# Scotland England Green Link 1 / Eastern Link 1 - Marine Scheme

Environmental Appraisal Report
Volume 2

## Chapter 8 - Benthic Ecology

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# Executive Summary

This chapter of the Environmental Appraisal Report (EAR) contains an appraisal of the potential interaction of the Marine Scheme and benthic ecology, focusing on the marine area between Mean High Water Springs (MHWS) at the Scottish landfall area at Thorntonloch Beach in East Lothian, and MHWS at the English landfall area at Seaham, County Durham. Based on the routeing and siting work for the Marine Scheme, approximately 99 % of the marine installation corridor comprised sediment-based habitat types.

The appraisal follows the methodology as set out within Chapter 4: Approach to Environmental Appraisal, with the identification and appraisal of effects and mitigation following the Chartered Institute of Ecology and Environmental Management (CIEEM) Guidelines for Ecological Impact Assessment in Britain and Ireland – Terrestrial, Freshwater, Coastal and Marine (CIEEM, 2018, and updated September 2019) and based on expert judgments.

The benthic ecology baseline is presented in Section 8.5 of this EAR Chapter. This identifies relevant designated sites and features which may be impacted by the Marine Scheme. Determination of the baseline has been informed by a project specific benthic characterisation survey (Fugro, 2021) and extensive studies identified in this chapter reporting the benthic ecology receptors in the western North Sea.

The potential effects of the Marine Scheme on benthic ecology have been appraised in Section 8.6. Where appropriate, proportionate measures to avoid or mitigate for any identified adverse effects are identified. This appraisal concludes that, potential impacts during the installation, operation (including maintenance and repair) and decommissioning of the Marine Scheme on benthic ecology receptors are **not significant**.

The potential for interaction between the Project and other plans/projects to result in significant cumulative effects, is considered in Chapter 16: Cumulative and In-Combination Effects. No interaction is anticipated between the Marine Scheme, and the Scottish and English Onshore Schemes because there are no associated project activities in the marine environment due to the use of Horizontal Directional Drill (HDD) at the landfalls.

# 8 Benthic Ecology

## 8.1 Introduction

This chapter of the Environmental Appraisal Report (EAR) presents an appraisal of the potential interaction of the Marine Scheme with intertidal and subtidal benthic ecology.

The Marine Scheme comprises the marine component of the Scotland England Green Link 1 (SEGL1) / Eastern Link 1 (EL1) and extends from the Mean High-Water Springs (MHWS) at the Scottish landfall at Thorntonloch beach, East Lothian, to the MHWS at the English landfall near Seaham. The Marine Scheme is located within both Scottish and English territorial waters, up to 12 nautical miles (NM) from the coast. The Marine Scheme comprises an installation corridor of approximately 176 km in length and of 500 m maximum width, within which cables will be installed (hereinafter referred to as the 'marine installation corridor'). The marine installation corridor extends from kilometre point (KP) 0, at its landfall in Scotland, to KP 176, at its landfall in England (see Figure 8-1). The Marine Scheme activities cover the following phases: installation, operation (including maintenance and repair) and decommissioning.

A description of the benthic ecology receptor baseline is presented in Section 0 of this EAR chapter. Potential impacts of the Marine Scheme on these receptors are appraised in Section 8.6 for the installation, operation (including maintenance and repair) and decommissioning phases of the Marine Scheme. Where appropriate, proportionate measures to avoid or mitigate for any identified adverse effects are proposed in Section 8.7.

The potential for interaction between the Marine Scheme and other plans and / or projects, which may result in significant cumulative effects on benthic ecology, is considered in detail within Chapter 16: Cumulative and In-Combination Effects.

Impacts to benthic ecology may also be interrelated with impacts on fish and shellfish (Chapter 9) and ornithology (Chapter 11) as a result of predator-prey relationships between these groups.

This chapter is supported by the following documents in Volume 3:

- Appendix 8.1: Marine Protected Area (MPA) and Marine Conservation Zone (MCZ) Assessment; and
- Appendix 8.2: Habitat Regulations Assessment (HRA) Report.

## 8.2 Legislation, Policy and Guidance

This section outlines legislation, policy, and guidance relevant to the appraisal of the potential effects on benthic ecology associated with the installation, operation (including maintenance and repair) and decommissioning of the Marine Scheme. For further information regarding the legislative and policy context refer to Chapter 3: Legislative and Policy Framework.

A number of policies and regulations aim to assure that benthic ecology is taken into account during planning and execution of projects within UK waters. For the Marine Scheme these include the UK Marine Policy Statement (MPS) and the UK Marine Plans, specifically the Scottish National Marine Plan (Scottish Government, 2015), and the North East Inshore and North East Offshore Marine Plan[1] (HM Government, 2021), have a number of relevant policies specific to benthic ecology which are presented in EAR Volume 3 Appendix 3.1: Marine Plan Compliance Checklist.

A number of policies and laws require decision makers to consider the environmental impacts of a project. Legislation and policy relevant to the appraisal of Marine Scheme's effects on benthic ecology is presented in EAR Volume 3 Appendix 3.2: Topic Specific Legislation.

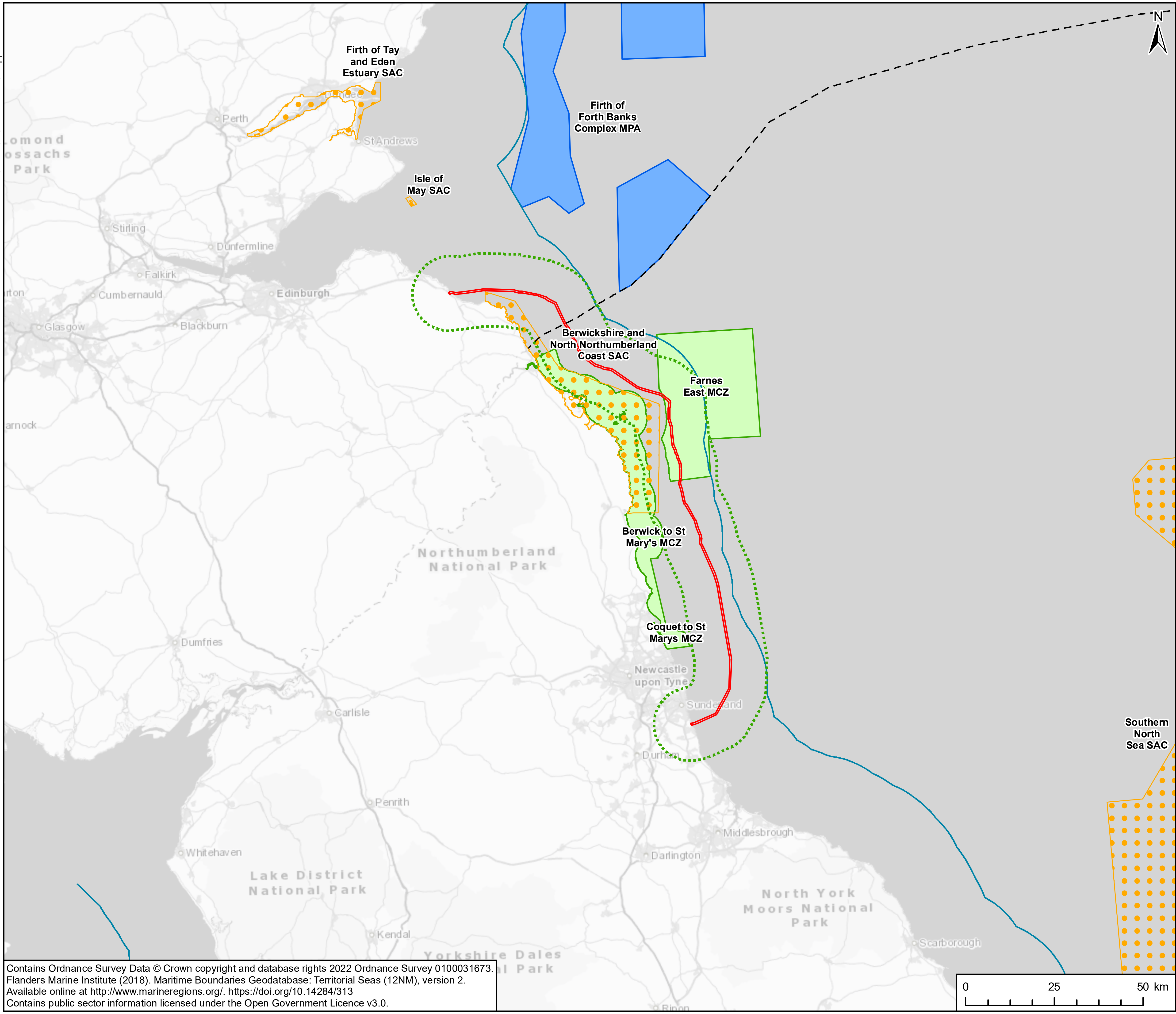
[1] The Project Marine Scheme falls entirely within the UK territorial waters (i.e. 12 NM), therefore within the Inshore portion of the North East marine area. The marine plan for the North East area has combined both inshore and offshore portions.

## 8.3 Study Area

The benthic ecology appraisal covers a 10 km corridor centered on the marine installation corridor (Figure 8-1). This study area has been selected to encompasses all likely zones of influence (ZOI) for benthic habitats and species as identified in Section 8.6.

The Marine Scheme installation will use Horizontal Directional Drilling (HDD) at both landfalls (Figure 8-2), avoiding work in the intertidal area. The breakouts, where the cable will be pulled for subsequent subsea installation, will be entirely in the subtidal environment, in a water depth between 4 and 10 m. There will, therefore, be no activities undertaken in the intertidal environment, and hence no impact pathways to affect intertidal benthic ecology.

A benthic survey (Fugro, 2021) was undertaken to characterise benthic ecological conditions and map the distribution and extent of marine benthic habitats across and along the 500 m wide marine installation corridor.






Coordinate System: WGS1984 Zone 30N

Scale @ A3 1:1,000,000



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PROJECT

**Scotland England Green Link 1 / Eastern Link 1**

KEY

- Marine Installation Corridor
- 10km Study Area
- UK Territorial Sea Limit
- Scottish Adjacent Waters Boundary
- Special Area of Conservation (SAC)
- Nature Conservation Marine Protected Area (MPA)
- Marine Conservation Zone (MCZ)


TITLE

**Figure 8-1**
**Study Area**

REFERENCE

SEGL1_M_EAR_8-1_v1_20220426

SHEET NUMBER 1 of 1

DATE 26/04/2022

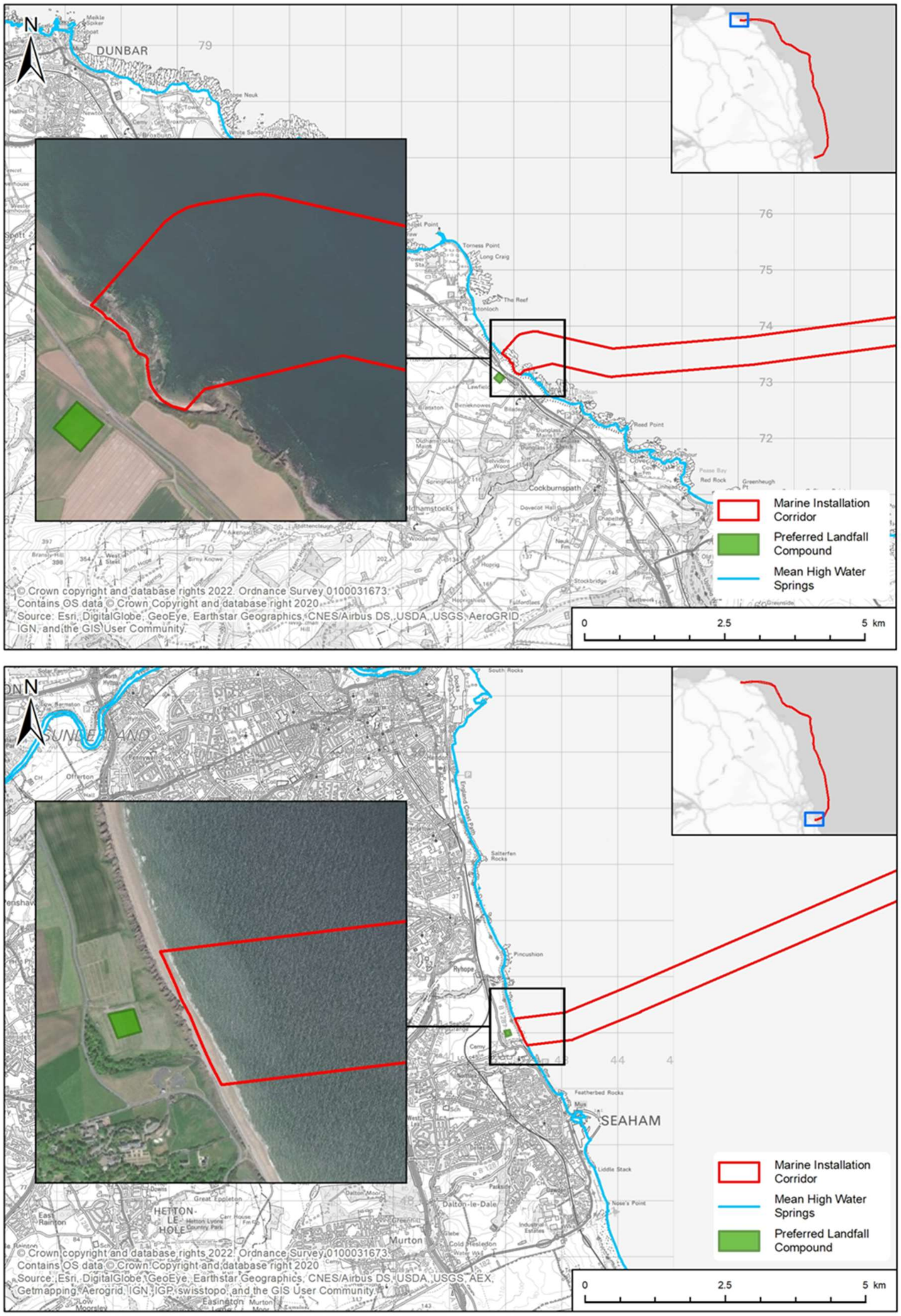



**Figure 8-2: Marine landfall sites. Top: Scotland, Bottom: England.**

# 8.4 Approach to Appraisal and Data Sources

## 8.4.1 Appraisal Methodology

This appraisal applies the methodology as detailed in Chapter 4: Approach to Environmental Appraisal. The identification and appraisal of effects and mitigation are based on a combination of professional judgment and the application of the following guidelines:

- Chartered Institute of Ecology and Environmental Management (CIEEM) Guidelines for Ecological Impact Assessment in Britain and Ireland – Terrestrial, Freshwater, Coastal and Marine (CIEEM, 2018).

In the absence of Environmental Quality Standards for *in situ* sediments in the UK, the following guidance has been used to help inform a 'Weight of Evidence' (WoE) approach to appraise whether benthic ecology is at risk from concentrations of toxic contaminants:

- Centre for Environment, Fisheries and Aquaculture Science (Cefas) Chemical Action Levels (Marine Management Organisation, 2014) (Reviewed 2020) These values are used in conjunction with a range of other assessment methods to make management decisions regarding the fate of dredged material. The action levels are not 'pass/fail' criteria but triggers for further assessment. In general, contaminant levels in dredged material below action level 1 are of no concern and are unlikely to influence the licensing decision. However, dredged material with contaminant levels above action level 2 is generally considered unsuitable for sea disposal. Dredged material with contaminant levels between action levels 1 and 2 requires further consideration and testing before a decision can be made. Action Levels are therefore, used as a guide in assessments of sediment contamination in non-dredging activities;
- UK Offshore Operators Association (UKOOA) sediment quality guidelines for the UK North Sea (UKOOA, 2001);
- Data from 'Clean Seas Environmental Monitoring Programme at TyneTees (CSEMP, 2019) and a station at the Firth of Forth (Marine Scotland, 2020);
- OSPAR background concentrations and background assessment concentrations and effect range low (ERL) and effect range median (ERM) concentrations for contaminants (OSPAR, 2009); and
- Canadian sediment quality guidelines (Canadian Council of Ministers of the Environment, 2001) applied to contaminants where no other regional threshold value is available. Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. The Canadian Sediment quality guidelines were developed by the Canadian Council of Ministers of the Environment as broadly protective tools to support the functioning of healthy aquatic ecosystems.

In March 2021 a non-statutory scoping report was submitted to and consulted on by Marine Scotland Licensing Operations Team (MS-LOT) and the Marine Management Organisation (MMO)[2]. The scoping report identified aspects of the Marine Scheme that have the potential to impact benthic ecology (NGET & SPT, 2021). The responses to the scoping report, and details of how they are addressed in the appraisal, are provided in Section 8.4.2.2.

The design for the Marine Scheme comprises two High Voltage Direct Current (HVDC) cables laid either in two separate parallel trenches (unbundled) or else in a single trench with the cables bundled together. If the two-trench approach is used the cables will be spaced up to 30 m apart (referred to as a '30 m separated bipole'). For both approaches the target burial depth is 1.5 m and the minimum depth without cable protection will be 0.6 m. Therefore, the appraisal considers the two-trench scenario only, as the worst-case situation that will also encompass any potential effect should the cables be bundled.

[2] The non-statutory scoping report is publicly available on
https://marine.gov.scot/sites/default/files/segl_el1_marine_scoping_report_-_base_report_rev_2.0.pdf

### 8.4.2 Data Sources and Consultations

#### 8.4.2.1 Data Sources

The benthic ecology baseline has been established through a combination of desktop review of published information, project-specific survey data, and consultation with relevant organisations. The baseline provides a robust and up-to-date characterisation of the benthic environment within the study area.

***Desk study***

Desk study information was collected for the 10 km study area. Every effort has been made to obtain data concerning the existing environment and to accurately predict the likely environmental effect of the proposed development. A large amount of publicly available benthic ecology data exists for the North Sea, including information that is relevant to the Study Area. Much of this information has been produced for existing and historical offshore developments, such as offshore wind farms and subsea cable projects, which have required statutory or non-statutory Environmental Impact Assessments (EIA).

In addition, a range of other data sources have been used to inform the baseline description and appraisal including:

- The MAGIC website (https://magic.defra.gov.uk/home.htm) which provides authoritative geographic information about the natural environment from across government;
- European Marine Observation Data Network (EMODnet) (EUSeaMap 2021) Seabed Habitats Project (https://www.emodnet-seabedhabitats.eu/) for broad-scale predictive habitat maps which cover the study area;
- European Union Nature Identification System (EUNIS) (European Environment Agency, 2012) for classifying benthic habitats;
- European Environment Agency (European Environment Agency, 2019). European Nature Information Service [EUNIS] habitat type hierarchical view. (http://eunis.eea.europa.eu/habitats-code-browser.jsp);
- Joint Nature Conservation Committee Marine Protected Area (MPA) Habitat Mapper for detailed information on MPAs in the region (https://jncc.gov.uk/our-work/marine-protected-area-mapper/);
- Defining and managing Sabellaria spinulosa reefs (Gubbay, 2007) (Jenkins, et al., 2015); and
- The identification of the main characteristics of Annex I stony reef habitats under the Habitats Directive (Irving, 2009) (Golding, Albrecht, & McBreen, 2020).

***Field Surveys***

A dedicated benthic characterisation survey programme was undertaken across the 500 m marine installation corridor. A summary of the detailed information related to the benthic surveys (Fugro, 2021) is below.

Nearshore survey operations were conducted on 6 November 2021 (English landfall at Seaham) and 25 to 26 November 2021 (Scottish landfall). Offshore surveys were conducted on 22 October to 16 December 2020. Intertidal surveys were also completed between 17 to 19 November 2021, though it has now been confirmed there will not be any works taking place in the intertidal environment at either landfall location. There are no optimal survey periods as such, with surveys being undertaken in appropriate weather conditions.

Geophysical, geotechnical and environmental surveys of the subtidal regions of the marine installation corridor included an offshore section, in water depths > 15 m, and a nearshore section, in water depths of 3 m to 15 m.

Geophysical, geotechnical and benthic survey techniques were used to:

- Identify obstructions and debris on the seabed;
- Inform the route engineering;
- Determine whether any features and/or habitats of conservation importance were present; and
- Characterise seabed conditions.

The benthic environmental survey comprised drop-down video (DDV) and benthic grab sampling using a 0.1 $m^2$ dual van Veen (DVV) grab or 0.1 $m^2$ Hamon grab during the offshore operations and a 0.1 $m^2$ Day grab during the nearshore operations. A total of 46 subtidal environmental sampling stations and 31 camera transects were selected across the marine installation corridor. A modified Phase I walkover habitat mapping survey and core sampling of the intertidal habitats was also undertaken at the landfall locations, though this information is no longer referred to due to the absence of works in the intertidal area. Grab and core samples were acquired to characterise the benthic environment in terms of physico-chemical characteristics and biological communities.

The results of video and grab samples were combined to classify the habitats and associated biological communities in terms of biotopes in line with the EUNIS habitat classification. This allowed evaluation of the presence and extent of habitats, with a focus on features / habitats of conservation importance (FOCI / HOCI) including Annex I habitats and species, Priority Marine Features (PMFs), and any designated features of nearby MPAs and MCZs.

#### 8.4.2.2 Summary of Consultations

Following the submission of the non-statutory scoping report in March 2021, MS-LOT, the MMO and respective consultees and advisers had the opportunity to provide feedback on the proposal and EAR scope, which is presented in Table 8-1, and where applicable and appropriate has been considered in this chapter.

Consultation has also been undertaken with the MMO, MS-LOT, Scottish Environment Protection Agency (SEPA), Cefas, Joint Nature Conservation Committee (JNCC), Natural England, NatureScot, Environment Agency (EA), and Inshore Fisheries and Conservation Authority (IFCAs).

Further details of the project level consultation process and associated responses are presented in Chapter 6: Consultation and Stakeholder Engagement.

## Table 8-1: Scoping report consultation

| Consultee | Consultee response/ comment | How and where addressed |
|---|---|---|
| Marine Scotland Science | Impact of electromagnetic field (EMF) on the benthic environment<br>MSS advise MS-LOT that there is a need to consider potential impact of EMF on sensitive species or taxa as there is uncertainty on the effects of EMF on species in Scottish waters. Recent research demonstrates that EMF may affect species even at low levels of emissions. MSS advise that both the magnetic field and the induced electric field may still be detectable by electro-sensitive and magneto-sensitive organisms even when the cable is buried. Literature such as Hutchison et al. (2020) describes how cable burial separates the source of the EMF emissions to an animal on the seabed surface; however, it does not shield the cable from the emissions. Moreover, Formicki et al. (2019), Newton et al. (2018) and Hutchison et al. (2020) demonstrate that the magnetic field and hence the induced electric field from a buried cable is still perceivable to species residing on the seabed surface even when at levels similar to the background geomagnetic field. Therefore low levels of EMF emissions may cause effects on sensitive species.<br><br>Although there are few published studies on benthic species relevant to Scotland, MSS would like to make MS-LOT aware that there is further evidence in preparation (Scott et al. in prep.) on the impacts of EMF (0.5 to 1 mT) on stress hormones and sheltering behaviour in lobster (Homarus gammarus) adults, and negative effects in egg development of lobster (Homarus gammarus) and brown crab (Cancer pagurus). The same team has also found effects on the embryo development of whelk (0 – 40 mT) and long-finned squid (2.8 mT). Advice on modelling emissions and on potential reduction of EMF emissions in DC cables is to be published shortly in Hutchison et al. (2021).<br><br>MSS advise that the EIAR should include:<br>• A section detailing the models used to calculate EMF emissions for the various types of cables used, i.e. a buried DC export cable and free-hanging/surface-laid AC inter-array cables, together with the interaction with the local natural electromagnetic environment.<br>• A qualitative evaluation of the potential behavioural and physiological effects from EMF for the various species / taxa for which there is evidence (examples in Scott et al. 2018; Cresci et al. 2019; Hutchison et al. 2020; Gill and Desender 2020; Taormina et al. 2020) and the uncertainty for those species for which there is not yet evidence. | The potential effects of electromagnetic field (EMF) and cable protection on benthic receptors have been scoped into the appraisal. See Sections 8.6.2.2 and 8.6.3.1. |
| Marine Scotland Science | Impact of cable protection on the benthic environment<br>MSS note that the scoping report states they will scope in permanent loss of habitats from installation of the cable. MSS advise that this impact should also include impact of the cable protection on benthic communities. For example, deposition of rock dump or laying of mattresses over a surface-laid cable will result in a change from a soft / hard bottom habitat to an artificial one, which is likely to attract a different community of species. MSS advise that | The potential effect of cable protection has been appraised in Section 8.6.2.2. |

| Consultee | Consultee response/ comment | How and where addressed |
|---|---|---|
| | the EIAR should provide information on the anticipated types of cable protection and an assessment of the change in habitat types expected as a result.<br>From the perspective of benthic ecology, MSS recommend the burial of cables over the addition of cable protection, unless cable burial would cause significant damage to a sensitive habitat. Should cable protection be necessary, MSS recommend, where possible, minimising the amount that is installed in order to reduce the deposition of artificial, hard structures on the natural substrates. Consideration should be given to choice of cable protection with a view to selecting a type that matches the receiving environment and can be removed during decommissioning. | |
| Marine Scotland Science | In the summary, the scoping report states that pre-construction intertidal and subtidal benthic surveys will be completed to ensure the full range of habitats and any potentially sensitive and/ or protected species located within proximity to the Marine Scheme are identified. MSS recommend extending this to state that micro-siting around features of conservation importance may be recommended depending on what is found. It may therefore be useful for a wider area to be surveyed in order to inform micro-siting. | Wherever possible the installation will be micro-sited around rock habitats within the 500 m consented corridor during the design phase. |
| NatureScot | We broadly agree with the proposed approach for this topic, but disagree with the conclusion that EMF should be scoped out at this stage. Whether it is appropriate to include in this chapter or within Chapter 8 fish and shellfish ecology, we advise that EMF should be given consideration within the Environmental Appraisal. EMF levels from the cable should be modelled and consideration given to the fish and shellfish species that are present and may be affected by EMF. There is still uncertainty around the effects of EMP on both shellfish and fish species and we would welcome further consideration of this topic within both the environmental appraisal but also as part of any strategic monitoring. | The potential effect of EMF on the benthic environment has been appraised in Section 8.6.3.1. |
| NatureScot | Once baseline surveys have been completed we will be happy to advise further on any issues that may be seen as environmental constraints and require further consideration.<br>We are aware that currently there is no requirement for the planning of decommissioning or removal of cables. However, we advise that given the increasing shared nature of the marine space, this should be given further consideration and any requirements for cable protection measures and the cable construction should be designed to also assist with any future. | The potential effect of decommissioning has been considered in Section 8.6.4. |
| SFF | Moving to Chapter 7, the evidence quoted is for species from other parts of the world and is not relevant to this area, eminent scientists will confirm that not enough is known about sound or EMF, so both should be scoped in. | The potential effect of EMF on the benthic environment has been appraised in Section 8.6.3.1. |
| East Lothian Council | The Scoping Report notes that Protected Species will be considered and this is welcomed. The Wildlife Information Centre (http://www.wildlifeinformation.co.uk/ ) collects records locally and should be consulted for any records they hold of protected and other species in the area.<br>Any anticipated impacts arising from Invasive Non Native Species should be considered. | The presence of INNS has been considered in Section 8.5.5 and potential impacts from INNS in Section 8.6.2.6 |

| Consultee | Consultee response/ comment | How and where addressed |
|---|---|---|
| MMO | Consideration needs to be given to the possibility that hard materials required for cable protection could facilitate the spread of fouling invasive non-native species. This could be of particular concern if the cable passes through areas where hard substrates are otherwise rare or absent. This potential impact must either be scoped in or scoped out with justification.<br>The influence of the proposed works on the spread of invasive non-native species should also be considered in the Environmental Appraisal Report. | The baseline characterisation, and the potential for the introduction and spread of INNS has been considered in Sections 8.5.5 and 8.6.2.6 respectively. |
| MMO | It is appropriate that the report proposes Phase I biotope mapping and Phase II faunal sampling at the English and Scottish landfall sites. No details are provided regarding Phase II sampling. The surveys for Phase II should cover the range of benthic habitats identified during the Phase I surveys and include the collection of sediment core samples for fauna, sediment composition (particle size analysis) and contaminants. | Phase II sampling was undertaken at both landfall locations. This involved the collection of sediment core samples for fauna, particle size analysis (PSA) and contaminants. Full data are available though no pathways t have been identified as cable installation in the intertidal will be via HDD. |
| MMO | In relation to subtidal benthic ecology, it is proposed that surveys are conducted along the length of the Marine Scheme in both Scottish and English waters. These surveys will include the collection of grab samples for fauna, sediment composition (particle size analysis) and sediment chemistry. Drop-down video (DDV) footage will also be collected in areas where sensitive habitats are thought to occur, and side-scan sonar data will be collected to aid habitat characterisation and sampling station selection. This is considered to be appropriate. | Noted. No further action required. |
| MMO | The pressures that have been scoped in for intertidal benthic ecology are temporary physical disturbance, temporary increases in suspended sediment concentration and subsequent sediment deposition, changes to marine water quality, and thermal emissions from cables. The MMO agree with the decision to scope in these pressures.<br>The pressures that have been considered and scoped out of the assessment are underwater sound and the influence of cables on the electromagnetic. The MMO agree with the justification and the decision to scope out these pressures. | EMF has been scoped back into the appraisal due to request from MS-LOT and is appraised in Section 8.6.3.1. |
| MMO | No specific benthic ecology receptors are identified at this stage, as the characterisation surveys have not yet been conducted. However, the report does identify benthic species and habitats that are protected features within designated sites that the Marine Scheme would either pass through or come close to. If surveys indicate that such features are present within the footprint of the proposed works, either inside or outside of designated sites, then these features should be scoped in as key receptors in the assessment of impacts. Of particular note is that the cable route would pass through the Farnes East MCZ, within which every sedimentary broadscale habitat is protected. It would therefore appear that routing the cable through this site will inevitably have impacts on protected benthic features. | Agreed, all identified protected habitat and species, and features of conservation interest have been scoped into the appraisal. See Sections 8.5.3 and 8.6. |

| Consultee | Consultee response/ comment | How and where addressed |
|---|---|---|
| National Trust | As the route passes through Farnes East MCZ, with features including sponges, anemones, segmented worms, ocean quahog, seapens and burrowing species such as Norway lobster, these benthic species could be impacted by the proposal. If there are direct and significant effects arising from the proposal NT would like to understand how impacts can either be avoided or minimised wherever possible and if harm arises how this might be mitigated for and how 'net gain' for these features might be secured | A full MCZ assessment for Farnes East MCZ, and all other MCZs and MPAs is provided in Appendix 8.1.<br>Features protected in this MCZ include:<br>• Moderate energy circalittoral rock<br>• Subtidal coarse sediment<br>• Subtidal sand<br>• Subtidal mud<br>• Subtidal mixed sediments<br>• Seapen and burrowing megafauna<br>• Ocean quahog |
| TWT | TWT would like to raise at this early-stage that we have serious concerns regarding the routing of the cable through Farnes East MCZ, which is in unfavorable condition. The placement of a cable through this site could not only hinder the recovery of the site but could cause further decline. We request that the cable is rerouted to avoid the MCZ to avoid both risk to the MCZ and the project. | A full MCZ assessment for Farnes East MCZ, and all other MCZs and MPAs is provided in Appendix 8.1. |

### 8.4.3 Data Gaps and Limitations

Although the survey sampling design and collection process provided robust data on the benthic communities, interpreting these data by classifying and grading biotopes has three main limitations:

- It can be difficult to interpolate data collected from discrete sample locations to cover the whole study area and to define the precise extent of each biotope, even with site-specific geophysical data;
- Benthic communities generally show a transition from one biotope to another and, therefore, exact boundaries of where one biotope ends and the next begins cannot be defined with absolute precision; and
- The classification of the community data into biotopes is not always straightforward, as some communities do not readily fit the available descriptions in the biotope classification system and the classification for subtidal benthic communities is generally regarded as incomplete. In particular, there is still poor coverage of circalittoral rock and sediment habitats occurring in waters deeper than 50 m (see: jncc.defra.gov.uk/MarineHabitatClassification).

Despite these limitations, every effort has been made to obtain data concerning the existing environment and to accurately predict the likely environmental effect of the proposed development. It is considered that the baseline information collected and used for this appraisal is representative of the study area.

## 8.5 Baseline Conditions

This section describes the benthic ecology baseline, for both the intertidal and subtidal areas, for the Marine Scheme, with respect to the diversity, abundance, and function of organisms living on (epifauna) or in (infauna) the seabed. Physical factors such as seabed or sediment type, water depth and associated level of available light and supply of organic matter determine the habitats present, and therefore the composition of benthic communities.

### 8.5.1 Intertidal Ecology

Although no intertidal works associated with the Project Maine Scheme are proposed as the landfalls will be installed via HDD, an intertidal survey was still undertaken for the Marine Scheme (Fugro, 2021). Whilst the use of HDD under the transition zone between the onshore and offshore elements will avoid impacts on intertidal habitats and species, a summary of the baseline conditions at each landfall is provided below for completeness.

The landfall in Scotland (KP 0) is located at Thorntonloch Beach, south of Torness Point, East Lothian (referred to as the Scottish landfall hereafter). British Geological Survey (BGS) data indicate the intertidal habitat at the Scottish landfall is primarily rock platform with banks of gravel[3], which aligns with the EUNIS broad scale habitat type A3 - Infralittoral rock and other hard substrata. The Marine Scheme survey confirmed the Scottish landfall foreshore to be bedrock slabs with occasional areas of overlying coarse sediment (boulders, pebbles and cobbles). Some areas of sand were observed on the lower shore to the western extent and on the upper shore on the eastern edge of the marine installation corridor (Fugro, 2021). The majority of habitats within the Scottish landfall intertidal area were considered typical of a moderately exposed rocky shore with a standard zonation (Table 8-2).

The landfall in England (KP 176) is located at Hawthorn Pit, Seaham, County Durham (referred to as English landfall hereafter). Habitat mapping carried out by the Department for Environment, Food and Rural Affairs (Defra) characterises it as having a sandy foreshore, with a rock platform backshore[3].The Marine Scheme survey report confirmed the English landfall foreshore as having sand at the lower shore, with coarse sediment (sand, pebbles, cobbles) at the upper shore, backed by cliffs. Littoral bedrock outcrops were present on the lower shore to the south-east and north-east of the survey area.

[3] DEFRA Habitat Mapping. Available online: https://magic.defra.gov.uk/magicmap.aspx

The majority of habitats within the English landfall intertidal area were considered typical of a sandy and coarse sediment shore (Table 8-2)

## 8.5.2 Subtidal Ecology

The subtidal benthic habitats identified along the marine installation corridor were generally dominated by areas of mud, sand, and coarse sediments[4]. A variety of other habitats are distributed throughout the length of the Marine Scheme, with a greater diversity of benthic habitats in the higher energy, coastal areas of the route.

### 8.5.2.1 Subtidal Habitats and Communities

A detailed interpretation of benthic habitats across the marine installation corridor are summarised in this EAR chapter in Table 8-2 and described below. Existing habitat mapping data (EUSeaMap 2021) are presented in Figure 8-3.

A total of 19 EUNIS biotope complexes were recorded across the subtidal area of marine installation corridor during the benthic characterization survey (Table 8-2). The sediment characteristics of the marine installation corridor are heterogeneous, comprising varying proportions of gravel, sand, and fine sediments. Each of the biotype complexes is described below.

#### *Infralittoral (A3) and Circalittoral Rock (A4)*

The marine installation corridor was characterised by sporadic patches of circalittoral rock in the offshore subtidal region (Fugro, 2021). Whilst infralittoral rock and other hard substrata was mostly associated with the cobbles and boulders at both landfall locations, several sections of circalittoral rock supporting a community of echinoderms, such as starfish, brittlestars, sea urchins, and faunal and algal crusts were also recorded (Fugro, 2021).

The nearshore sections of the marine installation corridor were found to support a greater diversity of benthic habitats. These included the EUNIS habitats A3.1 - *Atlantic and Mediterranean high energy infralittoral rock*, A4.2 / A5.44 - *Atlantic and Mediterranean moderate energy circalittoral rock / Circalittoral mixed sediment* and A4.21 - *Echinoderms and crustose communities on circalittoral rock* (Fugro, 2021). Rock habitat was also found in the following areas of the marine installation corridor:

- Nearshore Scottish landfall (KP 0.7 – KP 10.1), where it was interspersed by the biotope complex A5.2 *Sublittoral sand;*
- KP 10.1 – KP 28.1 and KP 42.9 – KP 67.7, where it was associated with the biotope complex A5.45 *Deep circalittoral mixed sediments and interspersed by the biotope complex* A5.27 *Deep circalittoral sand;*
- KP 84.2 – KP 106.2, where it was associated with the biotope complex A5.45 *Deep circalittoral mixed sediments;*
- KP 106.2 – KP 119.7, where it was associated and interspersed by the biotope complex A5.45 *Deep circalittoral mixed sediments;*
- KP 168.4 – KP 173.9 where it was associated and interspersed by the biotope complex A5.*27 Deep circalittoral sand*. Ross worm (*Sabellaria spinulosa*) was also observed here; and
- English landfall (KP 175.1 – KP 176.2) where it was associated and interspersed by the biotope complex A5.44 *Circalittoral mixed sediments.*

[4] EMODnet seabed habitat mapping. Available online: https://www.emodnet-seabedhabitats.eu/access-data/launch-map-viewer/?zoom=3&center=-15.000,51.600&layerIds=3&baseLayerId=-3&activeFilters=

### *Sublittoral Sediment (A5)*

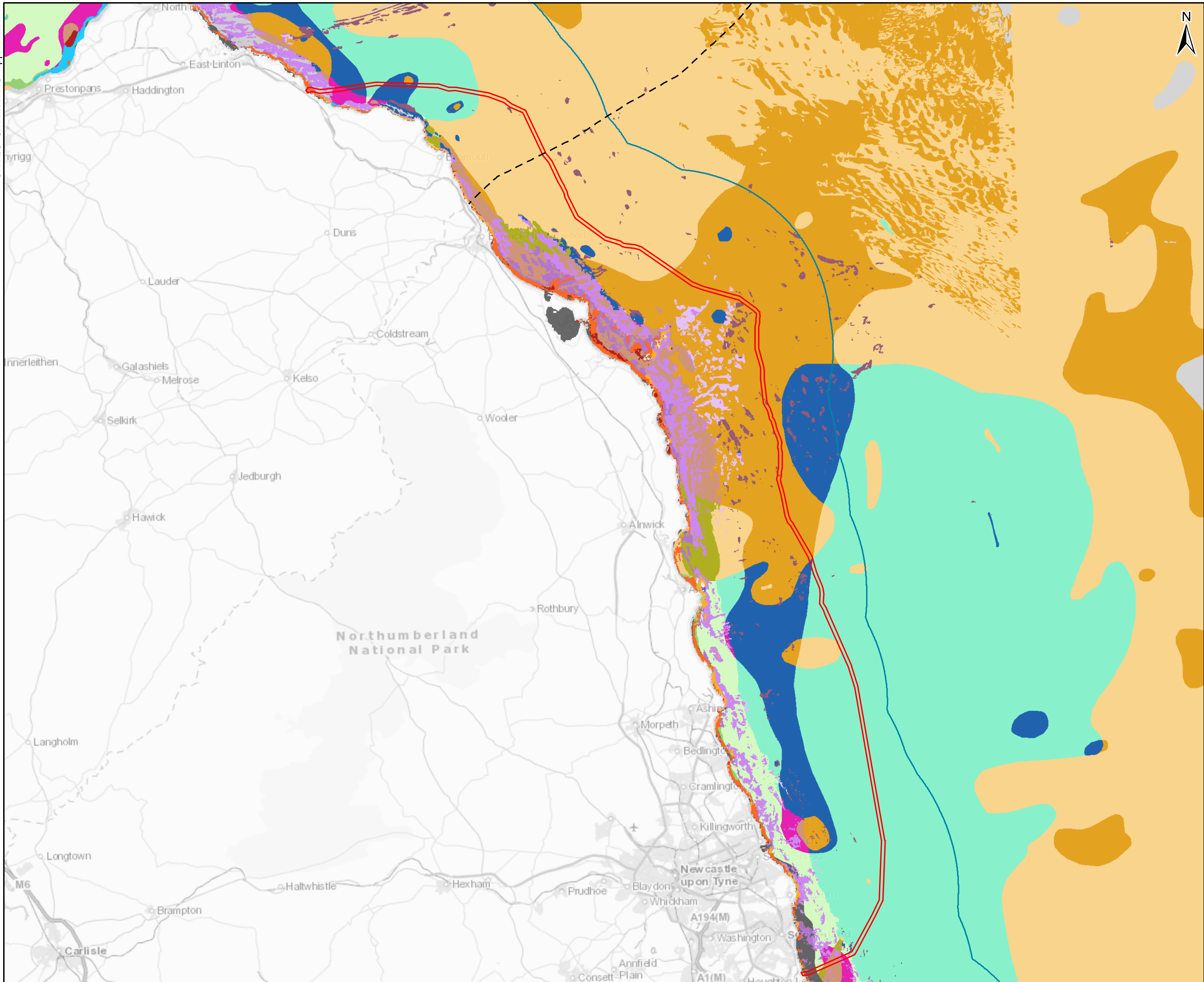
Based on the routeing and siting work for the Marine Scheme, approximately 99 % of the marine installation corridor comprised sediment-based habitat types (Fugro, 2021) (Figure 8-3). The data show the seabed is characterised by the following EUNIS habitats:

- The nearshore subtidal areas at the Scottish landfall were dominated by *Circalittoral mixed sediment* (A5.44) transitioning to patches of *Deep circalittoral mixed sediments* (A5.45) and *Deep circalittoral mud (A5.37);*
- The northern subtidal areas of the marine installation corridor (up to approximately KP84) were dominated by *Deep circalittoral sand* (A5.27);
- The mid to southern subtidal areas of the marine installation corridor (approximately KP84 to KP173) were dominated by *Deep circalittoral coarse sediment* (A5.15) and *Deep circalittoral mud* (A5.37) with patches of *Deep circalittoral mixed sediments* (A5.45) and *Echinoderms and crustose communities on circalittoral rock (*A4.21); and
- The southern to nearshore subtidal areas at the English landfall were also dominated by sediment habitats of *Deep circalittoral mud (*A5.37) and a mosaic of *Circalittoral coarse sediment and Circalittoral mixed sediments* (A5.14 / A5.494) in shallower waters.

It was found that most stations located in the marine installation corridor featured the biotope *Thyasira spp. and Nuculoma tenuis in circalittoral sandy mud* (A5.352). The biotopes *Amphiura filiformis* and *Nuculoma tenuis in circalittoral and offshore muddy sand* (A5.353) and *Amphiura filiformis, Mysella bidentata and Abra nitida in circalittoral sandy mud* (A5.351), were also common.

At stations located at the nearshore landfall sites, the biotope *Fabulina fabula and Magelona mirabilis with venerid bivalves and amphipods in infralittoral compacted fine muddy sand* (A5.242) was recorded.

GIS: LC Checked: RG Approved: MW





Information contained here has been derived from data that is made available under the European Marine Observation Data Network (EMODnet) Seabed Habitats initiative (http://www.emodnet-seabedhabitats.eu/), financed by the European Union under Regulation (EU) No 508/2014 of the European Parliament and of the Council of 15 May 2014 on the European Maritime and Fisheries Fund.

Coordinate System: WGS1984 Zone 30N

Scale @ A3 1:500,000



nationalgrid

SP TRANSMISSION

PROJECT

**Scotland England Green Link 1 / Eastern Link 1**

KEY

- Marine Installation Corridor
- UK Territorial Sea Limit
- Scottish Adjacent Waters Boundary

EUSeaMap (2019) - EUNIS Classification

- A3: Infralittoral rock and other hard substrata
- A3.1: Atlantic and Mediterranean high energy infralittoral rock
- A3.2: Atlantic and Mediterranean moderate energy infralittoral rock
- A3.3: Atlantic and Mediterranean low energy infralittoral rock
- A4: Circalittoral rock and other hard substrata
- A4.1: Atlantic and Mediterranean high energy circalittoral rock
- A4.2: Atlantic and Mediterranean moderate energy circalittoral rock
- A4.3: Atlantic and Mediterranean low energy circalittoral rock
- A4.27: Faunal communities on deep moderate energy circalittoral rock
- A4.33: Faunal communities on deep low energy circalittoral rock
- A5: Sublittoral sediment
- A5.13: Infralittoral coarse sediment
- A5.14: Circalittoral coarse sediment
- A5.15: Deep circalittoral coarse sediment
- A5.23 or A5.24: Infralittoral fine sand or Infralittoral muddy sand
- A5.25 or A5.26: Circalittoral fine sand or Circalittoral muddy sand
- A5.27: Deep circalittoral sand
- A5.33: Infralittoral sandy mud
- A5.35: Circalittoral sandy mud
- A5.36: Circalittoral fine mud
- A5.37: Deep circalittoral mud
- A5.43: Infralittoral mixed sediments
- A5.44: Circalittoral mixed sediments
- A5.45: Deep circalittoral mixed sediments
- Na

TITLE

**Figure 8-2**
**Subtidal Habitats (EUSeaMap 2019)**

REFERENCE

SEGL1_M_EAR_8-2_v1_20220426

SHEET NUMBER | DATE
1 of 1 | 26/04/2022

### Table 8-2: Summary of subtidal broad-scale habitats and biotope complexes identified during surveys

| Broad Scale Habitat | Habitat Complex | Biotope Complex |
|---|---|---|
| Infralittoral rock and other hard substrata (A3) | Atlantic and Mediterranean high energy infralittoral rock (A3.1) | Foliose red seaweeds on exposed lower infralittoral rock (A3.116) |
| | | Mixed Kelps with Scour-tolerant and Opportunistic Foliose Red Seaweeds on Scoured or Sand-covered Infralittoral Rock (A3.125) |
| | Atlantic and Mediterranean moderate energy infralittoral rock (A3.2) | Kelp and red seaweeds (moderate energy infralittoral rock (A3.21) |
| Circalittoral rock and other hard substrata (A4) | Atlantic and Mediterranean moderate energy circalittoral rock (A4.2) | Echinoderms and crustose communities on circalittoral Rock (A4.21) |
| | | Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock (A4.214) |
| Sublittoral sediment (A5) | Sublittoral coarse sediment (A5.1) | Circalittoral coarse sediment (A5.14) |
| | | Deep circalittoral coarse sediment (A5.15) |
| | | *Glycera lapidum* in impoverished infralittoral mobile gravel and sand (A5.135) |
| | Sublittoral sand (A5.2) | Deep circalittoral sand (A5.27) |
| | | *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand (A5.242) |
| | | *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand (A5.252) |
| | | Circalittoral muddy sand (A5.26) |
| | Sublittoral mud (A5.3) | *Amphiura filiformis*, *Mysella bidentata* and *Abra nitida* in circalittoral sandy mud (A5.351) |
| | | *Thyasira* spp. and *Nuculoma tenuis* in circalittoral sandy mud (A5.352) |
| | | *Amphiura filiformis* and *Nuculoma tenuis* in circalittoral and offshore muddy sand (A5.353) |
| | Sublittoral mixed sediments (A5.4) | Circalittoral mixed sediments (A5.44) |
| | | *Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediments' (A5.445) |
| | | Deep circalittoral mixed sediments (A5.45) |
| | | Polychaete-rich deep venus community in offshore mixed sediments' (A5.451) |

### 8.5.2.2 Subtidal Macrofauna

The subtidal section of the marine installation corridor survey area comprised rich and diverse macrofaunal communities, made up of infaunal and epifaunal invertebrates. A detailed description of the benthic macrofauna across the marine installation corridor is summarised below.

The abundance of macrofauna was evenly distributed across the taxa recorded, and the spatial pattern of distribution was found to be broadly associated with sediment type and depth. Most stations featured muddy sand and/or gravelly muddy sand, and hosted biological communities characterised by polychaetes, bivalves, crustaceans and brittlestars. These communities had a high macrofaunal richness because the combination of sediment types supports the presence of both infauna and epifauna taxa. In predominantly muddy habitats the macrofaunal richness of communities was low by comparison, with these stations being devoid of colonial epifauna because no larger particles were present.

Community structure was dominated by annelids (segmented worms) throughout the marine installation corridor, ranging from 38.2 % to 53.6 % of the total diversity of animals present. The polychaete worms *P. jeffreysii*, *Lumbrineris* cf. *cingulata*, *Sabellaria spinulosa, Magelona filiformis,* and *Peresiella clymenoides* were amongst the most abundant annelids.

Arthropods had the second highest diversity at most stations, except nearshore Scottish landfall, with diversity values ranging from 19.0 % to 31.8 % of total taxa. This group was represented mainly by crustacean amphipods such as *Bathyporeia elegans, Centraloecetes kroyeranus, Harpinia antennaria* and *Ampelisca tenuicornis*, and the isopod *Astacilla dilatate.* The latter two species were also the most frequently occurring crustaceans.

Molluscs had the third highest contribution to diversity, accounting for between 15.3 % and 21.6 % of species present. Mollusca were mainly represented by bivalves such as *E. tenuis, Chamelea striatula* and *Nucula nucleus* and gastropods such as *Retusa umbilicata* and *Cylichna cylindracea*. *E. tenuis* and *R. umbilicata* were the most frequently occurring molluscs.

At the nearshore Scottish landfall, arthropoda had the third highest contribution to the taxa composition (26.3 %), whereas mollusca had the second highest contribution (27.6 %).

Echinoderms were absent from the English landfall nearshore and at some other areas of the marine installation corridor. They contributed to diversity, ranging from 2.3 % to 5.4 % of taxa present. Echinoderms were represented mainly by the brittlestar *Amphiura filiformis* and the sea urchin *Echinocyamus pusillus.*

The highest macrofaunal diversity was recorded along sections of the marine installation corridor that featured mixed sediment, specifically KP84.22 to KP105.61 and, to a lesser extent at mixed sediment habitats which also had a high abundance of the tube building polychaete *S. spinulosa* (KP 106.24 to KP 118.95).

### 8.5.3 Protected Habitats and Species of Conservation Importance

A number of sensitive seabed habitats and species, typical of the North Sea, have been identified as occurring within the marine installation corridor or the wider study area, as outlined below in Table 8-3 and discussed in detail in the following sections.

**Table 8-3: Summary of sensitive benthic habitats and species relevant to SEGL1 / EL1**

| Protected Feature | Legislation | Description | Designation / Status |
|---|---|---|---|
| Subtidal sands and gravels | UK Post-2010 Biodiversity Framework | Broad scale habitat | Priority habitat; HOCI in MCZ; PMF in offshore waters |
| Mud habitats in deep water | UK Post-2010 Biodiversity Framework | Broad scale habitat | Priority habitat; HOCI in MCZ; PMF in offshore waters |
| Seapens and burrowing megafauna communities | UK Post-2010 Biodiversity Framework | Broad scale habitat | HOCI in MCZ; PMF |
| | OSPAR List of Threatened and/or Declining Species and Habitats | | Threatened species (region II and III) |
| *Sabellaria*, bedrock and stony reefs | UK Post-2010 Biodiversity Framework | Geogenic reef<br>Biogenic reef | Priority habitat; HOCI in MCZ |
| | Conservation of Habitats and Species (Amendment (EU Exit) Regulations 2019 | | Annex I habitat |
| *Arctica islandica* | UK Post-2010 Biodiversity Framework | Ocean quahog | Priority species; FOCI in MCZ; PMF |
| | OSPAR List of Threatened and/or Declining Species and Habitats | | Threatened and declining species |

#### 8.5.3.1 Subtidal Sands and Gravels

Subtidal sands and gravels are a listed UK Post-2010 Biodiversity Framework Priority habitat under Section 2(4) of the Nature Conservation (Scotland) Act 2004 and Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006 (England) (formally UK BAP Priority Habitat) (Table 8-3). In offshore locations this habitat is also listed as a PMF in Scottish waters, but not in nearshore locations.

These habitats occur in a variety of environments, from sheltered to very exposed conditions. The sediment of these habitats ranges from mainly sand, through various combinations of sand and gravel, to mainly gravel. While very large areas of seabed are covered by mixes of sand and gravel in various proportions, much of this habitat is covered by very thin deposits over bedrock, glacial drift or mud (Joint Nature Conservation Committee, 2016). The strength of tidal currents and exposure to wave action are important determinants of the topography and stability of sand and gravel habitats. The diversity of flora and fauna living within the biotopes varies according to the level of environmental stress to which they are exposed. In nearshore areas, sand and gravel habitats are ecologically important as nursery grounds for juvenile commercial species such as flatfishes and bass, whereas offshore they support internationally important fish and shellfish fisheries (Biodiversity Reporting and Information Group, 2011).

The following habitat classifications and biotope complexes, present across the subtidal marine installation corridor as confirmed by the benthic survey (Fugro, 2021), are considered representative of the Subtidal Sands and Gravels habitat:

- *Glycera lapidum in impoverished infralittoral mobile gravel and sand* (A5.135) at KP162.4;
- *Circalittoral coarse sediment* (A5.14) at KP0.70; KP0.87 and KP2.26;
- *Circalittoral muddy sand* (A5.26) in very small patches (not mapped) at KP2.263 to KP100.059;
- *Deep circalittoral sand* (A5.27) KP99.625 to KP100.059;
- *Fabulina fabula and Magelona mirabilis with venerid bivalves and amphipods in infralittoral compacted fine muddy sand (A5.242)* nearshore stations at both the Scottish and English landfall; and
- *Abra prismatica, Bathyporeia elegans and polychaetes in circalittoral fine sand* (A5.252) KP162.394 to KP 168.377.

#### 8.5.3.2 Mud Habitats in Deep Water

Mud habitats in deep water are a listed UK Post-2010 Biodiversity Framework Priority habitat under Section 2(4) of the Nature Conservation (Scotland) Act 2004) and Section 41 of the NERC Act 2006 (England) (formally UK BAP Priority Habitat) (Table 8-3).

Mud habitats in deep water (circalittoral muds) occur below 20–30 m in many areas of the UK's marine environment. The relatively stable conditions associated with these deep mud habitats often lead to the establishment of communities of burrowing megafaunal species where bathyal species may occur with coastal species. The burrowing megafaunal species include crustaceans such as the Norway lobster *Nephrops norvegicus* and the burrowing shrimp *Callianassa subterranea*. The mud habitats in deep water can also support seapen (Pennatulacea) populations and communities with the brittlestar *Amphiura* spp. (Biodiversity Reporting and Information Group, 2011).

The following habitat classifications and biotope complexes, found to be present across the subtidal marine installation corridor during the benthic survey, are considered representative of *Mud Habitats in Deep Water* (A5.35: Circalittoral sandy mud):

- *Amphiura filiformis, Mysella bidentata and Abra nitida in circalittoral sandy mud* (A5.351) at KP 2.3 (ST02 and TR03); KP 106 (ST23), KP 116 (ST25) and KP 162 (ST37 and TR20);
- *Thyasira spp. and Nuculoma tenuis in circalittoral sandy mud* (A5.352) at KP 44 (St11), KP 106 (ST24); KP 116 (ST25) and KP 119 (ST26); and
- *Amphiura filiformis and Nuculoma tenuis in circalittoral and offshore muddy sand* (A5.353) was very common, found at 17 stations between KP 4.7 and KP 162.4.

The biotope complex *seapens and burrowing megafauna* was not found in the marine installation corridor during the benthic survey.

#### 8.5.3.3 Seapens and Burrowing Megafauna

This habitat type occurs in muddy areas at water depths of 15 m to over 200 m. It is characterised by mounds and burrows caused by the burrowing of animals, such as the Norway lobster, mud shrimps and Fries' goby *Lesueurigobius friesii*. The burrows offer shelter to smaller animals, and large invertebrates may be seen scavenging on the surface of the mud. The tall seapen *Funiculina quadrangularis,* which is rare in UK waters, can occur within this habitat, as can the burrowing fireworks anemone *Pachycerianthus multiplicatus*, which is scarce in the UK and appears to be restricted to this habitat. The inclusion of this habitat in the OSPAR list of threatened and/or declining habitats and species is based on its ecological significance and its decline, the latter associated with habitat quality rather than extent (OSPAR Commision, 2020). It is also listed as a PMF in Scottish waters (Table 8-3).

The seapens *Pennatula phosphorea* and *Virgularia sp*., the characteristic burrowing Norway lobster, and burrows of this species, were recorded at many locations between KP 11.3 and KP 166.3, though none were identified within the Farnes East MCZ. The abundance of Norway lobster burrows ranged between ‘common’ and ‘abundant’. The abundance of seapens ranged between ‘occasional’ and ‘frequent’.

Previous survey data within the Farnes East MCZ have recorded limited observations of this habitat predominantly located in patches of subtidal mud in the south east of the MCZ suggesting that the habitat ‘Mud Habitats in Deep Water’, provides a suitable habitat for seapen and burrowing megafauna communities (CEFAS, 2015). The presence of individual *Nephrops* and their burrows was identified at a small number of locations – 10 grab stations (ST04-08; ST10; ST28; ST31; ST34; ST35) and in 3 transects (TR15, TR16 and TR18) within the marine installation corridor during the benthic characterization survey. Despite the presence of some of the characterising species, there was no clear evidence of the presence of the biotope *Seapens and burrowing megafauna in circalittoral fine mud* (A5.361) observed during the 2021 baseline survey. However, due to sporadic observations of these key species, in addition to burrows around the wider Farnes East MCZ, it was concluded that there is the potential for this habitat to occur at some locations within the marine installation corridor. It should also be noted that no observations were recorded from the section of the marine installation corridor located within the MCZ during the benthic survey, though the habitat observed had potential for them (see Appendix 8.1).

### 8.5.3.4 Annex I Reefs

Reefs are rocky marine habitats or biological concretions that rise from the seabed. They are generally subtidal but may extend as an unbroken transition into the intertidal zone, where they are exposed to the air at low tide. Annex I reef habitats are protected under the European Commission Habitats Directive 92/43/EEC. The definition of an Annex I reef based on the Interpretation Manual of European Union Habitats is as follows:

*‘Reefs can be either biogenic concretions or of geogenic origin. They are hard compact substrata on solid and soft bottoms, which arise from the sea floor in the sublittoral and littoral zone. Reefs may support a zonation of benthic communities of algae and animal species as well as concretions and corallogenic concretions’*

Within UK waters, three types of Annex I reef have been identified: stony, bedrock and biogenic reef (Golding, Albrecht, & McBreen, 2020).

‘Rocky reefs’ are variable in structure and in the communities they support. A range of topographical reef forms meet the definition of this habitat type under the Habitats Directive. These range from vertical rock walls to horizontal ledges, sloping or flat bed rock, broken rock, boulder fields, and aggregations of cobbles. Rocky reefs are characterised by communities of attached algae on the shore and in the shallow subtidal (where there is sufficient light) as well as invertebrates, and fish. The specific communities that occur vary according to the nature and topography of the substrate, as well as exposure to waves and tides (Joint Nature Conservation Committee, 2022).

#### *Stony Reef*

Across the marine installation corridor, the biotope *Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock* (A4.214) was identified. This habitat is contained within Annex I Reefs and its sub features including ‘Stony reefs’ and ‘Circalittoral rock’ (Fugro, 2021).

Areas of potential reef were assessed for stony reef resemblance, then rated from low to high, on the basis of sediment type, composition, elevation and percentage epibiota (Irving, 2009) (Table 8-4). Where the assessment indicates a medium resemblance rating, the habitat is considered to qualify as Annex I reef habitat.

### Table 8-4: Location of identified stony reef resemblance marine installation corridor

| Transect/ Station | Nearest KP | Description | Resemblance rating |
|---|---|---|---|
| TOR_ST02 | KP0.87 | Cobbles and boulders on sand. Some cobbles and boulders on top of other cobbles and boulders | Medium |
| TOR_TR01 | KP0.87 | Low-lying cobbles and boulders embedded in sediment; and cobbles and boulders on sand. Some cobbles and boulders on top of other cobbles and boulders | Medium |
| TOR_TR02 | KP0 | Cobbles and boulders on sand. Some cobbles and boulders on top of other cobbles and boulders; and cobbles and boulders on sand | Medium |
| TOR_TR03 | KP0.87 | Cobbles and boulders on sand. Some cobbles and boulders on top of other cobbles and boulders | Medium |
| TR01 | KP0.87 | Cobbles and large boulders on sand. Some cobbles and boulders on top of other cobbles and boulders | Medium |
| TR06 | KP57.38 | Cobbles and boulders embedded in gravelly muddy sand. Hard substrate with a veneer of muddy sand | Medium |
| TR09 | KP76.17 | Cobbles and boulders embedded in or on gravelly muddy sand | Medium |
| TR18 | KP162.39 | Boulders embedded in muddy sand and with boulders on boulders | Medium |
| TR21 | KP162.39 | Cobbles and boulders embedded in or on gravelly sand | Medium |
| TR24 | KP168.38 | Cobbles and boulders on sand with cobbles and boulders on top of other cobbles and boulders in places | Medium |
| HAW_TR01 | KP173.90 | Cobbles and boulders | Medium |
| HAW_TR02 | KP173.90 | Cobbles and boulders | Medium |
| HAW_TR03a | KP168.38 | Cobbles and boulders on sand | Medium |
| HAW_TR03b | KP168.38 – KP173.90 | Cobbles and boulders on sand | Medium |

#### *Bedrock Reef*

Areas of bedrock were recorded within the marine installation corridor (Fugro, 2021). Whilst there are no assessment criteria for bedrock reef, exposed bedrock is considered bedrock reef if it is observed to be topographically distinct from the surrounding seabed.

There were locations within the marine installation corridor where bedrock reef habitat was found (Table 8-5). Transect TR11 at KP 84.2 was located within the Farnes East MCZ, which is designated for several different features including bedrock and a range of different sediment habitats.

**Table 8-5: Location of identified bedrock reef in marine installation corridor**

| Transect / Station | Nearest KP | Description |
|---|---|---|
| TR05 | KP 31.17 | Low-lying bedrock outcrop overlain with muddy sand and occasional cobbles and boulders |
| TR06 | KP 57.38 | Bedrock outcrops with cobbles and boulders interspersed with gravelly muddy sand |
| TR08 | KP 75.39 | Bedrock outcrop, some low-lying |
| TR11 | KP 84.22 | Bedrock outcrops interspersed with gravelly muddy sand cobbles and boulders or gravelly muddy sand with shell fragments and pebbles |
| TR18 | KP 162.39 | Bedrock outcrops and boulders on muddy sand. Hard substrate with a veneer of muddy sand |
| TR21 | KP 162.39 | Bedrock outcrop with a veneer of sand |
| ST39 | KP 168.38 | Bedrock outcrop with a veneer of sand |
| TR22 | KP 168.38 | Bedrock outcrops interspersed with low-lying bedrock with cobbles and boulders overlain |
| TR23 | KP 168.38 | Bedrock outcrops with cobbles and boulders overlain, and in some areas with a veneer of sand |

***Sabellaria spinulosa* Reef**

Biogenic reefs are those created by animals and include reef-building worms such as the ross worm *Sabellaria spinulosa*. *S. spinulosa* is a small, tube-building polychaete worm found in the subtidal and lower intertidal/sublittoral fringe and is widely occurring across the UK. In most parts of its geographical range, it does not form reefs but is solitary or found in small groups, encrusting pebbles, shell, kelp holdfasts and bedrock. When conditions are favourable, dense aggregations may be found, forming reefs up to about 60 cm high and extending over several hectares, often raised above the seabed (OSPAR Commision, 2013).

Individuals of the *S. spinulosa* were recorded in benthic grab samples from ten stations taken in the marine installation corridor (Fugro, 2021). High abundance, > 700 individuals per $m^2$, was recorded in grab samples at three stations (ST15 – KP 57.37, ST17 – KP 76.17 and ST19 – KP 84.22). Although a relatively high abundance of worms was recorded; these were predominantly recorded as thin crusts on gravel.

There was no evidence of conspicuous *S. spinulosa* aggregations at these locations from the DDV data and all instances were classified as 'not a reef' in accordance with (Gubbay, 2007) and (Jenkins, et al., 2015) (Fugro, 2021).

### 8.5.3.5 Ocean Quahog

The ocean quahog *Arctica islandica* is a marine bivalve that occurs in sandy and muddy sediments from the low intertidal zone to water depths of 400 m. The species occurs on both sides of the North Atlantic and within the OSPAR Maritime Area and its distribution includes the North Sea. The ocean quahog is among the longest lived and slowest growing marine bivalves, with specimens recorded as being over 100 years old. It is a designated feature of the Farnes East MCZ where it is currently under a 'recover to favorable' management approach; it is also a PMF in Scottish waters. It is also included in the OSPAR list of threatened and/or declining species (OSPAR, 2008) with the main threat being associated with seabed disturbance from anthropogenic activities (OSPAR Commision, 2009).

Previous surveys within the Farnes East MCZ have identified individuals of ocean quahog (mostly juveniles) predominately in the east and southwest of the site (CEFAS, 2015). No evidence of the presence of the ocean quahog was recorded along the marine installation corridor during the benthic baseline survey (Fugro, 2021). A full assessment of ocean quahog in relation to the Farnes East MCZ is present in Appendix 8.1.

#### 8.5.3.6 Other Benthic Species of Interest

Burrowing anemones of the family Edwardsiidae, including the timid burrowing anemone *Edwardsia timida* and *E. claparedii*, were recorded at 19 stations, including within the Farnes East MCZ (stations ST17 to ST21). However, they were only present as one or two individuals.

### 8.5.4 Fish Spawning Grounds

Benthic conditions, particularly the type of sediment present, is an important determinant of the presence of spawning grounds, for sandeel and herring in particular. Data collected during the benthic survey were used to assess the potential for key habitat for these species (Fugro, 2021). Details on the presence of sandeel and herring spawning habitat, and potential impacts on this receptor, are provided in Chapter 9: Fish and Shellfish Ecology.

### 8.5.5 Invasive and Non-Native Species

Two non-native species (NNS) and two cryptogenic species were recorded during the surveys (Fugro, 2021). The non-native species were:

- *Goniadella gracilis (polychaete)* - 15 individuals were recorded at a single subtidal station at KP 2.26, close to the Scottish landfall; and
- *Sargassum muticum (*brown algae) which was observed in the Scottish landfall intertidal survey area.

The recorded cryptogenic species were:

- *Nereis zonata* (polychaete) - eight individuals across three subtidal sampling stations between KP 57.377 and KP 76.170 of the marine installation corridor; and
- *Polydora cornuta* (polychaete) - a single individual recorded at one station at KP 29.188.

### 8.5.6 Relevant Designated Sites

Three designated sites overlap with the marine installation corridor. These are the Outer Firth of Forth and St Andrew's Bay Complex Special Protection Area (SPA) designated to protect seabirds and waterbirds, the Northumberland Marine SPA, designated to protect seabirds, and the Farnes East MCZ, designated to protect several marine benthic habitats and species.

Although SPA designations are designated under the European Union Directive on the Conservation of Wild Birds, they may also protect key benthic foraging grounds for birds. The area seaward of the Scottish landfall is located within the Outer Firth of Forth and St Andrews Bay Complex SPA[5]. This site hosts a variety of habitats which support a diversity of fish and invertebrate species, including sandeel and crustaceans, molluscs, and marine worms. The large range of prey species available for seabirds and waterbirds in shallow and sheltered waters of this SPA is reflected in the diversity of bird species using the area throughout the year. Further detail on the effects of the Marine Scheme on ornithology is presented in Chapter 11: Ornithology of this EAR.

[5] Designated site fact sheet. Available online: https://jncc.gov.uk/our-work/outer-firth-of-forth-and-st-andrews-bay-complex-spa/

There are no sites designated for the protection of benthic features solely in Scottish waters within 10 km of the marine installation corridor. However, the following site lies in both Scottish and English waters:

- **Berwickshire and North Northumberland Coast SAC:** The northern boundary of the SAC is approximately 338 m to the south of the marine installation corridor at the closest point. The SAC straddles both Scottish and English territorial waters. The site, which covers an area of approximately 652.26 $km^2$, is designated for several Annex I habitats including large shallow inlets and bays, intertidal mudflats and sandflats, reefs and submerged or partially submerged sea caves.

Key sites designated for the protection of benthic features within 10 km of the marine installation corridor in English waters[6] are:

- **Farnes East MCZ:** The marine installation corridor passes through this MCZ for approximately 26 km. The site covers an area of approximately 945 $km^2$ and is designated for the following benthic habitats: moderate energy circalittoral rock, subtidal mud, subtidal sand and subtidal course sediment. The general management approach[7] for these protected features is 'maintain in favourable condition'. The MCZ is also designated for seapen and burrowing megafauna communities as well as the ocean quahog both listed on the OSPAR list of threatened and/or declining species and habitats; the general management approach for these features is 'Recover to favourable condition';
- **Durham Coast SAC:** The southern boundary of this SAC is approximately 326 m from the marine installation corridor at the closest point. The site is designated for vegetated sea cliffs of the Atlantic and Baltic Coasts. The site covers an area of approximately 3.89 $km^2$;
- **Berwick to St Mary's MCZ:** At the closest point, the MCZ is approximately 1.4 km from the marine installation corridor. This site is designated for the protection of breeding and non-breeding common eider, *Somateria mollissima*; and
- **Coquet to St Mary's MCZ:** At the closest point, the MCZ is approximately 8.7 km from the marine installation corridor. The site is designated for several benthic habitats including rock, mud, sand and mixed broad scale habitats.

An HRA and MCZ Screening and Assessment has been undertaken for the Marine Scheme and can be found in Volume 3 Appendix 8.1 and Appendix 8.2 respectively.

### 8.5.7 Summary of Receptors

The benthic ecology receptors considered in the appraisal have been determined based upon the potential activity / receptor interactions identified within Table 8-6 of this chapter. Those species considered to have greatest sensitivity to a particular effect or are specifically designated have been appraised at the species level, whereas all other macrofauna is considered as part of the relevant habitat type or biotope.

[6] Natural England designated site fact sheets. Available online: https://designatedsites.naturalengland.org.uk/SiteSearch.aspx

[7] Features within an MCZ are given a 'general management approach' to help inform decision making; this acts much like a conservation objective.

**Table 8-6: Benthic ecology receptors considered in this EAR and their assigned value**

| Receptor group | Description | Rationale | Value |
|---|---|---|---|
| Benthic habitats | Subtidal sands and gravels | • Priority Marine Feature in Scotland<br>• NERC Section 41 habitat<br>• Have some capacity to absorb change<br>• Common and widespread habitats | Medium |
| | Subtidal mixed and coarse sediments | • Common and widespread habitats<br>• Have some capacity to absorb change | Low |
| | Mud habitats in deep water | • Priority Marine Feature in Scotland<br>• NERC Section 41 habitat<br>• Have some capacity to absorb change | Medium |
| | Annex 1 Reef: stony, bedrock and *Sabellaria spinulosa* | • Annex 1 habitat<br>• Priority Marine Feature<br>• Have some capacity to absorb change | Medium |
| | Seapens and burrowing megafauna | • Priority Marine Features in Scotland<br>• OSPAR Threatened habitats and species | High |
| Benthic species | Norway lobster *Nephrops norvegicus* | • Commercially important species<br>• Feature of burrowing megafaunal habitats | Low |
| | Ocean quahog *Arctica islandica* | • Priority Marine Feature in Scotland<br>• NERC Section 41 habitat<br>• OSPAR Threatened species | High |

# 8.6 Appraisal of Potential Impacts

This section describes the potential impacts of the Marine Scheme on the benthic ecology receptors during installation, operation (including maintenance and repair) and decommissioning phases of the Marine Scheme as presented in Chapter 2: Project Description. The appraisal has been undertaken in accordance with the methodology presented in Chapter 4: Approach to Environmental Appraisal. The following pathways detailed in Table 8-7 have been scoped into the appraisal.

### Table 8-7: Summary of impacts pathways and ZOIs

| Potential impact | Zone of influence (ZOI) |
|---|---|
| **Route preparation and cable installation** | |
| Temporary physical disturbance to intertidal and subtidal benthic habitats and species | Maximum disturbance footprints are 50 m for pre-installation and 30 m for installation |
| Permanent loss of subtidal benthic habitats and species due to placement of hard substrates on the seabed | Rock berm width a maximum of 7 m |
| Temporary increase in suspended sediment concentrations (SSC) sediment deposition leading to contaminant mobilisation, turbidity and smothering effects on subtidal habitats and species | 1.4 km is expected to be the maximum distance to which an increase in fine sediment (silts and muds) would occur from the point of disturbance within the marine installation corridor |
| Changes to marine water quality effects from the use of HDD drilling fluids and accidental leaks and spills from vessels, including loss of fuel oils | Footprint of the proposed works plus 1.4 km buffer; based on professional judgement and consideration of worst-case for fine particulates (Chapter 7: Physical Environment) |
| **Cable operation and maintenance** | |
| Disturbance to intertidal and subtidal benthic habitats and species due to subsea cable thermal emissions | Approximately 1 m from the cable, dependent upon the heat carrying capacity of particular sediments. |
| Disturbance to intertidal and subtidal benthic habitats and species due to subsea cable electromagnetic field (EMF) emissions | For the separated cables, the magnetic field resulted in a combined field slightly above the background level at 20 m from the cable. |
| Maintenance the same as route preparation and cable installation | As above |
| **Decommissioning** | |
| Potential effects the same as route preparation and cable installation | As above |

The unintentional or inadvertent loss of drilling fluids during drilling operations from the borehole to the ground surface from points other than its entry and exit points (known as frac-out) has not been considered during this appraisal.

## 8.6.1 Embedded Mitigation

The following mitigation has been built into the Marine Scheme, to avoid and/or minimise impacts to benthic ecology receptors and is presented in Table 8-8.

**Table 8-8: Benthic ecology embedded mitigation**

| Measure | Description |
|---|---|
| **Pre-Installation** | |
| CEMP | A CEMP, including an Emergency Spill Response Plan, Waste Management Plan, Marine Mammal Protection Plan, Fisheries Liaison and Co-existence Plan and Fisheries Management and Mitigation Strategy will be developed prior to commencement of works. |
| Micro-routeing | Detailed route development and micro-routeing to be undertaken within the marine installation corridor to avoid or minimise localised engineering and environmental constraints. |
| Legislative requirements and mitigation | • All vessels will follow the International Regulations for Preventing Collisions at Sea 1972 (COLREGS) and International Convention for the Safety of Life at Sea 1974 (SOLAS);<br>• All vessel wastes will be managed in accordance with the requirements set out within the International Convention for the Prevention of Pollution from Ships (MARPOL) (the discharging of contaminants is not permitted within 12 nm from the coast to preserve bathing waters);<br>• All non-local vessels will operate to IMO regulations for ballast water management to manage INNS risks; and<br>• Guard vessels will use radio detection and ranging (RADAR) with Automatic RADAR Plotting Aid (ARPA) to monitor vessel activity and predict possible interactions, will be employed to work alongside the installation vessel(s) during installation and maintenance work (which will also minimize anchor disturbance on the seabed). |
| Route preparation works | • Route preparation works would be carried out as locally as possible to minimise disturbance to sensitive habitats potentially suitable for marine ecological receptors. |
| **Installation** | |
| Landfall installation | HDD has been selected for installation of the cable in the transition zone between the onshore and offshore schemes which avoids any works in the intertidal environment; |
| Biodegradable drilling fluids | Drilling fluids used will be biologically inert and will be selected from the Centre from Environment, Fisheries, and Aquaculture Science (Cefas) approved list of drilling fluids, and the OSPAR List of Substances/Preparations Used and Discharged Offshore which are Considered to Pose Little or No Risk to the Environment (PLONOR).<br>During drilling, drilling fluids will be recycled, treated, and reused, and any waste drilling fluid will be transported offsite for treatment and disposal. |

## 8.6.2 Installation Phase

### 8.6.2.1 Temporary physical disturbance to subtidal benthic habitats and species

There are several route preparation and cable installation activities that will temporarily disturb seabed habitats, resulting in short term (approximately 12 months) physical disturbance to, and temporary loss of seabed habitats, and in some instances physical damage to less mobile benthic species such as bivalves, other molluscs and echinoderms.

Sensitivity to the impact of habitat disturbance varies between habitats and species; it depends upon the stability of the habitat and its resilience to disturbance, and the vulnerability of an individual species to mechanical disturbance. Mobile sands, or habitats in shallow water where there is significant wave and tidal energy, are considered to have greater capacity to accommodate physical disturbance. The same is true for mobile species, such as crabs, that can avoid installation activities.

There are several activities associated with route preparation and cable installation. These have been separated into the temporary disturbance occurring as a result of landfall activities, and those that occur during the offshore route preparation and cable installation.

#### *Landfall Activities*

Installation activities at the landfall location, which have the potential to cause temporary disturbance to and/or loss of benthic habitats and species include the following:

- **HDD** – completed boreholes will breakout between 4 and 10 m below lowest astronomical tide (LAT) within the marine installation corridor. There will be a maximum of six breakouts (allows for two possible failures) at each landfall location and up to 1500 m has been allowed for the length of each completed borehole, though the actual length is likely to be less than this. Each borehole diameter will be 75 cm, assuming a maximum of 10m$^2$ sediment disturbance at each borehole, a maximum 60 m$^2$ will potentially be disturbed. This area will be covered by temporary protection as detailed below.
- **Temporary Breakout Protection** – up to 20 temporary protective concrete mattresses may be used at borehole breakouts within the Marine Scheme to protect the breakout from damage before or during cable installation. Each mattress will cover an area of up to 18 m$^2$, be up to 0.3 m thick, and weigh up to 9.1 tonnes and so the total area temporarily affected will be 360 m$^2$; and
- **Cable installation at the breakout** – several vessels including a cable lay barge (CLB) and a jack-up barge (JUB) will install the cable at the breakout using the most appropriate burial method(s) depending on conditions, including Mass Flow Excavation (MFE), backhoe digger or diver operated jetting.

The habitat type at the breakout at both landfall locations is *Sublittoral sand (*A5.2), with patches of *Atlantic and Mediterranean high energy infralittoral rock* (A3.1). The sediment habitat type supports a diverse range of infauna including polychaetes, crustaceans, molluscs, and echinoderms, as well as fauna from other less abundant phyla. There will also be a range of mobile fauna present.

There will be disturbance of sediments and associated communities at breakout as sediments are moved aside by the exiting drill, creating exit pits. Some less mobile fauna is likely to be damaged or destroyed during breakout, but the area affected will be very small; the ZOI at the breakout locations will be limited to an area of several metres around each breakout. More mobile species are likely to have already moved away from the area due to the vibration from the HDD as it moves closer to the breakout and will rapidly return to the area once the activity is complete. Thus, the magnitude of the disturbance as a result of HDD breakout is considered to be negligible.

The temporary protective mattresses required at the HDD breakouts represent the largest area of temporary disturbance but, at up to 360 m$^2$ at each location, are still considered small in extent. There will also be some disturbance from anchoring and jack up barge leg footprints, though this will be limited in spatial extent and confined to the marine installation corridor. These activities could lead to some mortality for immobile species. Following removal of these structures, given the highly dynamic nature of subtidal sand habitats, sediments would be expected to recover from penetration, abrasion and disturbance, returning to baseline conditions suitable for recolonisation within a short period of time (i.e. <1 year). Disturbance here will be temporary, in a localised area only with rapid recovery and no long-term or significant effect on macrobenthic communities. The magnitude of the impact is considered to be negligible.

The habitat at the immediate breakout locations and associated area of cable installation is considered to be of low sensitivity, as sands are highly mobile and resilient to a level of natural disturbance. Coupled with their medium value, the effect has been determined to be **negligible** and therefore **not significant**.

### *Route Preparation and Cable Installation*

The activities associated with route preparation and cable installation for the offshore elements of the Marine Scheme, that have the potential to result in temporary physical disturbance to benthic habitats and species, include:

- **Cable route clearance** – prior to installation obstructions (e.g. big boulders, abandoned fishing equipment etc.) may need to be removed from the marine installation corridor. This will be achieved using one or more clearance methods, which may include a selection of methods including pre-lay grapnel across a 3m swath, a plough towed across the seabed to push boulders aside, with a swathe of 10 – 15 m, and / or a grab to clear boulders across a swathe of 10 - 25 m per cable (a total assumed disturbance width of 50 m);
- **Burial trials** – in areas of very hard or very soft seabed, it may be necessary to include trials of pre-trenching using a displacement plough and / or a mechanical trencher to determine what burial depth can be achieved; and
- **Cable installation** – cable installation will be either simultaneous cable lay and burial or surface lay followed by post-lay burial of the cable system. Post-lay burial has the potential to have a marginally greater effect because it involves two separate periods of disturbance for each activity, with mobile species returning to the area following the initial disturbance associated with cable laying. There are three generic types of equipment for burying cables into the seabed: cable burial ploughs, jetting trenchers, and tracked mechanical trenchers. The most appropriate methodology is dependent on sediment type and is therefore likely to vary along the length of the marine installation corridor.

The nature, scale, and spatial extent of temporary physical disturbance to and/or loss of subtidal habitats associated with the different burial techniques are broadly similar; however, jetting trenchers and mechanical trenchers fitted with a jetting system are likely to generate higher concentrations of suspended sediments and deposition, affecting a wider area.

Temporary disturbance from these activities will occur along the entire marine installation corridor (176 km in length). The dominant habitat type along the marine installation corridor is sand, accounting for 70 % of the total habitat, dominating the shallower areas from KP 8 to KP 65 and from KP 101 to KP 168. The deeper water region between KP 66 and KP 100 is characterised by a mosaic of mixed and coarse sediments with a small number of stations categorised as medium resemblance stony reef.

Displacement ploughs would result in the widest disturbance swathe per cable trench, at between 10 and 25 m; however, the disturbed seabed footprint due to ploughing would only be 2 to 5 m. Assuming a worst-case scenario of a disturbance swathe of up to 25 m wide per trench (which would also include any disturbance effects from cable route clearance) the total area of temporary disturbance along the whole of the marine installation corridor would be a maximum of 8.8 $km^2$ which, in comparison to the surface area of the North Sea (750,000 $km^2$), equates to <0.001 %.

At locations where cable burial cannot be achieved e.g., at cable crossings, hard ground and shallow layers of and, and where the cable needs to be stabilised and provided with protection, rock placement and cable mattresses will also be required. At these locations, there will be permanent habitat loss, which has been appraised in further detail as a separate impact pathway (Section 8.6.2.2).

Sensitivity to physical disturbance varies between habitats and receptors. For sandy sediment, particularly in shallow waters where there may be natural disturbance of the seabed from waves and tides, communities are expected to be relatively tolerant of disturbance. Most animals will be sediment dwelling and will be disturbed as those sediments are ploughed or jetted aside to an adjacent location. As sediments are displaced and backfilled there will be some mortality of larger and less mobile species but for many animals, displacement will have only a temporary impact, and fauna will be able to redistribute within the sediment as needed once the cable lay vessels have moved away. Recovery of habitats is expected to be relatively rapid.

In deeper waters, from KP 66 to KP 100, the habitats comprise mixed and coarse sediments which support benthic communities of infaunal and epifaunal species. There were some small areas of medium resemblance stony reef identified in this region, indicating the higher presence of species living on larger particles. Disturbance and mortality effects are likely to be greater in areas supporting sessile epifaunal communities as larger particles become buried and some sessile epifauna becomes smothered. However, a review of cable installation activities in similar habitats found that habitats that comprised mostly of sediments, such as subtidal sands and gravels, typically recovered swiftly after disturbance, rapidly returning to pre-construction baselines and those of adjacent unimpacted areas (RPS, 2019).

Cable installation disturbance will be temporary, limited in extent (<0.001 % of North Sea surface area) and the habitat types identified in the marine installation corridor will recover in the short term. Thus, the magnitude of the impact of temporary disturbance from cable installation is considered to be low. Combined with the low to high value of this receptor and low to medium sensitivity, the effect is therefore appraised as **minor / negligible** and **not significant.**

#### 8.6.2.2 Permanent loss of subtidal benthic habitats and species due to placement of hard substrates on the seabed

As part of the cable installation, there is a requirement to use rock protection and/or concrete mattressing within the subtidal (including nearshore and offshore zones) marine installation corridor to protect cable crossings and cable joints and in locations where the target burial depth cannot be achieved (Chapter 2: Project Description) as follows:

- **Crossings** – seven cable crossings have been identified that will require cable protection. No other infrastructure has been identified that needs to be crossed. Of the seven identified crossings, four are currently installed and three are planned. Of the three planned crossings, the crossing of Havingsten S2 is located at KP 141.4; the exact locations of the crossings of power cables for the Berwick Bank Offshore Windfarm and are currently unknown.
- **Rock placement** – rock berms will be added to some areas of the seabed where a safe burial depth cannot be achieved. The size (grade) of rock needed for a dynamically stable rock berm decreases with increasing water depths.

Hard substrates will permanently change areas of seabed including fine to coarse mobile substrates. This may lead to the permanent loss or disturbance to benthic habitats and species.

##### *Crossing of third-party assets*

Crossing protection is required for seven crossings. Crossing protection for each cable is expected to be on average 7 m wide, 1 km length and 1 m high for two non-bundled cables resulting in a maximum area of 49,000 $m^2$.

The scale of permanent habitat loss associated with cable and pipeline crossings is dependent not only on the number of crossings but also:

- The type of crossing structure;
- The burial depth of the asset which is to be crossed;
- The water depth (which dictates the size of the outer rock placement); and
- The distance from the crossing point where trenching has to stop or can start again.

Generally, the cables will cross over other infrastructure on a ‘bridge’ comprised of either a rock berm or concrete mattresses. In addition to the seven planned cable crossings, artificial hard substrates may also be added to the seabed to stabilise out-of-service cables and cable joints. The size of each concrete mattress is expected to be 18 $m^2$, with a maximum of up to 300 rock mattresses required within the marine installation corridor, resulting in a maximum area of 5,400 $m^2$. The total area of both rock berms and concrete mattresses required to protect cables and cover out of service cables and cable joints is 54,400 $m^2$.

The benthic habitat present at all the cable crossings is *Deep circalittoral sand* (A5.27), a habitat type which covers a considerable portion of the marine installation corridor. This biotope is generally characterised by an infaunal community comprising polychaetes, crustaceans and bivalves (European Environment Agency, 2019). Within this biotope, several seapens and burrowing megafaunal species, including *Pennatula phosphorea* and the *Nephrops norvegicus*, were identified within the marine installation corridor in close proximity to cable crossing locations (Fugro, 2021). However, these species had a sporadic presence, and their distribution and abundance were not found to be representative of the sensitive habitat of 'seapens and burrowing megafauna' although its potential presence in the wider area was recognised.

All habitats and species under the footprint of the cable protection would be sensitive to rock or mattress placement, with up to 54,400 $m^2$ of direct habitat loss. This is considered as a worst case, as mattresses may leave gaps between the seabed and the mattress leaving some of the sand community unaffected.

The introduction of hard substrata to soft sediments creates a 'reef effect', which is sometimes advocated as a positive anthropogenic impact as reefs generally have higher abundance, diversity, biomass and density of species, such as epifauna and crustaceans, compared to the surrounding soft sediment. Sessile organisms common to the area include sponges and ascidians, species which have been observed colonising hard structures put in place during cable installation on other projects (Kogan, et al., 2003). However, rock placement and artificial reefs do change the representativeness of the existing habitat and they also have the potential to facilitate the introduction and spread of INNS by providing hard habitat that may have previously not been available, acting as 'ecological stepping stones' (Glasby, Connell, Holloway, & Hewitt, 2007) (Inger, et al., 2009) (Adams, Miller, Aleynik, & Burrows, 2014). An appraisal of the impact of the potential introduction and spread of INNS on benthic communities has been undertaken in Section 8.6.5.2.

Although there will be habitat loss, none of the habitats or species likely to be affected by crossing protection are considered to be rare or geographically restricted. Given the prevalence of these habitats and species within the wider area and the small spatial scale of permanent losses (<0.001 % of North Sea surface area), this effect would not be expected to compromise the functional integrity of general habitats and species or diminish biodiversity at the regional scale. Although valuable habitats are potentially present (seapens and burrowing megafauna) within sections of cable protection, any loss would be highly localised and small in scale, limited to isolated areas. Although seapens and burrowing megafauna such as *Nephrops norvegicus* are highly intolerant to substrate loss, they show moderate recovery, provided there is still suitable substrate remaining nearby (Hill & Wilson, 2000).

Compared to the extent of the habitat *Deep circalittoral sand* (A5.27) elsewhere in the North Sea and the small-scale loss, the magnitude of impact is predicted to be negligible. Combined with the medium value of this receptor and low to medium sensitivity, the overall effect is appraised as **negligible** and therefore **not significant**.

#### *Rock placement*

Rock protection will be required at specific locations to protect the cable where the target burial depth cannot be achieved (see Chapter 2: Project Description). A total of 52.17 km of the route has been identified as requiring rock protection. A further 7 km of protection will be required for crossings per cable and an additional 1.8 km of additional remediation. The height and width of these berms will be kept to a practical and safe minimum, typically, a height of 0.5 m to 0.8 m, with a width of 6 to 7 m.

The actual level of rock placement varies depending on seabed conditions and not all of the identified areas will need full coverage by rock. Categories 2, 3, 4 and 5 (25%, 50%, 75% and 100% coverage respectively) have been used to distinguish different levels of rock protection required at each location (Chapter 2: Project Description). When considering these percentages, 34.5 km of rock berm is anticipated to be required for the protection of the each of the cables.

All estimates of habitat loss in this appraisal, as reported in Table 8-9, are worst-case estimates based on full rock coverage and maximum berm size and excluding contingency.

**Table 8-9: Summary of length and area of rock placement and habitats affected**

| EUNIS code | EUNIS Biotope Description | Estimated length of habitat loss beneath rock placement (km) | Total estimated area of habitat loss beneath rock placement ($km^2$) for 2 cables | % Area of marine installation corridor (total = 88 $km^2$) for 2 cables |
|---|---|---|---|---|
| A5.45 | Deep circalittoral mixed sediments | 19.29 | 0.270 | 0.31 |
| A5.27 | Deep circalittoral sand | 14.85 | 0.208 | 0.24 |
| A5.15 | Deep circalittoral coarse sediment | 5.63 | 0.079 | 0.09 |
| A5.45 / A5.27 | Deep circalittoral mixed sediments / Deep circalittoral sand | 4.71 | 0.066 | 0.07 |
| A5.44 | Circalittoral mixed sediments | 2.71 | 0.038 | 0.04 |
| A5.44 / A4.2 | Circalittoral mixed sediments / Atlantic and Mediterranean moderate energy circalittoral rock | 1.76 | 0.025 | 0.03 |
| A4.21 | Echinoderms and crustose communities on circalittoral rock | 1.71 | 0.024 | 0.03 |
| A5.14 | Circalittoral coarse sediment | 0.73 | 0.010 | 0.01 |
| A5.2 | Sublittoral sand | 0.45 | 0.006 | 0.01 |
| A4.2 | Atlantic and Mediterranean moderate energy circalittoral rock | 0.31 | 0.004 | 0.00 |
| A3.1 | Atlantic and Mediterranean high energy infralittoral rock | 0.01 | 0.000 | 0.00 |
| A5.26 | Circalittoral muddy sand | 0.01 | 0.000 | 0.00 |
| **TOTAL** | | **52.17** | **0.730** | **0.83** |

The habitats that would lie directly underneath the proposed rock placement locations are presented in Table 8-9. *Deep circalittoral mixed sediments* (A5.45) is the habitat estimated to have the highest amount of rock placement (0.31 % of marine installation corridor). Mixed sediment comprises mud, sand and gravel and as such supports both infaunal and epifaunal invertebrates. Consequently, mixed sediment habitats tend to have a high diversity of species including polychaetes, bivalves, soft corals, crustaceans and echinoderms as well as more unusual epifaunal organisms such as anemones, phoronids, hydroids and bryozoans.

The width of the rock placement berm, for each of the two cables, is assumed to be up to 7 m and the rock placement methodology, using fall pipe technology, will ensure accurate placement of material on the seabed. Thus, the potential worst-case loss of mixed sediment habitat is estimated to be 0.40 $km^2$ (Table 8-9). It should be noted that wherever possible the installation will be micro-sited around rock habitats during the design phase. The materials placed on the seabed would, wherever possible, be of a similar grading to the existing seabed, where the existing substrate is mixed and coarse sediment.

A period of between 2 and 4 years is generally considered a likely time for recovery of communities in coarse sediments, such as gravel, that are subject to significant disturbance through activities such as dredging (Newell, Seiderer, & Hitchcock, 1998). Colonisation of rock placement areas will attract species known to occur in other habitat patches in the marine installation corridor and the wider North Sea and so colonisation is expected to occur soon after installation. As the material used will be similar to the existing habitat, comprising coarse sediments, the communities that develop in these small areas of cable protection will also be similar.

Where rock protection is required in sandy sediment areas there is likely to be a shift to a more epifaunal community. The introduction of hard substrata to soft sediments such as sand, creates a 'reef effect', which could be regarded as a positive anthropogenic impact as it can increase local biodiversity. However, there this will be a modification of the natural habitat and the introduction of larger particles has the potential to facilitate the introduction and spread of INNS by providing ideal habitat that may have previously not been available, acting as 'ecological stepping stones' (Glasby, Connell, Holloway, & Hewitt, 2007) (Inger, et al., 2009) (Adams, Miller, Aleynik, & Burrows, 2014). The impacts of the introduction and spread of INNS on benthic communities is described in Section 8.6.2.6.

The area of sand habitat requiring rock placement is estimated to be a maximum of 0.28 $km^2$, which is a very small percentage of this habitat type within the marine installation corridor (Table 8-9) and the central North Sea more widely. As such, the magnitude of the change is negligible. Combined with the medium value of this receptor and low sensitivity the effect is therefore appraised as **negligible** which is **not significant**.

The habitats *Echinoderms and crustose communities on circalittoral rock*, *Atlantic and Mediterranean high energy infralittoral rock* and *Atlantic and Mediterranean moderate energy circalittoral rock* are associated with areas of sensitive stony reef habitat, with brittlestars *Amphiura filiformis* and sea urchin *Echinocyamus pusillus* dominating fauna. Direct effects and loss of habitat due to rock placement would result in mortality of individuals (Hill & Wilson, 2008). Faunal and algal crusts have very little resilience to physical disturbance and loss of/changes to habitat (Stamp & Tyler-Walters, 2016). Approximately 0.03 $km^2$ of these more sensitive habitats will be subject to rock placement (approximately 0.06 % of the marine installation corridor) (Table 8-9).

Potential recoverability of stony habitats is considered to be moderate given that alternative suitable habitat is available nearby and, considering the presence of large particulate material present in stony reefs, the rock placement will be able to support some of the same epifaunal species. However, given the localised loss of habitat, the scale of change is also expected to be small. Therefore, the magnitude of this impact on potential stony reef is expected to be negligible. Combined with the medium value and sensitivity of this receptor, the effect of rock placement on potential stony reef habitat is expected to be **negligible,** and therefore **not significant.**

Bedrock has been identified in three locations for rock placement (KP 0.74, KP 2-KP 5 and KP 173), where category 5 rock placement is proposed, which has the potential to physically disturb a very small and localised area of bedrock reef. However, it is thought that bedrock reef would pose difficulties during cable installation, and therefore wherever possible the cable will be micro-routed around the habitat. Therefore, the magnitude of impact on any bedrock reef is expected to be negligible. Combined with the medium value and sensitivity of this receptor, the effect of rock placement on bedrock reef is expected to be **negligible,** and therefore **not significant**.

No habitats in the marine installation corridor were classified as the biotope *Seapens and burrowing megafauna* (A5.361) though there are some areas where rock placement is required that were noted as habitats that included these species but presence was sporadic along the marine installation corridor (Fugro, 2021). Although rock placement would result in direct loss of this sensitive habitat, the small area of loss would be small and highly localised, which would most likely be characterised by low quality examples of this habitat. Burrowing megafauna such as *Nephrops norvegicus* are highly intolerant to substrate loss, but they show moderate recovery, provided there is suitable substrate nearby (Hill &

Wilson, 2000). The magnitude of this impact on potential sand and mixed sediments is expected to be negligible. Combined with the low to high value of this receptor, the impact of rock placement is expected to be **minor / negligible** and therefore **not significant**.

Considering the effects of rock placement on subtidal benthic habitats and species as a whole, although the value of species characterising the biotopes and sensitive habitats present ranges between low and high, the areas affected are very small relative to the scale of these habitats and biotopes elsewhere in the North Sea. Therefore, the magnitude of impact is predicted to be low. When combined with the low to high values of all receptors considered in this impact appraisal, the overall effect of rock placement on subtidal benthic habitats and species is predicted to be **minor,** and therefore **not significant**.

#### 8.6.2.3 Temporary increase in suspended sediment concentrations (SSC) and sediment deposition leading to contaminant mobilisation, turbidity, and smothering effects

The following installation activities associated with the preparation and installation of the Marine Scheme will result in physical disturbance to the seabed:

- **Cable route clearing** – in specific identified regions, a swathe of between 5 m and 10 m width will be cleared of surface boulders, using a plough or grabs. There will also be a pre-lay grapnel run to remove any debris in the cable corridor;
- **Pre-installation trenching** – this is required only at the landfall locations, in a section of up to 200 m in length from the breakout point; and
- **Cable installation** – the cable installation method will vary along the route, depending on seabed conditions. Thus, installation will involve a mixture of ploughing, jet trenching and mechanical trenching.

There were no sand waves substantial enough to require clearing/sweeping prior to installation and so no requirement for pre-sweep dredging has been identified for the Marine Scheme.

This disturbance has the potential to increase suspended sediment concentrations (SSC) and turbidity, creating a sediment plume in the water column that can travel away from the marine installation corridor before the sediment is deposited on the seabed.

There are several potential effects to benthic receptors, associated with increased SSC and sediment deposition including:

- Reduced photosynthesis resulting in reduced primary production in marine seaweed and algae;
- Smothering of invertebrate species and clogging of respiratory apparatus;
- Reduced success of filter feeding in invertebrates by clogging of feeding apparatus; and
- Indirect effects of the release of sediment contaminants, such as heavy metals and hydrocarbons, on benthic species.

***Increased SSC and sediment deposition***

The largest sediment plumes and highest levels of SSC will be associated with disturbance of sediments with a high proportion of fine particulate material, such as muds and clays, that will remain in suspension longest and settle to the seabed more slowly.

The Marine Scheme is characterised by a range of different seabed types but is dominated by long stretches of sublittoral sand (KP 101-168), a mosaic of sublittoral sand with small patches of mixed sediment (KP 8-65) and an extensive region of mixed and coarse sediments (KP 65-101) in deeper waters (Fugro, 2021). Coarse material such as gravel is expected to settle quickly i.e. within a few hours of disturbance, with the sediment plume extending to only tens of metres from the source. Finer sediments such as fine sand, silt and clay are expected to produce a more persistent plume lasting up to a few days depending on the duration of disturbance. Mean PSA across stations sampled across the marine installation corridor recorded an average of 16.82 ± 14.63 % silt compared to 73.51 ± 19.12 %

sand (Fugro, 2021), suggesting the majority of the sediment particles are larger and will therefore settle to the seabed within hours.

Calculations have been undertaken to estimate the extent of sediment dispersion before deposition as a result of trenching activities. The method for these calculations, and the results, are reported in further detail in Chapter 7: Physical Environment.

The distance travelled by suspended coarse sand, typical of the majority of the sediments affected, before deposition, is expected to be around 200 m. Fine sands, silts and clay may, however, be transported beyond the marine installation corridor with any fine sand settling on the seabed up to 1.4 km from the point where it is mobilised. Based on the calculated settling velocities silt-sized material could remain in suspension for several days and may therefore travel significant distances. However, given the small proportion of fine sediment, primarily located between KP 120 – 162, and that dispersion processes will also act to dilute the concentration of silt carried in suspension, elevated concentration levels at 1.4 km from the source will be negligible. It is considered that there will be no significant elevated concentration levels beyond the travel distance calculated for fine sand which corresponds to a maximum 1.4 km from the point of mobilisation within the marine installation corridor.

Based on these calculations, any measurable change in suspended sediment concentrations will be temporary and localised, i.e. mostly within the bottom 5 m of the water column. The finer fractions that are transported further also be rapidly diluted so that the suspended sediment concentration will be low and the deposition thickness on the seabed, where the sediment will settle, will be negligible.

The potential effects on each of the habitat types that have been identified within or have the potential to occur within the marine installation corridor, are considered separately below.

#### *Stony reefs and bedrock reefs*

Small patches of low to medium resemblance stony reef were also identified within both landfall nearshore areas (KP 0 to KP 2.26 and KP 173.90 to KP 176.25). Patchy bedrock habitats were also identified in the vicinity of the English landfall (KP 162.39 to KP 168.38). However, these areas were considered outside the immediate breakout locations.

Sessile assemblages such as coral, sponges and ascidians associated with both stony and bedrock reefs will be unable to avoid increases in SSC. *Alcyonium digitatum* was associated with many sections which were described as having low and medium resemblance to stony reefs. Although species such as these are sessile, their height (up to 20 cm in some cases) results in low sensitivity to turbidity and smothering (Budd, 2008). The duration of any sediment plumes will be dependent on the sediment composition in which the activity is occurring. Given the patchy nature of these rocky habitats, the presence of high proportions of large particles, and the travel distance calculated for SSC, the magnitude of impact to stony reefs in considered to be negligible. The value of this receptor would typically be considered as being medium. However, the examples along the cable installation corridor are only considered to have low and medium resemblance to stony reefs, and, as such, are usually associated with lower biodiversity and abundance compared to those with high resemblance. This, coupled with the dispersal of sediment by water movements in the coastal area and likely high tolerance of such assemblages to turbid conditions and smothering mean the effect of SSC is considered to be **negligible** and therefore **not significant**.

#### *Seapens and megafauna burrowing communities*

Several locations in the deeper waters of the marine installation corridor were observed to support the seapens *Pennatula phosphorea* and *Virgularia* spp. Although sessile organisms such as seapens are unable to avoid SSC and sediment deposition they appear relatively insensitive to smothering and turbid conditions, with quick recovery rates reported where there are short-term changes in conditions (Hill, Tyler-Walters, & Garrard, 2020). Burrowing megafauna associated with this community include *Nephrops norvegicus*. Individuals and burrows of this species were identified during the benthic survey, but occurrence was sporadic. This species can burrow down to depths of 20-30 cm (Bell, Redant, & Tuck, 2006), suggesting that small-scale increases in deposition will not pose a major risk to this species. The expected short-term increase in SSC and smothering associated with cable installation would result in a low magnitude effect, and given the species' insensitivity to smothering, despite its high value, the effect would be **negligible** adverse effect and therefore **not significant**.

### *Sabellaria spinulosa reef*

Thin crusts of the tube-building Ross worm *S. spinulosa* were found within the marine installation corridor, approximately 1.3 km from the English landfall and were also identified in high abundance at a small number of stations. However, at none of the stations or DDV transects were these considered to be reef habitats. While also acknowledging that where *S. spinulosa* occurs there is also potential for reef habitat to occur, further consideration is given to potential effects below.

The Ross worm requires a supply of suspended sediment sufficient for feeding and tube formation activities, meaning they thrive in turbid conditions. It has been reported that *S. spinulosa* are likely to be able to tolerate 5 cm of sediment deposition over several weeks, which suggests their adaptability to sediment deposition is high (Holt, Rees, Hawkins, & Seed, 1998) (Jackson & Hiscock, 2008).

Given the expected short-term duration of cable installation activities and the quick dispersal and settlement of coarser sediment plumes, which account for most sediments affected, the magnitude of impact to *S. spinulosa* is considered negligible. This receptor is of medium value but with low sensitivity to increased SSC and depositional loads, the overall impact is predicted to be **negligible** and therefore **not significant**.

### *Less sensitive communities*

The most common habitat in the marine installation corridor, accounting for around 70% of the habitats, was sublittoral sand (Fugro, 2021). This habitat supports infaunal communities but there may also be some mobile species including crustaceans and echinoderms. SSC and depositional loads will vary along the marine installation corridor depending upon the local environmental conditions. The infaunal communities that dominate this habitat type are generally tolerant of the levels of SSC and sediment deposition anticipated to result from construction of the Marine Scheme and therefore it is expected that they will have a good capacity to quickly recover. As a result, this receptor is considered of low sensitivity. The short-term and highly localised increases of SSC, turbid conditions and smothering are considered to be of low magnitude. The overall effect is considered to be **negligible** and therefore **not significant**.

### *Mobilisation of contaminants*

Contaminants, such as heavy metals and polycyclic aromatic hydrocarbons (PAHs), present in concentrations above thresholds of concern, could have detrimental impacts on benthic species when resuspended into sediment plumes or redeposited to the seabed. For example, hydrocarbons in sediments are known to reduce the abundance of some species, particularly crustaceans such as amphipods.

Project specific sediment chemistry analysis found all heavy metals and hydrocarbons to be present in low concentrations, with the exception of a small number of stations where some thresholds for one or more of the following metals – arsenic, nickel, chromium and lead – exceeded the Cefas Action Level 1 threshold or the Canadian threshold effect levels (TEL) [8]. (Fugro, 2021). No heavy metal concentrations exceeded Cefas Action Level 2 though there were two stations where the concentration of arsenic was above the Canadian PEL threshold. However, metal concentrations were within background levels reported from a Marine Scotland monitoring station in the Firth of Forth and a Clean Safe Seas Environmental Monitoring Programme (CSEMP) station at Tyne/Tees (Fugro, 2021) indicating that these levels of contamination are typical for North Sea sediments.

There were no stations with levels of hydrocarbons above quality standards but there were a number of Canadian PEL thresholds exceeded for PAHs, though this was limited to a single station (ST37) at

[8] In the absence of Environmental Quality Standards for in situ sediments in the UK, the above guidance has been used to help inform a 'Weight of Evidence' (WoE) approach to assess whether benthic ecology is at risk from concentrations of toxic contaminants.

KP162. The concentration of the heavy metals' arsenic, chromium, nickel and lead were also elevated at this station but were below Cefas Action Level 1.

Contaminants will be associated with finer material such as silts and clays, which are limited within the mostly coarse sediments within the marine installation corridor. Where finer sediments do occur, the potential for mobilisation of contaminants is limited, in the same way as the mobilisation of the sediments themselves will be limited, as set out in Section 8.6.2.3. In addition, dilution of suspended particulate matter, is anticipated to occur rapidly. Thus, the concentration of contaminants is not expected to exceed the background levels reported from the Firth of Forth and the Tyne/Tees monitoring stations. In addition, natural disturbance to the sediment such as during storm events and periods of strong wave action will mobilise contaminants and subject benthic habitats and species to temporary and localised changes in water quality and as a result, these habitats and species will have a tolerance to moderate changes in the surrounding water quality. These factors mean that the resulting magnitude of effect will be negligible. Irrespective of the value and sensitivity of benthic species, it can therefore be concluded that the effect on benthic receptors from the disturbance of sediment-bound contaminants is also **negligible** and therefore **not significant**.

### 8.6.2.4 Changes to marine water quality from the use of HDD drilling fluids

Operational discharge of drilling fluids from HDD works at the breakout location of the marine installation corridor has the potential to alter water quality and affect benthic habitats and ecology at each of the landfall locations.

During HDD works the estimated discharge to the sea per borehole is up to 2,000 $m^3$ of fluid and up to 80 $m^3$ of solids giving an estimated maximum of 12,000 $m^3$ of fluid and 480 $m^3$ of solid discharged from the six drills at each landfall. These will be located at a water depth of between 4 m and 10 m below chart datum at both HDD breakout locations (see Chapter 2: Project Description). The drilling fluid discharges from the Marine Scheme's HDD operations will be single events over a short period of time and rapidly dispersed in the shallow, open sea coastal environment.

Drilling fluids will be selected from the OSPAR List of Substances/Preparations Used and Discharged Offshore which are Considered to Pose Little or No Risk to the Environment (PLONOR). Industry standard drilling fluids and additives required during the HDD operations will also be biodegradable. For example, the most widely used fluid, bentonite, consists predominately of clay minerals. This PLONOR substance is generally considered to be an inert, and generally non-polluting substance. Bentonite is also not listed under the Environmental Quality Standards Directive.

To be included as a PLONOR substance there must be clear evidence of low bioaccumulation (log POW < 3 or BCF < 100 or molecular weight > 700 g/mol), low toxicity (LC50 or EC50 > 100 mg/l) of the substance, and it must be readily biodegradable (OSPAR, 2019). A review by Aslan et al. (2019) found no evidence of a lethal response or reduced survival in bivalve molluscs or crustaceans, in conditions representative of realistic concentrations for discharges in an open marine environment such as the open coasts where the breakouts are located.

Embedded mitigation measures will be implemented to minimise the release of drilling fluid leaks from the end of the ducts (Section 8.6.1). The discharged drilling fluids will also be subject to immediate dilution and rapid dispersal within the marine environment, particularly as the release will be in the shallow nearshore area where there is likely to be significant wave and tidal water movement.

The drilling fluid discharges from the Marine Scheme's HDD operations will be single events over a short period of time and rapidly dispersed in an open sea coastal environment. Only receptors in the immediate vicinity of the HDD breakouts are likely to be in contact with drilling fluids, which pose little risk to the environment. Overall, the magnitude of impact on benthic receptors is low and effects are predicted to be **negligible** and therefore **not significant**.

### 8.6.2.5 Accidental leaks and spills from vessels, including loss of fuel oils

The accidental release of pollutants (e.g. oil, fuels, lubricants, chemicals) could occur from any of the vessels associated with the cable lay operations and any support vessels present during cable installation. Vessels involved in cable lay operations could have cleaning fluids, oils, and hydraulic fluids onboard (as well as fuels), which could be accidentally discharged, releasing hydrocarbons and chemical pollutants into the surrounding seawater, which could then settle on the seabed with consequences for benthic habitats and species.

The benthic habitats within the Marine Scheme route are primarily dominated by areas of sand, and coarse sediment with patches of mud. Of these, several NERC (2006) priority habitats have identified: *Deep circalittoral mud* (A5.37*), Deep circalittoral sand* (A5.27), *Deep circalittoral coarse sediment* (A5.15), *Deep circalittoral mixed sediments* (A5.45), and *Faunal communities on deep low energy circalittoral rock* (A4.33).

These habitats support diverse communities of benthic invertebrates, which can be highly susceptible to effects from spills, as contaminants can settle into and remain in the sediments. Studies have indicated that benthic sediments contaminated with oils and hydrocarbons can contribute to reduced densities of macrofauna, as well as differences in recruitment and development of assemblages (Berge, 1990; Stark, Snape, & Riddle, 2003). However, these effects are related to extensive spills such as from large oil tankers rather than small spills from other vessels.

Although benthic habitats and species would be sensitive to the accidental release of pollutants, there is considered to be limited potential for accidental spills to occur during the installation of the Marine Scheme. Firstly, there will be relatively few large vessels involved in route preparation and cable installation works, and potential pollutants would be limited to relatively small volumes of engine diesel oil and fuels, and any materials held on the deck, and so any spills would be relatively minor in extent. Evidence shows that most of the accidental oil and chemical releases in UK waters are associated with wells and hydraulic systems rather than vessels involved in cable installation (OGUK, 2019).

The most recent analysis of marine pollution from the Advisory Committee on Protection of the Sea (ACOPS, 2017) indicated 644 incidents of accidental discharge. Most (>400) occurred in relation to UKCS oil and gas installations, with only seven being attributed to offshore support vessels.

To ensure the risk of accidental spills is as low as reasonably practicable (ALARP), the project will undertake a risk assessment and produce environmental management and contingency plans as a matter of course. Health, Safety, and Environment (HSE) procedures will also be implemented, with strict weather and personnel limits to reduce any risk of accidental spillage. Furthermore, preparedness and swift response is essential for effective spill management and as such, response plans will be in place should an incident occur. Details of embedded mitigation are presented in Section 8.6.1 above and in Chapter 2: Project Description.

Thus, the risk of an accidental spill occurring is considered to be unlikely. Should an accidental spill or leak occur, it would be very small in extent and subject to immediate dilution and rapid dispersal within the marine environment and thus would have only a low magnitude. Thus, the overall appraisal of the effect to benthic ecology from accidental leaks and spills from vessels and equipment is appraised to be of **minor** risk and therefore **not significant**.

### 8.6.2.6 Accidental introduction of invasive non-native species (INNS)

The accidental introduction of INNS, such as from international vessels' ballast water, has the potential to cause detrimental changes to benthic habitats. Whilst most non-native species are unlikely to become invasive, those that do can out-compete native species and introduce diseases which could result in significant changes to community composition and mortality. The introduction of INNS could occur from the different vessels that may be required during various phases of the Marine Scheme.

If INNS were to be introduced by vessels, the effect on benthic habitats could be significant and long-term. For this reason, all project vessels will adhere to the International Convention for the Control and Management of Ships' Ballast Water and Sediments with the aim of preventing the spread of INNS (IMO, 2022). These measures lower the probability of INNS transmission from vessels to the benthic habitat. If IMO measures are followed, the risk of INNS introductions is considered to be unlikely and as such, subsequent effects are not considered further.

Rock placement and concrete mattresses are proposed for a number of locations along the marine installation corridor, to protect the cable in areas where the target burial depth cannot be achieved. They will also be used at intersections with other cables or pipeline infrastructure. These artificial hard structures can function as artificial rocky reef, which are known to be preferred habitat for many INNS acting as 'ecological stepping stones' (Adams, Miller, Aleynik, & Burrows, 2014). This could facilitate the colonisation and spread of INNS in areas of the benthos which may have previously been unsuitable.

Rock placement is proposed in 21 areas along the cable route, and at seven crossings locations (Chapter 2: Project Description). This means there is the possibility for hard substratum to be available for colonisation by marine fauna, including the potential for INNS to be introduced, at these locations along the marine installation corridor. A large proportion of the rock placement at the offshore locations along the cable route is proposed in soft sediment, with some also proposed in gravel and cobble substrate and on bedrock near the English landfall. The introduction of artificial hard substrate to areas otherwise characterised by fine to coarse mobile substrates will alter the localised benthic habitat and could facilitate the introduction and spread of new INNS. However, to date, no spread of INNS caused by subsea cabling has been documented, though this remains a concern given the exponential growth of marine infrastructure in the North Sea.

The GB Invasive Non-Native Species Strategy provides guidance for the prevention, detection, eradication and management of INNS, including marine species (NBN, 2021). Best practice measures will be adopted, in particular, compliance with the relevant IMO guidance regarding ballast water. These measures will reduce the overall risk of introduction.

The non-native polychaete species, *Goniadella gracilis*, was identified in the Marine Scheme benthic survey (Fugro, 2021) at one of the proposed rock placement locations. However, as this species prefers sandy sediment habitats it is not thought that the placement of rock would facilitate the proliferation of this species. No other INNS were identified in the study area and so the risk of the spread of any existing non-native species is considered unlikely.

The introduction and subsequent risk of non-native invasive species is appraised to be unlikely and any associated effects are considered **minor** and therefore **not significant.**

### 8.6.3 Operation (including maintenance and repair) Phase

#### 8.6.3.1 Potential effects on benthic habitats and species due to subsea cable electromagnetic field (EMF) emissions

The design for the Marine Scheme comprises two HVDC cables laid either in two separate parallel trenches (unbundled) or else in a single trench with the cables bundled together. If the two-trench approach is used the cables will be spaced 30 m apart (referred to as a '30 m separated bipole'). For both approaches the target burial depth is 1.5 m and the minimum depth without cable protection will be 0.6 m. In a two-cable configuration the distance between the cables generates a stronger magnetic field than that generated by a bundled, single-trench configuration (Hutchison, Gill, Sigray, He, & King, 2021). Therefore, the appraisal considers the 2-trench scenario only, as the worst-case situation that will also encompass any potential effect should the cables be bundled.

Modelling completed for the Marine Scheme provides data on the level and attenuation of the EMF emissions for both possible design options (see Chapter 2: Project Description). The modelling accounts for cable configuration, the design of HVDC cable, and the properties of electromagnetic fields in water (magnetic fields attenuate rapidly in water) with and without the influence of background geomagnetic fields. These estimates indicate that EMF from a 30 m separated bipole configuration, buried at a depth of 1 m reduces to background levels at a distance of 20 m from the cable, both vertically and horizontally.

There is very little information about the sensitivity of benthic species to EMF but there have been a small number of investigations in laboratory experiments. For example, it has been shown that in addition to visual and hydrodynamic cues, the spiny lobster *Panulirus argus* uses the Earth's magnetic field to orient (Boles & Lohmann, 2003). This lobster is a Caribbean species, but it suggests some crustaceans have the ability to detect EMF. In another study, the blue mussel, *Mytilus edulis*, the brown shrimp, *Crangon crangon* and the crab, *Rhithropanopeus harrisii*, were all exposed to a static B-field of 3.7 µT (37 G) for several weeks. No differences in survival between experimental and control animals was detected (Bochert & Zettler, 2004). In a more recent laboratory study, Scott et al. (2021) found behavioural responses to EMF in the edible crab *Cancer pagurus*, exposed to EMF over 24 hours at strengths of 500 and 1000 µT. The crabs showed a clear attraction to EMF at these levels, with a significant reduction in time spent roaming. However, at 250 µT the EMF exposure was found to have limited physiological and behavioural impacts, indicating a possible strength dependent response. The EMF strength at the cable for the Marine Scheme is predicted to be 400 µT, reducing to less than 200 µT a metre away from the cables. In enclosure experiments with the lobster *Homerus americanus*, around an active HVDC cable, behavioural responses were observed but these were subtle, and no significant difference was observed in the total distance travelled or speed of movement (Hutchison, Gill, Sigray, Haibo, & King, 2020).

Therefore, it appears some detection in benthic invertebrates may be possible but there have been no negative impacts observed at the EMF levels predicted for the Marine Scheme, with most animals having the ability to move away from any effects. Thus, whilst EMF will be emitted whenever the cable is active, and is therefore a permanent impact during cable operation, the spatial extent is very small and impacts are restricted to small short-term behavioural responses. Thus, the magnitude of the impact is considered to be negligible. Thus, the effect of EMF in relation to benthic ecology is appraised as **negligible** and therefore **not significant**.

#### 8.6.3.2 Potential effects on benthic habitats and species due to subsea cable thermal emissions

Both high voltage AC and DC submarine power cables have been shown to generate and dissipate heat when active, reaching cable surface temperatures of up to 70°C (Emeana, et al., 2016). Such heat has the potential to cause sediment dwelling and demersal mobile organisms to move away from the affected area. Increased heat may also alter physico-chemical conditions and bacterial activity in surrounding sediments, contributing to altered faunal composition and localised ecological shifts (Meissner, Schabelon, Bellebaum, & Sordyl, 2008). While the full effect of temperature changes on sediment composition and related biogeochemical cycling are unknown, preliminary studies have indicated shifts in bacterial community composition with increased temperatures, with corresponding changes in $NH_4$ concentration and nitrogen cycling (Hicks, et al., 2018).

Sediment particle size composition has been found to influence heat transfer, with coarse silts experiencing the greatest temperature change, but to a shorter distance from the source, while fine and coarse sands had a lower temperature change but a greater affected distance (Emeana, et al., 2016).

The Marine Scheme cable design comprises two HVDC cables, installed either in a 30 m separated bipole or bundled together in a single trench. Heat dissipation modelling for bundled cables buried at a depth of 1.5 m indicates that within 50 cm of the seabed surface the increase in sediment temperature is limited to approximately 3°C which has been calculated based upon a maximum seabed ambient surface sediment temperature of 15°C (Chapter 2: Project Description). For unbundled cables the heat profile of each individual cable at the surface may be lower but the affected area will be around two cables, rather than one.

A range of sediment types have been classified within the Marine Scheme, with the majority classified as coarse sediment and sand. These contribute to a wide variety of habitats and biotopes, which support a range of infaunal and epifaunal benthic organisms, including polychaetes, crustaceans, bivalve molluscs and echinoderms. Increased sediment temperature has the potential to affect infaunal species and assemblages directly, however, whilst the sediment surrounding the cable may be heated there is negligible capability to heat the overlying water column because of the very high heat capacity of water, meaning there would be little or no effect on epifauna.

Of the biotopes and habitats present within the marine installation corridor, several habitats and species of conservation importance have been identified: stony reefs, bedrock reefs, seapens, *Nephrops*, *Sabellaria spinulosa* reefs, and the burrowing anemone *Edwardsia timida*. Of these, only the seapens, *Nephrops* and burrowing anemones are found within the sediment itself.

Stony, bedrock and biogenic reef habitats arise from the seafloor and host a range of mobile and sessile epifaunal species (Irving, 2009; JNCC, 2011). Survey data from the marine installation corridor indicate that there are areas of low to medium resemblance to stony reef and patches of bedrock. Some *Sabellaria spinulosa* was observed, with high abundance at only 2 of the 46 stations, but in all areas only thin crusts on gravel were identified. These habitats support macrofauna that live on or above the surface of the seabed, which any minor heating effects in the sediment around the cable will not affect. Therefore, the effects on reef habitats and species have been deemed **negligible** and therefore **not significant**.

At a sediment depth of 50 cm the temperature increase is predicted to be approximately 3°C. However, as most species living within the sediment will only occur in the top 10 to 20 cm the temperature increase experienced by any fauna present will be less than this. Most infaunal species are mobile, and all will have the opportunity to move away from the area of temperature increase after activation of the current. The fauna will become redistributed and whilst there may be a lower abundance of animals directly above the cable this will be very localised, within a metre or so, and affect only local distribution rather than the overall diversity of fauna present within the wider marine installation corridor. Also, sediment temperature does change seasonally, though to a much lesser extent than the water column, and so some animals may tolerate an increase in temperature of a degree or two, without the need for avoidance behaviour. Thus, for a receptor of low to medium sensitivity and an effect of negligible magnitude the impact for infauna species and communities is appraised to be **negligible** and therefore **not significant.**

It is also noted that there are important fisheries for *Nephrops norvegicus* located in the study area, distributed according to the extent of cohesive muddy sediments, in which they construct their burrows (Howard, 1989) (see Chapter 14: Commercial Fisheries). These sediment conditions allow the excavation of an often extensive but shallow system of branching unlined *Nephrops* burrows (Atkinson, 1974). Burrow systems have multiple branches and are generally fairly shallow, to a depth of 20 cm where any increase in sediment temperature will be minimal. In addition, the burrow system is regularly flushed with water, from both the behaviour of *Nephrops* and natural water movement. This water movement is expected to increase heat dissipation. The magnitude of impact is predicted to be negligible, coupled with the low value of this receptor, the effect on *Nephrops* is considered **negligible** and **not significant**.

Seapens are also found in similar sediment types to *Nephrops,* while burrowing anemones, such as *Edwardsii timida,* were also sporadically observed at several locations in the marine installation corridor. Such species have part of their body buried in the sediment but only in the upper layers where any thermal effects will be **negligible** which is **not significant**. These species are relatively sedentary but can move, for example in response to disturbance or to avoid unfavourable conditions. Thus, these species can also avoid any highly localised effects.

In summary, although thermal effects would be long-term, occurring continuously for the operational lifetime of the Marine Scheme the temperature increase is low level, likely to be only a few degrees higher than ambient at the shallow depths at which these burrowing species are found. Coupled with the fact that any impacts would be highly localised, the overall magnitude of impact on benthic species is considered to be negligible. Although the sensitivity of the benthic communities has been appraised to be between low and high, depending on their conservation status, the effect of thermal emissions from the Marine Scheme, on benthic ecology, is predicted to be **negligible** and therefore **not significant**.

#### 8.6.3.3 Maintenance and Cable Repair Effects

Maintenance activities and cable repair, where required, will be carried out using the same or similar methods as cable installation, and therefore the potential pathways for impact to benthic ecology would be the same as those identified for the cable installation phase of the Marine Scheme.

Repair works are likely to be highly localised to the area of concern and therefore the spatial extent of any impacts would be small in extent. Furthermore, any maintenance or repairs works would be anticipated to take no more than several weeks to complete meaning the duration of impact would also be short.

The only exception is where rock protection would be required as part of maintenance and cable repair works to achieve cable reburial. In the event additional placement of rock, concrete mattresses or grout bags on the seabed are required to achieve reburial of the subsea cable, further permanent physical disturbance to and/or loss of benthic habitats would likely arise.

The marine installation corridor will be routed to avoid any unstable habitats and to achieve the precautionary target burial depths as much as possible. However, a detailed review of rock placement requirements has already been undertaken and the need for additional cable protection as part of maintenance and cable repair works are not predicted to fall beyond the estimated volumes during installation and the significance of permanent physical disturbance effects remains as reported for cable installation.

Maintenance and unforeseen cable repair (although unlikely) are routine, and the procedures and processes are well defined and common in the industry. Impacts of maintenance and cable repair works would be of smaller magnitude than cable installation, and the effect is predicted to be **negligible** and therefore **not significant**.

### 8.6.4 Decommissioning Phase

At the end of the operational life of the cable the options for decommissioning will be evaluated and taking into consideration with other Project constraints (e.g. safety and liability), with the least environmentally damaging option chosen if possible.

The principal options for decommissioning described in Chapter 2: Project Description are:

- Leave the cable *in-situ*, buried;
- Leave *in-situ* and provide additional protection where exposed;
- Remove sections of the cable that present a risk; or
- Remove the entire cable.

Should full removal from the seabed be required, this would have the potential to cause similar impacts to the cable installation phase of the Marine Scheme.

Thus, as a worst-case scenario, impacts during decommissioning may be of a similar magnitude to cable installation, depending upon the decommissioning option chosen. Therefore, as a worst case, the effects on benthic ecology are predicted to be **negligible / minor** and therefore **not significant**.

## 8.7 Mitigation and Monitoring

No significant effects are predicted on benthic ecology receptors as a result of the marine installation, operation (including maintenance and repair) and decommissioning; therefore, no additional specific mitigation measures are required.

## 8.8 Residual Impacts

As no additional mitigation was required because there were no likely significant effects on benthic ecology identified, the residual effects of the Marine Scheme remain as reported in Section 8.6.

## 8.9 Cumulative and In-Combination effects

The full cumulative and in-combination effects appraisal is presented in Chapter 16: Cumulative and In-Combination Effects.

This includes a matrix (Table 16-7) to identify potential benthic ecology impact pathway interactions between the Marine Scheme and the English and Scottish Onshore Schemes. No interaction is anticipated because there are no project activities associated with the English and Scottish Onshore Schemes in the marine environment, due to the use of HDD at the landfalls.

In-combination effects are where receptors could be affected by more than one environmental impact. Where a receptor has been identified as only experiencing one effect or where only one topic has identified effects on that receptor, there is no potential for in-combination effects. The receptor groups within this chapter do not interact between chapters, therefore receptors have been wholly appraised within this respective topic chapter.

## 8.10 Summary of Appraisal

This chapter has considered the potential effects of the Marine Scheme on benthic ecology receptors. A summary of the effects is presented in Table 8-10.

No significant effects are predicted during installation, operation (including maintenance and repair), and decommissioning of the Marine Scheme.

## Table 8-10: Summary of environmental appraisal

| Phase | Potential Impact | Receptor | Sensitivity | Magnitude | Significance | Project Specific Mitigation | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|
| **Route preparation and cable installation** | Temporary physical disturbance to subtidal benthic habitats and species | All benthic habitats and species | Low to high | Low / Negligible | **Minor / Negligible** | None required | **Minor / negligible** which is **not significant** |
| | Permanent loss of and/or disturbance subtidal benthic habitats and species due to placement of hard substrates on the seabed | All benthic habitats and species | Low to high | Low | **Minor** | None required | **Minor** which is **not significant** |
| | Temporary increase in SSC and sediment deposition leading to contaminant mobilisation, turbidity and smothering effects | All benthic habitats and species | Low to high | Negligible | **Negligible** | None required | **Negligible** which is **not significant** |
| | Changes to marine water quality from the use of HDD drilling fluids and accidental spills from vessels, including loss of fuel oils and INNS | All benthic habitats and species | Low to high | Low | **Minor** | None required | **Minor** which is **not significant** |
| **Cable operation (including maintenance and repair)** | Effects of Electromagnetic field (EMF) emissions from buried cable | All benthic habitats and species | Low to high | Negligible | **Negligible** | None required | **Negligible** which is **not significant** |
| | Effects of thermal emissions from buried cable | All benthic habitats and species | Low to high | Negligible | **Negligible** | None required | **Negligible** which is **not significant** |
| | Maintenance potential effects the same as route preparation and cable installation | | | | | | |
| **Decommissioning** | Potential effects of decommissioning the same as route preparation and cable installation | | | | | | |

## 8.11 References

ACOPS. (2017). *Annural survey of reproted discharges and releases attributed to vessels and offshore oil and gas installations operating in the United Kingdom's exclusive economic zone. .* Maritime and Coastguard Agency.

Adams, T., Miller, R., Aleynik, D., & Burrows, M. (2014). Offshore marine renewable energy devices as stepping stones across biogeographical boundaries. *Journal of Applied Ecology*, 330-338.

Aslan, J. F., Weber, L. I., Iannacone Junior, J., Saraiva, V. B., & Oliveira, M. M. (2019). Toxicity of drilling fluids in aquatic organisms: a review. *Ecotoxicology and Environmental Contamination, 14*(1), 34-47.

Atkinson, R. (1974). Spatial distribution of Nephrops burrows. *Estuarine and Coastal Marine Science, 2*(2), 171-176.

Bell, M., Redant, F., & Tuck, I. (2006). *Chapter 13: Nephrops Species. In: Phillips, B.F. (ed) Lobsters: biology, management, aquaculture and fisheries.*

Berge, J. A. (1990). Macrofauna recolonization of subtidal sediments. Experimental studies on defaunated sediment contaminated with crude oil in two Norwegian fjords with unequal eutrophication status. *Marine Ecology Progress Series, 66*, 103-115.

Biodiversity Reporting and Information Group. (2011). *UK Biodiversity Action Plan Priority Habitat Descriptions.*

Bochert, R., & Zettler, M. (2004). Long-term Exposure of Several Marine Benthic Animals to Static Magnetic Fields. *Bioelectromagnetics*, 498-502.

Boles, L., & Lohmann, K. (2003). True Navigation and Magnetic Maps in Spiny Lobsters. *Nature*, 60-63.

Budd, G. (2008). *Alcyonium digitatum Dead man's fingers. In Tyler-Walters, H. and Hiscock, K. Marine Life Information Network: Biology and Sensitivity Key Information Reviews. Plymouth.* Plymouth: Marine Biological Association of the United Kingdom.

Canadian Council of Ministers of the Environment. (2001). *Canadian Sediment Quality Guidelines for the Protection of Aquatic Life*. Retrieved from https://www.pla.co.uk/Environment/Canadian-Sediment-Quality-Guidelines-for-the-Protection-of-Aquatic-Life

CEFAS. (2015). *Farnes East rMCZ Post- Survey Site Report.*

CIEEM. (2018). *Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine.* Version 1.1 – Updated September 2019. Chartered Institute of Ecology and Environmental Management, Winchester.

CIEEM. (2018, and updated September 2019). *Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine. Version 1.1.* Winchester: artered Institute of Ecology and Environmental Management.

Defra. (2011). *Biodiversity 2020: A strategy for England's wildlife and ecosystem services.* [Online]. Available at:https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69446/pb13583-biodiversity-strategy-2020-111111.pdf .

Emeana, C. J., Hughes, T. J., Dix, J. K., Gernon, T. M., Henstock, T. J., Thompson, C. E., & Pilgrim, J. A. (2016). The thermal regime around buried submarine high-voltage cables. *Geophysical Jounral International, 206*(2#), 1051-1064.

European Environment Agency. (2012). *EUNIS habitat classification*. Retrieved from https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification-1

European Environment Agency. (2019). *European Nature Information Service [EUNIS] habitat type hierarchical view.* Retrieved from http://eunis.eea.europa.eu/habitats-code-browser.jsp.

Fugro. (2021). *Eastern Link Marine Survey.* Fugro GB Marine Limited.

Fugro. (2021). *Eastern Link Marine Survey Benthic Characterisation Report.*

Glasby, T., Connell, S., Holloway, M., & Hewitt, C. (2007). Nonindigenous biota on artificial structures: could habitat creation facilitate biological invasions? *Marine Biology*, 887-895.

Golding, N., Albrecht, J., & McBreen, F. (2020). *Refining the criteria for defining areas with a 'low resemblance' to Annex I stony reef.* Peterborough: Joint Nature Conservation Committee.

Gubbay, S. (2007). *Defining and managing Sabellaria spinulosa reefs: Report of an interagency workshop. .* JNCC report. .

Hicks, N., Liu, X., Gregory, R., Kenny, J., Lucaci, A., Lenzi, L., . . . Duncan, K. R. (2018). Temperature driven changes in benthic bacterial diversity influences biogeochemical cycling in coastal sediments. *Frontiers in Marine Science*. doi:10.3389/fmicb.2018.01730

Hill, J., & Wilson, E. (2000). *Virgularia mirabilis Slender sea pen. In Tyler-Walters, H. and Hiscock, K. Marine Life Information Network: Biology and Sensitivity Key Information Reviews.* Plymoth: Marine Biological Association of the United Kingdom.

Hill, J., & Wilson, E. (2008). *Amphiura filiformis A brittlestar. In Tyler-Walters, H. and Hiscock, K. Marine Life Information Network: Biology and Sensitivity Key Information Reviews.* Plymouth: Marine Biological Association of the United Kingdom.

Hill, J., Tyler-Walters, H., & Garrard, S. (2020). *Sea pens and burrowing megafauna in circalittoral fine mud. In Tyler-Walters, H. and Hiscock, K. Marine Life Information Network: Biology and Sensitivity Key Information Reviews.* Plymouth: Marine Biological Association.

HM Government. (2021). *North East Inshore and North East Offshore Marine Plan.* https://www.gov.uk/government/publications/the-north-east-marine-plans-documents. Retrieved from https://www.gov.uk/government/publications/the-north-east-marine-plans-documents

Holt, T., Rees, E., Hawkins, S., & Seed, R. (1998). *Biogenic reefs (Volume IX). An overview of dynamic and sensitivity characteristics for conservation management of marine SACs. (UK Marine SACs Project).* Scottish Association for Marine Science.

Howard, F. G. (1989). The Norway Lobster. *Scottish Fisheries Information Pamphlet Number 7 1989* (03099105).

Hutchison, Z., Gill, A., Sigray, P., Haibo, H., & King, J. (2020). Anthropogenic electromagnetic fields (EMF) influence the behaviour of bottom-dwelling marine species. *Scientific Reports*.

Hutchison, Z., Gill, A., Sigray, P., He, H., & King, J. (2021). A modelling evaluation of electromagnetic fields emitted by buried subsea power cables and encountered by marine animals: Considerations for marine renewable energy development. *Renewable Energy, 177*, 72-81.

Inger, R., Attril, M., Bearhop, S., Broderick, A., Grecian, W., Hodgson, D. M., . . . Godley, B. (2009). Marine Renewable Energy: Potential Benefits to Biodiversity? An Urgent Call for Research. *Journal of Applied Ecology*.

Irving, R. (2009). *The identification of the main characteristics of stony reef habitats under the Habitats Directive. Summary report of an inter-agency workshop 26-27 March 2008 (Report No. 432).* Joint Nature Conservation Committee [JNCC]. .

Jackson, A., & Hiscock, K. (2008). *Sabellaria spinulosa Ross worm. In Tyler-Walters, H. and Hiscock, K. Marine Life Information Network: Biology and Sensitivity Key Information Reviews.* Plymouth: Marine Biological Association of the United Kingdom.

Jenkins, C., Eggleton, J., Albrecht, J., Barry, J., Duncan, G., Golding, N., & O'Connor, J. (2015). *North Norfolk Sandbanks and Saturn reef SCI management investigation report. .* Cefas and JNCC report (87 pp.).

JNCC. (2011). *Consultation on the selection of three UK offshore Special.* Department for Environment, Food and Rural Affairs.

JNCC and Defra (on behalf of 4CBG). (2018). *UK Post-2012 Biodiversity Framework: Revised Implementation Plan (2018-2020).* [Online]. Available at: https://data.jncc.gov.uk/data/587024ff-864f-4d1d-a669-f38cb448abdc/UKBioFwk-RevisedImpPlan-Jun2018.pdf .

John, S., Meakins, N., Basford, K., Craven, H., & Charles, P. (2015). *Coastal and marine environmental site guide (second edition) (C744).* CIRIA.

Joint Nature Conservation Committee. (2016). *UK biodiversity action plan priority habitat descriptions: subtidal sands and gravels.* Department for Environment, Food & Rural Affairs.

Joint Nature Conservation Committee. (2022). *1170 Reefs Description and ecological characteristics*. Retrieved from https://sac.jncc.gov.uk/habitat/H1170/

Kogan, I., Paull, C., L, K., Burton, E., S, V. T., Greene, G., & Barry, J. (2003). *Environmental Impact of the ATOC/Pioneer Seamount Submarine Cable.*

Marine Management Organisation. (2014). *Cefas Chemical Action Levels*. Retrieved from https://www.gov.uk/guidance/marine-licensing-sediment-analysis-and-sample-plans###Suitability%20of%20material

Marine Scotland. (2020). *Contaminant and biological effect data 1999-2017 for the National Performance Framework Clean Seas Indicator 2018. .*

Meissner, K., Schabelon, H., Bellebaum, J., & Sordyl, H. (2008). *Impacts of submarine cables on the marine environment.* Institute of Applied Ecology for the Federal Agency of Nature Conservation .

NatureScot. (2014). *Priority Marine Features Guidance. A2086517 .*

NBN. (2021). *Marine Pathways Project*. Retrieved from http://www.nonnativespecies.org/index.cfm?pageid=588.

Newell, R., Seiderer, L., & Hitchcock, D. (1998). The impact of dredging works in coastal waters: A review of the sensitivities to disturbance and subsequent recovery of biological resources on the seabed. *Oceanography and Marine Biology*.

NGET & SPT. (2021). *Scotland to England Green Link (SEGL) ~ Eastern Link 1 Marine Scheme - Scoping Report.* https://marine.gov.scot/sites/default/files/segl_el1_marine_scoping_report_-_base_report_rev_2.0.pdf.

OSPAR. (2008). *OSPAR List of Threatened and/or Declining Species and Habitats*. Retrieved from https://www.ospar.org/documents?d=32794 (2017-09-05)

OSPAR. (2009). *Background Document on CEMP assessment criteria for the QSR 2010.* OSPAR.

OSPAR. (2019). *The OSPAR List of Substances/Preparations Used and Discharged Offshore which are Considered to Pose Little or No Risk to the Environment (PLONOR).* OSPAR Commission.

OSPAR Commision. (2009). *OSPAR Background for Ocean Quahog Arctica islandica.* OSPAR Commision.

OSPAR Commision. (2013). *Background document on Sabellaria spinulosa reefs.* OSPAR Commision.

OSPAR Commision. (2020). *Background Document for Seapen and Burrowing Megafauna Communities.* OSPAR Commision.

RPS. (2019). *Review of cable installation, protection, mitigaiton, and habitat recoverability.* The Crown Estate.

Scott, K., Harsanyi, P., Easton, B., Piper, A., Rochas, C., & Lyndon, A. (2021). Exposure to Electromagnetic Fields (EMF) from Submarine Power Cables Can Trigger Strength-Dependent Behavioural and Physiological Responses in Edible Crab, Cancer pagurus (L.). *Marine Science and Engineering, 9*, 776.

Scottish Government. (2014). *Scotland’s Third National Planning Framework.* Edinburgh.

Scottish Government. (2014). *Scottish Planning Policy.*

Scottish Government. (2015). *Scotland's National Marine Plan*. Retrieved from https://www.gov.scot/publications/scotlands-national-marine-plan-9781784128555/

Stamp, T., & Tyler-Walters, H. (2016). *Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock. In Tyler-Walters, H. and Hiscock, K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews.* Plymouth: Marine Biological Association.

Stark, J. S., Snape, I., & Riddle, M. J. (2003). The effects of petroleum hydrocarbon and heavy metal contamination of marine sediments on recruitment of Antarctic soft-sediment assemblages: a field experimental investigation. *Jounrnal of Experimental Marine Biology and Ecology, 283*, 21-50.

UKOOA. (2001). *Contaminant Status of the North Sea.*