and are within the range of uncontaminated marine sediment concentrations.

68. Following consultation through the Seabed ETG sediments were analysed for organotin contamination because of a link between these compounds and the disruption of the reproductive capabilities of a number of gastropod mollusc species. All recorded organotin (TBT) concentrations were below the levels expected to affect the reproductive capability of sensitive gastropod species (Fugro, 2020a, 2020b).

10.5.3 Macrofaunal Communities

69. The species identified during the project benthic characterisation surveys were either infauna (living within the sediment) and epifauna (living on the surface of the seabed). Epifauna comprised sessile solitary species such as sea anemones, and colonial organisms such as bryozoans. The infauna was assessed for species diversity, abundance and distribution. The sessile colonial epifauna was assessed for taxa composition and distribution and the solitary epifauna was assessed for species diversity, abundance and distribution.

70. Multivariate statistical analysis has been conducted on the survey data to identify statistically significant macrofaunal communities and this showed that the spatial pattern of infaunal distribution was influenced by the sediment type. It should be noted that multivariate statistical analysis to identify macrofaunal groups was undertaken separately for the DEP and SEP survey areas, and therefore they are not comparable between survey areas (i.e. ‘DEP Group A’ is not the same as ‘SEP Group A’). The geographical distribution of infaunal groups identified is shown on **Figure 10.3** (DEP) and **Figure 10.4** (SEP). More information on macrofaunal communities recorded during the benthic characterisation surveys are provided in **Appendix 10.1** and **Appendix 10.2**.

10.5.3.1 DEP offshore survey area

71. The benthic communities recorded across the DEP offshore survey area are considered to be typical of sandy and gravelly sediments within the southern North Sea (Heip and Craeymeersch, 1995; Rees et al., 2007).

72. The survey recorded 272 benthic taxa following rationalisation of the dataset, of which 122 (44.9%) were annelids, 87 (32.0%) were arthropods, 47 (17.3%) were molluscs, 7 (2.6%) were echinoderms, 9 (3.3%) were other phyla (cnidarians, nemerteans, phoronids, platyhelminthes and sipunculids).

10.5.3.1.1 Infauna

73. Five different faunal communities were grouped statistically, described below, distinguished by having different dominant taxa as well as the absence of other key taxa within other groups. The variations in communities were driven by the different sediment types observed.

- **Group A** comprised 2 samples in the offshore export cable corridor. Defining infaunal taxa are the polychaetes *Lanice conchilega*, *Sabellaria spinulosa*, *Spiophanes bombyx* agg., which all show preference for medium to coarse sands which they use to build their protective tubes. The sea snail *Rissoa parva* was the second most abundant infaunal species in Group A.
- **Group B** comprised 26 samples distributed across the survey area in mixed sediment habitat comprising sandy gravel with a variable mud content. Defining taxa include the slipper limpet *Crepidula fornicata*, the crab *Pisidia longicornis* and the squat lobster *Galathea intermedia*, which have preference for gravelly sediments where they can either attach (in the case of *C. fornicata*) or take shelter. *S. spinulosa* was present although not in sufficient numbers to constitute reef. More information on determination of *S. spinulosa* reef is provided in **Section 10.5.4** below.
- **Group C** comprised 4 samples, all located in the interlink cable corridors with sediments comprising poorly sorted gravelly sand with no mud content. The most abundant taxa were the bivalve *Goodallia triangularis*, and the polychaetes *SphaerosInyllis bulbosa*, *Glycera lapidum, Schistomeringos neglecta*.
- **Group D** comprised two samples, one in the offshore export cable corridor (EC_11) and one in the interlink corridor between DEP South and the SEP wind farm site (CC_06). Defining taxa were the sipunculid worm *Nephasoma minutum* and the polychaetes *Leiochone*, *S. spinulosa*, *Spio goniocephala,* and *Lanice conchilega*, which are considered typical of sandy gravel/gravelly sand sediments.
- **Group E** comprised 19 samples, primarily located in the DEP wind farm sites but also in the offshore export cable corridor. Defining species were the polychaete *Ophelia borealis* and the amphipod *Bathyporeia elegans* which show preference for sandy sediments. The shrimp-like crustacean *Gastrosaccus spinifer* was the second most abundant species in Group E.

10.5.3.1.2 Epifauna

74. As epifauna rely on a hard surface for epilithic attachment, the characteristic epifauna within each sediment group deduced from the multivariate analysis are described.

75. A total of 11 taxa of solitary epifauna were identified across three phyla; cnidarians, arthropods and tunicates. The barnacle *Balanus crenatus* was the dominant species, being abundant across all groups.

76. A total of 81 colonial epifaunal taxa were identified across 7 phyletic groups, of which 43 (54.4%) were bryozoans, 18 (22.8%) were cnidarians, 8 (10.1%) were tunicates, 6 (7.6%) were porifera, 2 (2.5%) were entoproctas, and 1 (1.3%) of each annelids and ciliophoras. Bryozoans were the most abundant taxa across all of the groups, including *Conopeum reticulum* and also Alcyonidiidae, *Bicellariella ciliata* and *Flustra foliacea*. The cnidarian Sertulariidae and the ciliophoran Folliculinidae were also abundant.

77. As with the infaunal communities, statistical analysis showed epifaunal communities are being driven by the proportion and type of sand present, as well as whether any coarse material such as gravel or pebbles was present.

10.5.3.2 SEP offshore survey area

78. The results of the macrofauna analysis across the SEP offshore area are indicative of a dynamic area subject to a degree of physical disturbance with subsequent reworking of the sediments which prevents the establishment of permanent biotic communities. The presence of fines contributes to a degree of sediment compactness which allows the establishment of molluscs, which generally occur in more compacted sediment, while the presence of coarse sediment provides suitable substrate for the attachment of epifauna.

10.5.3.2.1 Infauna

79. The survey recorded 238 taxa represented by 6,053 individuals following rationalisation of the dataset, of which 44.6% were annelids, 31.3% were arthropods, 20.0% were molluscs and 1.5% were echinoderms. Other phyla comprised 2.6% of the taxa composition and included platyhelminthes, nemerteans, sipunculids, phoronids and Enteropneusta.

80. Different faunal communities were grouped statistically, described below, distinguished by having different dominant taxa as well as the absence of other key taxa within other groups. Four groups, A, B, C and D, and two single stations, EC_09 and EC_11, were identified through the multivariate analysis.

    Group A comprised 13 stations across the SEP wind farm site and offshore export cable corridor, plus two stations (EC_17 and EC_23) with a lower degree of similarity. Characterising taxa included the slipper limpet *C. fornicata*, the polychaetes *S. spinulosa* and *Polycirrus*, the brittlestar *Amphipholis squamata*, and the squat lobster *Galathea intermedia*. Group A was subdivided in to three distinct sub-groups (A1, A2 and A3). Differences between the sub-groups were related largely to species abundance.

- **Group B** comprised two stations (EC_07 and EC_14) from the offshore export cable corridor. Of the characterising taxa, *L. conchilega* was present at the highest mean abundance (10 individuals) and other characterising taxa included the sea snail *R. parva*, the polychaetes *S. spinulosa* along with *S. bombyx*, sea spiders such as *Anoplodactylus petiolatus* and *Achelia echinata*, and amphipods, such as *Bathyporeia guilliamsoniana* and *Abludomelita obtusata*.
- **Group C** comprised four stations from the SEP wind farm site characterised by the bivalve *G. triangularis*, the slipper limpet *C. fornicata* and the polychaetes *G. lapidum*, *Polycirrus* and *Spio symphyta*.
- **Group D** comprised three stations characterised by a low number of taxa and individuals, represented by the amphipod *B. elegans* and *Urothoe brevicornis* and the polychaetes *O. borealis, Nephtys cirrosa, Travisia forbesii* and *S. bombyx*.

10.5.3.2.2 Epifauna

81. The characteristic epifauna within each sediment group deduced from the multivariate analysis are described below.
82. A total of 11 taxa of solitary epifauna were identified comprising sea anemones of the order Actiniaria, the barnacles *B. crenatus* and *Verruca stroemia*, and tunicates. Stations SS_08, EC_08, EC_09, EC_11, EC_15 and EC_19, were devoid of solitary epifauna.
83. Seventy-six colonial epifaunal taxa were identified including bryozoans, notably *F. foliacea*, *Escharella immersa*, *C. reticulum* and *B. ciliate*; cnidarians, notably *Cliona*; and hydroids, notably *Hydrallmania falcata*, *Calycella syringa*, *Nemertesia antennina* and *Nemertesia ramosa*.
84. The epifauna recorded was typical of those reported for the shallower sediment areas of the southern North Sea (Callaway et al., 2002; Jennings et al., 1999) indicative of a dynamic area subject to a degree of physical disturbance with subsequent reworking of the sediments which prevents the establishment of permanent biotic communities (Fugro, 2020b).

10.5.4 Seabed Habitats and Biotopes

85. The seabed video and still image data collected at stations across the DEP and SEP offshore survey areas were used in conjunction with the particle size data and macrofaunal data to classify stations in terms of habitats and biotopes in line with the hierarchical European Nature Information System (EUNIS) habitat classification (EUNIS, 2019). An example of the classification hierarchy is provided in **Table 10-13**.

Table 10-13 EUNIS (2019) biotope classification hierarchy example

Level	Example Classification Name	Example Classification Code
1. Environment	Marine Habitats	A
2. Broad habitat types	Sublittoral sediments	A5

Level	Example Classification Name	Example Classification Code
3. Main habitats	Sublittoral sand	A5.2
4. Biotope complexes	Infralittoral fine sand	A5.23
5. Biotopes	*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand	A5.233

86. **Table 10-14** summarises the habitats and biotopes identified in the DEP and SEP offshore survey areas. Confidence in the classifications at the biotope level is generally lower than further up the EUNIS hierarchy. Further information on the classification of biotopes is available in **Appendix 10.1** and **Appendix 10.2**.

87. Benthic habitat maps have been produced using geophysical data sets along with the benthic sample data to interpret the distribution of habitats and biotopes in between survey stations. A summary report of habitat mapping process, completed by Envision (2021) using geostatistical processing and spatial statistical analysis, in provided in **Appendix 10.3 DEP and SEP Habitat Mapping**. The spatial distribution of the EUNIS Level 3 main habitats identified (equivalent to Marine Habitat Classification for Britain and Ireland 'habitat complexes') are presented in **Figure 10.4** and distribution of the EUNIS Level 5 biotopes identified are presented in **Figure 10.5**.

Table 10-14 Summary of Habitats and Biotopes Identified in the DEP and SEP Offshore Survey Areas

Broad Habitat Level 2	Habitat Level 3	Biotope Complex Level 4	Biotope Level 5	Recorded in DEP?	Recorded in SEP?
A3 Infralittoral rock and other hard substrata	-	-	-	Yes. Export cable corridor (station EC_26).	Yes. Export cable corridor (station EC_26).
A4 Circalittoral rock and other hard substrata	A4.1 Atlantic and Mediterranean high energy circalittoral rock	A4.13 Mixed faunal turf communities on circalittoral rock	A4.134 *Flustra foliacea* and colonial ascidians on tide-swept moderately wave-exposed circalittoral rock	No. However, likely to be present in the export cable corridor near EC_26.	Recorded across the survey area on larger pebbles, cobbles and boulders in coarse and mixed sediment areas.
	A4.2 Atlantic and Mediterranean moderate energy circalittoral rock	A4.23 Communities on soft circalittoral rock	A4.231 Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay	No	Observed within the transect at SS21 – Western corner of SEP wind farm site. Piddocks could not be confirmed.
A5 Sublittoral sediment	A5.1 Sublittoral coarse sediment	A5.13 Infralittoral coarse sediment	Possible A5.133 *Moerella* spp. with venerid bivalves in	A5.13 in DEP interlink and offshore export cable corridors (EC_07, EC_09, EC_11, EC_14).	A5.13 in the offshore export cable corridor. A5.133 not identified.

Broad Habitat Level 2	Habitat Level 3	Biotope Complex Level 4	Biotope Level 5	Recorded in DEP?	Recorded in SEP?
			infralittoral gravelly sand	Possible A5.133 in interlink corridors (CC_03, CC_05, CC_12, CC_15)	
	A5.2 Sublittoral sand	A5.23 Infralittoral fine sand	Possible A5.233 *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand	A5.23, and possibly A5.233 in all DEP project areas.	A5.233 in offshore export cable corridor (EC_08, EC_15, EC_19).
	A5.4 Sublittoral mixed sediment	A5.43 Infralittoral mixed sediment	A5.431 *Crepidula fornicata* with ascidians and anemones on infralittoral coarse mixed sediment (?)	A5.43, and possibly A5.431 identified in all DEP project areas.	A5.43, and possibly A5.431 identified in all SEP project areas.
		A5.44 Circalittoral mixed sediments	-	Identified in all DEP project areas.	Identified in all SEP project areas.
		A5.45 Deep circalittoral mixed sediments	A5.451 Polychaete-rich deep Venus community in	No	Impoverished version or a transition of the biotope A5.451 identified in the SEP wind farm site.

Broad Habitat Level 2	Habitat Level 3	Biotope Complex Level 4	Biotope Level 5	Recorded in DEP?	Recorded in SEP?
			offshore mixed sediments		
	A5.6 Sublittoral biogenic reefs	A5.61 Sublittoral polychaete worm reefs on sediment	A5.611 *Sabellaria spinulosa* on stable circalittoral mixed sediment	Not recorded in Fugro, (2020a). However, Fugro, (2020b) confirms a mosaic of this biotope with A5.431 in the offshore export cable corridor.	Possible A5.611 identified in all SEP project areas (in multivariate group A with A5.431). No Annex I habitat identified.

10.5.4.1 DEP offshore survey area

88. The following habitats and biotopes were recorded across the DEP survey area (including the wind farm sites, interlink and offshore export cable corridors):
    - A3 Infralittoral rock and other hard substrata (A4 Circalittoral rock also likely to be present in the export cable corridor near landfall)
    - A5 Sublittoral sediment
        - A5.1 Sublittoral coarse sediment
            - A5.13 Infralittoral coarse sediment
                - A5.133 *Moerella* spp. with venerid bivalves in infralittoral gravelly sand
        - A5.2 Sublittoral sand
            - A5.23 Infralittoral fine sand
                - A5.233 *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand
        - A5.4 Sublittoral mixed sediments
            - A5.43 Infralittoral mixed sediments
                - A5.431 *Crepidula fornicata* with ascidians and anemones on infralittoral coarse mixed sediment
        - A5.6 Sublittoral biogenic reef (Not recorded in Fugro (2020a) but noted in the SEP offshore export cable corridor in Fugro (2020b)). No Annex I habitat identified.
89. The majority of stations (26) were classified as the biotope complex 'Infralittoral mixed sediment' (A5.43) and included stations across DEP North and South, the interlink and offshore export cable corridors. Sediments primarily comprised sandy gravels with a variable mud content. The macrofaunal and epifaunal assemblages present at these stations were typical of mixed sediments with low to moderate levels of exposure to tide and wave action. The infaunal community showed similarities to the biotope '*Crepidula fornicata* with ascidians and anemones on infralittoral coarse mixed sediment' (A5.431), which was therefore thought possible to be present at these stations. This biotope was also identified within the Dudgeon OWF site (MMT, 2019).
90. Nineteen stations, distributed across DEP North and South, the interlink and offshore export cable corridors, were classified as 'Infralittoral fine sand' (A5.23) due to the high sand and low gravel/mud content and faunal assemblages being typical of clean sands with moderate exposure to wave or tidal action. The infaunal community showed similarities to the biotope '*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand' (A5.233), which was therefore thought possible to occur at these stations. This biotope was identified throughout the Dudgeon OWF site where the seabed comprised sand (MMT, 2019).

91. Eight stations were classified as biotope complex 'Infralittoral Coarse Sediment' (A5.13) due to the sediments comprising sandy gravels/gravelly sands with low mud content. These included three stations in the EC survey area and five in the CC survey area. These stations included samples that were grouped, based on their infaunal assemblages, into groups A, C and D. The macrofaunal and epifaunal assemblages present at these stations were typical of moderately exposed coarse sediments. The infaunal community identified in samples within group C showed similarities to the biotope '*Moerella* spp. with venerid bivalves in infralittoral gravelly sand' (A5.133) and was therefore thought possible to be present at those stations.

92. The distribution of the biotopes identified did not show any distinct pattern in distribution. This is likely to be due to the heterogeneity of the sediments across the survey area, evident on the side scan sonar data. Sand waves and megaripples were both interpreted as present across the survey area, which typically result in the sand crests comprise mobile sediment environments and tend to have low diversity, and the troughs contain more stable gravelly sediments, due to less sediment movements (Koop et al., 2019), allowing an accumulation of organic material and therefore support more diverse infaunal and epifaunal communities.

93. Infralittoral rock (A3) and other hard substrata was recorded amongst sandy gravel in the export cable corridor near landfall at station EC_26 in water depths ranging from 2.8m to 5.5m below sea level (BSL). Circalittoral rock (A4) also likely to be present in this area. Exposed chalk areas were colonised by red and brown seaweed, starfish (*Asterias rubens*), and anemones (*Sagartia* sp., Sagartiidae and *Urticina* sp.) (Fugro, 2020e).

10.5.4.2 SEP offshore survey area

94. The following habitats and biotopes were recorded across the SEP offshore survey area (including the wind farm site and offshore export cable corridor):

- A3 Infralittoral rock and other hard substrata
- A4 Circalittoral rock and other hard substrata
    - A4.1 Atlantic and Mediterranean high energy circalittoral rock
        - A4.13 Mixed faunal turf communities on circalittoral rock
            - A4.134 *Flustra foliacea* and colonial ascidians on tide-swept moderately wave-exposed circalittoral rock
    - A4.2 Atlantic and Mediterranean moderate energy circalittoral rock
        - A4.23 Communities on soft circalittoral rock
            - A4.231 Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay
- A5 Sublittoral sediment
    - A5.1 Sublittoral coarse sediment
        - A5.13 Infralittoral coarse sediment
    - A5.2 Sublittoral sand
        - A5.23 Infralittoral fine sand

        - A5.233 *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand
  - A5.4 Sublittoral mixed sediments
    - A5.45 Deep circalittoral mixed sediments
      - A5.451 Polychaete-rich deep Venus community in offshore mixed sediments (Impoverished or a transition biotope)
    - A5.43 Infralittoral mixed sediments
      - A5.431 *Crepidula fornicata* with ascidians and anemones on infralittoral coarse mixed sediment
  - A5.6 Sublittoral biogenic reef
    - A5.61 Sublittoral polychaete worm reefs on sediment
      - A5.611 *Sabellaria spinulosa* on stable circalittoral mixed sediment

95. Coarse and mixed habitats were recorded across most of the SEP survey area with associated benthic communities influenced strongly by sediment type. Three stations in the SEP wind farm site and five stations along the offshore export cable corridor featured rippled sand with shell fragments and little or no epifauna recorded, indicative of sediment disturbance associated with waves and tides.
96. A combination of the biotopes ‘*Crepidula fornicata* with ascidians and anemones on infralittoral coarse mixed sediment’ (A5.431) and ‘*Sabellaria spinulosa* on stable circalittoral mixed sediment’ (A5.611), was assigned to most stations that featured coarse mixed sediments, high diversity and a numerical dominance of *C. fornicata* and *S. spinulosa*.
97. The biotope ‘Polychaete-rich deep Venus community in offshore mixed sediments’ (A5.451) was assigned to four stations in the SEP wind farm site characterised by coarse sediment with negligible percentage of fines, and an infaunal community dominated by *G. triangularis* and polychaetes.
98. The biotope ‘*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand’ (A5.233) was assigned to three stations along the offshore export cable corridor, characterised by rippled sand with reduced diversity, compared to other stations, and dominated by *N. cirrosa* and *B. elegans.* This biotope has also been recorded by surveys of the Sheringham Shoal OWF (Fugro, 2013).
99. The biotope complex ‘Infralittoral coarse sediment’ (A5.13) was assigned at four stations in the offshore export cable corridor. These stations were found to represent transitional areas, between heterogeneous mixed and homogeneous sandy sediments, with video images indicating accumulation of coarse sediment in the troughs of sand waves, in line with the literature of the North Sea describing wave environment (Koop et al., 2019).
100. The biotope ‘*Flustra foliacea* and colonial ascidians on tide-swept exposed circalittoral mixed substrata’ (A4.1343) occurred as an epibiotic overlay of sedimentary communities across the entire survey area, where coarse sediment suitable for the attachment of large epibiotic taxa occurred.

101. As described under the DEP offshore survey area, infralittoral rock (A3) and other hard substrata was recorded in the export cable corridor near landfall (Fugro, 2020e). Circalittoral rock (A4) also likely to be present in this area.

10.5.4.3 Offshore Export Cable Corridor within the Cromer Shoal Chalk Beds MCZ

102. It is useful to specify the benthic habitats and biotopes identified within the Cromer Shoal Chalk Beds MCZ for the assessment of impacts on marine ecology receptors represented within the MCZ designated features. Based on Fugro (2020b) these are:

- A3 Infralittoral rock and other hard substrata
- A4 Circalittoral rock and other hard substrata
- A5 Sublittoral sediment
  - A5.1 Sublittoral coarse sediment
    - A5.13 Infralittoral coarse sediment
  - A5.2 Sublittoral sand
    - A5.23 Infralittoral fine sand
      - A5.233 *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand
  - A5.4 Sublittoral mixed sediments
    - A5.43 Infralittoral mixed sediments
      - A5.431 *Crepidula fornicata* with ascidians and anemones on infralittoral coarse mixed sediment
  - A5.6 Sublittoral biogenic reef
    - A5.61 Sublittoral polychaete worm reefs on sediment
      - A5.611 *Sabellaria spinulosa* on stable circalittoral mixed sediment

10.5.4.4 Sensitive species / habitats

103. Benthic habitats and associated species which could occur within the DEP or SEP offshore survey areas are described in **Table 10-15**.

Table 10-15 Summary of sensitive habitats/species potentially present in DEP or SEP offshore survey area

Listed Feature		Relationship*	Related Feature	
Description	Designation/ Status		Description	Designation/ Status
Geogenic reef	Habitats Directive Annex I habitat; habitat FOCI	May occur	Bedrock reef	Annex I habitat; Subtidal chalk
	Annex I habitat	May occur	Stoney reef	Annex I habitat

Listed Feature		Relationship*	Related Feature	
Description	**Designation/ Status**		**Description**	**Designation/ Status**
Subtidal sands and gravels	Priority habitat; habitat FOCI	Contains	Offshore subtidal sands and gravel	UK BAP priority habitat; MPA search feature
	Annex I habitat	May occur	Sandbanks which are slightly covered by sea water all the time	Annex I habitat
Peat and clay exposures with piddocks	Priority habitat	Contains	Peat and clay exposures with piddocks	UK BAP priority habitat
Subtidal chalk	Priority habitat; habitat FOCI	May occur	Subtidal chalk	UK BAP priority habitat
	Annex I habitat	May occur	Reefs	Annex I habitat
Sabellaria spinulosa reef	OSPAR threatened and/or declining habitat; English priority habitat; habitat FOCI	May occur	Reefs	Annex I habitat

Notes
FOCI = Feature of Conservation Interest
UK BAP = United Kingdom Biodiversity Action Plan
OSPAR = Oslo and Paris Commission
MPA = Marine Protected Area
* = Summarises the relationship between different protected habitat designations. For example, where Annex I geogenic reef occurs, bedrock reef may occur, in this case from subtidal clay. Similarly, the priority habitat ‘Subtidal sands and gravels; contains the UK BAP priority habitat and MPA Search feature ‘Offshore subtidal sands and gravels’ (JNCC, 2018)

Geogenic Reef

104. A geophysical survey of the offshore export cable corridor (Gardline, 2020a) identified an area of high reflectivity close to landfall, identified as outcropping chalk. Video transect EC_26 targeted this feature and the imagery confirmed hard compacted substrate (soft rock, likely chalk) emerging from the surrounding sediment. This is potential bedrock reef, however, due to the lack of defined assessment criteria for this habitat, it is not possible to confirm whether this falls within the Annex I ‘Reefs’ definition, so an area of ‘Potential reef’ was assigned (Fugro, 2020d, 2020e).

105. To qualify as a 'Stony reef' there should be a minimum elevation of 64mm above the seabed, a coverage of at least 10% cobbles and boulders and a minimum area extent of 25m^2 (Irving, 2009). At stations in the DEP and SEP wind farm sites and interlink cable corridors seabed was classed as 'not a reef' at all transects due to the elevation of cobble, percentage of cobble and boulder coverage and epifaunal species composition less than 80%. Therefore, coarse sediments within these survey areas do not fulfil the definition of Annex I habitat (Fugro, 2020d, 2020e).

106. Along the offshore export cable corridor, the majority of the transects were classed as 'Not a reef', except for transects EC_03 and EC_24, which were classed as 'Low reef'. These two transects were located within close proximity of each other towards the nearshore end of the offshore export cable corridor. This was due to the higher percentage of cobble coverage (10% to 40%) and elevation observed.

Subtidal Chalk

107. Sample planning selected stations within suspected areas of chalk/rock areas but only one station (EC_26) was successfully sampled, meaning mapping and confidence in the distribution of the habitat "A3 / A4 –Subtidal rock" is relatively low. As described above, transect EC_26 had areas of outcropping chalk bedrock that had the potential to form the UK BAP priority habitat 'Subtidal chalk' (UK BAP, 2008a). This may represent part of the Cromer Shoal Chalk Beds Marine Conservation Zone designated subtidal chalk feature (**Section 10.5.5.1**). The area of chalk within the EC_26 transect was not rich in species and was characterised by red algae (Rhodophyta), starfish and anemones. The lack of species diversity was expected due to the 'hostility' of the environment in which the subtidal chalk habitats occur (UK BAP, 2008a).

Subtidal Sands and Gravels

108. Most of the DEP and SEP surveys area were classified within three EUNIS habitats, 'Sublittoral coarse sediment' (A5.1), 'Sublittoral sand' (A5.2) and 'Sublittoral mixed sediments' (A5.4). 'Sublittoral coarse sediment' and 'Sublittoral sand', and the biotope complexes identified under them (A5.13 Infralittoral coarse sediment, A5.23 Infralittoral fine sand) are categorised within the broad habitat of 'subtidal sands and gravels' defined by UK BAP (UK BAP, 2008b). Although, offshore subtidal sands and gravels are identified as a priority habitat and thought to be of conservation importance, this habitat is widespread within UK waters.

Peat and Clay Exposures

109. A section of transect SS_21A in the SEP wind farm site represented the biotope A4.231 'Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay', which is classed as an illustrative biotope of the UK BAP habitat 'Peat and Clay Exposures with Piddocks', which are known to occur on the south and east coasts of England (UK BAP, 2008c). Although piddocks could not be confirmed to have been responsible for the burrows present along SS_21A, the definition of the UK BAP habitat also encompasses occurrences of peat and clay exposures with no evidence of either past or present piddock activity, but which have the potential for this community to develop on the basis of environmental conditions and presence of similar beds locally (UK BAP, 2008c). Peat and clay exposures have been reported within the nearby Cromer Shoals Chalk Beds MCZ.

Other Potentially Sensitive Habitats and Species

110. Gardline (2020a, 2020b) highlighted features with potential to be *S. spinulosa* reefs in the DEP and SEP offshore survey areas. Specimens of *S. spinulosa* were present within grab samples and camera transects within the DEP and SEP wind farm sites, DEP interconnector cable corridors and the offshore export cable corridor. corridors. *S. spinulosa* reefs are classified as a UK BAP listed priority habitat, an OSPAR threatened and/or declining habitat and a Habitats Directive Annex I habitat. However, the specimens found were either in the forms of single tubes, veneer, or very small clumps and therefore did not warrant a full assessment to confirm that the Annex I reef habitat was not present.

111. No other Annex I habitats or Annex II species, OSPAR threatened and/or declining species and habitats or UK Biodiversity Action Plan priority habitats and species (OSPAR, 2008; JNCC & Defra, 2012) were observed within the survey area.

10.5.5 Designated Sites

112. The following section provides a brief summary of the designated sites and associated interest features with the potential to be affected by DEP and SEP. **Section 10.6.1** describes the approach taken to the consideration of potential impacts on designated sites in this chapter.

10.5.5.1 Cromer Shoal Chalk Beds MCZ

113. The DEP and SEP offshore export cable corridor passes through the Cromer Shoal Chalk Beds MCZ, as shown in **Figure 10.7** The Cromer Shoal Chalk Beds MCZ begins 200m offshore of the North Norfolk Coast and extends 10km out to sea, covering a total area of 321km^2 (DEFRA, 2016).

114. The site is designated for the following features:

- Marine Habitat Features of Conservation Interest (FOCI)
  - Subtidal chalk
  - Peat and clay exposures
- Broadscale Marine Habitat features
  - Moderate energy infralittoral rock
  - High energy infralittoral rock
  - Moderate energy circalittoral rock
  - Subtidal coarse sediment
  - Subtidal mixed sediments
  - Subtidal sand
- North Norfolk Coast (subtidal geological feature)

115. Seabed habitats representative of all three broadscale marine sediment habitat features have been recorded in the export cable corridor within the MCZ, as well as an area of infralittoral rock.

10.5.5.1.1 Subtidal rock

116. A single video transect (EC_26) was completed in an area close to landfall identified as outcropping rock by geophysical surveys. Locations on the transect were classified to EUNIS level 2 only, as infralittoral rock (A3), although it is likely that these are part of the subtidal chalk FOCI MCZ feature and also moderate or high energy infralittoral rock. It should be noted that the mapped habitat of “A3 Infralittoral rock” is also likely to include circalittoral rock (A4) (Envision, 2021) and therefore the moderate energy circalittoral rock (MCZ) feature (**Figure 10.5**).

10.5.5.1.2 Subtidal sand

117. Areas of sublittoral sand (A5.2) have been identified close to landfall offshore of an area of infralittoral (and possibly also circalittoral rock) and near the seaward boundary of the MCZ, associated with the Sheringham Shoal sandbank feature. These coincide with areas of the subtidal sand feature previously mapped within the MCZ (Defra, 2015).

10.5.5.1.3 Subtidal coarse and subtidal mixed sediments

118. The remainder of the offshore export cable corridor in the MCZ is a mixture of subtidal coarse sediment (A5.1) and subtidal mixed sediment (A5.4) habitats. There is generally a low percentage of fine material with a mean fraction of 1.7% for grab samples in the MCZ, and therefore all stations not classified as sand (S) are sandy gravel (sG) based on the BGS modified Folk classification (**Figure 10.2**).

119. However, there are some mismatches between biological communities and physical habitats recorded in the benthic sample data on which the habitats maps are based. This suggests there is sufficient fine material in some areas to support species associated with mixed sediment habitats. As such, some stations have been modified from subtidal coarse sediment habitat (A5.1) to subtidal mixed sediment (A5.4) habitat based on their biological community. Biological groupings often do not adhere to exact sediment classes and the two habitats could be considered to be variations of each other (Envision, 2021). Indeed Fugro (2020a,b) suggested the biological communities present to be uncertain and that the appropriate habitat at the next level up in the EUNIS hierarchy has be assigned to relevant samples. In summary, it is difficult to delineate subtidal coarse and subtidal mixed sediment habitats in the offshore export cable corridor due to their similarity, with mixed sediment areas being close the coarse sediment areas with a relatively low percentage of fines, but sufficient fine material to influence benthic communities.

10.5.5.2 Greater Wash SPA

120. The DEP and SEP offshore export cable corridor passes through the Greater Wash Special Protection Area (SPA) as shown in **Figure 10.6**. The Greater Wash SPA stretches between the counties of Yorkshire to Suffolk over an area of 3,536km^2. The site is primarily designated for the protection of seabirds including breeding terns and non-breeding red-throated diver and little gull. Further information on the designated features of the SPA is provided in **Chapter 13 Offshore Ornithology**.

121. The supporting features of the Greater Wash SPA include marine habitats and species which will overlap with the proposed offshore export cable corridors. The supporting features which could be present in the DEP and SEP offshore export cable corridor including the following:

- Subtidal sandbanks;
- Biogenic reef including *Sabellaria* reefs and mussel beds; and
- Coarse sediments, with occasional areas of sand, mud and mixed sediments.

10.5.5.3 The Wash and North Norfolk Coast SAC

122. The Wash and North Norfolk Coast Special Area of Conservation (SAC) covers an area of 1,077km^2 within The Wash Estuary and along the Norfolk Coast (**Figure 10.6**). Through the site selection process an offshore export cable route through the Wash and North Norfolk Coast SAC was avoided to prevent direct impacts on its designated features.

123. At the closest point, the boundary of the DEP and SEP offshore export cable corridor is 1.26km east of the SAC at its closest point near landfall. The Wash and North Norfolk Coast SAC is designated for the following features:

- Sandbanks which are slightly covered by sea water all the time
- Mudflats and sandflats not covered by seawater at low tide
- Reefs
- Large shallow inlets and bays
- Salicornia and other annuals colonizing mud and sand
- Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)
- Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*)
- Coastal lagoons
- Harbour seal *Phoca vitulina*
- Otter *Lutra lutra*

124. Of the designated marine features, sandbanks which are slightly covered by sea water all the time may be located near the eastern boundary of the SAC in closest proximity to the offshore export cable corridor (Natural England, 2017).

10.5.5.4 Inner Dowsing, Race Bank and North Ridge SAC

125. The Inner Dowsing, Race Bank and North Ridge SAC covers an area of 845km^2 and is located off the south Lincolnshire coast (**Figure 10.6**). At the closest point, the boundary of the SEP wind farm site is approximately 2.2km east of the SAC (and the DEP North is approximately 10.3km to the east).

126. The Inner Dowsing, Race Bank and North Ridge SAC is designated for the following features:

- Sandbanks which are slightly covered by sea water all the time; and
- Reefs.

10.5.6 Climate Change and Natural Trends

127. The baseline conditions for benthic ecology are considered to be relatively stable within DEP and SEP and the wider area, with multiple data sets covering several years exhibiting similar patterns, including DOW and SOW post-construction monitoring.

128. The existing environment within DEP and SEP is influenced by the physical processes which exist within the southern North Sea, including waves and tidal currents driving changes in sediment transport and then seabed morphology (see **Chapter 8 Marine Geology Oceanography and Physical Processes**). Long term established patterns may be affected by climate change driven sea-level rise, however this will have a reduced impact offshore compared to along the coastline. Warming sea temperatures and ocean acidification are likely to result in changes to the composition and geographical distribution of benthic communities, with a general northerly shift in the latitudinal ranges of many species.

129. Anthropogenic pressures that currently exist across the study area such as commercial fishing, particularly using bottom towed gear, have the potential to influence future change in the existing benthic environment (**Chapter 14 Commercial Fisheries**). Fisheries management measures have the potential to reduce fishing effort in the certain areas, therefore reducing fishing related pressures on benthic ecology; but may also displace fishing effort and potentially increase impacts in other areas. The cumulative impacts of other plans and projects, including fisheries management measures, are assessed in **Section 10.7**.

10.6 Potential Impacts

130. As described in **Section 10.4.3.1.1**, the sensitivity of benthic receptors is based on the MarESA method which describes the sensitivity of biotopes in relation to different MarESA pressures. These sensitivities are modified, where appropriate, by local evidence, for example from post construction benthic monitoring surveys at the Dudgeon and/or Sheringham Shoal OWFs, or if habitats or biotopes are of conservation value as described in **Section 10.4.3.1.2**.

131. MarESA sensitivity is only available at the biotope level. However, confidence in the classification of biotopes present across the DEP and SEP offshore survey areas is lower than classification at the habitat level (EUNIS Level 3). Therefore, where sensitivity at the habitat level is assessed it is based on the worst case sensitivity of biotopes identified within the habitat. The sensitivity of relevant habitats and biotopes is summarised throughout this section. Further information presenting the resistance and resilience assessments determining biotope sensitivity is presented in **Appendix 10.4**.

132. As described in **Section 10.3.3**, there will be no direct impacts on the intertidal zone as a result of the use of HDD to approximately 1,000m from the coastline. Additionally, the assessment provided in **Chapter 8 Marine Geology, Oceanography and Physical Processes** concludes that there will be no significant indirect impacts on the nearshore environment. Therefore, no impacts are predicted on the intertidal zone and it is not considered further in this chapter.

10.6.1 Consideration of Potential Impacts on Designated Sites

133. As described in **Section 10.5.5**, the export cable corridor passes through the Cromer Shoal Chalk Beds MCZ and Greater Wash SPA (**Figure 10.7**). DEP and SEP are also in proximity to The Wash and North Norfolk Coast SAC and the Inner Dowsing, Race Bank and North Ridge SAC. The following summarises the approach taken to the consideration of potential impacts on these designated sites in this chapter:

- Impacts on the Cromer Shoal Chalk Beds MCZ are assessed in the **draft Information for Marine Conservation Zone Assessment Report**. However, for context and to provide a link between the EIA and the MCZ, where relevant an assessment is also provided in EIA terms in this chapter.
- Impacts on the supporting features of the Greater Wash SPA are not assessed explicitly in the chapter, although the benthic ecology impact assessment provides context to the assessments presented in **Chapter 13 Offshore Ornithology** and the **draft Information for Habitats Regulations Assessment Report**.
- Impacts on The Wash and North Norfolk Coast SAC and the Inner Dowsing, Race Bank and North Ridge SAC are assessed in the **draft Habitats Regulations Assessment Report** . However for context and to provide a link between the EIA and the HRA, where relevant an assessment is also provided in EIA terms in this chapter.

10.6.2 Potential Impacts during Construction

10.6.2.1 Impact 1: Temporary habitat loss / physical disturbance

134. Temporary habitat loss and physical disturbance will occur during the construction phase as a result of seabed preparation for the installation of cables and foundations, cable installation, placement of anchors during wind turbine and cable installation, and jack up vessel operations. Some activities will result in disturbance of surface sediments, and some will result in habitat loss (removal of substratum).

135. Where disturbed sediments (e.g. preparation areas for foundations) are subsequently covered with infrastructure, habitat loss is long term or permanent, therefore this has been assessed as an operational impact in **Section 10.6.3.2** and is not considered further here.

Sensitivity

136. The sensitivity of the biotopes identified in the DEP and SEP offshore areas has been assessed in relation to MarESA pressures relevant to construction phase temporary habitat loss / physical disturbance. These are:

- Habitat structure changes – removal of substratum (extraction)
- Abrasion/disturbance of the surface of the substratum or seabed
- Penetration or disturbance of the substratum subsurface

137. The sensitivity of identified habitats and biotopes to temporary habitat loss / disturbance pressures are summarised **Table 10-16** below. Further information describing the resistance and resilience of these habitats and biotopes, used to determine sensitivity, is provided in **Appendix 10.4**.

138. It should be noted that the DEP and SEP surveys only identified the broad habitat A3 Infralittoral rock and other hard substrata in the offshore export cable corridor close to landfall, but although the bedrock was identified as chalk no biotope was assigned. Natural England's Advice on Operations for the Cromer Shoal Chalk Beds MCZ references 'A4.232 *Polydora* sp. tubes on moderately exposed sublittoral soft rock' as the relevant biotope for the Subtidal chalk feature and therefore this has been used for the sensitivity assessment. However, it should be noted that the degree of certainty in this assessment is relatively low.

Table 10-16 Habitat and biotope sensitivity to temporary habitat loss / disturbance pressures

Habitat and Biotope	MarESA sensitivity		
	Removal of substratum	Abrasion / disturbance	Substratum penetration / disturbance
A3/4 Infralittoral / Circalittoral rock and other hard substrata	High		
A4.232 *Polydora* sp. tubes on moderately exposed sublittoral soft rock	High	Medium	Medium
A4.1 Atlantic and Mediterranean high energy circalittoral rock	Low		
A4.134 *F. foliacea* and colonial ascidians on tide-swept moderately wave-exposed circalittoral rock	Not relevant	Low	Not relevant
A4.2 Atlantic and Mediterranean moderate energy circalittoral rock	High		
A4.231 Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay	High	Medium	High
A5.1 Sublittoral coarse sediment	Medium		
A5.133 '*Moerella* spp. with venerid bivalves in infralittoral gravelly sand'	Medium	Low	Low
A5.2 Sublittoral sand	High		

Habitat and Biotope	MarESA sensitivity		
	Removal of substratum	Abrasion / disturbance	Substratum penetration / disturbance
A5.233 *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand	Medium	Low	Low
A5.4 Sublittoral mixed sediments	Medium		
A5.431 *Crepidula fornicata* with ascidians and anemones on infralittoral coarse mixed sediment	Medium	Low	Low
A5.451 Polychaete-rich deep Venus community in offshore mixed sediments	Medium	Low	Low
A5.6 Sublittoral biogenic reefs	Medium		
A5.611 *S. spinulosa* on stable circalittoral mixed sediment	Medium	Medium	Medium

10.6.2.1.1 DEP in Isolation

Sensitivity

139. The habitat map (**Figure 10.5**) indicates that the majority of the DEP offshore area is comprised of sublittoral coarse sediment (A5.1); sublittoral sand (A5.2); and sublittoral mixed sediment (A5.4) habitats. Biotopes identified, with a higher degree of uncertainty, were A5.133 *Moerella* spp. with venerid bivalves in infralittoral gravelly sand, A5.233 *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand, and A5.431 *Crepidula fornicata* with ascidians and anemones on infralittoral coarse mixed sediment (**Figure 10.6**, **Section 10.5.4.1**). The biotope assigned to A3 Infralittoral rock and other hard substrata has high sensitivity to removal of substratum (extraction) and habitat structure changes. However, there will be no direct impacts on this nearshore feature due to the use of HDD on approach to the landfall.

140. The sensitivity of DEP biotopes to these pressures ranges from low to medium according to MarESA, with the highest sensitivity being to penetration or removal of substratum (extraction) and disturbance of the substratum subsurface (both medium sensitivity). A post-construction survey of the Dudgeon OWF was completed in August and September 2018, less than one year after the wind farm became operational. It identified A5.233 *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand, and A5.431 *Crepidula fornicata* with ascidians and anemones on infralittoral coarse mixed sediment, and showed no significant differences between the pre-construction and post-construction surveys (MMT, 2019). This suggests that recovery of these biotopes is possible within two years, and supports the MarESA sensitivity assessments which are based on high resilience / recovery. Therefore, as a worst case scenario a sensitivity of medium has been determined in relation to temporary habitat loss / disturbance.

Magnitude of Effect

141. Activities associated with the offshore construction works of DEP in isolation will result in direct temporary loss/disturbance to subtidal habitats. Relevant construction activities are:

- Seabed preparation for the installation of cables and foundations (sandwave clearance, levelling, PLGR)
- Burial of offshore cables (including export, infield, interlink cables)
- Vessel moorings (jack up, anchor placements)

142. The disturbance would be temporary and intermittent over a construction period of up to two years. The total footprint of disturbance is summarised in **Table 10-2**. The area of disturbance is considered to be small in the context of the extent of these benthic habitats present across the wider southern North Sea. A discernible, temporary (for part of the project duration) change, over a small area of the receptor is anticipated and, therefore, the magnitude of this effect is considered to be negligible.

Impact Significance

143. Based on the worst case medium sensitivity of habitats and biotopes and the negligible magnitude of temporary habitat loss/physical disturbance during the DEP construction phase, the impact is assessed as **minor adverse** significance.

10.6.2.1.2 SEP in Isolation

Sensitivity

144. The habitat map (**Figure 10.5**) indicates that the majority of the SEP offshore area is comprised of sublittoral coarse sediment (A5.1) and sublittoral mixed sediment (A5.4) with some areas of sublittoral sand (A5.2). Biotopes identified, with a higher degree of uncertainty, were A4.134 *Flustra foliacea* and colonial ascidians on tide-swept moderately wave-exposed circalittoral rock, A5.431 *Crepidula fornicata* with ascidians and anemones on infralittoral coarse mixed sediment, A5.611 *Sabellaria spinulosa* on stable circalittoral mixed sediment, and an impoverished or transition version of A5.451 Polychaete-rich deep Venus community in offshore mixed sediments. In sand areas A5.233 *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand was identified (**Figure 10.6**, **Section 10.5.4.2)**. Sublittoral coarse sediment habitat was not classified to the biotope level.

145. As discussed above, the biotope assigned to A3 Infralittoral rock and other hard substrata has high sensitivity to removal of substratum (extraction) and habitat structure changes but there will be no direct impacts on this nearshore feature due to the use of HDD on approach to the landfall.

146. A single record of the biotope A4.231 Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay was identified at station SS_21 in the western area of the SEP wind farm site. This UK BAP priority habitat has also been recorded outside the offshore survey area in the vicinity of the Sheringham Shoal offshore export cable (Fugro, 2020c) and in the Cromer Shoal Chalk Beds MCZ.

147. The sensitivity of SEP biotopes to these pressures ranges from low to medium for all biotopes except A4.231 which has high sensitivity to removal and/or penetration of the substratum. Like the Dudgeon OWF post-construction survey, year one and two post construction surveys of the Sheringham Shoal OWF site showed likely recovery within two years in most areas (Fugro, 2013; 2014). However, the offshore export cable trenches in coarse sediment areas still represented a disturbed benthic habitat by the time of the second post-construction monitoring survey. By the time of a third post-construction benthic survey of the export cable in the Cromer Shoal Chalk Beds MCZ in August 2020, epifaunal community structure had recovered such that it was not significantly different to unimpacted areas (Fugro, 2020c). Recovery of benthic communities in localised areas impacted by Sheringham Shoal OWF export cable installation took longer than recovery of benthic communities impacted by Dudgeon OWF export cable installation (up to 10 years compared to up to 2 years). It is understood that this was due to the cable trenching technique used by the Sheringham Shoal OWF, which left a trench that persisted in coarse sediment areas. However, SEP (and DEP) export cable installation will use techniques that avoid creating persistent trenches.

148. A4.231 Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay is not widespread in the SEP project area and it is likely that there will be no direct impacts on it from construction. However, as a worst case scenario a sensitivity of high has been determined in relation to temporary habitat loss / disturbance.

<u>Magnitude of Effect</u>

149. Activities associated with the offshore construction works of SEP in isolation will result in direct temporary loss/disturbance to subtidal habitats. Relevant construction activities are:

- Seabed preparation for the installation of foundations (levelling, PLGR)
- Burial of offshore cables (including export and infield cables)
- Vessel moorings (jack up, anchor placements)

150. The disturbance would be temporary and intermittent over a construction period of up to two years. The total footprint of disturbance is summarised in **Table 10-2**. The area of disturbance is considered to be small in the context of the extent of these benthic habitats present across the wider southern North Sea. A discernible, temporary (for part of the project duration) change, over a small area of the receptor is anticipated and, therefore, the magnitude of this effect is considered to be negligible.

Impact Significance

151. Based on the worst case high sensitivity of one habitat (A4.231) and the negligible magnitude of temporary habitat loss/physical disturbance during the SEP construction phase, the impact is assessed as **minor adverse** significance.

10.6.2.1.3 DEP and SEP Together

Sensitivity

152. The worst case sensitivity assessment for DEP and SEP together remains the same as the sensitivity presented for SEP in isolation (high), based on the assessment of the most sensitive receptor.

Magnitude of Effect

153. Activities associated with the offshore construction works of DEP and SEP together will result in direct temporary loss/disturbance to subtidal habitats. Relevant construction activities are:

- Seabed preparation for the installation of cables and foundations (sandwave clearance, levelling, PLGR)
- Burial of offshore cables (including export, infield, interlink cables)
- Vessel moorings (jack up, anchor placements)

154. The disturbance would be temporary and intermittent over a construction period of two years if the projects are constructed in tandem, or up to four years over a five year offshore construction period if constructed sequentially. The total footprint of disturbance is summarised in **Table 10-2** and would be greater than for each project in isolation. However, the area of disturbance is still small in the context of the extent of these benthic habitats present across the wider southern North Sea. A discernible, temporary (for part of the project duration) change, over a small area of the receptor is anticipated and, therefore, the magnitude of this effect is considered to be negligible.

Impact Significance

155. The worst case sensitivity assessment for DEP and SEP together remains the same as the sensitivity presented for SEP in isolation (high), based on the most sensitive receptor. Additionally, the magnitude of the impact of temporary habitat loss/physical disturbance for DEP and SEP together remains negligible. Therefore, the impact of temporary habitat loss/physical disturbance is assessed as **minor adverse** significance.

10.6.2.1.4 Cromer Shoal Chalk Beds MCZ

Sensitivity

156. Based on the habitats and biotopes recorded in the Cromer Shoal Chalk Beds MCZ (**Section 10.5.4.3**), sensitivity to temporary habitat loss / physical disturbance ranges from low to high. However, there will be no direct impacts on the nearshore rock habitat feature due to the use of HDD on approach to the landfall, and therefore the assigned biotope (A4.232 *Polydora* sp. tubes on moderately exposed sublittoral soft rock) which has high sensitivity to this impact will not be affected. Therefore, the worst case sensitivity is medium. The sensitivity of MCZ habitats can be modified based on their value (**Section 10.4.3.1.2**), but the worst case sensitivity remains medium.

Magnitude of Effect

157. The maximum area of seabed within the MCZ that could be disturbed by cable installation activities, HDD exit point trenching and deposition, and jack up footprint would be 0.035km^2 each for DEP or SEP in isolation, and up to 0.069km^2 for DEP and SEP together (**Table 10-2**). This is approximately 0.01%% and 0.02%% of the MCZ area respectively.

158. The magnitude of effect from temporary habitat loss/physical disturbance remains negligible.

Impact Significance

Based on the worst case medium sensitivity of habitats and biotopes and the negligible magnitude of temporary habitat loss/physical disturbance during the DEP and/or SEP construction phase, the impact on the Cromer Shoal Chalk Beds MCZ is assessed as **minor adverse** significance.

10.6.2.2 Impact 2: Temporary increases in SSC and deposition

159. Increases in SSC within the water column and subsequent deposition onto the seabed may occur as a result of seabed preparation for the installation of foundations and cables and through sediment disturbed due to installation of offshore infrastructure, including foundations and cables. Activities such as seabed disturbances from jack-up vessels and placement of cable protection are not expected to increase suspended sediment concentrations to the extent to which there would be a discernible impact to benthic ecology receptors. **Chapter 8 Marine Geology, Oceanography and Physical Processes** provides details of changes to suspended sediment concentrations and subsequent sediment deposition.

160. Increased suspended sediments have the potential to affect benthic ecology receptors by blocking feeding apparatus as well as by smothering sessile species upon redeposition.

Sensitivity

161. The sensitivity of the biotopes identified in the DEP and SEP offshore areas has been assessed in relation to MarESA pressures relevant to construction phase increased SSC and deposition. The relevant pressures are:

- Smothering and siltation rate changes
- Changes in suspended solids (water clarity)

162. The sensitivity of identified habitats and biotopes to increased SSC and deposition pressures are summarised in **Table 10-17** below (see also **Figure 10.6**). Further information describing the resistance and resilience of these habitats and biotopes, used to determine sensitivity, is provided in **Appendix 10.4**. As stated in **Section 10.6.2.1**, biotope A4.232 has been used as the relevant biotope for the sensitivity assessment of the nearshore infralittoral / circalittoral rock feature.

163. **Chapter 9 Geology Oceanography and Marine Physical Processes** states that during foundation installation, drill arisings deposited on the seabed would be deposited near to the point of release up to thicknesses of approximately 3cm over a seabed area local to each foundation (within 200 metres). Therefore, the MarESA pressure 'Smothering and siltation rate changes (light)' has been used for the sensitivity assessment because 'Light' deposition is defined as "of up to 5cm of fine material added to the habitat in a single, discrete event", as opposed to 'Heavy' deposition "of up to 30cm of fine material added to the habitat in a single discrete event".

Table 10-17 Habitat and biotope sensitivity to increased SSC and deposition pressures

Habitat and Biotope	**MarESA sensitivity**	
	Smothering and siltation rate changes (light)	Changes in suspended solids (water clarity)
A3/4 Infralittoral / Circalittoral rock and other hard substrata	**Low**	
A4.232 *Polydora sp*. tubes on moderately exposed sublittoral soft rock	Not sensitive	Low
A4.1 Atlantic and Mediterranean high energy circalittoral rock	**Low**	
A4.134 *F. foliacea* and colonial ascidians on tide-swept moderately wave-exposed circalittoral rock	Not sensitive	Low
A4.2 Atlantic and Mediterranean moderate energy circalittoral rock	**Medium**	
A4.231 Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay	Medium	Not sensitive

Habitat and Biotope	MarESA sensitivity	
	Smothering and siltation rate changes (light)	Changes in suspended solids (water clarity)
A5.1 Sublittoral coarse sediment	**Low**	
A5.133 ‘*Moerella* spp. with venerid bivalves in infralittoral gravelly sand’	Low	Low
A5.2 Sublittoral sand	**Low**	
A5.233 *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand	Low	Not sensitive
A5.4 Sublittoral mixed sediments	**Low**	
A5.431 *Crepidula fornicata* with ascidians and anemones on infralittoral coarse mixed sediment	Not sensitive	Low
A5.451 Polychaete-rich deep Venus community in offshore mixed sediments	Low	Low
A5.6 Sublittoral biogenic reefs	**Not sensitive**	
A5.611 *S. spinulosa* on stable circalittoral mixed sediment	Not sensitive	Not sensitive

10.6.2.2.1 DEP in Isolation

Sensitivity

164. As stated in **Section 10.6.2.1.1**, the habitats present across the majority of the DEP offshore survey area are sublittoral coarse sediment (A5.1); sublittoral sand (A5.2); and sublittoral mixed sediment (A5.4) (**Figure 10.5**).

165. A review of the sensitivities of the biotopes associated with the habitats present across DEP offshore area in relation to the pressures of increased SSC and deposition indicates that all biotopes are either not sensitive or have a low sensitivity to these pressures (**Table 10-16**). Therefore, a worst case scenario of low sensitivity has been determined in relation to increased SSC and deposition.

Magnitude of Effect

166. Activities associated with the offshore construction works of DEP in isolation will result in temporary increases in SSC and subsequent deposition of suspended sediment. Relevant construction activities are:

- Seabed preparation;
- Wind turbine foundation installation;

- OSP foundation installation;
- Export cable installation, and
- Interlink and infield cable installation.

167. **Chapter 8 Marine Geology, Oceanography and Physical Processes** describes the expected movement of sediment suspended during DEP construction phase, which has been summarised below. Due to the predominance of medium and coarse grained sand across the DEP wind farm site most disturbed sediment would fall rapidly (minutes or tens of minutes) to the seabed as a highly turbid dynamic plume immediately upon its discharge (within a few tens of metres along the axis of tidal flow).

168. Some of the finer sand fraction from this release and the very small proportion of mud that is present are likely to stay in suspension for longer and form a passive plume which would become advected by tidal currents. Due to the sediment sizes present, this is likely to exist as a measurable but modest concentration plume (tens of mg/l) for around half a tidal cycle (up to six hours). Sediment would eventually settle to the seabed in proximity to its release (within a few hundred metres up to around a kilometre along the axis of tidal flow) within a short period of time (hours to days). Whilst lower suspended sediment concentrations would extend further from the dredged area, along the axis of predominant tidal flows, the magnitudes would be indistinguishable from background levels.

169. In relation to the export cable installation activities the sand and gravel-sized sediment (which represents most of the disturbed sediment) would settle out of suspension rapidly to the bed within 20m of the export cable corridor. Fine sand will most likely remain in the bottom 1-2m of the water column, and with settling velocities of around 10mm/s, this will ensure the fine sand settles within half an hour or less or become part of the ambient near bed transport (Soulsby, 1997), with no sand being transported further than 100m of the cable.

170. 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. Chalk dispersion could extend for around 10km to the west and less to the east, with SSCs dropping to less than 1mg/l within a single flood or ebb excursion

171. Drill arisings during the installation of piled foundations from wind turbines is expected to generate the largest deposition of sediment. The coarser sediment sand/gravel would be deposited near to the point of release up to thicknesses of approximately 3cm over a seabed area local to each foundation (within 200m). For the most part, the deposited sediment layer across the wider seabed area would be very thin, and confined to a maximum of two foundations in DEP.

172. Overall, increases in SSC are expected to be localised at the point of discharge and short-term. Fine suspended sediment may then be transported by tidal currents, however due to the small quantities of fine-sediment released it is likely to be widely and rapidly dispersed. In most cases the elevation of suspended sediment is expected to be lower than concentrations that would develop in the water column during storm conditions. Deposition of sediment is expected to be localised to the point of disturbance, with deposits of up to approximately 3cm.

173. Given the localised and short-term increases in SSC around the point of discharge, and negligible changes in seabed level expected due to deposition, the magnitude of effect is considered to be negligible.

Impact Significance

174. Based on a worst case low sensitivity of habitats and biotopes and the negligible magnitude of temporary increases in SSC and deposition during the DEP construction phase, the impact is assessed as **negligible adverse** significance.

10.6.2.2.2 SEP in Isolation

Sensitivity

175. As stated in **Section 10.6.2.1.2** the majority of the SEP offshore area is comprised of sublittoral coarse sediment (A5.1) and sublittoral mixed sediment (A5.4) with some areas of sublittoral sand (A5.2) (**Figure 10.5**).

176. A review of the sensitivities of the biotopes associated with the habitats present across SEP offshore area in relation to the pressures of increased SSC and deposition indicates that most biotopes are either not sensitive or have a low sensitivity to these pressures (**Table 10-16**), except for one biotope A4.231 Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay, which has a sensitivity of medium. This biotope is not widespread in the SEP project area and it is likely that construction activities will be a sufficient distance from this receptor such that the pathway for an effect is limited. However, as a worst case scenario a sensitivity of medium has been determined in relation to temporary increases in SSC and deposition.

Magnitude of Effect

177. The activities causing increases in SSC and subsequent deposition during the construction of SEP are the same as presented for DEP in isolation (**Section 10.6.2.2.1**) except for the interlink cable installation which would not be required in the SEP in isolation scenario.

178. The fate of suspended sediment during the SEP construction phase has been determined in **Chapter 8 Marine Geology Oceanography and Marine Physical Processes**. Due to the sediment composition across the SEP offshore area being similar to DEP offshore area, suspended sediment is expected to disperse and settle in a similar way to that described for DEP offshore area.

179. In summary, increases in SSC are expected to be localised at the point of discharge and short-term. Fine suspended sediment may then be transported by tidal currents, however due to the small quantities of fine-sediment released it is likely to be widely and rapidly dispersed. In most cases the elevation of suspended sediment is expected to be lower than the concentrations that would develop in the water column during storm conditions. Deposition of sediment is expected to be localised to the point of disturbance, with deposits of up to approximately 3cm.

180. Given the localised and short-term increases in SSC around the point of discharge, and negligible changes in seabed level is expected due to deposition, the magnitude of effect is considered to be negligible.

Impact Significance

181. Based on the worst case medium sensitivity of one habitat (A4.231) and the negligible magnitude of temporary increases SSC and deposition during the SEP construction phase, the impact is assessed as **minor adverse** significance.

10.6.2.2.3 DEP and SEP Together

Sensitivity

182. The worst case sensitivity assessment for DEP and SEP together remains the same as the sensitivity presented for SEP in isolation (medium), based on the assessment of the most sensitive receptor.

Magnitude of Effect

183. Although the area over which SSC and deposition effects would occur will be greater for DEP and SEP together in comparison to the DEP or SEP in isolation, the increases in SSC are still expected to cause localised and short-term increases in SSC around the point of discharge, with negligible changes in seabed level expected due to deposition. The impact magnitude is therefore considered to remain as negligible.

Impact Significance

184. The worst case sensitivity assessment for DEP and SEP together remains the same as the sensitivity presented for SEP in isolation (medium) based on the most sensitive receptor. Additionally, the magnitude of the impact of increased SSC and deposition for DEP and SEP together remains negligible. Therefore, the impact of increased SSC and deposition during the construction phase in the DEP and SEP together scenario is assessed as **minor adverse** significance.

10.6.2.2.4 Cromer Shoal Chalk Beds MCZ

Sensitivity

185. Based on the habitats and biotopes recorded in the Cromer Shoal Chalk Beds MCZ (**Section 10.5.4.3**) sensitivity to increased SSC and deposition ranges from not sensitive to low. The sensitivity of MCZ habitats can be modified based on their value (**Section 10.4.3.1.2**), and because they are component biotopes of MCZ designated features the worst case sensitivity is increased to medium.

Magnitude of Effect

186. The magnitude of effect from temporary habitat loss/physical disturbance remains negligible.

Impact Significance

Based on the worst case medium sensitivity of habitats and biotopes and the negligible magnitude of increased SSC and deposition during the DEP and/or SEP construction phase, the impact on the Cromer Shoal Chalk Beds MCZ is assessed as **minor adverse** significance.

10.6.2.2.5 Inner Dowsing, Race Bank and North Ridge SAC

187. The Inner Dowsing, Race Bank and North Ridge SAC is located approximately 2.2km west of the SEP wind farm site boundary. A full assessment of potential impacts on the designated features of the SAC is provided in the **draft Information for Habitats Regulations Assessment Report**.

Sensitivity

188. Using Natural England's advice on operations for the Inner Dowsing, Race Bank and North Ridge SAC in relation to the relevant pressure of smothering and siltation rate changes (Light) all biotopes associated with the Annex I sandbanks have either a low sensitivity or are not sensitive, except for the following two biotopes which have medium sensitivity:

- A5.432 *Sabella pavonina* with sponges and anemones on infralittoral mixed sediment; and
- A5.445 *Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment.

189. These biotopes have not been confirmed within the extent of the effect, however, taking a precautionary approach the worst case sensitivity is medium. The sensitivity of habitats can be modified based on their value (**Section 10.4.3.1.2**), and because there may be an impact on Annex I habitats within a SAC boundary the worst case sensitivity is increased to high.

Magnitude of Effect

190. The potential for increases in SSC is considered greatest during the construction phase. **Chapter 9 Geology Oceanography and Marine Physical Processes** assessed the potential increased SSC and deposition from construction sources foundation installation.

191. Mobilised sediment may be transported by wave and tidal action in suspension in the water column. Conceptual evidence-based assessment suggests that, due to the predominance of medium and coarse grained sand across DEP and SEP areas, sediment disturbed at the sea bed would remain close to the bed and settle back to the bed rapidly. Most of the sediment released at the water surface (e.g. from a dredger vessel) would fall rapidly to the seabed within a few tens of metres along the axis of tidal flow. Some of the finer sand fraction from this release and the very small proportion of mud that is present are likely to stay in suspension for longer and form a passive plume which would become advected by tidal currents. Due to the sediment sizes present, this is likely to exist as a measurable but modest concentration plume (tens of mg/l) for around half a tidal cycle (up to six hours). Sediment would settle to the seabed within a few hundred metres up to around a kilometre from the release location along the axis of tidal flow within a short period of time (hours). Whilst lower suspended sediment concentrations would extend further from the dredged area, along the axis of predominant tidal flows and potentially as far as the Inner Dowsing, Race Bank and North Ridge SAC (which is within the zone of tidal influence from the western boundary of the SEP wind farm site), the magnitudes would be indistinguishable from background levels. Deposited sediment would be to a maximum thickness of less than 0.1mm within the SAC and is also likely to be indistinguishable from background levels.

192. Based on the assessment provided in **Chapter 9 Geology Oceanography and Marine Physical Processes**, the effect of temporary increases in SSC and deposition on the Inner Dowsing, Race Bank and North Ridge SAC is expected to be negligible.

Impact Significance

193. Based on the worst case high sensitivity of habitats and biotopes and the negligible magnitude of increased SSC and deposition during the SEP construction phase, the impact on the Inner Dowsing, Race Bank and North Ridge SAC is assessed as **minor adverse** significance. No impact is anticipated from the construction of DEP.

10.6.2.3 Impact 3: Re-mobilisation of contaminated sediments

10.6.2.3.1 DEP and SEP in Isolation and Together

Magnitude of Effect

194. As described in **Section 10.5.2**, data collected during the benthic characterisation surveys was analysed for contaminants. **Chapter 9 Marine Sediment and Water Quality** has conducted a comparison of levels of sediment contamination against recognised sediment quality guidelines. Sediment contamination levels in the surveyed area are not considered to be of significant concern and are low risk in terms of potential impacts on the marine environment. Specifically, the organotin concentrations recorded were low and insufficient to affect the reproductive capability of sensitive gastropod species.

195. Therefore, there is no risk to benthic ecology receptors from re-mobilisation of contaminated sediments.

Sensitivity

196. The MarESA pressure benchmark for ‘Pollution and other chemical changes’ is set at ‘compliance with all Annual Average Environmental Quality Standards (EQS), conformance with PELs, and OSPAR Environmental Assessment Criteria (EACs) or Effects Range Lows (ER-Ls’)’ and that compliance with ‘all relevant environmental protection’ is likely to result in no effects on the features (Tyler-Walters et al., 2018). Given contaminant levels are within environmental protection standards, marine species and habitats are not sensitive to changes that remain within these standards.

Impact Significance

197. Due to there being no contaminated sediments above levels of concern within DEP and SEP offshore areas there is no pathway for effect to benthic receptors. Therefore there is **no impact** for all scenarios. This impact is not considered further in the operational phase and decommissioning phase due to there being no pathway for impact on benthic receptors.

10.6.2.4 Impact 4: Underwater noise and vibration

10.6.2.4.1 DEP and SEP in Isolation and Together

198. Underwater noise and vibration from UXO clearance, pile driving for the installation of some foundation types, and other construction activities including seabed preparation, cable installation and rock placement, and from vessels (as described in **Chapter 5 Project Description**) have potential to impact on benthic ecology receptors.

Sensitivity

199. Noise sources other than piling and UXO clearance are unlikely to have a significant effect on benthic ecology as the benthos in this area is likely to be habituated to ambient noise such as that created by shipping.

200. The sensitivity of the biotopes identified in the DEP and SEP offshore areas has been assessed in relation to MarESA pressures relevant to construction phase underwater noise and are summarised in **Table 10-18** below.

Table 10-18 Habitat and biotope sensitivity to underwater noise pressures

Habitats and Biotopes	Underwater noise changes
A3/4 Infralittoral / Circalittoral rock and other hard substrata	**Not sensitive**
A4.232 *Polydora* sp. tubes on moderately exposed sublittoral soft rock	Not sensitive
A4.1 Atlantic and Mediterranean high energy circalittoral rock	**Not sensitive**
A4.134 *F. foliacea* and colonial ascidians on tide-swept moderately wave-exposed circalittoral rock	Not sensitive
A4.2 Atlantic and Mediterranean moderate energy circalittoral rock	**Not relevant**
A4.231 Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay	Not relevant
A5.1 Sublittoral coarse sediment	**Not relevant**
A5.133 ‘*Moerella* spp. with venerid bivalves in infralittoral gravelly sand’	Not relevant
A5.2 Sublittoral sand	**Not relevant**
A5.233 *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand	Not relevant
A5.4 Sublittoral mixed sediments	**Not relevant**
A5.431 *Crepidula fornicata* with ascidians and anemones on infralittoral coarse mixed sediment	Not relevant
A5.451 Polychaete-rich deep Venus community in offshore mixed sediments	Not relevant
A5.6 Sublittoral biogenic reefs	**Not relevant**
A5.611 *S. spinulosa* on stable circalittoral mixed sediment	Not relevant

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

202. During seismic surveys, polychaetes have been observed to retreat into the bottom of their burrows or retract their palps, and bivalve species withdrew their siphons (Richardson et al., 1995). 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.

203. Evidence suggests that some benthic species perceive and react to noise, however the MarESA sensitivity assessment for the biotopes recorded within the DEP and SEP offshore survey areas is that they are either 'not sensitive' or that noise impacts are 'not relevant' (**Table 10-18**). 'Not relevant' is recorded where the evidence suggests that there is no direct interaction between the pressure and the habitat (biotope) or species. Therefore, the sensitivity of benthic biotopes and species to underwater noise and vibration is considered to be negligible.

Magnitude of Effect

204. Underwater noise from the worst case sources (described in **Table 10-2**) may result in a discernible, temporary (for part of the construction phase) change, or over a small area of the receptor. Therefore, the magnitude of this effect is considered to be negligible.

Impact Significance

205. Based on the worst case negligible sensitivity of habitats and biotopes and the negligible magnitude of effects of underwater noise on benthic ecology receptors during the construction phase, the impact is assessed as **negligible adverse** significance. Although the duration and spatial extent of noise effects would be greater for DEP and SEP together, the magnitude is still assessed as negligible and therefore the impact remains negligible.

10.6.2.5 Impact 5: Invasive Non-Native Species (INNS)

206. Potential INNS 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. The primary pathway for the potential introduction of INNS is from the use of vessels and infrastructure that has originated from outwith the North Sea and Northeast Atlantic region, particularly from regions that are ecologically distinct from the southern North Sea. Ship ballast water appears to be the largest single vector for INNS, and bio-fouling communities on ships are also a contributor (Glasby et al. 2007).

207. This pathway for introduction of INNS will be greatest during the construction phase and is assessed here. The impacts from colonisation and establishment of INNS following introduction has been considered as an operational impact (**Section 10.6.3.7**), including the potential introduction of species non-native to otherwise soft substrate habitats (**Section 10.6.3.5**).

Sensitivity

208. The sensitivity of the biotopes identified in the DEP and SEP offshore areas has been assessed in relation to MarESA pressure ‘introduction or spread of INNS’.

209. The sensitivity of identified habitats and biotopes to INNS pressures are summarised **Table 10-19** below. Further information describing the resistance and resilience of these habitats and biotopes, used to determine sensitivity, is provided in **Appendix 10.4**

Table 10-19 Habitat and biotope sensitivity to INNS

Habitat and Biotope	MarESA sensitivity
	Introduction or spread of INNS
A3/4 Infralittoral / Circalittoral rock and other hard substrata	**Not Relevant**
A4.232 *Polydora* sp. tubes on moderately exposed sublittoral soft rock	Not Relevant
A4.1 Atlantic and Mediterranean high energy circalittoral rock	**Not sensitive**
A4.134 *F. foliacea* and colonial ascidians on tide-swept moderately wave-exposed circalittoral rock	Not sensitive
A4.2 Atlantic and Mediterranean moderate energy circalittoral rock	**Not sensitive**
A4.231 Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay	Not sensitive
A5.1 Sublittoral coarse sediment	**High**
A5.133 ‘*Moerella* spp. with venerid bivalves in infralittoral gravelly sand’	High
A5.2 Sublittoral sand	**Not sensitive**
A5.233 *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand	Not sensitive
A5.4 Sublittoral mixed sediments	**High**
A5.431 *Crepidula fornicata* with ascidians and anemones on infralittoral coarse mixed sediment	Not relevant

A5.451 Polychaete-rich deep Venus community in offshore mixed sediments	High
A5.6 Sublittoral biogenic reefs	**Not sensitive**
A5.611 *S. spinulosa* on stable circalittoral mixed sediment	Not sensitive

10.6.2.5.1 DEP in Isolation

Sensitivity

210. The sensitivity of DEP biotopes to INNS is either not sensitive or high according to MarESA, with the highest sensitivity biotope being A5.133 '*Moerella* spp. with venerid bivalves in infralittoral gravelly sand'.

Magnitude of Effect

211. The risk of spreading INNS will be mitigated by employing biosecurity measures in accordance with the following relevant regulations and guidance:

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

212. These commitments would be secured in the Project Environmental Management Plan (PEMP) which will be agreed prior to the start of construction.

213. With mitigations in place it is not expected INNS will be introduced, therefore the magnitude of effect is assessed as negligible.

Impact Significance

214. Based on the worst case high sensitivity of habitats and biotopes and the negligible magnitude of effect during the DEP construction phase, the impact is assessed as **minor adverse** significance.

10.6.2.5.2 SEP in Isolation

Sensitivity

215. The sensitivity of SEP biotopes to INNS is either not sensitive or high according to MarESA, with the highest sensitivity biotopes being A5.133 '*Moerella* spp. with venerid bivalves in infralittoral gravelly sand' and A5.451 Polychaete-rich deep Venus community in offshore mixed sediments, although the latter is an impoverished version of the biotope and therefore its sensitivity is likely to be lower.

Magnitude of Effect

216. The risk of spreading INNS will be mitigated by application of the same regulations and guidance as described for DEP above and commitments would be secured in the PEMP which will be agreed prior to the start of construction. Therefore, with mitigations in place it is not expected INNS will be introduced, therefore the magnitude of effect is assessed as negligible.

Impact Significance

217. Based on the worst case high sensitivity of habitats and biotopes and the negligible magnitude of effect during the SEP construction phase, the impact is assessed as **minor adverse** significance.

10.6.2.5.3 DEP and SEP Together

Sensitivity

218. The worst case sensitivity assessment for DEP and SEP together remains the same as the sensitivity presented for DEP and SEP in isolation (high), based on the assessment of the most sensitive receptors.

Magnitude of Effect

219. Although the number of vessels on site during construction will be greater is DEP and SEP and both developed, either concurrently or sequentially, with mitigation measures in place the magnitude of effect is assessed as the same as for DEP and SEP in isolation, negligible.

Impact Significance

220. Based on the worst case high sensitivity of habitats and biotopes and the negligible magnitude of effect during DEP and SEP construction, the impact is assessed as **minor adverse** significance.

10.6.3 **Potential Impacts during Operation**

10.6.3.1 Impact 1: Temporary habitat loss / physical disturbance

10.6.3.1.1 DEP and SEP – All Scenarios

221. Temporary habitat loss / physical disturbance will occur during the operational phase of DEP and SEP including cable repairs and reburial, and turbine repairs, potentially requiring deployment of jack up vessels or vessel anchors. The area disturbed would be extremely small in comparison to during construction (**Table 10-2**). For this impact it is considered that there is no clear difference in the assessment outcomes between the different development scenarios. As such a single assessment is provided that applies to all scenarios.

Sensitivity

222. The sensitivity of the biotopes identified in the DEP and SEP offshore areas has been assessed in relation to MarESA pressures relevant to construction phase temporary habitat loss / physical disturbance, set out in **Table 10-16.**

223. As described in **Section 10.6.2.1**, post-construction monitoring surveys of the Dudgeon OWF and Sheringham Shoal OWF have been undertaken. The results of the surveys suggest that recovery of biotopes is possible within two years, and supports the MarESA sensitivity assessments which are based on high resilience / recovery.

224. A worst case medium sensitivity was determined for biotopes within the DEP offshore area, and a worst case high sensitivity for the biotopes in the SEP offshore area. The Scoping Response (PINS, 2019) requested that potential impacts occurring during maintenance activities on *S. spinulosa* reef that may colonise the cables during the operational phase be assessed (**Table 10-1**). 'A5.611 S. spinulosa on stable circalittoral mixed sediment' has been recorded in the DEP and SEP offshore area but not in as reef that qualifies as Annex I habitat. The absence of biogenic reef features suggests they are unlikely to form naturally in the project area. The introduction of stable artificial substrate in the form of external cable protection and turbine foundations may encourage reef formation but would not be considered Annex I habitat as it would not naturally occur at the location. The sensitivity of 'A5.611 S. spinulosa on stable circalittoral mixed sediment' to temporary habitat loss and physical disturbance pressures is medium and this is the case for all biotopes relevant to *S. spinulosa* reefs (based on AoO advice on the Wash and North Norfolk Coast SAC 'Subtidal biogenic reefs: Sabellaria spp' feature). As such impacts on *S. spinulosa* reef that may colonise the cables during the operational phase are covered by the general assessment.

Magnitude of Effect

225. The impact will be intermittent, highly localised and temporary. The area of disturbance is considered to be very small in the context of the extent of these benthic habitats present across the wider southern North Sea, and a fraction or the area affected during the construction phase. A discernible, temporary (for part of the project duration) change, over a small area of the receptor is anticipated and, therefore, the magnitude of this effect is considered to be negligible.

Impact Significance

226. Based on the worst case medium sensitivity of habitats and biotopes and the negligible magnitude of temporary habitat loss/physical disturbance during the DEP and SEP operation phase, the impact is assessed as **minor adverse** significance for DEP and SEP in isolation and together.

10.6.3.1.2 Cromer Shoal Chalk Beds MCZ

227. The magnitude of temporary habitat loss / physical disturbance in the Cromer Shoal Chalk Beds MCZ during the operation phase will be smaller than during construction. The assessment of significance is consistent with the construction phase assessment (**Section 10.6.2.1**). Based on the worst case medium sensitivity of habitats and biotopes and the negligible magnitude of temporary habitat loss/physical disturbance, the impact on the Cromer Shoal Chalk Beds MCZ is assessed as **minor adverse** significance.

10.6.3.2 Impact 2: Permanent habitat loss

228. Habitat loss will occur during the lifetime of DEP and SEP as a result of structures, scour and external cable protection installed on the seabed. It is currently unknown which structures will be removed or remain *in situ* at the point of decommissioning. Removal of accessible installed components such as the wind turbine components and foundations (above the seabed level) is expected, however, there is a potential for some structures to be left *in situ* such as external cable protection or scour protection.

229. A decommissioning plan will be agreed with the relevant authorities at the point of decommissioning. Therefore, it is currently unknown if habitat loss during the operational phase will be lasting/long term or permanent. As a precautionary approach, habitat loss has been considered as permanent with the exception of where the Applicant has made a commitment to removal on decommissioning, which is addressed by Impact 3 below.

Sensitivity

230. The sensitivity of the biotopes identified in the DEP and SEP offshore areas has been assessed in relation to MarESA pressures relevant to permanent habitat loss (MarESA pressure 'Physical change to another seabed type').

231. It is possible that artificial hard substratum installed in rock habitat areas will be colonised by the same benthic community present before installation, and therefore there would be no long term or permanent loss. However, artificial hard substratum may also differ in character from natural hard substratum, so that replacement of natural surfaces with artificial hard substratum may lead to changes in the biotope through changes in species composition, richness and diversity.

232. The sensitivity of identified habitats and biotopes to habitat loss is summarised in **Table 10-20** below. Further information describing the resistance and resilience of these habitats and biotopes, used to determine sensitivity, is provided in **Appendix 10.4**.

Table 10-20 Habitat and biotope sensitivity to habitat loss pressures

Habitat and Biotope	MarESA sensitivity
	Physical change to another seabed type
A3/4 Infralittoral / Circalittoral rock and other hard substrata	**High**
A4.232 *Polydora* sp. tubes on moderately exposed sublittoral soft rock	High
A4.1 Atlantic and Mediterranean high energy circalittoral rock	**High**
A4.134 *F. foliacea* and colonial ascidians on tide-swept moderately wave-exposed circalittoral rock	High
A4.2 Atlantic and Mediterranean moderate energy circalittoral rock	**High**
A4.231 Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay	High
A5.1 Sublittoral coarse sediment	**High**
A5.133 'Moerella spp. with venerid bivalves in infralittoral gravelly sand'	High
A5.2 Sublittoral sand	**High**

Habitat and Biotope	MarESA sensitivity
	Physical change to another seabed type
A5.233 *Nephtys cirrosa* and Bathyporeia spp. in infralittoral sand	High
A5.4 Sublittoral mixed sediments	**High**
A5.431 *Crepidula fornicata* with ascidians and anemones on infralittoral coarse mixed sediment	High
A5.451 Polychaete-rich deep Venus community in offshore mixed sediments	High
A5.6 Sublittoral biogenic reefs	**High**
A5.611 *S. spinulosa* on stable circalittoral mixed sediment	High

233. By definition, the sensitivity of benthic ecology receptors to permanent habitat loss is high. Therefore, in the context of an individual biotope in a spatially distinct area where the biotope is present the sensitivity is high. However, in the context of the wider community level impacts for these biotopes which are known to be present across the wider area in the southern North Sea, the sensitivity is considered to be medium. This assessment applies equally to all DEP and SEP receptors.

10.6.3.2.1 DEP in Isolation

Magnitude of Effect

234. The worst case DEP footprint of permanent infrastructure (which may not be decommissioned) includes scour protection for up to 32 turbines (14MW) with GBS foundations and one OSP with suction bucket foundations, unburied cable protection and cable crossings. The maximum area of permanent habitat loss 0.51km^2 (**Table 10-2**). Permanent habitat loss represents 0.49% of the total seabed area within the DEP wind farm sites. Some of this habitat loss would occur along the export cable corridor, however areas for the interlink and export cables are not currently known, therefore the total habitat loss across the entire DEP offshore area would be smaller.

235. Although the effect is permanent, it is over a small proportion of the total benthic ecology resource due to the presence of comparable habitats identified throughout the DEP and SEP offshore survey area, and the wider region, as demonstrated by survey data from DOW and SOW and Hornsea 3 OWF (RPS, 2018). Therefore, the magnitude of this effect is considered low.

Impact Significance

236. Based on the worst case medium sensitivity of biotopes and a low impact magnitude in relation to permanent habitat loss during and potentially after the operational phase, the impact significance is assessed as **minor adverse**.

10.6.3.2.2 SEP in Isolation

Magnitude of Effect

237. The worst case SEP footprint of permanent infrastructure (which may not be decommissioned) includes scour protection for up to 24 turbines (14MW) with GBS foundations and one OSP with suction bucket foundations, unburied cable protection and cable crossings. The maximum area of permanent habitat loss 0.36km^2 (**Table 10-2**). Permanent habitat loss represents 0.44% of the total seabed area within the SEP wind farm site. However, some of this habitat loss would actually occur along the export cable however areas for the export cable are not currently known, therefore total habitat loss across the entire SEP offshore area would be smaller.

238. As for DEP in isolation, although the effect is permanent, it is over a small proportion of the total benthic ecology resource due to the presence of comparable habitats identified throughout the DEP and SEP offshore survey area, and the wider region, as demonstrated by survey data from DOW and SOW and Hornsea 3 OWF (RPS, 2018). Therefore, the magnitude of this effect is considered low.

Impact Significance

239. Based on the worst case medium sensitivity of biotopes and a low impact magnitude in relation to permanent habitat loss during and potentially after the operational phase, the impact significance is assessed as **minor adverse**.

10.6.3.2.3 DEP and SEP Together

Magnitude of Effect

240. The worst case footprint of permanent DEP and SEP infrastructure includes scour protection for up to 56 turbines (14MW) with GBS foundations, two OSPs with suction bucket foundations, unburied cable protection and cable crossings. The maximum area of permanent habitat loss 0.86km^2 (**Table 10-2**). Permanent habitat loss represents 0.44% of the total seabed area within the DEP and SEP wind farm sites. However, some of this habitat loss would actually occur along the export cable however areas for the interlink and export cable are not currently known, therefore total habitat loss across the entire DEP and SEP offshore area would be smaller.

241. As for DEP and SEP in isolation, although the effect is permanent, it is over a small proportion of the total benthic ecology resource due to the presence of comparable habitats identified throughout the DEP and SEP offshore survey area, and the wider region, as demonstrated by survey data from DOW and SOW and Hornsea 3 OWF (RPS, 2018). Therefore, the magnitude of this effect is considered low.

Impact Significance

242. Based on the worst case scenario of medium sensitivity of biotopes and a low impact magnitude in relation to permanent habitat loss during and potentially after the operational phase of DEP and SEP together, the impact significance is assessed as **minor adverse**.

10.6.3.3 Impact 3: Long term habitat loss

10.6.3.3.1 Cromer Shoal Chalk Beds MCZ

243. As described in **Table 10-2,** rock bags may be used for cable protection inside the Cromer Shoal Chalk Beds MCZ, at the offshore export cable HDD exit transition zone and as external cable protection, where necessary, for unburied cables along the offshore export cable route through the MCZ. Rock bags are designed to be removable and the Applicant has committed to remove offshore export cable protection material within the MCZ at the decommissioning stage to avoid permanent impact to MCZ benthic habitats.

Sensitivity

244. The sensitivity of identified habitats and biotopes to habitat loss is summarised in **Table 10-20** above. Further information describing the resistance and resilience of these habitats and biotopes, used to determine sensitivity, is provided in **Appendix 10.4**.

245. Artificial hard substratum installed in rock habitat areas may be colonised by the same, or a similar benthic community to that present before installation, thereby reducing the impact. However, the offshore export cable corridor within the Cromer Shoal Chalk Beds MCZ and in the areas where external cable protection may be installed comprises primarily subtidal sediment habitats. Infralittoral and circalittoral rock and other hard substrata are restricted to the area landward of the HDD exit location with the exception of occasional sublittoral rock biotopes on larger cobbles and boulders in predominantly sediment areas.

246. The sensitivity of habitats and biotopes recorded in the offshore export cable corridor to habitat loss is high. In the context of an individual biotope in a spatially distinct area where the biotope is present the sensitivity is high. However, in the context of the wider community level impacts for these biotopes which are known to be present across the wider area in the southern North Sea, the sensitivity is considered to be medium. The sensitivity of MCZ habitats can be modified based on their value (**Section 10.4.3.1.2**), but the worst case sensitivity remains medium.

Magnitude of Effect

247. The worst case footprint of DEP and SEP cable protection in the MCZ, and therefore the maximum area of long term habitat loss, is 900m^2 for DEP or SEP in isolation or 1,800m^2 for DEP and SEP together (**Table 10-2**). The worst case habitat loss of 1,800m^2 represents 0.0006% of the Cromer Shoal Chalk Beds MCZ area.

248. If the cable protection in the MCZ were to be decommissioned *in situ* habitat loss would be permanent and the magnitude of effect would be assessed as medium. However, with the commitment to remove this infrastructure at decommissioning it is expected that habitat loss will last for the duration of the DEP and/or SEP operational phase (35 years).

249. Therefore, the impact will be temporary (throughout the project duration), but over a minority of the receptor, and the magnitude is assessed as low.

Impact Significance

250. Based on the worst case medium sensitivity of receptors and a low impact magnitude in relation to long term habitat loss during the operational phase of DEP or SEP in isolation, or DEP and SEP together, the impact significance is assessed as **minor adverse**.

10.6.3.4 Impact 4: Temporary increases in SSC and deposition

251. Increases in SSC within the water column, and subsequent deposition onto the seabed may occur as a result of operation and maintenance activities that require the use of jack-up vessels, as well as cable repair, replacement and reburial activities.

10.6.3.4.1 DEP and SEP – All Scenarios

252. For this impact it is considered that there is no clear difference in the assessment outcomes between the different development scenarios. As such a single assessment is provided that applies to all scenarios.

Sensitivity

253. The sensitivity of the biotopes identified in the DEP and SEP offshore areas has been assessed in relation to MarESA pressures relevant to operational phase temporary increases in SSC and deposition, which has been set out in **Table 10-17**.

254. A worst case scenario of low sensitivity was determined for biotopes within the DEP offshore area, and a worst case scenario of medium sensitivity for the biotopes in the SEP offshore area (**Section 10.6.2.2**).

Magnitude of Effect

255. As outlined in **Table 10-2**, operation phase maintenance is likely to require periodic jack up vessel deployments and cable repair, replacement and reburial activities. Increased SSCs due to jack up vessels are expected to be very small. Cable repair, replacement and reburial will mobilise larger volumes of sediment but these will be small in magnitude relative to cable installation during construction. Increases in SSC and deposition as a result of operation phase activities are expected to cause localised and short-term increases in SSC at the point of discharge. Released sediment may then be transported by tidal currents in suspension in the water column. As described in **Section 10.6.2.2**, localised and short-term increases in SSC around the point of discharge are expected with negligible changes in seabed level due to deposition, and the impact magnitude is considered to be negligible.

Impact Significance

256. The worst case sensitivity assessment for DEP and SEP together is medium based on the most sensitive receptor in the SEP wind farm site (DEP sensitivity is likely to be low). The magnitude of the effect is negligible. Therefore, the impact of increased SSC and deposition during the operational phase of DEP or SEP in isolation, or DEP and SEP together, is assessed as **minor adverse** significance.

10.6.3.5 Impact 5: Colonisation of foundations and cable protection

257. The DEP and SEP benthic survey (**Appendix 10.1, 10.2**) and habitat mapping study (**Appendix 10.3**) show that most of the seabed within the PEIR boundary consists of subtidal soft sediments (**Figure 10.4** and **Figure 10.5**). Therefore, introduction of hard substrate will have a direct effect on benthic ecology by facilitating the establishment of species uncharacteristic of soft sediment habitats.

258. Studies of operational wind farms in the North Sea have found that widespread colonisation of sub-sea surfaces occurs. For example, boulders and mattresses used as cable protection have been found to add habitat complexity and increase heterogeneity of the environment in and around offshore wind farms (Lindeboom et al., 2011; Goriup, 2017).

259. 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).

260. A study of the FINO 1 Research platform located in the immediate vicinity of the Alpha Ventus, a German Offshore Wind Farm in the North Sea also reported findings of epifaunal communities colonising offshore foundations (Krone et al., 2013). *Mytilus edulis* was found to dominate the communities that colonised the offshore foundations. Additionally, the shells of the *M. edulis* were found to provide additional hard substrate for epifauna to colonise (Krone *et al*., 2013).

<u>Sensitivity</u>

261. The most relevant MarESA pressure in relation to the presence of new artificial structures is ‘physical change to another seabed type’. However, this impact has been assessed in relation to permanent habitat loss, indicating a medium sensitivity due to the limited proportion of the benthic receptors impacted.

262. Although the relevant pressure is the same, the impact itself is different to habitat loss. The presence of hard substrate will increase the structural complexity of the substrata, providing refuge and niche habitats as well as increasing feeding opportunities for a range of larger and more mobile species. The species potentially introduced through artificial reef structures created by the turbine foundations may have indirect and adverse effects through increased predation on, or competition with, neighbouring subtidal sediment species.

263. 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.

264. Therefore, due to the presence of artificial hard substrate in an area of predominantly sediment habitats, species that colonise the artificial hard substrate would represent a change in biodiversity in the area. However, the change will be limited to the artificial structures themselves, therefore in the context of the wider community level impacts for the biotopes present across the wider area where the same habitats and species are known to be present, the sensitivity is considered to be medium.

10.6.3.5.1 DEP in isolation

Magnitude of Effect

265. The footprint of DEP artificial hard substrate which has a potential to be colonised by benthic fauna has been provided within operation Impact 2: Permanent habitat loss in **Section 10.6.3.2.1** and **Table 10-2**. The habitat area available for colonisation on three dimensional structures will be larger than this footprint.

266. The change of habitat from a sedimentary substrate to hard substrate will result in potential increases in the diversity and biomass of the marine community in the area. However, there is likely to be only a small interaction between the remaining available seabed and the introduced hard substrate and any interactions would be highly localised. Relative to the extent of benthic communities in the project area and the wider southern North Sea, which are predominantly associated with sediment habitats, the magnitude of this effect is considered to be low.

Impact Significance

267. The sensitivity assessment for DEP is medium and the magnitude of the effect is low. Therefore, the impact of colonisation of foundations and cable protection during the operational phase of DEP in isolation is assessed as **minor adverse** significance.

10.6.3.5.2 SEP in Isolation

Magnitude of Effect

268. The footprint of SEP artificial hard substrate which has a potential to be colonised by benthic fauna has been provided within operation Impact 2: Permanent habitat loss in **Section 10.6.3.2.2** and **Table 10-2**. The habitat area available for colonisation on three dimensional structures will be larger than this footprint.

269. As for DEP in isolation, relative to the extent of benthic communities in the project area and the wider southern North Sea, which are predominantly associated with sediment habitats, the magnitude of this effect is considered to be low.

Impact Significance

270. The sensitivity assessment for SEP is medium and the magnitude of the effect is low. Therefore, the impact of colonisation of foundations and cable protection during the operational phase of SEP in isolation is assessed as **minor adverse** significance.

10.6.3.5.3 DEP and SEP Together

Magnitude of Effect

271. The worst case footprint of DEP and SEP artificial hard substrate which has a potential to be colonised by benthic fauna has been provided within operation Impact 2: Permanent habitat loss in **Section 10.6.3.2.3** and **Table 10-2**. The habitat area available for colonisation on three dimensional structures will be larger than this footprint.

272. As for DEP and SEP in isolation, relative to the extent of benthic communities in the projects area and the wider southern North Sea, which are predominantly associated with sediment habitats, the magnitude of this effect is still considered to be low.

Impact Significance

273. The sensitivity assessment for DEP and SEP together is medium and the magnitude of the effect is low. Therefore, the impact of colonisation of foundations and cable protection during the operational phase of DEP and SEP together is assessed as **minor adverse** significance.

10.6.3.5.4 Cromer Shoal Chalk Beds MCZ

274. Cable protection in the Cromer Shoal Chalk Beds MCZ will be colonised by a different benthic community to the primarily soft sediment communities present prior to installation. As for the wider DEP and SEP areas, the sensitivity is considered to be medium. The sensitivity of MCZ habitats can be modified based on their value (**Section 10.4.3.1.2**), but the worst case sensitivity remains medium.

275. The maximum footprint of external cable protection is summarised in **Table 10-2** under operation Impact: Long term habitat loss. The magnitude of effect is still considered to be low given the extent of benthic communities in the projects area, the MCZ and the wider southern North Sea.

276. Based on the worst case medium sensitivity of habitats and biotopes and the low magnitude of effect, the impact on the Cromer Shoal Chalk Beds MCZ is assessed as **minor adverse** significance.

10.6.3.6 Impact 6: Underwater noise and vibration

277. Underwater noise and vibration as a result of operation and maintenance activities are largely associated with operational wind turbines, vessel activities and maintenance including cable repair, replacement and reburial (**Table 10-2**).

10.6.3.6.1 DEP and SEP – All Scenarios

278. For this impact it is considered that there is no clear difference in the assessment outcomes between the different development scenarios. As such a single assessment is provided that applies to all scenarios

Sensitivity

279. As described in **Section 10.6.2.4**, evidence suggests that some benthic species perceive and react to noise, however the MarESA sensitivity assessment for the biotopes recorded within the DEP and SEP offshore survey areas is that they are either 'not sensitive' or that noise impacts are 'not relevant' (**Table 10-18**). 'Not relevant' is recorded where the evidence suggests that there is no direct interaction between the pressure and the habitat (biotope) or species. Therefore, the sensitivity of benthic biotopes and species to underwater noise and vibration is considered to be negligible.

Magnitude of Effect

280. As described in **Section 10.6.2.4** operational activities such as vessel activity are unlikely to have a significant effect on benthic ecology as the benthos in this area is likely to be habituated to ambient noise such as that created by shipping. Additionally, the magnitude of noise and vibration effect during construction piling and UXO clearance is much greater than from operation phase sources, therefore it is considered any operational noise and vibration impacts will be negligible.

Impact Significance

281. The sensitivity of benthic ecology receptors identified in the DEP and SEP areas to underwater noise and vibration is negligible, and the magnitude of the effect is negligible. Therefore, the impact of underwater noise and vibration during the operational phase of DEP or SEP in isolation, or DEP and SEP together, is assessed as **negligible** adverse significance.

10.6.3.7 Impact 7: Invasive Non Native Species

282. Artificial hard substrates introduced by DEP and SEP including foundations, scour and cable protection could act as potential 'stepping stones' or vectors for INNS, as well as supporting species non-native to otherwise soft substrate habitats (the latter considered under operation Impact 5).

283. The primary pathway for the potential introduction of INNS is from the use of vessels and infrastructure that have originated from outwith the North Sea and Northeast Atlantic region, particularly from regions that are ecologically distinct from the southern North Sea, as discussed in **Section 10.6.2.5** for construction. Construction phase mitigation measures will be applied to vessel activities and the introduction of materials throughout the operational phase of the Projects.

284. The vector capability of introduced artificial hard substrate would be most pronounced during the operational lifetime of DEP and SEP when the likelihood of INNS establishing and extending their range would be greatest. 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. This is evidenced by the presence of the slipper limpet *C. fornicata* in DEP and SEP benthic surveys, a characterising species in the biotope A5.431 *Crepidula fornicata* with ascidians and anemones on infralittoral coarse mixed sediment, identified in the DEP and SEP areas. The slipper limpet has accidentally introduced with Pacific oyster, imported for shellfish aquaculture, and has since colonised extensive areas of the North Sea.

10.6.3.7.1 DEP and SEP – All Scenarios

285. For this impact it is considered that there is no clear difference in the assessment outcomes between the different development scenarios. As such a single assessment is provided that applies to all scenarios.

<u>Sensitivity</u>

286. As discussed in **Section 10.6.2.5** the sensitivity of DEP and SEP biotopes to INNS is either not sensitive or high according to MarESA, with the highest sensitivity biotopes being A5.133 '*Moerella* spp. with venerid bivalves in infralittoral gravelly sand' and A5.451 Polychaete-rich deep Venus community in offshore mixed sediments, although the latter is an impoverished version of the biotope and therefore its sensitivity is likely to be lower.

<u>Magnitude of Effect</u>

287. As discussed in construction **Section 10.6.2.5**, the risk of spreading INNS will be mitigated by application of regulations and guidance secured in the PEMP which will be agreed prior to the start of construction. Therefore, with mitigations in place it is not expected INNS will be introduced.

288. It is not expected INNS will be introduced if the mitigation measures are adhered to, and the risk of introduction to the southern North Sea is not considered to be significantly increased as a result of DEP and SEP, the magnitude of effect is considered to be negligible.

Impact Significance

289. Based on the worst case scenario of high sensitivity of habitats and biotopes and a negligible magnitude of effect, the impact or INNS has been assessed as **minor adverse** significance.

10.6.3.7.2 Cromer Shoal Chalk Beds MCZ

290. The sensitivity of biotopes identified in the DEP and SEP offshore benthic survey area is summarised in **Table 10-19**. Of the biotopes recorded in the offshore export cable corridor inside the Cromer Shoal Chalk Beds MCZ, sensitivity to INNS ranges for 'not sensitive' or 'not relevant'. However, due to the lack of information about sensitivity to INNS, a precautionary approach has been taken and a sensitivity of low has been assigned.

291. It is not expected INNS will be introduced if the biosecurity measures are adhered to, and given that if INNS were to be introduced it is not expected they would become established, the magnitude of effect is considered to be negligible. However, given the potential sensitivity of benthic receptors to INNS impacts, a **minor adverse significance** is anticipated.

10.6.4 Potential Impacts during Decommissioning

292. The scope of the decommissioning works would most likely involve removal of the accessible installed components. This is outlined in **Chapter 5 Project Description** and the detail would be agreed with the relevant authorities at the time of decommissioning. Offshore, this is likely to include removal of all the wind turbine components, part of the foundations (those above seabed level), removal of some or all of the infield cables, interlink cables, and export cables. Scour and cable protection would likely be left *in situ,* other than in the MCZ where cable protection will be removed.

293. During the decommissioning phase, there is potential for wind turbine foundation and cable removal activities to cause effects that would be comparable to those identified for the construction phase (construction phase impacts 1, 2, 3, 4, and 5) and the operational phase (operational phase impacts 1, 4, and 6). These impacts are:

- Temporary habitat loss / physical disturbance
- Temporary increases in SSC and deposition
- Re-mobilisation of contaminated sediments
- Underwater noise and vibration
- Invasive Non Native Species

294. Permanent habitat loss as a result of infrastructure decommissioned *in situ* is assessed and as operational impact (**Section 10.6.3.2**) because the impact begins from the beginning of the operation phase when wind farm infrastructure in in place. The same is true for colonisation of foundations and cable protection (**Section 10.6.3.5)**.

295. The magnitude of decommissioning effects will be comparable to or less than those identified for the construction and operational phases. Accordingly, given the construction and operational phase assessments concluded no significant impacts (i.e. **minor adverse** impact or lower) for benthic ecology receptors, it is anticipated that the same would be valid for the decommissioning phase regardless of the final decommissioning methodologies. The magnitude of effects will be the same for DEP or SEP in isolation and for DEP and SEP together.

296. The significance of impacts on other related receptors is addressed within relevant chapters of this PEIR (**Chapter 8 Marine Geology, Oceanography and Physical Processes**, **Chapter 9 Marine Water and Sediment Quality**, **Chapter 11 Fish and Shellfish Ecology**, **Chapter 12 Marine Mammal Ecology** and **Chapter 13 Offshore Ornithology**).

10.7 Cumulative Impacts

10.7.1 Identification of Potential Cumulative Impacts

297. The first step in the cumulative assessment is the identification of which residual impacts have the potential for a cumulative impact with other plans, projects and activities (described as ‘impact screening’). This information is set out in **Table 10-21** below, together with a consideration of the confidence in the data that is available to inform a detailed assessment and the associated rationale. Only potential impacts assessed in **Section 10.6** as negligible or above are included in the CIA (i.e. those assessed as ‘no impact’ are not taken forward as there is no potential for them to contribute to a cumulative impact).

Table 10-21: Potential Cumulative Impacts (impact screening)

Impact	Potential for Cumulative Impact	Data Confidence	Rationale
Construction			
Impact 1: Temporary habitat loss / physical disturbance	No	High	Impacts occur at discrete locations for a time-limited duration and are local in nature with a negligible impact magnitude. This applies to DEP or SEP in isolation, and DEP and SEP together.

Impact	Potential for Cumulative Impact	Data Confidence	Rationale
Impact 2: Temporary increases in SSC and deposition	No	High	Increases in SSC are expected to be localised at the point of discharge and short-term. The small quantities of fine-sediment present may be transported up to approximately 1km, however it will be widely and rapidly dispersed. In most cases the elevation of SSC is expected to be lower than concentrations that would develop in the water column during storm conditions.
Impact 4: Underwater noise and vibration	No	High	The sensitivity of benthic ecology receptors to underwater noise and vibration is considered to be negligible and underwater noise effects will be localised, with the highest magnitude noise sources being short term and intermittent.
Impact 5: INNS	No	High	Biosecurity measures will be used to prevent the introduction of INNS. The risk of introduction to the southern North Sea is not considered to be significantly increased as a result of DEP and SEP.
Operation			
Impact 1: Temporary habitat loss / physical disturbance	No	High	Impacts occur at discrete locations for a time-limited duration and are local in nature with a low impact magnitude. This applies to DEP or SEP in isolation, and DEP and SEP together.
Impact 2: Permanent habitat loss	Yes	High	Additive habitat loss across the region. Other developments in the region have the potential to have cumulative habitat loss impacts.

Impact	Potential for Cumulative Impact	Data Confidence	Rationale
Impact 3: Long term habitat loss	Yes	High	Additive temporary but long term habitat loss across the region, including on the protected features of designated sites e.g. Cromer Shoal Chalk Beds MCZ. Although habitat loss in the MCZ will not be permanent, there will be a cumulative impact over the operational phase of DEP and SEP.
Impact 4: Temporary increases in SSC and deposition	No	High	Impacts occur at discrete locations for a time-limited duration and are local in nature with a negligible impact magnitude. This applies to DEP or SEP in isolation, and DEP and SEP together.
Impact 5: Colonisation of foundations and cable protection	No	High	The effects of recolonisation would be highly localised on the introduced structures and therefore there is no potential cumulative impact. Embedded mitigation is proposed for DEP and SEP to avoid the spread of INNS and it is expected that other projects would follow best practice.
Impact 6: Underwater noise and vibration	No	High	The sensitivity of benthic ecology receptors to underwater noise and vibration is considered to be negligible and underwater noise effects will be localised and of negligible magnitude.
Impact 7: INNS	No	High	Biosecurity measures will be used to prevent the introduction of INNS. The risk of introduction to the southern North Sea is not considered to be significantly increased as a result of DEP and SEP.
Decommissioning			
Impact 1: Temporary habitat loss / physical disturbance	No	High	

Impact	Potential for Cumulative Impact	Data Confidence	Rationale
Impact 2: Temporary increases in SSC and deposition	No	High	Impacts occur at discrete locations for a time-limited duration and are local in nature with a negligible impact magnitude. This applies to DEP or SEP in isolation, and DEP and SEP together.
Impact 4: Underwater noise and vibration	No	High	The sensitivity of benthic ecology receptors to underwater noise and vibration is considered to be negligible and underwater noise effects will be localised, with the highest magnitude noise sources being short term and intermittent.
Impact 5: INNS	No	High	Biosecurity measures will be used to prevent the introduction of INNS. The risk of introduction to the southern North Sea is not considered to be significantly increased as a result of DEP and SEP.

10.7.2 Other Plans, Projects and Activities

298. The second step in the cumulative assessment is the identification of the other plans, projects and activities that may result in cumulative impacts for inclusion in the CIA (described as 'project screening'). This information is set out in **Table 10-22** below, together with a consideration of the relevant details of each, including current status (e.g. under construction), planned construction period, closest distance to DEP & SEP, status of available data and rationale for including or excluding from the assessment.

299. The project screening has been informed by the development of a CIA Project List which forms an exhaustive list of plans, projects and activities in a very large study area relevant to DEP and SEP. The list has been appraised, based on the confidence in being able to undertake an assessment from the information and data available, enabling individual plans, projects and activities to be screened in or out.

300. The only impact to be screened into the CIA is permanent/long term habitat loss which is a direct impact limited to the spatial footprint of the DEP and SEP infrastructure. Other projects with potential to have cumulative habitat loss impacts within the boundary of the CSCB MCZ have been included.

Table 10-22: Planned projects within 5km of DEP or SEP

Project	Status	Construction Period	Closest Distance from the Project (km)	Distance from the cable corridor (km)	Confidence in Data	Included in the CIA (Y/N)	Rationale
Dudgeon OWF	Operational	N/A	0.0 (DEP North and South)	0.0	High	N	Dudgeon OWF and Sheringham Shoal OWF are operational. Impacts from operation and maintenance activities are considered to be non-significant for both projects, as shown in the environmental assessments accompanying the marine licence applications for operational and maintenance (O&M) activities: • Sheringham O&M generation (MLA/2020/00095) • Sheringham O&M Transmission (MLA/2020/00096) • Dudgeon O&M generation (MLA/2018/00511
Sheringham Shoal OWF	Operational	N/A	0.0 (SEP wind farm site)	0.0	High	N	

Project	Status	Construction Period	Closest Distance from the Project (km)	Distance from the cable corridor (km)	Confidence in Data	Included in the CIA (Y/N)	Rationale
							• Dudgeon O&M Transmission (MLA/2019/00049) Indirect impacts to DEP and SEP are considered to be small scale and localised, meaning there is no pathway for interaction with DOW and SOW.
EIFCA Byelaw 12 Inshore trawling restriction and Byelaw 15 Towed gear restriction for bivalve molluscs	Active	N/A	0.0 (Export cable corridor)	0.0	High	N	The restrictions on the use of bottom towed gear have the potential to be beneficial to benthic ecology receptors with potential to be impacted by DEP and SEP. Therefore, there is no potential for cumulative adverse impacts.

Project	Status	Construction Period	Closest Distance from the Project (km)	Distance from the cable corridor (km)	Confidence in Data	Included in the CIA (Y/N)	Rationale
EIFCA Restricted area 35 (closed to bottom towed gear)	Active	N/A	0.0 (Export cable corridor)	0.0	High	N	
Weybourne Beck outfall to Walcott coastal frontage - Maintenance works	Active	Unknown (open licence until 3rd July 2028)	0.0 (Export cable corridor)	0.0	High	N	Maintenance works and project impacts will not interact because the nearest marine components of the projects are the HDD exit pits located approximately 1km offshore.
Hornsea Project Three OWF	Consented	2023 (earliest construction start 2021 with offshore export cable construction in year 3)	0.0 (Export cable corridor)	0.0	High	Y	The potential for cumulative impacts are in relation to the Hornsea Project Three offshore export cables only, as the OWF area is 80km away at its closest point.

Project	Status	Construction Period	Closest Distance from the Project (km)	Distance from the cable corridor (km)	Confidence in Data	Included in the CIA (Y/N)	Rationale
Blythe Hub Development	Under construction	2021 - ?	0.5 (Elgood well to DEP wind farm site)	3.6	High	N	First gas is expected in Q3 2021 therefore the project will be operational before DEP and SEP construction begins in 2024 at the earliest. Given all impacts were considered not significant (except for permanent habitat loss in the MCA/SPA) and are local in nature it is considered there is no impact pathway for interaction between the two projects.
Sheringham lifeboat station - maintenance works	Active	Unknown (open licence until 31st May 2027)	2.1	2.1	High	N	Maintenance works and project impacts will not interact because the nearest marine components of the projects are the HDD exit pits located approximately 1km offshore.

10.7.3 Assessment of Cumulative Impacts

10.7.3.1 Cumulative Impact 1: Permanent habitat loss

301. As discussed in **Section 10.6.3.2**, the sensitivity of benthic habitats and biotopes to habitat loss is considered to be medium. The Hornsea Project Three OWF will result in a permanent loss of approximately 3.6km^2 of habitat (RPS, 2018). DEP and SEP together will result in a permanent loss of 0.87km^2 of seabed habitat. Although the cumulative area of permanent habitat loss is considerably larger than for DEP and SEP in isolation or together, given the small scale of habitat loss in the context of the extent of impacted habitats in the wider southern North Sea the magnitude of the cumulative effect remains low. Therefore the impact of cumulative habitat loss is assessed as minor adverse significance.

10.7.3.2 Cumulative Impact 2: Long term habitat loss

302. As discussed in **Section 10.6.3.3** the sensitivity of benthic habitats and biotopes to habitat loss is considered to be medium. The Hornsea Project Three offshore export cables will, like the DEP and SEP offshore export cables, route through the Cromer Shoal and Chalk Beds MCZ. Construction of Hornsea Project Three will result in up to 2,940m^2 of cable protection in the Cromer Shoal Chalk Beds MCZ within an area identified as part of the designated Subtidal Sand broadscale feature. This equates to approximately 0.016% of the extent of this MCZ feature and 0.0009% of the total MCZ area (RPS, 2020). The developer, Orsted, has committed to remove this cable protection at the decommissioning stage at the end of the operational life of the project (approximately 35 years). Similarly, and as discussed in **Section 10.6.3.3**, the Applicant has committed to remove DEP and SEP cable protection in the Cromer Shoal and Chalk Beds MCZ, totalling up to 1,800m^2. The locations of cable protection are not known at this time so the MCZ designated habitat features and the percentage of their estimated extent that will be lost is not known. However, as a worst case up to 0.0006% of the total MCZ area could be impacted by long term habitat loss as a result of DEP and SEP.

303. Together, cumulative long term habitat loss from Hornsea Project Three and DEP and SEP together represents less than 0.0015% of the MCZ. Although the cumulative area of long term habitat loss is considerably larger than for DEP and SEP in isolation or together, given the small scale of habitat loss in the context of the extent of impacted habitats in the Cromer Shoal Chalk Beds MCZ and the wider southern North Sea the magnitude of the cumulative effect remains low.

304. Therefore, the impact of cumulative habitat loss is assessed as **minor adverse** significance. An assessment of potential impacts on the Cromer Shoal Chalk Beds MCZ with an assessment of implications for achieving the site's conservation objectives is included in the DEP and SEP **draft Information for Marine Conservation Zone Assessment Report**.

10.8 Transboundary Impacts

305. Transboundary impacts for benthic ecology have been scoped out of the assessment in line with the recommendation of the Planning Inspectorate in the Scoping Opinion (Planning Inspectorate, 2019) (**Table 10-1**, **Section 10.2**).

306. This is because potential impacts on benthic ecology are localised in nature, being restricted to the project boundaries and immediate surrounding area (see **Section 10.6**). DEP and SEP are a minimum of 187km from any international territory boundary.

10.9 Inter-relationships

307. **Table 10-23** describes the inter-relationships between impacts discussed in this chapter and those discussed in other chapters. All of the identified inter-relationships have been considered in the relevant chapters, as indicated below.

Table 10-23: Benthic ecology inter-relationships

Topic and description	Related chapter	Where addressed in this chapter	Rationale
Construction			
Fish and Shellfish – edible crabs, prey resources, nursery and spawning ground	**Chapter 11 Fish and Shellfish Ecology**	This chapter informs **Chapter 11**	The benthic environment represents a habitat for many fish and shellfish species. Additionally, a number of benthic species are prey for fish and shellfish. Therefore, impacts on benthic ecology can lead to in-direct impacts on fish and shellfish.
Suspended sediments and deposition	**Chapter 8 Marine Geology, Oceanography and Physical Processes**	Impacts as a result of suspended sediments and deposition are assessed in **Section 10.6.2.2**	Changes in suspended sediment concentrations due to DEP and SEP are assessed in **Chapter 8 Marine Geology, Oceanography and Physical Processes.** Changes in suspended sediment concentrations and associated sediment deposition could have potential impacts on benthic habitats and species.

Topic and description	Related chapter	Where addressed in this chapter	Rationale
Re-mobilisation of contaminated sediments	**Chapter 9 Marine Water and Sediment Quality**	Re-mobilisation of contaminated sediments during construction is assessed in **Section 10.6.2.3**	**Chapter 9 Marine Water and Sediment Quality** provides an assessment of the potential for contaminants to be present in the study area. Re-mobilisation of contaminated sediments and associated deposition could have potential impacts on benthic habitats and species
Operation			
Fish and Shellfish – edible crabs, prey resources, nursery and spawning ground	**Chapter 11 Fish and Shellfish Ecology**	This chapter informs **Chapter 11**	The benthic environment represents a habitat for many fish and shellfish species. Additionally, a number of benthic species are prey for fish and shellfish. Therefore, impacts on benthic ecology can lead to in-direct impacts on fish and shellfish.
Suspended sediments and deposition	**Chapter 8 Marine Geology, Oceanography and Physical Processes**	Impacts as a result of suspended sediments and deposition are assessed in **Section 10.6.3.3**	Changes in suspended sediment concentrations due to DEP and SEP are assessed in **Chapter 8 Marine Geology, Oceanography and Physical Processes**. Changes in suspended sediment concentrations and associated sediment deposition could have potential impacts on benthic habitats and species.
Decommissioning			

Topic and description	Related chapter	Where addressed in this chapter	Rationale
Fish and Shellfish – edible crabs, prey resources, nursery and spawning ground	**Chapter 11 Fish and Shellfish Ecology**	This chapter informs **Chapter 11**	The benthic environment represents a habitat for many fish and shellfish species. Additionally, a number of benthic species are prey for fish and shellfish. Therefore, impacts on benthic ecology can lead to in-direct impacts on fish and shellfish.
Suspended sediments and deposition	**Chapter 8 Marine Geology, Oceanography and Physical Processes**	Impacts as a result of suspended sediments and deposition are assessed in **Section 10.6.2.2**	Changes in suspended sediment concentrations due to DEP and SEP assessed in **Chapter 8 Marine Geology, Oceanography and Physical Processes**. Changes in suspended sediment concentrations and associated sediment deposition could have potential impacts on benthic habitats and species.

10.10 Interactions

308. The impacts identified and assessed in this chapter have the potential to interact with each other. The areas of potential interaction between impacts are presented in **Table 10-24**. This provides a screening tool for the identification of which impacts have the potential to interact, accounting for the assessment outcomes presented in **Section 10.6**. **Table 10-25** then provides an assessment for each receptor (or receptor group) as related to these impact/s.

309. The impacts are first assessed relative to each development phase (‘phase assessment’, i.e. construction, operation or decommissioning) to see if (for example) multiple construction impacts affecting the same receptor could increase the level of impact upon that receptor. Following this, a ‘lifetime assessment’ is undertaken which considers the potential for impacts to affect receptors across all development phases.

310. None of the potential interactions identified with respect to benthic ecology are expected to result in a synergistic or greater impact than those assessed in **Section 10.6**.

Table 10-24 Interactions between impacts

<table>
<tr><th colspan="8">Potential Interaction between Impacts</th></tr>
<tr><th colspan="8">Construction</th></tr>
<tr><td></td><td>Impact 1: Temporary habitat loss / physical disturbance</td><td colspan="2">Impact 2: Temporary increases in SSC and deposition</td><td>Impact 3: Re-mobilisation of contaminated sediments</td><td>Impact 4: Underwater noise and vibration</td><td colspan="2">Impact 5: INNS</td></tr>
<tr><td>Impact 1: Temporary habitat loss / physical disturbance</td><td>-</td><td colspan="2">Yes</td><td>No</td><td>No</td><td colspan="2">No</td></tr>
<tr><td>Impact 2: Temporary increases in SSC and deposition</td><td>Yes</td><td colspan="2">-</td><td>No</td><td>No</td><td colspan="2">No</td></tr>
<tr><td>Impact 3: Re-mobilisation of contaminated sediments</td><td>No</td><td colspan="2">No</td><td>-</td><td>No</td><td colspan="2">No</td></tr>
<tr><td>Impact 4: Underwater noise and vibration</td><td>No</td><td colspan="2">No</td><td>No</td><td>-</td><td colspan="2">No</td></tr>
<tr><td>Impact 5: Invasive non-native species</td><td>No</td><td colspan="2">No</td><td>No</td><td>No</td><td colspan="2">-</td></tr>
<tr><th colspan="8">Operation</th></tr>
<tr><td></td><td>Impact 1: Temporary habitat loss / physical disturbance</td><td>Impact 2: Permanent habitat loss</td><td>Impact 3: Long term habitat loss</td><td>Impact 4: Temporary increases in SSC and deposition</td><td>Impact 5: Colonisation of foundations and cable protection</td><td>Impact 6: Underwater noise and vibration</td><td>Impact 7: INNS</td></tr>
</table>

Potential Interaction between Impacts							
Impact 1: Temporary habitat loss / physical disturbance	-	Yes	Yes	No	Yes	No	Yes
Impact 2: Permanent habitat loss	Yes	-	Yes	No	Yes	No	Yes
Impact 3: Long term habitat loss	Yes	Yes	-	No	No	No	Yes
Impact 4: Temporary increases in SSC and deposition	No	No	No	-	No	No	No
Impact 5: Colonisation of foundations and cable protection	Yes	Yes	No	No	-	No	Yes
Impact 6: Underwater noise and vibration	No	No	No	No	No	-	No
Impact 7: INNS	Yes	Yes	Yes	No	Yes	No	-
Decommissioning							
The magnitude of decommissioning effects will be comparable to or less than those identified for the construction and operational phases.							

Table 10-25 Interaction between impacts – phase and lifetime assessment

Receptor	Highest significance level				
	Construction	Operation	Decommissioning	Phase assessment	Lifetime assessment
Benthic habitats and biotopes	Minor adverse	Minor adverse	Minor adverse	**No greater than individually assessed impacts:** • Permanent and long term habitat loss during operation increase the potential for interactions with other impacts assessed for that phase. • However, all potential impacts are non-significant (minor adverse or less) and localised in nature, being restricted to the project boundaries and immediate surrounding area. The majority of impacts are also temporary in nature. Together, these factors limit the potential for different impacts to interact within each phase. • As a result, none of the potential interactions identified with respect to benthic ecology are expected to result in a synergistic or greater impact than those already assessed.	**No greater than individually assessed impacts:** • As with the phase assessment, all potential impacts are non-significant and localised in nature, limiting the potential for different impacts to interact across the different phases. • Impacts from construction and decommissioning are temporary in nature, limiting their potential to result in a synergistic or greater impact with those considered in other phases.

10.11 Potential Monitoring Requirements

311. As described in this chapter, a large amount of geophysical and benthic ecology monitoring information is available from the existing Dudgeon and Sheringham Shoal OWFs, much of which will be highly relevant to DEP and SEP given their close proximity and the similarity of the developments. The Applicant intends to focus any further monitoring requirements on addressing any remaining areas of uncertainty and on those features of greatest sensitivity e.g. the MCZ.

312. Monitoring requirements will be discussed with stakeholders in the preparation of the final Environmental Statement (ES) and described in the in-principle monitoring plan (IPMP), which will be submitted alongside the DCO application. They will then be further developed and agreed prior to construction based on the IPMP and taking account of the final detailed design of DEP and SEP.

10.12 Assessment Summary

313. This chapter has provided a characterisation of the existing environment for benthic ecology based on both existing data and extensive site specific surveys.

314. Seabed sediments across the project areas (DEP, SEP and the cable corridors) are dominated by sands and gravels, with the corresponding benthic communities recorded considered to be typical of sandy and gravelly sediments within the southern North Sea. Benthic habitat maps produced using the site specific geophysical and benthic sample data show a range of EUNIS Level 3 sublittoral habitats and their associated biotopes including coarse sediment, sand, mixed sediment and biogenic reefs. No Annex I reef (biogenic or geogenic) was identified by the surveys, with the possible exception of the nearshore area of outcropping chalk, however this area has been completely avoided through the commitment to long HDD from the landfall.

315. The assessment has established that there will be some minor adverse residual impacts during the construction, operation and decommissioning phases of DEP and SEP. Impacts are generally localised in nature, being restricted to the project boundaries and immediate surrounding area.

316. A summary of the impact assessment for benthic ecology is provided in **Table 10-26**.

Table 10-26: Summary of potential impacts benthic ecology

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation impact	Mitigation measures proposed	Residual impact
Construction						
Impact 1: Temporary habitat loss / physical disturbance	Benthic habitats and species within the benthic ecology study area.	High	Negligible	**Minor adverse impact**	N/A	**Minor adverse impact**
Impact 2: Temporary increases in SSC and deposition	Benthic habitats and species within the benthic ecology study area.	Medium	Negligible	**Minor adverse impact**	N/A	**Minor adverse impact**
Impact 3: Re-mobilisation of contaminated sediments	Benthic habitats and species within the benthic ecology study area.	N/A	N/A	**No impact**	N/A	**No impact**
Impact 4: Underwater noise and vibration	Benthic habitats and species within the benthic ecology study area.	Negligible	Negligible	**Negligible adverse impact**	N/A	**Negligible adverse impact**

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation impact	Mitigation measures proposed	Residual impact
Impact 5: INNS	Benthic habitats and species within the benthic ecology study area.	High	Negligible	**Minor adverse impact**	Employment of biosecurity measures in accordance with relevant regulations and guidance such as MARPOL and BMW convention	**Minor adverse impact**
Operation						
Impact 1: Temporary habitat loss / physical disturbance	Benthic habitats and species within the benthic ecology study area.	High	Negligible	**Minor adverse impact**	N/A	**Minor adverse impact**
Impact 2: Permanent habitat loss	Benthic habitats and species within the benthic ecology study area.	Medium	Low	**Minor adverse impact**	N/A	**Minor adverse impact**
Impact 3: Long term habitat loss	Benthic habitats and species within the benthic ecology study area.	Medium	Low	**Minor adverse impact**	N/A	**Minor adverse impact**

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation impact	Mitigation measures proposed	Residual impact
Impact 4: Temporary increases in SSC and deposition	Benthic habitats and species within the benthic ecology study area.	Low	Negligible	**Negligible**	N/A	**Negligible**
Impact 5: Colonisation of foundations and cable protection	Benthic habitats and species within the benthic ecology study area.	Medium	Low	**Minor adverse impact**	N/A	**Minor adverse impact**
Impact 6: Underwater noise and vibration	Benthic habitats and species within the benthic ecology study area.	Negligible	Negligible	**Negligible adverse impact**	N/A	**Minor adverse impact**
Impact 7: INNS	Benthic habitats and species within the benthic ecology study area.	High	Negligible	**Minor adverse impact**	Employment of biosecurity measures in accordance with relevant regulations and guidance such as MARPOL and BMW convention	**Minor adverse impact**
Decommissioning						

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation impact	Mitigation measures proposed	Residual impact
Impact 1: Temporary habitat loss / physical disturbance	Benthic habitats and species within the benthic ecology study area.	High	Negligible	**Minor adverse impact**	N/A	**Minor adverse impact**
Impact 2: Permanent habitat loss	Benthic habitats and species within the benthic ecology study area.	Medium	Low	**Minor adverse impact**	N/A	**Minor adverse impact**
Impact 3: Temporary increases in SSC and deposition	Benthic habitats and species within the benthic ecology study area.	Medium	Negligible	**Negligible**	N/A	**Negligible**
Impact 4: Colonisation of foundations and cable protection	Benthic habitats and species within the benthic ecology study area.	Medium	Low	**Minor adverse impact**	N/A	**Minor adverse impact**
Impact 5: Underwater noise and vibration	Benthic habitats and species within the benthic ecology study area.	Negligible	Negligible	**Negligible adverse impact**	N/A	**Minor adverse impact**

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation impact	Mitigation measures proposed	Residual impact
Impact 6: INNS	Benthic habitats and species within the benthic ecology study area.	High	Negligible	**Minor adverse impact**	Employment of biosecurity measures in accordance with relevant regulations and guidance such as MARPOL and BMW convention	**Minor adverse impact**

10.13 References

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