Chapter 14 Benthic Ecology

14.1 Introduction

1 This chapter describes the marine benthic habitats and associated biological communities recorded within and in the vicinity of the proposed Neart na Gaoithe offshore site. An assessment of the potential ecological impacts arising from the construction, operation and decommissioning of the Neart na Gaoithe offshore wind farm has been carried out, and potential mitigation measures to address these impacts are discussed in this chapter.

2 Information is provided on biotopes (defined as a habitat supporting a specific assemblage of plants and animals, operating together at a specific scale) occurring within the proposed development. The term biotope is often used in a manner synonymous with the term habitat, although in reality a habitat may support several biotopes. Conversely, a biotope may extend over what appears to be more than one habitat (Hooper *et al.,* 2011). The presence of specific benthic habitats and species is discussed within the context of the wider population and extents within the North Sea region.

14.2 Guidance and Legislation

3 The relevant legislative frameworks governing benthic ecology are common to wider policies concerning ecology and nature conservation and are discussed in Chapter 11: Nature Conservation.

4 The following guidance and publications were used in the preparation of this chapter:

- The identification of the main characteristics of stony reef habitats under the Habitats Directive (Irving, 2009);
- Interpretation Manual of European Union Habitats (European Commission, 2007);
- Best methods for identifying and evaluating *Sabellaria spinulosa* and cobble reef (Limpenny *et al*., 2010);
- Natura 2000 in UK Offshore Waters: Advice to support the implementation of the EC Habitats and Birds Directives in UK offshore waters (Johnston *et al*., 2002);
- Guidance and publications from Scottish Natural Heritage (SNH) and Marine Scotland on Priority Marine Features (PMF) and Marine Protected Area (MPA) search features (SNH, 2012);
- European Union (EU) Guidance on wind energy development in accordance with the European Union nature legislation (EU, 2010);
- OSPAR Guidance on Environmental Considerations for Offshore Wind Farm Development (OSPAR, 2008a);
- Department for Environment, Food and Rural Affairs (Defra) 'Nature Conservation Guidance on Offshore Windfarm Development: A guidance note on the implications of the EC Wild Birds and Habitats Directives for developers undertaking offshore windfarm developments' (Defra, 2005);
- International Union for Conservation of Nature (IUCN) publication 'Greening Blue Energy: Identifying and managing the biodiversity risks and opportunities of offshore renewable energy' (Wilhelmsson *et al*., 2010);
- SNH guidance on Habitats Regulations Appraisal (HRA) of Plans (Tyldesley and Associates, 2010);
- Guidelines for Ecological Impact Assessment (EcIA) in Britain and Ireland (Marine and Coastal) (IEEM, 2010); and
- Scottish Offshore Wind Farms – East Coast. Discussion Document (2) – Approach to Cumulative Effects Assessment (Royal Haskoning, 2010).

14.3 Data Sources

14.3.1 Desk Study

5 A variety of literature and data sources were used to undertake the desk-based benthic habitat and species review. Sources include academic and regulatory agency publications and websites of the statutory nature conservation bodies (the Joint Nature Conservation Committee (JNCC) and SNH), Government Departments (e.g., Marine Scotland, the former Department for Business, Enterprise and Regulatory Reform (BERR), now DECC), the Scottish Environment Protection Agency (SEPA) and UK Biodiversity Action Plan. Additionally publications and data from non-governmental organisations and international bodies were used, such as those from the IUCN, the Marine Life Information Network (MarLIN) and the National Biodiversity Network (NBN).

14.3.2 Surveys

6 A geophysical survey of the site was undertaken in 2009 (EMU, 2009a). Using results from the geophysical survey, an ecological survey was also carried out in 2009 (see Appendix 14.1: Benthic Ecology Characterisation Survey). Surveys were undertaken of the intertidal and subtidal areas within and around the proposed offshore site and export cable corridor. Sampling stations were selected to ensure adequate coverage of the different sediment types within the offshore site and cable route to ascertain the distribution of habitat types and associated biological communities.

7 The surveys included a variety of sampling techniques, including benthic grabs, video sampling and scientific 2 m beam trawls. The full technical report with survey methodology and scope is provided in Appendix 14.1: Benthic Ecology Characterisation Survey.

14.4 Engagement and Commitments

14.4.1 Strategic and Site Level Requirements

8 There are a number of requirements and commitments made on behalf of the developer as well as recommendations provided in the form of advice through documents such as the Scoping Opinion (see Chapter 7: Engagement and Commitments). In addition to general requirements from statutory consultees and regulators, there are a number of issues specific to benthic ecology; these are detailed as received in Table 14.1 with cross references to discussion points within this chapter or the wider Environmental Statement (ES).

14.4.2 Consultation

9 Prior to the 2009 benthic ecology survey, consultation was undertaken with Marine Scotland to discuss and agree the survey approach and methodology.

10 Building on the results of the 2009 survey, a preliminary assessment was undertaken of the coarse sediment benthic habitats found at the site and their potential status as an Annex I reef habitat (see Appendix 14.2: Preliminary Assessment of Coarse Sediment Habitats). This assessment was presented to Marine Scotland to seek a regulatory opinion on the relative nature conservation value of these habitats.

11 Further information on consultation, undertaken with stakeholders on wider issues surrounding protected species and habitats, is presented in Chapter 11: Nature Conservation.

Source	Comment	Relevance/reference
Blue Seas - Green Energy: A Sectoral Marine Plan for Offshore Wind Energy in Scottish Territorial Waters. Part A: The Plan (Marine Scotland, 2011)	Specific impacts on species and habitats (including fisheries) should be reduced through appropriate design, and selection and use of appropriate construction and operation methods.	Section 14.7: Impact Assessment; and See also Chapter 15: Fish and Shellfish Ecology.
Scoping Opinion (SNH advice)	Assessment of structures and foundations and scour required with reference to fish species assemblages and indirect impacts such as changing the species composition away from important prey species for seabirds.	Section 14.7.2: Impact Assessment – Operation and Maintenance; and See also Chapter 15: Fish and Shellfish Ecology.
	Indirect impacts of the reef effects, caused by structures, scour etc., need assessing with relationship to species assemblages and prey for birds.	Section 14.7.2.1: Introduction of New Substrates; and See also Chapter 15: Fish and Shellfish Ecology.
	Assessment needed of impacts on SACs and their qualifying and supporting habitats and species (e.g., sandeel) and subsequent indirect impacts (e.g., on marine mammals).	Section 14.9: Cumulative and In-Combination Impacts; and See also Chapter 15: Fish and Shellfish Ecology for assessment of sandeel habitats requirements and potential impacts.
	Note development will cause permanent benthic habitat loss, but this is small overall (relative to site size).	Section 14.7: Impact Assessment.
	Benthos recovery will vary (e.g., turbine layout hydrodynamics). Suggest excluding mobile fishing gear could aid recovery. Suggest could result in higher commercial stocks in area (including unexploited) and overspill to adjacent areas.	Section 14.8: Mitigation and Residual Impacts and Section 14.9: Cumulative and In-Combination Impacts; and See also Chapter 15: Fish and Shellfish Ecology.
	Loss to biogenic or geogenic reef features should be avoided, due to high biodiversity, high ecosystem service value, sensitivity and long recovery.	Section 14.8: Mitigation and Residual Impacts.
	Any *S. spinulosa* near the site needs highlighting (and whether they comprise reef forming aggregations). Assessment of the vulnerability of these from the development is required.	No *S. spinulosa* reef or potential reef were recorded within and peripheral to the Neart na Gaoithe development.
	Reefs may be present along the cable routes; also maerl and horse mussel beds could be present in the development area. The cable route should seek to minimise contact with such features within other operational and environmental constraints.	Section 14.8.1.2: Mitigation for Heating Effects from Cables.
	Clarify that the Isle of May is a SAC with reefs as a qualifying interest. Also it may be relevant to consider reefs as a qualifying interest of the Berwickshire to North Northumberland Coast SAC.	Section 14.6.2.5: Subtidal Benthic Habitats of Ecological and Conservation Interest; Section 14.6.2.6: Benthic Species of Conservation Interest; and See also Chapter 11: Nature Conservation.
	The amount of rock dumping, cable protection or any other type of additional material being put on the seabed should be calculated and shown spatially where this is likely to occur and what habitats this coincides with.	Section 14.5.1: The Rochdale Envelope and Section 14.7: Impact Assessment.
	Artificial structures/material could create a fundamental habitat change. This is likely to be a small change overall for NNG. Suggest cumulative and in-combination impacts of habitat change assessed for the region.	Section 14.9: Cumulative and In-Combination Impacts.
	Highlight that use of rock armouring (especially varied) on turbines can increase potential habitat and biodiversity locally.	Section 14.8: Mitigation and Residual Impacts.
	Development should avoid causing direct or indirect damage to seapen species, a UK Biodiversity Action Plan (UKBAP) species and identified as threatened/declining by OSPAR.	Section 14.7: Impact Assessment.
	Strongly advise that all cables should be buried if at all possible (minimises any electromagnetic field effects).	Section 14.7: Impact Assessment and Section 14.8.1.2: Mitigation for Heating Effects from Cables.
Scoping Opinion (SEPA advice)	ES should show areas of seabed affected by cabling/shore development including intertidal zone. Also consider existing coastal developments (e.g., use concept of 'system capacity' to measure impacts to morphological conditions). Cumulative regional impacts need assessing.	Section 14.9: Cumulative and In-Combination Impacts.
	UKBAP species (*S. spinulosa* reefs, horse mussel beds, native oysters, saltmarsh, sea grass beds) should be included in surveys so that they are not omitted from proposed mitigation measures. Guidance on 'sensitivity' and 'recoverability' available from MarLIN.	Section 14.5.2: The Approach to Impact Assessment.
	The ES should also provide clarification on protocols to be followed to ensure that no marine non-native species are introduced into this area either during the development of this project or during the operational phase of the wind farm.	Section 14.7: Impact Assessment.
Scoping Opinion (RSPB comments)	Welcome assessment of hydrodynamic regime and sediment changes with relation to impacts on bird prey (e.g., sandeel, sprats).	Section 14.9: Cumulative and In-Combination Impacts.
	Note the proposal could indirectly impact birds (SPA qualifiers) through benthic impacts, this should be addressed.	Section 14.9: Cumulative and In-Combination Impacts.
Advice to Forth and Tay Offshore Wind Developer Group (SNH)	Qualifying features of designated marine and coastal SACs will need to be considered in respect of cabling activities.	Noted.
	Suggest continued liaison with Marine Scotland and SNH regarding MPAs.	Noted.
Advice to Forth and Tay Offshore Wind Developer Group (Fife Council)	Consideration should be given to the potential cumulative impact of colonisation of underwater turbine structures.	Section 14.5.1: The Rochdale Envelope and Section 14.7: Impact Assessment.
Comment to Forth and Tay Offshore Wind Developer Group (RSPB)	Potential area for assessing sediment transport changes should take into account impacts on prey species over the wider area, and include alternative prey species such as sprat.	Section 14.9: Cumulative and In-Combination Impacts.
	Potential for impacts of non-native species should be considered.	Section 14.7: Impact Assessment.

Table 14.1: Strategic and site level commitments and requirements

14.5 Impact Assessment Methodology

12 The overall approach to the assessment of environmental impacts is described in Chapter 6: The Approach to Environmental Impact Assessment. A more detailed discussion of the approach to the benthic assessment is also discussed in this chapter.

13 Effects have been defined for each receptor or receptor group, given the parameters of the proposed construction, operation and decommissioning methods as defined within the project Rochdale Envelope (see below). Impacts are assessed relative to the phase of development, i.e., those arising in the construction, operation or decommissioning phases, and are discussed individually.

14.5.1 The Rochdale Envelope

14 The approach to defining the 'Rochdale Envelope' is described Chapter 6: The Approach to Environmental Impact Assessment, and is adapted in this chapter to take account of the outputs from the physical processes modelling. As discussed in detail in Chapter 9: Physical Processes, it was necessary to start the modelling before the limits of the Rochdale Envelope were defined. As a result of this, the Rochdale parameters assessed in this chapter take account of both the modelled worse case values and the parameters as described in Chapter 5: Project Description.

15 During the development process, the Rochdale Envelope evolved to beyond the original assessment within the metocean model, resulting in the increase of maximum values of individual development components. Certain model outputs have been applied to the benthic ecology assessment; for example, the sedimentation and scour outputs have been applied to the suspended sediments concentration, sediment deposition and scour evaluation. Consequently, two evaluation scenarios were used in the assessment: the project Rochdale Envelope that describes the actual project parameters; and the metocean model outputs that were calculated based on a slightly different set of values. It is not the intention of this chapter to further discuss the rationale of the model parameters but rather to explain how the outputs have been applied (refer to Chapter 9: Physical Processes for more detail on the metocean model Rochdale Envelope). The worst (realistic) case scenario applied in the assessment of benthic impact varies with both the receptor and the potential effect. By applying relevant parameters to each perceived impact the worst (realistic) case scenario has been assessed.

16 In terms of benthic habitat, the effects arising from offshore wind farms can be attributed directly to the physical presence of the structures in the water column or on the seabed and how this may alter the existing benthic habitat. This may occur via disturbance to or loss of natural habitat (e.g., through construction activities such as cable installation, anchoring, jacking-up), introduction of new substrates from the presence of infrastructure or by changes to the hydrodynamic regime that may, for example, cause changes in sediment deposition or the suspended sediment load.

17 The Rochdale Envelope and metocean model outputs are described in Table 14.2 including the definition of the assessment scenario for each potential construction phase effect. For parameters that are not yet defined in the project design process (refer to Chapter 5: Project Description), information has been obtained from relevant industry standards or publications.

Potential impact	Rochdale Envelope parameter	Value		Scenario for benthic ecology
Construction				
Direct habitat disturbance	**Wind turbine foundations**	Number	125	Direct habitat disturbance from: • Wind turbine foundation and installation = 0.52 km^2; • Substation foundation and installation = 0.01 km^2; • Inter-array cable plough = 1.4 km^2; • Inter-array cable anchoring = 0.18 km^2; • Export cable plough = 0.66 km^2; and • Export cable anchoring = 0.09 km^2.
		Overall type	Jackets	
		Footprint of foundation	250 m^2 including scour protection	
		Method of installation	Jack-up vessels	
		Footprint of jack-up vessel	Eight spud cans of 106 m^2 each	
		Jack-up vessel anchors	Eight anchors	
		Footprint of jack-up vessel anchors	Assumed to be approximately 16.38 m^2 (adapted from Wortelboer 2012; BERR, 2008)	
		Placements of jack-up vessel	Five locations per turbine	
	Substation foundations	Number	Two	
		Type	Jackets	
		Installation method	Assumed to be equal to that required per turbine with equal parameters for jack-up vessels	
	Inter-array cables	Length	140 km	
		Installation method	Cable laying vessel and plough	
		Cable laying vessel anchors	Eight (from BERR, 2008)	
		Footprint of cable laying vessel anchors	Assumed to be equal to jack-up vessel anchors	
		Cable laying vessel deployments	One per every 100 m (from BERR, 2008)	
		Cable laying plough total width on seabed footprint	10 m	
	Export cable	Number	Two	
		Length	33 km each	
		Installation method	Assumed to be equal to that required for the inter-array cables	
Increased suspended sediments concentration sediment deposition and scour	**Wind turbine foundations**	Number	126	Modelled release of up to 5,000 m^3 of sediment from 50 m^3 area around each foundation. See metocean model parameters for more detail (Chapter 9: Physical Processes).
		Overall type	Gravity base	
		Diameter	35 m	
		Seabed preparation dredging depth	2 m	
	Inter-array cables	Length	140 km	
	Export cables	Length	33 km	
	Inter-array and export cables	Trench parameters if buried	1 m wide x 2 m deep	Modelled sediment release of 800 m^3 per hour (see Chapter 9: Physical Processes).

Table 14.2: Rochdale Envelope worst (realistic) case parameters for benthic ecology

Potential impact	Rochdale Envelope parameter	Value		Scenario for benthic ecology
Operation and Maintenance				
Direct loss of habitat	**Wind turbine foundations**	Number	75	Direct habitat loss from: • Wind turbine foundations = 0.17 km^2; • Substation foundations = 0.001 km^2; • Inter-array cable scour protection= 0.14 km^2 and • Export cable scour protection = 0.05 km^2.
		Overall type	Gravity base	
		Footprint of foundation	1,600 m^2 plus 8 m additional beyond diameter for scour protection	
	Substation foundations	Number	Two	
		Overall type	Jackets	
		Footprint of foundation	Four x 3.5 m diameter piles	
	Inter-array cables	Length	140 km	
		Post-installation status	Scour protection for approximately 20% length, otherwise buried	
		Width of scour protection (BERR, 2008)	5 m	
	Export cable	Number	Two	
		Length	33 km each	
		Post installation status	Scour protection for approximately 15% length, otherwise buried	
Introduction of new substrate	**Wind turbine foundations**	Number	128	New substrate from: • Gravity base, including turbine tower, gravity base cone and extended scour protection = 0.23 km^2; • Substation foundations = unknown; • Inter-array cable scour protection = 0.14 km^2; and • Export cable scour protection = 0.09 km^2
		Type	Gravity base	
		Diameter of gravity base	30 m	
		Height of gravity base cone (see Chapter 9: Physical Processes)	34 m	
		Assumed turbine tower distance from top of cone to sea surface	20 m	
		Width of turbine tower	8 m	
		Width of scour protection surrounding gravity base	8 m	
	Substation foundations	Number	Two	
		Type	Jackets	
	Inter-array cables	Length	140 km	
		Post-installation status	Scour protection for approximately 20% length, otherwise buried	
		Width of scour protection (BERR, 2008)	5 m	
	Export cables	Number	Two	
		Length	33 km each	
		Post-installation status	Scour protection for approximately 15% length, otherwise buried	

Potential impact	Rochdale Envelope parameter	Value		Scenario for benthic ecology
Operation and Maintenance continued				
Temporary direct habitat loss from operation and maintenance vessels	**Wind turbines and foundations**	Number	125 (in a possible 128 locations)	Total temporary direct habitat disturbance is 0.05 km^2 over 25 years.
		Overall type	Jackets	
		Method of maintenance	Jack-up vessels	
		Footprint of jack-up vessel	Eight spud cans of 106 m^2 each	
		Jack-up vessel anchors	Eight anchors	
		Size of jack-up vessel anchors	Assumed equal to those used in construction (approx 16.38 m^2 footprint)	
		Operational time	25 years	
		Visits and placements of jack-up vessel	Two uses of jack-up vessel per year	
Change in hydrodynamics	**Wind turbines**	Number	126	Current speeds are predicted to increase by up to 0.02 m/s on the mean spring peak ebb tide and decrease by up to 0.04 m/s on the mean spring peak flood tide. This is against the background current speed of up to 0.6 m/s on both the flooding and ebbing spring tides and up to about 0.4 m/s on both the flooding and ebbing neap tides.
		Overall type	Jacket foundations	
Electromagnetic field (EMF)	**Inter-array cables**	Length	140 km	Qualitative assessment based on these parameters.
		Post-installation status	Buried in sediment to up depths of up to 1-3 m	
	Export cables	Number	Two	
		Length	33 km each	
		Post-installation status	Buried in sediment to depths of up to 2 m	

Table 14.2: Rochdale Envelope worst (realistic) case parameters for benthic ecology (continued)

18 For decommissioning, impacts are assumed to be broadly analogous to those arising during construction. Where this is not the case, an assessment of the effects has been undertaken and the resultant impacts and arising from decommissioning are presented in Section 14.7.3: Impact Assessment – Decommissioning.

14.5.2 The Approach to Impact Assessment

19 Using the conceptual *"source-pathway-receptor"* model presented in Chapter 5: The Approach to Environmental Impact Assessment, a number of direct and indirect effect-pathways can be identified between the effects arising from construction/decommissioning and operation of the wind farm and the impacts on associated benthic ecological receptors.

20 The assessment of impact significance is a multi-staged process involving definitions of effect magnitude and receptor vulnerability. If mitigation is required, the residual impacts are considered following mitigation and the final impact significance assessed.

21 The direct impacts identified are caused by physical changes to the environment and include:

- Habitat loss and disturbance (e.g., implications to benthic habitat loss and disturbance; change in nature of the seabed; displacement of reproductive faunal and floral populations and prey/food items);
- Increase in suspended sediment concentration (SSC) and associated turbidity (e.g., implications for filter feeders, visual predators), subsequent sediment settlement and siltation or scour of benthic communities and potential implications for survival and reproductive success; and
- Electromagnetic fields and heating from operating subsea cables on invertebrates and their different life cycle stages.

22 Indirect impacts occur as a consequence of a direct impact and may be experienced spatially and temporally away from the source. These impacts acknowledge the wider ecosystem and trophic interactions between associated habitats and include:

- Changes in hydrodynamics and nutrient transport (e.g., wind power structures will affect water flow and this may be critical to marine organisms since it influences larval recruitment, sedimentation rates, the availability of food and oxygen and the removal of waste); and
- Introduction of artificial substrate and alien species (e.g., increase of habitat heterogeneity and biodiversity of sessile organisms and potential to provide entry points and stepping-stones for alien rocky shore species brought in as larvae by ballast water, or indigenous species not naturally resident in the area, but facilitated by the presence of artificial substrate).

23 Inter-relationship impacts are changes which occur on a single receptor from multiple sources and pathways (e.g., displacement of species as a result of habitat disturbance or loss and smothering by increased SSC).

24 A key component to the impact assessment has been the application of peer-reviewed biological sensitivity/vulnerability data to various anthropogenic effects, including those associated with offshore wind farm development (e.g., habitat physical disturbance, increased suspended sediment). Literature and guidance, such as MarLIN (2011) and as identified in Section 14.2, provide an overview of vulnerability of benthic and aquatic marine life to the specific potential environmental impact of offshore wind farm development, based on field and experimental studies as well as theoretical models.

14.5.2.1 Magnitude of Effect

25 The characterisation of the effect magnitude is based on the following four criteria:

- Spatial extent (S): The geographic area of influence where the effect is noticeable against background variability;
- Duration (D): The temporal extent the effect is noticeable against background variability;
- Frequency (f): How often the effect occurs (important in terms of habitats/species' ability to recover between impacts; and
- Severity (v): The degree of change – toxicity, mass, volume, concentration.

26 Quantification of these criteria follows best practice guidelines detailed in Wilhelmsson *et al.* (2010) as presented in Table 14.3.

Characteristic	Categories	Definition/description
Spatial Extent (S)	Negligible	Apparent within 10 m from source.
	Low	Apparent 10-100 m from source.
	Medium	Apparent 100-1,000 m from source.
	High	Apparent >1,000 m from source.
Duration (D)	Negligible	Intermittent through construction or operation phase.
	Low	Through construction phase (of the order of two years).
	Medium	Through operational phase (of the order of 25 years).
	High	Effect persists beyond the operational and decommissioning phases.
Frequency (f)	Negligible	Intermittent through construction or operation phase.
	Low	Through construction phase.
	Medium	Through operational phase.
	High	Effects persist beyond the operational and decommissioning phases.
Severity (v)	Negligible	Should not influence or have very small impacts on size or structure of assemblage.
	Low	Potential to have small impacts on size or structure of assemblage.
	Medium	Impacts could moderately influence size or structure of species assemblages, generally, or for particular species.
	High	Impacts could significantly influence size or structure of species assemblages, generally, or for particular species.

Table 14.3: Magnitude of effect (modified categories from Wilhelmsson *et al.*, 2010).

14.5.2.2 Vulnerability of Receptor

27 As defined in Chapter 6: The Approach to Environmental Impact Assessment, the vulnerability is based on the adaptability, tolerance, recoverability and value of the receptor.

28 Criteria to define vulnerability for benthic ecology receptors are described in Table 14.4, based on guidelines produced by MarLIN (2011).

Characteristic	Categories	Definition/description
Adaptability (A)	Negligible	The habitat shows little adaptation to change thus it may be destroyed or severely damaged, and may be expected to partially recover over periods >25 years.
	Low	The habitat may be destroyed or damaged, but may be expected to recover between 10 and 25 years.
	Medium	The habitat may be damaged, but may be expected to recover between five and 10 years.
	High	The habitat is unlikely to be damaged, or is only minimally damaged such that physical and biological attributes can function normally.
Tolerance (T)	Negligible	The habitat may be destroyed and associated species lost. The habitat and associated species may partially recover over a period >25 years.
	Low	The habitat may be severely damaged with many associated species lost. The viability of the species populations and ecological functioning of the habitat may be impaired, but both are expected to recover between 10 and 25 years.
	Medium	The habitat may be damaged with a few associated species lost. However, the species population and the ecological functioning of the habitat are not impaired.
	High	No detectable impact effect on the structure and/or function of a habitat or its characterising species.
Recoverability (R)	Negligible	Species shows little or no recovery to change.
	Low	Partial recovery within 10 years, full recovery up to 25 years.
	Medium	Partial recovery within five years, full recovery up to 10 years.
	High	Full recovery within five years, but may occur within months or days.
Value (V)	Negligible	Widespread habitat/species, no conservation importance or key ecosystem role.
	Low	Widespread habitat/species, regional conservation importance, plays a key ecosystem role.
	Medium	The habitat/species hold national conservation value.
	High	The habitat/species hold international conservation status.

Table 14.4: Assessment of receptor vulnerability (modified categories from MarLIN, 2011)

14.5.3 Cumulative and In-Combination Impact Assessment Approach

14.5.3.1 In-combination Impacts

29 In-combination impacts are considered to be those arising from interactions with other (non-wind farm) developments or activities. In the case of fish and shellfish ecology, an in-combination impact may occur when a fish or shellfish species may be under pressure from an existing activity such as commercial fishing or port development, in addition to impacts as a result of development of offshore wind farms (refer to Appendix 6.2: Scottish Territorial Waters Offshore Wind Farms – East Coast Discussion Document – Cumulative Effects).

30 Potential cumulative effects may arise from the development of other offshore wind farms in the vicinity of Neart na Gaoithe. Cumulative effects may be:

- Additive through frequency, amount (quantity) or threshold (resilience);
- Secondary; or
- Synergistic.

31 In combination effects are considered to be those arising from interactions with other (non-wind farm) developments or activities. In the case of benthic ecology, in-combination impacts, such as aggregate activities or oil and gas installations have been screened out of the assessment as there are none active in the study area or region. Chapter 22: Other Users provides information on other activities in the region.

14.5.3.2 Schemes Considered

32 Currently there are plans for the development of two further offshore wind farms in the vicinity of Neart na Gaoithe (see Chapter 5: Project Description for further information on these projects) which could result in cumulative impacts on benthic ecology.

33 Through collaborative work with the Forth and Tay Offshore Wind Farm Developers Group (FTOWDG), information on other project parameters and site characterisation has been shared and a cumulative Rochdale Envelope derived (see Chapter 5: Project Description for more information).

34 This sharing of information and development parameters has allowed an assessment of a worst (realistic) case scenario on a cumulative basis. The potential cumulative effects arising from the developments of both the Inch Cape and Firth of Forth Round 3 Zone developments include those listed as potential at a site level.

35 The Rochdale Envelope for the Inch Cape and Round 3 Zone 2 (Phases 1, 2 and 3) is detailed in Table 14.5 and describes the effects assessed for potential cumulative impacts. It is important to note that since the assessment was completed the values for the Inch Cape offshore wind farm Rochdale Envelope were refined. As the calculations, particularly for habitat disturbance and habitat loss were derived using the original values it was decided to keep the higher values but also show where the numbers have reduced. As a result, the cumulative impact assessment can be considered to be more conservative than necessary.

36 There are further wind farms planned for development around the coast of the UK and further afield. For the purposes of this ES, these are not considered to have a cumulative impact on benthic ecology.

Potential Effect	Rochdale Envelope parameter		Value for Inch Cape	Value for the Firth of Forth Round 3 Zone 2 Development Phases 1, 2 & 3	Resulting assessment parameter	Notes
Construction						
Direct habitat disturbance	**Wind turbine foundations**	Number	286 *(revised down to 213)*	616	• Turbine foundation disturbance = 8.82 km^2; • Substation foundation disturbance = 0.32 km^2; • Met mast foundation disturbance = 0.12 km^2; • Inter Array cable installation disturbance = 4.2 km^2; • Export cable installation disturbance = 0.59 km^2; and • Total habitat disturbance from construction is therefore 14.04 km^2.	This calculation is made with the following assumptions: • Gravity bases are assumed the worst case for turbine foundations, using the maximum number of turbines and maximum footprint including scour protection for the Inch Cape offshore wind farm, and using the most likely number of turbines and maximum footprint for the Firth of Forth Round 3 Zone 2 development; • Met masts and offshore substations are assumed to have the same foundations and numbers as the assumptions for turbines; and • Inter-array and export cables are assumed to disturb a 3 m corridor. Inter-array cable lengths are assumed to be proportional to those in Neart na Gaoithe (0.31 km/MW site capacity).
		Footprint of foundation	7,300 m^2	10,923 m^2		
	Substation foundations	Number	5	2		
		Footprint of foundation	45,000 m^2	45,100 m^2		
	Met mast foundations	Number	3 *(revised to 1)*	9		
		Footprint of foundation	7,300 m^2	10,923 m^2		
	Inter-array cables	Length	311,000 m	1,089,000 m		
		Installation method	trench	trench		
		Width of trench (disturbance corridor)	3	3		
	Export cables and interconnectors	Length	75,000 m	120,000 m		
		Installation method	Trench	Trench		
		Width of trench (disturbance corridor)	3 m	3 m		
Change to suspended sediment concentrations (SSC), sediment settlement and smothering	Increase in SSC arising from the installation of 1,454 gravity base foundations and up to 939 km of export cables and 2,291 km of inter array cables: • 126 six MW gravity base turbine foundations (based on complete coverage of the site); • 328 seven to ten MW gravity base foundation within Inch Cape (based on complete coverage of site); • 1000 six MW gravity base foundations within Firth of Forth (based on consented capacity of site); • Release of up to 5,000 m^3 of sediment per each gravity base foundation (details in Chapter 9: Physical Processes); and • Release of up to a maximum of 800 m^3 of sediment per hour for cable installation, assuming a typical rate for trenching of 400 m per hour, a trench of 2 m depth and 1 m width and 100% sediment liberation during trenching.					For assumptions see Chapter 9: Physical Processes.
Operation and Maintenance						
Habitat loss	**Wind turbine foundations**	Number	286	616	• Turbine foundation loss = 8.82 km^2; • Substation foundation loss = 0.312 km^2; • Met mast foundation loss = 0.12 km^2; and • Total habitat loss through foundation footprints is, therefore, 9.25 km^2.	• Assumptions on parameters used are the same as those used for construction for turbine, met mast and substation parameters. • There is not assumed to be any habitat loss from cables, they are assumed to be buried in all places (no other information available)
		Footprint of foundation	7,300	10,923		
	Substation Foundations	Number	5	2		
		Footprint of foundation	45,000	45,100		
	Met mast Foundations	Number	3	9		
		Footprint of foundation	7,300	10,923		
Habitat disturbance	Based on two jack-up events (single location) per year for 25 year operation before repowering. Jack-up vessel dimensions are assumed equal to those used for installation. Total habitat disturbance for 25 year = 0.05 km^2					
Introduction of new substrate	Assumed to be equal to the amount of habitat loss (no assumption included for vertical new substrate for other developments)					
EMF and heating impacts from operational cables	Qualitative assessment					

Table 14.5: Cumulative (other developments) Rochdale Envelope worst (realistic) case parameters for benthic ecology

14.6 Baseline Description

37 This section presents an overview of the marine benthic habitats and biological communities that are characteristic of the North Sea area surrounding the offshore site and more specific information on the benthic habitats and species within the study area. The related regional physical characteristics of the area are described in Chapter 8: Geology and Water Quality.

38 The site specific survey undertaken in 2009 provides the basis for the detailed description of the existing benthic habitat in the proposed Neart na Gaoithe wind farm site and cable route. The full technical survey report is provided in Appendix 14.1: Benthic Ecology Survey Report, including the survey methodology and full results.

14.6.1 Study Area

39 The study area considers the offshore site and export cable route (Figure 14.1). To put the biotopes found on site into context, it is necessary to describe the benthic habitats in the wider North Sea. Information on the wider area has been principally derived from the NBN (NBN, 2011) and the JNCC-led Mapping European Seabed Habitats (MESH, 2011) programmes. The MESH programme provides an overview of benthic habitats (biotopes) in the region surrounding the offshore works area[1]. These areas are shown in Figure 14.2.

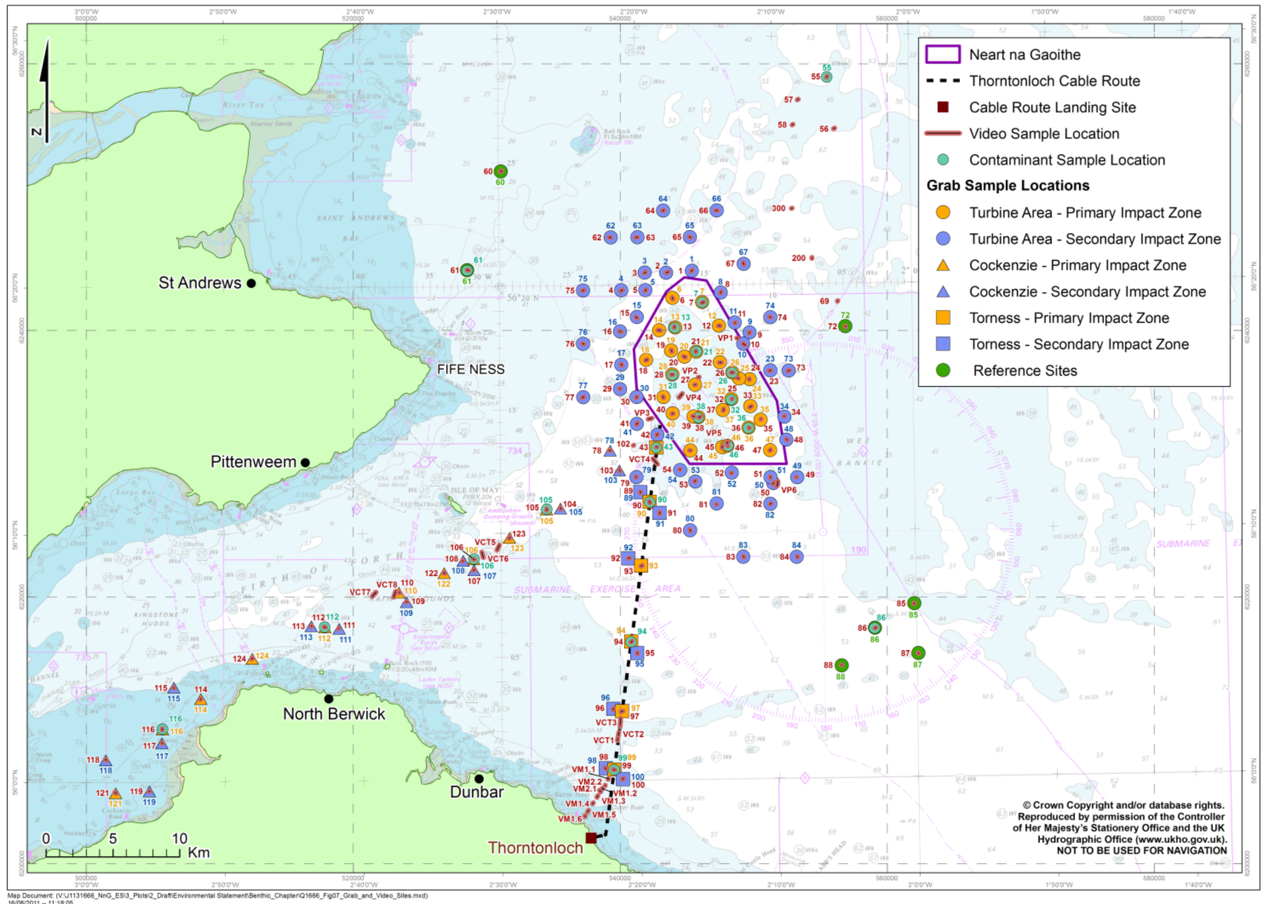

Figure 14.1: Neart na Gaoithe baseline survey array and benthic ecology study area (see Appendix 14.1: Benthic Ecology Survey Report)

[1] The term 'offshore work area' refers to all aspects of the project below MHWS, including the offshore site and cable corridor, and supporting operations

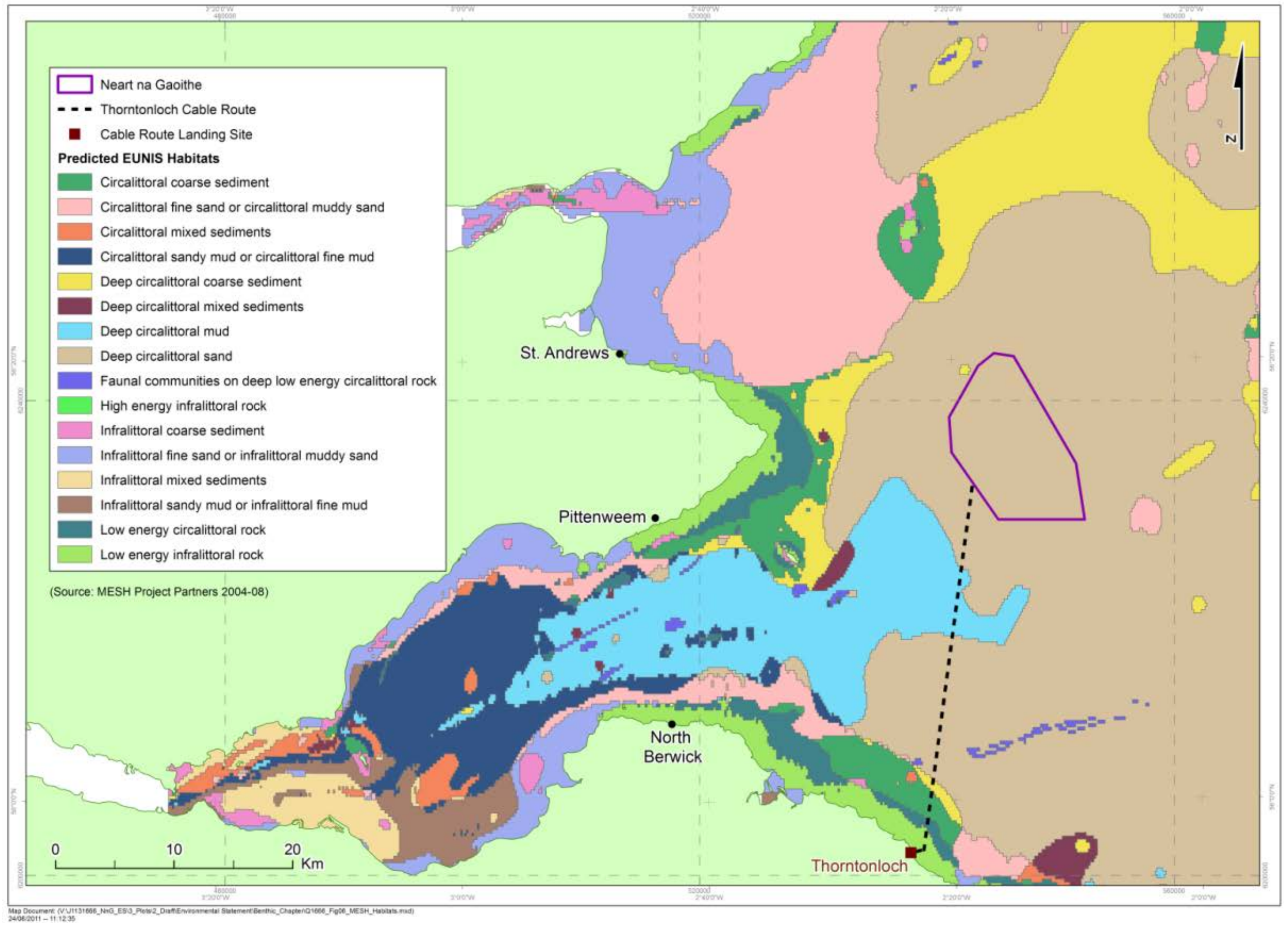

Figure 14.2: MESH predictions of habitats for the Firth of Forth region

14.6.2 Offshore Site Characterisation

14.6.2.1 Wider Area Characterisation

40 The characterisation of the offshore and nearshore benthic environments is based on both the available literature of the central North Sea and additional site specific information, obtained via the benthic survey to provide a broad overview of the wider area.

41 The biotope coverage of the area adjacent to the offshore site is broadly comparable to that observed in the shallower sediment areas of the southern North Sea (Calloway *et al.*, 2002; Jennings *et al.*, 1999). Characteristic epibenthic species, including the hydroid *Hydrallmania falcata* and soft coral dead man's fingers *Alcyonium digitatum,* have been observed with a typical mobile assemblage, including the common starfish *Asterias rubens*, brown shrimp *Crangon allmani* and the hermit crab *Pagurus bernhardus* (Jennings *et al.*, 1999).

42 Typical habitats and species occurring in the offshore Firth of Forth region, encompassing the offshore site, include the biotopes **SS.SMx.CMx** (circalittoral mixed sediments) and more specifically, mud with seapens (e.g., *Virgularia mirabilis*) and polychaetes (e.g., *Lagis* spp.) together with muddy sands with infaunal brittlestars (e.g., *Amphiura filiformis*) and the gastropod *Turritella communis* (Glémarec, 1973). The *S. spinulosa* is also reported to be common in the North Sea and has been recorded in the region of the offshore site although there are no records of Annex I *Sabellaria* reef habitats (EMU, 2010).

43 There are a variety of further biotopes found around Bass Rock and the Isle of May with 30 rock and mixed sediment biotopes being recorded in the coastal and shallow subtidal areas of the latter (Moore *et al*., 2009). In addition, there are further biotopes offshore to the east such as mixed shelly gravels (**CMx**), which occur with patchy cobbles and small boulders **SS.SCS.CCS** (circalittoral coarse sediments) (EMU, 2009b).

44 The benthic habitats in the vicinity of Bass Rock are predominantly sublittoral fringe habitats supporting dense kelp forests. Steep underwater cliffs surround the rock, extending to 15–40 m below chart datum. These are characterised by dense populations of dead man’s fingers and the plumrose anemone *Metridium senile* (Moore *et al.*, 2009).

45 Substrates inshore near North Berwick are more varied and characterised by mainly sedimentary species (Eleftheriou *et al.,* 2004; Irving, 1997), consisting primarily of the biotope of **LS.LMu.MEst** (polychaete/bivalve-dominated mid estuarine mud shores).

46 Whereas, further inshore from the offshore construction site, the habitat complex is **SS.SMu** (sublittoral cohesive mud and sandy mud communities). To the northwest of the offshore site, communities are more mixed (Figure 14.3), and include the biotopes:

- **SS.SSa.CMuSa.AalbNuc** (*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand and slightly mixed sediment); and
- **SS.SMu.CSaMu.ThyNten** (*Thyasira* spp. and *Nuculoma tenuis* in circalittoral sandy mud).

47 To the southwest, towards North Berwick, biotopes include:

- **SS.SSa.IMuSa.FfabMag** (*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand);
- **SS.SMu.CSaMu.AfilMysAnit** (*Amphiura filiformis*, *Mysella bidentata* and *Abra nitida* in circalittoral sandy mud); and
- **SS.SMx.CMx.MysThyMx** (*M. bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment).

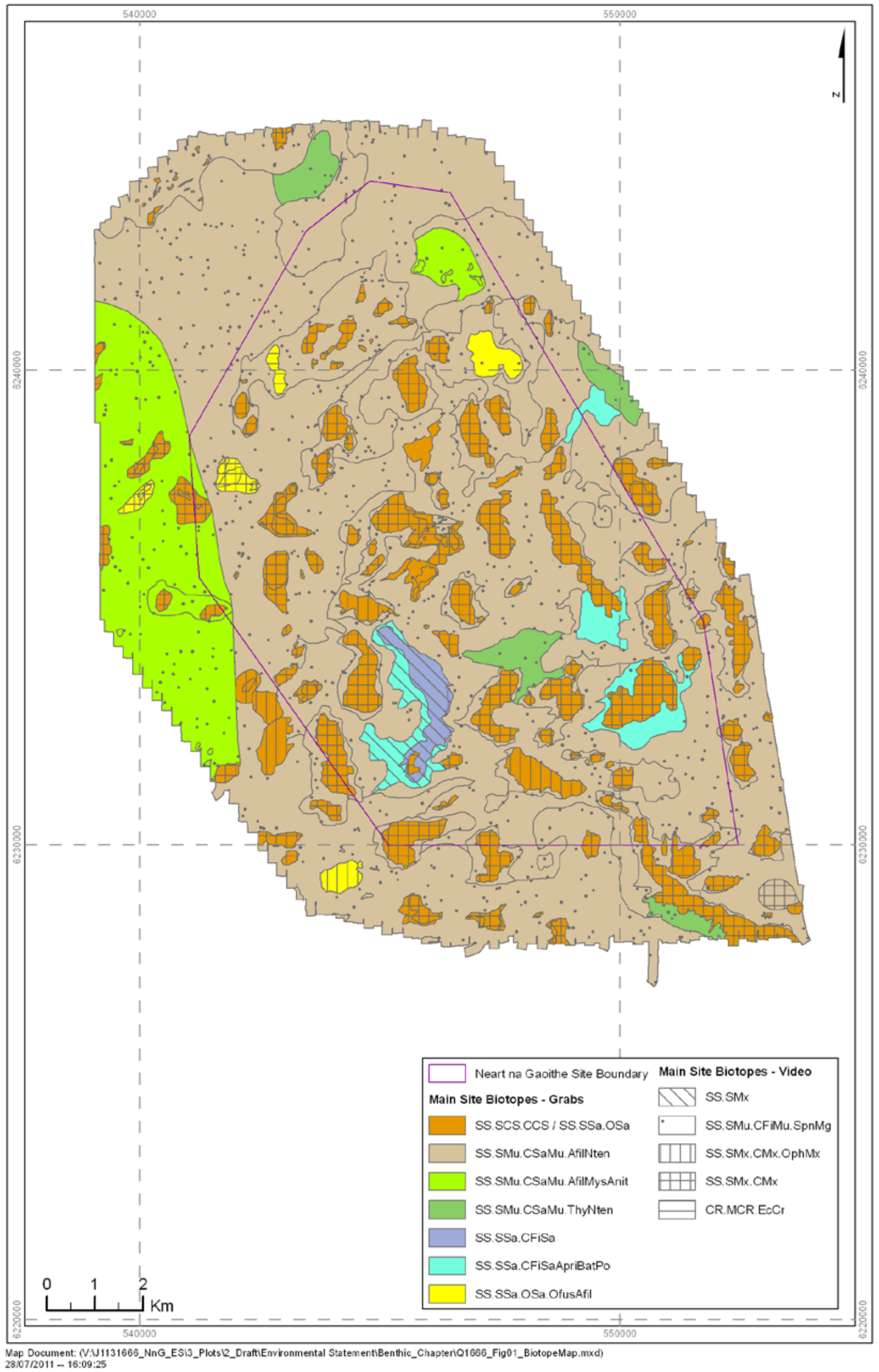

Figure 14.3: Biotopes identified by the offshore site characterisation

14.6.2.2 Site Survey

48 As discussed in Section 14.3, a detailed benthic survey was undertaken to characterise the offshore works area (refer to Appendix 14.1).

49 The subtidal survey included 0.1 m^2 Hamon grab sampling to collect quantitative seabed sediment samples for determination of macrofaunal content and particle size distribution analyses; seabed digital photography and video for collection of qualitative/semi-quantitative data on seabed habitats and associated sessile epibenthos; 2 m scientific beam trawling for information on larger mobile epibenthos such as fishes, crabs, shrimps and prawns; and 0.04 m^2 Shipek grab sampling of seabed sediment for analyses of contaminants.

50 Grab sampling stations were selected on a stratified random basis with consideration of the acquired geophysical data to ensure adequate coverage of the different types of sediment habitats anticipated to occur within the proposed turbine site and along each cable route option. Grab samples were collected in four broad areas:

- To include boundaries of the proposed offshore site;
- The adjacent area within the predicted maximum tidal excursion over a single spring tide;
- Outside the predicted area of primary and secondary effects of the development, i.e., reference stations; and
- Along the proposed export cable route.

51 The intertidal biotope mapping surveys were carried out at export cable landfall sites proposed at the time of the survey (Cockenzie, Skateraw and Thorntonloch/Torness). Survey methodologies followed those outlined in the JNCC Procedural Guidelines for Phase I Intertidal Biotope Mapping (Davies *et al*., 2001). Thorntonloch has since been confirmed as the proposed landfall location for the export cable (refer to Chapter 5: Project Description).

52 Further details on the site survey are also provided in Appendix 14.1: Benthic Ecology Survey Report.

14.6.2.3 Subtidal Biotopes

53 The dominant sediment type found in the offshore site is slightly gravelly muddy sand, although patches of coarser sediment (e.g., sandy gravel and gravelly sand) were also recorded at the offshore site. Sediment contaminants within the offshore site were present at levels below the Centre for Environment, Fisheries & Aquaculture Science (Cefas) contaminant action levels and Canadian Interim Sediment Quality Guidelines. Similarly, levels of the different tin and organochlorine pesticides tested were below analytical detection levels at all sites (see Appendix 14.1: Benthic Ecology Survey Report).

54 Typical of deeper waters, the offshore site is characterised by the biotope complex **SS.SMu.CSaMu** (circalittoral sandy mud) with epifaunal species present including seapens (e.g., *V. mirabilis*) and brittlestars (e.g., *Amphiura* spp.). Infaunal species include polychaetes (e.g., *Spiophanes bombyx*) and bivalves (e.g., *Mysella bidentata*, *Abra* spp. and *Nuculoma* spp.).

55 Covering over 73% of the seabed within the offshore site the biotope **SS.SMu.CSaMu.AfilNten** (*Amphiura filiformis* and *Nuculoma tenuis* in circalittoral and offshore sandy mud) was widespread (Figure 14.3). This and other **CSaMu** biotopes present are associated with the UK Biodiversity Action Plan (UK BAP) habitat, 'mud habitats in deep water'.

56 The second most extensive habitat present in the offshore works area was characterised by a mix of soft and hard sediments including **SS.SCS.CCS** and **SS.SSa.OSa** (offshore circalittoral sand). Pockets of circalittoral fine sand sediment habitats (**SS.SSa.CFiSa**) are also present including isolated areas of **SS.SSa.CFiSa.ApriBatPo** (*Abra prismatica, Bathyporeia elegans* and polychaetes in circalittoral fine sand). The offshore sand biotope **SS.SSa.OSa.OfusAfil** (*Owenia fusiformis* and *Amphiura filiformis* in offshore circalittoral sand or muddy sand) is also present in discrete patches.

57 Video analysis showed soft polychaete tubes, megafauna burrows, seapens (e.g., *Pennatula phosphoracea* and *V. mirabilis*) and *Chaetopterus* tubes over extensive soft sediment areas. These features suggested the presence of the draft priority marine feature 'burrowed mud' and the component biotope **SS.SMu.CFiMu.SpnMeg** (seapens and burrowing megafauna in circalittoral fine mud)**,** covering a large area of seabed within the turbine array and extending further into the peripheral area.

58 Over the coarse mixed sediment, dense common brittlestar, *Ophiothrix fragilis*, populations were noted, together with the dead man's fingers and keel worm *Pomatoceros* spp., which fitted the biotope description of **SS.SMx.CMx.OphMx** (*Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment). Where *O. fragilis* abundance was less, **CMx** was assigned. The latter was the second most extensive biotope identified by the video images comprising 15% of the offshore site seabed. Where sediments included mosaic habitats, such as superficial waves or ribbons of sand mixed with areas of gravel and lag deposits, the habitat complex **SS.SMx** (sublittoral mixed sediments) was assigned.

59 Video transects undertaken over a series of rocky substrates corresponding to the exposure of the Wee Bankie Formation indicated a highly variable seabed comprising a mix of substrate habitat types. These included large boulders and cobbles supporting a mosaic of the biotopes **CR.MCR.EcCr.FaAlCr.Pom** (faunal and algal crusts with *Pomatoceros triqueter* and sparse *A. digitatum* on exposed to moderately wave-exposed circalittoral rock) and **CR.MCR.EcCr.FaAlCr.Adig** (*A. digitatum*, *Pomatoceros triqueter*, algal and bryozoan crusts on wave-exposed circalittoral rock). These are part of the biotope complex **CR.MCR.EcCr** (echinoderms and crustose communities) and differ on the relative abundance of the characterising species.

14.6.2.4 Subtidal Mobile Epibenthic Species

60 Scientific 2 m beam trawls and grabs gave information on larger, more mobile epibenthic assemblages and colonial sessile communities. The fauna recorded included crustaceans (e.g., crabs), bryozoans (e.g., sea mats), cnidarians (e.g., sea firs, anemones), fishes, tunicates (sea squirts) and molluscs (e.g., bivalves). Of these, crustaceans were the most abundant and diverse with the brown shrimp *C. allmanni* dominant. The pink shrimp *Pandalus montagui*, the sea squirt *Ascidiella scabra,* and the seapen *P. phosphorea* were also relatively abundant and fairly widely distributed, together with the small spider crab *Macropodia rostrata*, the common brittlestar *O. fragilis*, long rough dab *Hippoglossoides platessoides* and gobies*.* Among non-enumerated colonial sessile fauna, the bryozoans *Euratea loricata* and *Alcyonidium parasiticum*, the hydroids *Abietinaria abietina* and *H. falcata* and dead man's fingers were the most frequent.

14.6.2.5 Subtidal Benthic Habitats of Ecological and Conservation Interest

61 The offshore site does not overlap with any sites currently designated for their conservation importance. Nevertheless there are certain benthic habitats and species that are found in the offshore site that are of conservation and wider ecological importance or interest. These habitats are discussed further below.

Stony or Cobble Reef

62 There are small areas within the site that have characteristics similar to those of 'stony reef' as listed in the EC Habitats Directive Annex I (see Chapter 11: Nature Conservation for more information on the relevant regulatory mechanisms).

63 These sites were identified according to definitions as discussed by Irving (2009) and concluded that although a few of these areas met some of the assessment criteria (e.g., elevation, extent and biota present), none of these satisfied the criteria in full (i.e., their resemblance to stony or cobble reef was assessed to be low). Furthermore, the video data showed that stony reef areas were not extensive and appeared to coincide with small areas of elevation and ridges arising from areas of exposed bedrock or Wee Bankie Formation (Figure 14.4). Therefore, they could not conclusively be classified as Annex I cobble reef. Appendix 14.2: Preliminary Assessment of Coarse Sediment Benthic Habitats provides more detail on the analysis.

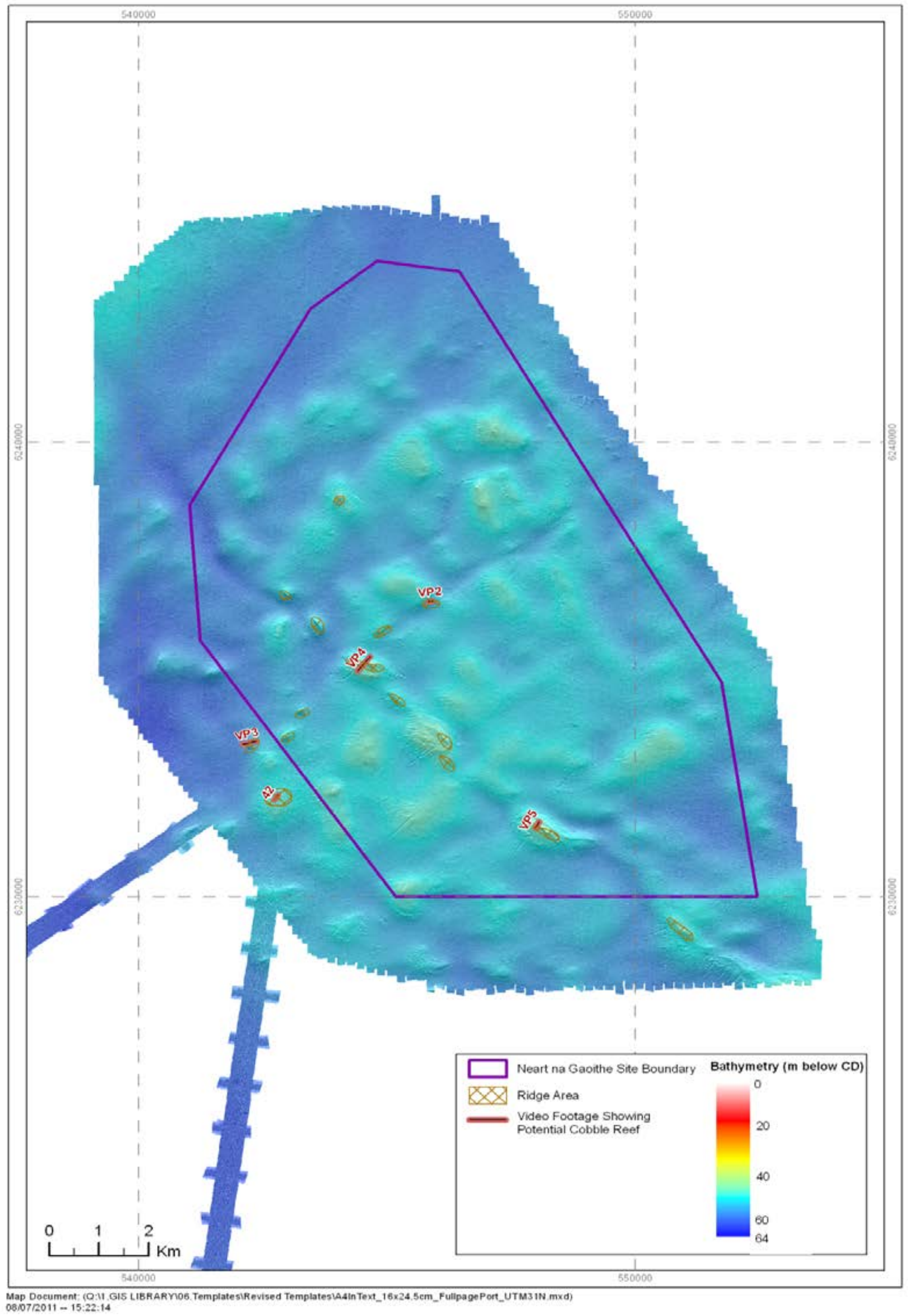

Figure 14.4: Sites identified as areas of potential stony or cobble reef (indicated as VP, i.e., Video of Potential cobble reef)

Burrowed Mud

64 Burrowed mud, comprising the biotope complex **SS.SMu.CSaMu** and several individual biotopes such as **SS.SMu.CFiMu.SpnMeg**, covers much of the offshore site (see Figure 14.2 and Figure 14.3). This habitat occurs extensively in deeper offshore waters of the North Sea (OSPAR, 2010) and is a Scottish Nature Conservation Marine Protected Area (MPA) search feature, a draft Scottish PMF and UK BAP habitat (mud habitats in deep water). It also corresponds with the OSPAR priority habitat 'seapen and burrowing megafauna communities' which is classified as under threat or decline (OSPAR, 2010). Importantly, the megafauna typically associated with this habitat include species of commercial significance such as Nephrops or Norway lobster *Nephrops norvegicus,* which is commercially targeted in the region (see Chapter 15: Fish and Shellfish Ecology and Chapter 16: Commercial Fisheries).

Circalittoral Sands and Coarse Sediments

65 The biotopes **CCS**, **OfusAfil**, and **ApriBatPo** (see Figure 14.2 and Figure 14.3) fall within the UK BAP habitat Subtidal sands and gravel (JNCC, 2010). These habitats also provide nursery grounds for juvenile commercial fish species, including flatfishes, bass *Dicentrarchus labrax*, skates, rays and sharks (UK BAP, 2008). Adult skates and rays are also present in the area, as are the commercially important shellfish (king scallop *Pecten maximus* and queen scallop *Aequipecten opercularis*) (see Chapter 15: Fish and Shellfish Ecology and Chapter 16: Commercial Fisheries).

Brittlestar Beds

66 The importance of the biotope **SS.SMx.CMx.OphMx** (*Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment) is its association with subtidal brittlestar beds. Dense brittlestars beds can occur on bedrock, boulder, gravel or sedimentary substrata. However, these brittlestar species do not occur solely in dense groups and are individually widespread and often common in other benthic biotopes around the British Isles. Brittlestar beds themselves have no economic importance, but they are of considerable scientific interest as they are considered keystone species in the recycling of benthic nutrients to demersal and pelagic species and communities (Dupont *et al.*, 2008).

14.6.2.6 Benthic Species of Conservation Interest

67 The site specific survey recorded some occurrences of species of conservation importance within the offshore works area (see Table 14.6). Further information on nature conservation designations and several of these species can be found in Chapter 11: Nature Conservation, Chapter 15: Fish and Shellfish Ecology and Appendix 14.1: Benthic Ecology Survey Report.

Species name	Conservation status (Chapter 11: Nature Conservation provides more detail)
Ocean quahog ***Arctica islandica***	OSPAR threatened and/or declining species. Scottish MPA Project search feature.
Common sea urchin ***Echinus esculentus***	IUCN Red List species.
Greater sandeel ***Ammodytes tobianus*** **(see Chapter 15: Fish and Shellfish Ecology)**	Scottish MPA Project search feature. Scottish Biodiversity List species.
Gastropod ***Simnia patula***	Scottish Biodiversity List species.
Bivalve mollusc ***Devonia perrieri***	Scottish Biodiversity List species.

Table 14.6: Species of conservation importance recorded by the site specific grab sampling survey at Neart na Gaoithe

14.6.3 Export Cable Route Characterisation

14.6.3.1 Subtidal Biotopes

68 The export cable route is characterised by deep circalittoral mud, typical of the outer Firth of Forth. Further inshore, the cable route is characterised by deep circalittoral coarse sediment and low energy rock habitats.

69 Survey results indicated that cable route sediments were similar to the offshore site, comprising mainly gravelly muddy sand, with an average higher percentage of mud than in the offshore site sampling stations.

70 Three habitat complexes and six biotopes were identified along the export cable route and the main features recorded were components of the muddy sand biotope complex (biotopes **SS.SMu.CSaMu.ThyNten**, **AfilMysAnit** and **AfilNten** (Figure 14.3). These were overlain by **SS.SMu.CFiMu.SpnMeg**, characterised by a plain of fine mud bioturbated by burrowing megafauna, with conspicuous populations of seapens, e.g., *V. mirabilis* and *P. phosphoracea*, and burrowing crustaceans including *N. norvegicus*.

71 Further inshore, the cable route was characterised by coarse sediment (e.g, **SS.SCS.CCS**) comprising cobbles, pebbles, gravel and coarse sand. Conspicuous fauna identified from the video images comprised keel worms *Pomatoceros* spp. and crustaceans such as *Munida rugosa*.

72 As with the offshore site, there were also areas with dense populations of the brittlestar *O. fragilis* recorded at the southern and northern-most cable route boundaries which fitted the biotope **SS.SMx.CMx.OphMx**.

14.6.3.2 Intertidal Biotopes

73 The coastline surrounding the Firth of Forth similarly encompasses a diverse range of intertidal habitats, including exposed bedrock platforms, sandy bays, mobile cobbles and shingle, boulders, areas of mixed substrate and occasional mud patches (Posford Haskoning, 2002). An overview of the intertidal habitat at the intertidal cable landfall site is presented in Table 14.7.

Location	Intertidal Habitats and biological communities of the Firth of Forth identified through literature review
Export cable route landfall (Thorntonloch)	**Dunbar to English border** (to the north and south of proposed landfall, respectively) The coast is characterised by extensive bedrock and boulder areas interspersed with small sandy bays. On vertical surfaces barnacles and limpets dominate. At Bar Ness the shore has a mix of boulders, cobbles, pebbles and broken bedrock outcrops, and lower shore habitats support rich assemblages of red algae growing on kelp stipes and adjacent rock surfaces. The latter are encrusted with the keel worm *P. triqueter* and encrusting red and brown algae; other conspicuous species include echinoderms, mostly the brittlestar *O. fragilis*. Occasional limestone boulders are bored by piddocks, which provide refuge for selected invertebrates. Mid shore rocky substrate is dominated by *Fucus vesiculosus* or barnacles and limpets, depending to the degree of exposure. Lower shore rocks support serrated wrack *F. serratus* with the red algae *Porphyra* spp. and *Chondrus crispus* together with the blue mussel, *Mytilus edulis* which occasionally occurs in extensive and dense patches. Deep rocky pools are inhabited by kelps and fucoid algae. Extensive areas of sand are either barren or support polychaetes including the lug worm *Arenicola marina* in places. **North of Dunbar** The shore comprises a complex rocky coastline of red sandstone, extensively sculptured by rock mills and rounded deeper pools overlaying a harder rock. Mid and lower eulittoral pools are dominated by the sea oak *Halidrys siliquosa* and the kelp *Laminaria digitata*. Sparse patches of the seagrass *Zostera angustifolia* grow in sediment between pebbles and cobbles on the bed of shallow upper shore pools (Posford Haskoning, 2002).

Table 14.7: Intertidal habitat overview for the Thorntonloch cable route landfall

74 For the export cable route aspect of the site specific survey (see Appendix 14.1: Benthic Ecology Survey Report) the survey area encompassed the region from the splash/lichen zone (supralittoral) to the sublittoral fringe, within an area extending 250 m either side of the proposed cable route landfall at Thorntonloch. Chapter 5: Project Description provides further information on the export cable landfall location.

75 A biotope map for the intertidal area (Figure 14.5) illustrates an area characterised by sandy beach, together with several outcrops of cobbles and boulders. Extensive areas of bedrock were also noted north of the survey area and a freshwater stream flowed across the centre of the beach.

76 The sandy habitats on the mid and lower shore were generally rippled or duned, further reflecting the exposed nature of the site. These habitats were either devoid of fauna (**LS.LSa.MoSa** barren or amphipod-dominated mobile sand shores) or hosted faunal communities typical of mobile clean sandy habitats hosting relatively poor faunal communities **LS.LSa.MoSa.AmSco** (amphipods and *Scolelepis* spp. in littoral medium-fine sand), **AmSco.Eur** (*Eurydice pulchra* in littoral mobile sand), and **AmSco.Sco** (*Scolelepis* spp. in littoral mobile sand). These mid and lower shore habitats were interrupted by bedrock areas supporting the biotopes **LR.FLR.Eph.EntPor** (*Porphyra purpurea* and *Enteromorpha* spp. on sand-scoured mid or lower eulittoral rock) and **LR.MLR.BF.Rho** (*Rhodothamniella floridula* on sand-scoured lower eulittoral rock), the distribution of which seemed to reflect the degree of sand scour within the survey area, with the former occurring in areas subjected to higher degree of sand scouring.

77 The sandy biotopes outlined above are common on the east coast of Scotland and their importance is associated with providing suitable habitat for little terns, sandwich terns and common terns which favour sand and shingle for nesting. Common terns also nest on bare scrapes in drift line seaweeds or on shell banks. Sandwich terns breed on coastal sand or shingle beaches, frequently in association with other terns or gull species. Invertebrates attracted to seaweed on the strandline provide an important food source for birds and juvenile fish (MarLIN, 2011).

78 Thorntonloch beach does not hold particular importance with respect to wading birds (Bloor and Barton, 2011, pers. comm.). The rocky stretches of coast nearby support small numbers of turnstone and purple sandpipers in the winter and there are a few pairs of ringed plover nesting on the beach during the summer (Barton and Bloor, 2011, pers. comm.). It is a popular place for bird watching, as there are sometimes migrant passerines including occasionally rare species, however these are considered to be of limited ecological interest within the context of this study (see Chapter 12: Ornithology).

79 The upper shore comprised dry afaunal sand, characteristic of the biotope **LS.LSa.MoSa.BarSa** (barren littoral coarse sand), which is typical of exposed shores, subject to high sediment dynamics and drainage which prevents the establishment of macrofaunal communities. Areas of littoral coarse sediment (**LS.LCS**) were present south of the stream bordering the landward extent of the upper shore and the lower shore at the southernmost extent of the survey area (Figure 14.5). These coarse sediments included pebbles, gravel, cobbles and small boulders within coarse sand and were generally devoid of macrofauna.

80 The transition between the upper shore intertidal environment to that of a more terrestrial nature is relatively abrupt, in part due sea defences. Further information on the intertidal-terrestrial habitat transition is provided in the onshore ES associated with the application for planning permission for onshore works.

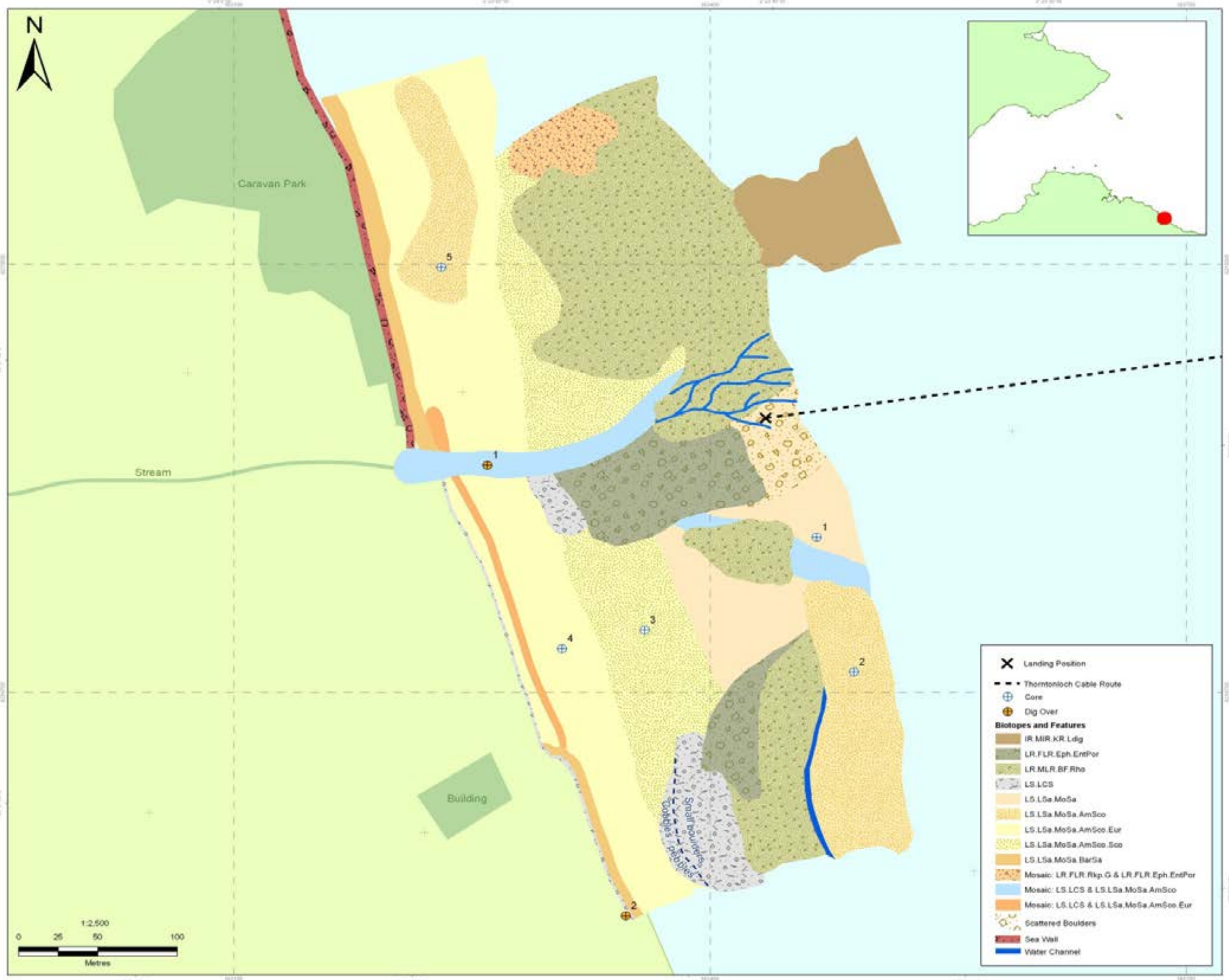

Figure 14.5: Biotope map for the intertidal area of the export cable route, as characterised from the site specific survey

Intertidal Biotopes of Ecological and Conservation Interest

81 The littoral biotopes **LR.FLR.RkpG**, **LR.FLR.Eph.EntPor** and **LR.MLR.BF.Rho** and the infralittoral **IR.MIR.KR.Ldig** (Figure 14.5) are contained within Annex I feature: reef (JNCC, 2010). The littoral rock features (**LR.FLR**) are also UK BAP priority habitats (JNCC, 2010). The biotopes **LR.FLR.Rkp.G** and **IR.MIR.KR.Ldig** are widespread at national level and their importance is associated with providing habitat for crustaceans (e.g., the copepod *Tigriopus fulvus*), and shelter for fish fry, which migrate into these habitats on occasion (MarLIN, 2011). In addition, the lumpsucker *Cyclopterus lumpus* lays its eggs in the infralittoral biotope (MarLIN, 2011).

82 The importance of the biotopes **LR.MLR.BF.Rho** and **Eph.EntPor** is their association with providing a food source to fish and crustaceans, migrating into the intertidal zone to feed as the tide rises. Shore birds also feed on the rocky shores because of the rich fauna available under macroalgae canopies. Algal patches may also act as nursery grounds for various species (e.g., Littorinids). The ephemeral green algae *Ulva intestinalis* provides shelter for the copepod, *T. brevicornis*, and chironomid larva *Halocladius fucicola* (MarLIN, 2011). In addition, *Ulva* spp. and associated epiphytes provide a major food source for the fauna of high rockpools (e.g., gastropods *Melarhaphe neritoides* and *Littorina saxatilis*). Green algae also provide an important food source for grazing teal, widgeon, shelduck and dark-bellied Brent geese.

14.6.4 Vulnerability of Benthic Ecology Receptors

83 This section outlines the vulnerability of benthic ecology receptors, as defined in Table 14.5.

84 The offshore benthic environment is subject to stress and natural change under normal circumstances. Fishing activities (refer to Chapter 16: Commercial Fisheries) are undertaken across the site, with evidence of bottom trawling in the north of the offshore works area. Storm events also cause stress on existing benthic communities.

85 The offshore works area does not overlap with any sites currently designated for their nature conservation interest at local, national or European level. Chapter 11: Nature Conservation describes the sites in the wider region designated as important for nature conservation, including Special Areas of Conservation (SACs) and Special Areas of Protection (SPAs). Consultation with SNH (see SNH, 2010) has resulted in some SACs and SPAs being identified as having ecological connectivity to such developments, and with the requirement to assess potential impacts on these sites under the Habitats Regulations through a process, known as Habitats Regulation Appraisal (HRA, refer to Chapter 11: Nature Conservation for more information). However, there are no benthic features of currently designated SACs that have been assessed as having ecological connectivity with the offshore works, and as such benthic habitats have been screened out from assessment at an HRA level.

86 Nevertheless, within the offshore works area some of the species and habitats recorded during the site specific survey are noted for their nature conservation importance and/or rarity, outwith areas currently designated for their conservation importance, as described in Sections 14.6.2.6 and 14.6.3.2. Chapter 11: Nature Conservation provides more information on the types of statutory and non-statutory protection for such species and features of conservation importance.

87 In addition to this there are several habitats found within the offshore works area that hold value because of their importance within the marine environment, for example, those that act as spawning or nursery grounds for certain species, or provide a habitat for keystone species. Similarly, some habitats support species of conservation or commercial importance.

88 With regard to the vulnerability of benthic receptors to sediment-metal contaminants, it should be noted that the results of the site specific benthic survey revealed that sediment contaminants within the proposed offshore site and export cable route were present at levels below Cefas sediment action levels and Canadian Interim Sediment Quality Guidelines. Therefore, the effect of potential contaminant release from sediment disturbance is not considered to pose a threat to marine benthic invertebrate communities and has been screened out of the impact assessment.

14.6.5 Benthic Ecology Receptors taken forward to Impact Assessment

89 All the biotopes recorded within the offshore site and the export cable route have been assessed in terms of potential impacts deriving from the development of the project and are all taken forward to be included in the assessment phase.

14.7 Impact Assessment

90 Effects arising from the construction/decommissioning and operation of the proposed wind farm have the potential to impact upon benthic habitats and species. This may occur directly as a result of physical disturbance or indirectly through changes to hydrodynamic conditions.

91 Any effects which alter the baseline condition of the habitat may have potential impacts not only on associated benthic species, but across the whole trophic chain (e.g., displacement of reproductive faunal and floral populations and prey/food items). Therefore, the potential impacts, appropriate to each phase and area, associated with the wind farm development are investigated and assessed in relation to benthic habitats and associated faunal communities.

92 The physical change effects and resulting direct impacts identified include:

- Habitat loss and physical disturbance to the benthic environment, including introduction of new substrates, which has impacts such as direct habitat loss, change in seabed nature and indirect impacts (see below);
- Increase in SSC, associated turbidity and sediment settlement and scour. These may have direct impacts on certain benthic species, particularly filter feeders and visual predators and impacts as a result of sediment settlement on factors such as reproductive behaviour; and
- Change in electromagnetic fields and heating from subsea cables, which may result in impacts on invertebrates and their associated life cycle stages.

93 Indirect impacts occur as a consequence of a direct impact and may be experienced spatially and temporally distant from the original source of the effect. These impacts acknowledge the wider ecosystem and trophic interactions between associated habitats, and may result from the following effects:

- Changes in hydrodynamics and nutrient transport resulting in impacts such as passive species movement[2] and change in localised trophic levels because nutrient cycles are diverted;
- Impacts resulting in changes in trophic links such as displacement or loss of key benthic prey for higher predators; and
- Reef effects caused by the introduction of artificial substrate. This increase of available hard substrate can cause indirect effects and artificially augment species richness and diversity, but also has potential to enhance settlement of non-native species, resulting in further indirect impacts.

94 A key component of the impact assessment has been the application of peer-reviewed biological sensitivity/vulnerability data to various anthropogenic effects, including those associated with offshore wind farm development (e.g., habitat physical disturbance, increased suspended sediment). This information is available on the MarLIN website, as well as in the current literature specific to this subject and includes Wilhelmsson *et al.* (2010); BERR (2008); OSPAR (2008b, 2009) and Cefas (2009). This literature provides an overview of vulnerability of benthic and aquatic marine life to the specific potential environmental impact of offshore wind farm development, based on field and experimental studies as well as theoretical models.

14.7.1 Construction

95 The environmental effects arising from the construction of the development are both permanent (e.g., habitat loss, discussed in Section 14.7.2) and temporary, the latter lasting only through the construction activities, and are associated with the turbine installation and the cable laying. These are presented and discussed separately in the following sections.

14.7.1.1 Offshore Site

96 Potential effects on benthic habitats within the main offshore site will be associated with the installation of the foundations, inter-array cables and associated structures (e.g., scour protection) and will include:

- Habitat disturbance or loss (displacement, physical disturbance and abrasion); and
- Increase in SSC and sediment settlement.

Physical Habitat Disturbance

97 The sources of physical disturbance to benthic habitats during the construction phase are:

- The jacking-up and anchoring of construction vessels;
- Placement of jacket foundations; and
- The installation of inter-array cables.

98 The impacts caused by the permanent loss of benthic habitats from actual foundation structures are assessed within the operational phase impacts. The relevant Rochdale Envelope parameters are defined in Table 14.8 to 14.15.

99 The ability of the biotopes to recover varies from moderate to high depending on the species specific growth patterns and reproductive strategies. For example, seapens and Nephrops within **SS.SMu.CFiMu.SpnMeg** has a low overall vulnerability, as although the intolerance is medium, the recoverability is high (MarLIN, 2011). Seapens, a slow growing, long-lived species of conservation importance, is generally considered to have patchy recruitment. Nephrops, a species of commercial importance, take at least three or four years to reach maturity with fecundity related to female size (average life span being eight to nine years). The females are most susceptible to direct habitat loss as they carry their eggs for nine months, tending them within their burrows. Consequently, it will take several years for the overall impacted community to reach maturity. Similarly, **SS.SMu.CSaMu** has medium recoverability to habitat loss as the key characterising species do not reach sexual maturity for several years. Conversely, key species of the biotopes **SS.SCS.CCS** and **SS.SMx.CMx.OphMx** and to a lesser extent **CR.MCR.EcCr** are fast colonisers, characterised by rapid growth and early reproduction as well as multiple reproductive phases which would allow the biotope to recover very quickly (MarLIN, 2011).

100 Assessment of vulnerability is based on species mobility (ability to burrow to avoid damage and repopulate from the immediate vicinity following cessation of disturbance), as well as recruitment potential associated with the high fecundity and reproductive strategies of the species within these biotopes. Reproductive traits that benefit recovery include a short time to reach sexual maturity (e.g., two years for venerid bivalves typical of **SS.SCS.CCS** and a few months for some species of polychaete worm typical of **SS.SMu.CSaMu**), annual breeding and multiple recruitment phases (e.g., brittlestars typical of **SS.SMx.CMx.OphMx**). In addition to their ability to repopulate with their short maturation period, brittlestars can withstand considerable damage to arms and even the central disk without suffering mortality and are capable of arm and even some disc regeneration. Similarly, the common starfish is able to tolerate damage, including the loss of one or more arms. However, the viability of a population with a high index of arm damage may be reduced because of the energetic costs of repair and growth at the expense of gametogenesis (MarLIN, 2011).

101 The majority of biotopes recorded within the turbine array have been assessed to have negligible vulnerability to temporary habitat disturbance associated with construction operations (Table 14.8) because of their high adaptability, tolerance and potential for rapid recovery following cessation of construction activities. This is despite a possible immediate and localised decline in species richness (caused by the mortality of permanently attached species, e.g., within **CR.MCR.EcCr** and species predated upon, during displacement). The exception is **SS.SMu.CFiMu.SpnMeg** which is moderately vulnerable. The magnitude of temporary sediment disturbance associated with habitat loss, displacement and physical abrasion from the construction process is predicted to be low as it will be short term and localised.

102 The overall impact of direct physical habitat during construction in the offshore site on benthic habitats and communities is predicted to be of ***minor significance***. This assessment carries low uncertainty levels.

[2] Passive species movement refers to organisms which are transported by the current (passively) rather than actively swimming.

Source	Pathway	Receptor	Magnitude of effect	Vulnerability of receptor	Significance of impact	Qualification of significance
Installation of turbines, inter-array cables and associated structures	Physical habitat disturbance	**SS.SMx. CMx.OphMx**	Low	Negligible	Minor significance	Probability is high and uncertainty is low. The majority of species in this biotope are tolerant of displacement as they can detach from the substratum and relocate. Burrowing infaunal species are able to re-burrow after displacement. Sessile fauna may be prone to physical damage. The biotope is of scientific interest if associated with the formation of brittlestar beds, but currently holds no conservation importance.
		SS.SCS.CCS, **SS.SSa.OSa. (OfusAfil),** **SS.SMu. CSaMu (ThyNten; AfilMysAnit and AfilNten)**	Low	Low	Minor significance	Probability is high and uncertainty is low. Some infauna are able to rebury following displacement. However, they may be vulnerable to predation while exposed and some mortality may occur. Permanently attached species would not be able to reattach following displacement and hence there would be a temporary minor decline in sessile fauna. Physical disturbance may cause damage and possibly mortality of fragile species whereas robust bodied or thick shelled species may be more resilient. It is unlikely that any species would be eradicated from the wider biotope and hence there would be no change in overall species richness.
		SS.SMu. CFiMu. SpnMeg	Low	Low	Minor significance	Probability is high and uncertainty is low. The biotope is assessed as having low vulnerability as the constituent species (e.g., Nephrops and seapens) are considered to have low tolerance to habitat disturbance and have moderate recoverability.
		CR.MCR.EcCr (FaAlCr.Pom and Adig)	Low	Low	Minor significance	Probability is high and uncertainty is Low. Erect epifaunal species, e.g., soft corals and hydroids cannot reattach if removed and would be lost. Mobile predators and epibenthos, e.g., crabs sea urchins and brittlestars are likely to survive displacement and return to suitable substrata. Abrasion (e.g., by anchor chains) is likely to result in loss of spines and some damage to tests of *urchin species.* Some spine regrowth is possible but most direct disturbance impact is likely to be lethal.

Table 14.8: Impact assessment of direct habitat disturbance from construction on biotopes in the offshore site

Increased Suspended Sediment Concentrations (SSC) and Sediment Settlement

103 An increase in SSC within the offshore site is likely to occur as a result of the preparation of the seabed for gravity base foundations and installation of the inter-array cables. The degree of seabed preparation will depend on the specific site conditions; however, a certain degree of dredging will required to level the seabed. Results of the model analysis (refer to Chapter 9: Physical Processes) show that the discharge of dredged material during the preparation of gravity base foundations will lead to elevated SSC with peaks of up to 300 mg/l (depth averaged) very close to the release location. However, the resulting plumes will not be transported beyond the immediate vicinity of the dredging site with concentrations predicted to be less than 10 mg/l within 1 km of the gravity base, which are negligible when compared to natural background levels ranging from 3 to 8 mg/l, particularly when put into the wide geographical context of the development. The suspended sediment plume (>1 mg/l) is predicted to extend up to 4 km from the release location and will settle out of the water column within one day if released near the surface. The resulting deposition footprint is likely to cover the development area with varying thickness, generally between 1 and 10 mm, and with localised peaks of between 3 and 30 cm, depending on the release location (near surface or near bed release).

104 These values are overestimates as they assume that the entire volume of the dredged material would be discharged at the turbine location. However, in practice, the material will be removed and disposed of in a licensed disposal area (Chapter 5: Project Description). In addition, the model assumes that the dredging process would be on a continual basis, with the dredging of each foundation taking 24 hours to complete and the commencement of each new base starting immediately after the previous one. However, in practice, the preparation and installation of each gravity base is likely to take several days (Chapter 5: Project Description) during which there will be periods of no discharge of dredged material (Chapter 9: Physical Processes).

105 An increase in SSC and subsequent sedimentation would have different effects depending on the nature of the receptor affected (Tables 14.9). Passive suspension feeders (e.g., brittlestars within **SS.SMx.CMx.OphMx**) are likely to favour an increase in sedimentation as this can often lead to the introduction of organic materials which is found in greater proportions in fine sediments. This could potentially enhance the energetic availability to a greater number of individuals in a brittlestar bed. However, smothering by 5 cm of sediment for one month (MarLIN benchmark) is likely to result in the death of most individuals, although, this biotope is potentially able to rapidly recover because of the annual breeding pattern of the main bed-forming brittlestar *O. fragilis,* which involves multiple recruitment phases. Other suspension feeding species (e.g., seapens in **SS.SMu.CFiMu.SpnMeg** and brittlestars in **SS.SSa.OSa.OfusAfil**) are able to self-clean, therefore, clogging of the feeding organs is unlikely. Burrowing infauna are unlikely to be affected by an increase in suspended sediment and subsequent smothering as most animals will be able to re-burrow or move up through the sediment within hours or days, based on the MarLIN benchmark value.

106 The shallow burrowing venerids within the **SS.SCS.CCS** biotope are more likely to be susceptible to increases of SSC and subsequent sediment settlement (Table 14.9). These invertebrates are active suspension feeders, trapping food particles on their gill filaments, which may be clogged as a result of increased suspended sediment unless the animal is able to self-clean. However, the process of self-cleaning will occur at some energetic cost. Smothering by 5 cm of sediment will result in temporary cessation of feeding and respiration and the consequent energetic cost may impair growth and reproduction but it is unlikely to cause mortality. The effect on growth and reproduction is unlikely to extend beyond six months, therefore, recoverability is considered to be very high at the MarLIN benchmark.

107 The sessile epifauna (e.g., hydroids and bryozoans within the biotope **CR.MCR.EcCr**) are likely to be the most susceptible organisms to an increase of SSC and subsequent sediment settlement leading to possible smothering, which may cause individual mortality leading to temporary and localised decline of species richness within the biotope, at the MarLIN benchmark (Table 14.9).

108 An increase in SSC may to lead to an increase in siltation which would tend to favour the deposit feeders with a consequent shift in community composition away from suspension feeders. However, the MarLIN benchmark is given as a constant increase of 100 mg/l in SSC over one month before mortality occurs, which is far higher than those predicted to occur during the construction phase (see Chapter 9: Physical Processes)

109 The magnitude of the effect is considered to be low (Table 14.9) as it will be limited in space and time, occurring intermittently during the construction phase. The vulnerability of the biotopes to increased SSC and subsequent sediment settlement are considered to be negligible (Table 14.9) as the fauna there is either burrowing or tolerant of higher sediment loads than those predicted to occur during the construction of the Neart na Gaoithe wind farm.

110 The resulting impact of increased SSC and turbidity and sediment settlement caused by construction activity in the offshore site is assessed to be of ***minor significance*** (Table 14.9) and this assessment carries low uncertainty.

Source	Pathway	Receptor	Magnitude of effect	Vulnerability of receptor	Significance of impact	Qualification of significance
Installation of gravity base foundations	Increase in SSC and sediment settlement/ smothering	**SS.SMu. CFiMu. SpnMeg**	Low	Negligible	Minor significance	Probability is high. Uncertainty is Low. The majority of species in this biotope are tolerant of displacement as they can detach from the substratum and relocate. Sessile fauna may be prone to physical damage. Burrowing infaunal species are able to re-burrow after displacement.
		SS.SMx. CMx. OphMx	Low	Negligible	Minor significance	Echinoderms can tolerate considerable damage to arms and even disks without suffering mortality and are capable of arm and even some disk regeneration although this can be at the expense of future reproductive outputs. *O. fragilis* need suspended material so are likely to tolerate different SSC levels except when sedimentation is excessive, causing fouling to the feeding apparatus. Levels are unlikely to be that high in the development area.
		SS.SMu. CSaMu **SS.SCS.CCS** **SS.SSa. OSa. (OfusAfil)**	Low	Negligible	Minor significance	Probability is high, uncertainty is low. Smothering may result in temporary cessation of feeding/ respiration. Consequently the energetic cost may impair growth/ reproduction. Unlikely to cause mortality. Effects will probably not extend beyond six months.
		CR.MCR. EcCr	Low	Negligible	Minor significance	Probability is high, uncertainty is low. An increase in SSC may reduce feeding efficiency in suspension feeders, and be detrimental to several members of the community, especially hydroids, bryozoans and juvenile sea urchins. This biotope is of medium value important because of due to its potential to constitute reefs.

Table 14.9: Impact assessment of increase in SSC and sediment settlement from construction on biotopes in the offshore site

14.7.1.2 Export Cable Route - Subtidal

111 The key impacts relating to cable laying in the marine environment are those arising during the installation process (BERR, 2008) and include the same as those associated with the turbine foundation installation, though to a lesser extent given the smaller footprint associated with the export cable laying.

112 In respect of the overall site, the subtidal biotopes recorded along the export cable corridor were also recorded within the proposed turbine array, and are discussed in relation to predicted effects of cable laying operations.

Habitat Disturbance

113 Although the corridor for export cable installation activities is 33 km long, sediment disturbance is likely to be restricted to 10 m either side of each installation trench, therefore, the magnitude of temporary habitat disturbance is predicted to be low.

114 The level to which the seabed is disturbed is primarily related to the nature of the ground and the type of tool selected to bury the cable. An estimate of the rate at which the sediment is disturbed can be made based on the size of the slot or trench created by the tool (BERR, 2008). Results of the sediment dynamics model study (see Chapter 9: Physical Processes) indicate that the maximum volume of sediment displaced is likely to be 800 m^3 per hour, based on a trench width of 1 m, dug to a depth of 2 m, and assuming a typical trenching rate of 400 m per hour. However in addition to this corridor of disturbance there will be a further area disturbed by the plough runners or skis (see Chapter 5: Project Description), but at a lower severity to the trenched area.

115 As a result of the restricted temporal and spatial nature of the cable installation activities, effects on the benthic communities are likely to be very localised and short term. The vulnerability of the benthic communities to this effect along the cable routes is assessed to be negligible as most species and biotopes are tolerant to this form of disturbance (see above) whilst others can easily adapt through physiological changes. Recovery is likely to be rapid. The spatial extent of the disturbance is small and the biotopes are widely distributed within the wider geographical context, therefore, the magnitude of effect is considered to be negligible.

116 The impact of export cable installation on subtidal benthic habitats and communities is assessed to be ***not significant*** (Table 14.10). A low uncertainty is ascribed to this assessment.

Source	Pathway	Receptor	Magnitude of effect	Vulnerability of receptor	Significance of impact	Qualification of significance
Installation of export cables	Direct habitat disturbance	Export cable route subtidal biotopes including **SS.SMu.CSaMu.ThyNten, AfilMysAnit, AfilNten** and **SS.SMu.CFiMu.SpnMeg**	Low	Negligible	Minor significance	Probability is high, uncertainty is low. The magnitude of the effect is expected to be lower beyond 1-2 m trench width. Although some biotopes in the export cable route have some insensitivity to disturbance, many are generally tolerant and adaptable and of low value.

Table 14.10: Impact assessment of habitat disturbance from construction on biotopes in the export cable route (subtidal)

Increased SSC, Turbidity and Sediment Settlement

117 Results of the modelling studies show that, regardless of the location along the cable route, the elevated SSC are predicted to be between 3 and 10 mg/l with some highly localised peaks in some small areas reaching 30 mg/l. The associated suspended sediment plumes are predicted to be less than 5 km in extent settling out within a maximum of 4 hours, with resulting localised deposition footprints. The maximum predicted deposition thickness is 3 mm, with a thickness of greater than 0.1 mm predicted to extend up to 2 km either side of the cable trench (see Chapter 9: Physical Processes). In reality, the amount of sediment that will be re-suspended into the water column is likely to be less, as the modelling study assumed that the entire volume of the trench would be suspended into the water column with no backfilling.

118 The subtidal biotopes identified along the export cable route are likely to be tolerant of increases in suspended sediment depending on the concentration, the sediment type and the period over which the increase occurs. Cable burial by ploughing minimises the amount of sediment likely to be brought into suspension because of the controlled operation by which the cable plough works, followed by the backfilling of the trench (BERR, 2008). However, the fine sediment (mud) is still likely to mix with water and to be dispersed by tidal currents. Coarser sediments are also likely to be brought into suspension, but are expected to quickly settle back to the seabed and are unlikely to be dispersed over long distances by tidal currents.

119 The magnitude of the effect is assessed to be negligible. The vulnerability of the affected biotopes to increased SSC and subsequent smothering is as discussed above and is assessed to be negligible.

120 The overall impact of increased SSC and sediment settlement associated with export cable installation (subtidal) is assessed to be ***not significant*** and low uncertainty is ascribed to this assessment (Table 14.11).

Source	Pathway	Receptor	Magnitude of effect	Vulnerability of receptor	Significance of impact	Qualification of significance
Installation of export cables	Increase in SSC and sediment settlement/smothering	Export cable route subtidal biotopes including **SS.SMu.CSaMu. ThyNten**, **AfilMysAnit**, **AfilNten** and **SS.SMu.CFiMu. SpnMeg**	Negligible	Negligible	Not significant	Probability is high, uncertainty is low. The magnitude of the effect, as outlined in Chapter 9: Physical Processes, is negligible. Most receptors in the export cable route are tolerant to levels of increased SSC.

Table 14.11: Impact assessment of increased SSC and sediment settlement/smothering from construction on biotopes in the export cable route (subtidal)

14.7.1.3 Export Cable Route – Intertidal Zone

121 Potential effects in the intertidal area likely to be associated with the construction phase are:

- Habitat disturbance (physical damage and abrasion) and displacement; and
- Sediment re-suspension and subsequent settlement.

Physical Disturbance to Habitats and Species

122 Disruption to intertidal habitats will occur as a result of cable laying and installation. The cable construction corridor for surface trenching is usually no wider than 3 m either side of the export cables (BERR, 2008) (see Chapter 5: Project Description). The corridor will support vehicle traffic, provide adequate space for cable assembly, sufficient space for excavation of the cable trenches as well as sufficient space for the removed sediment. The intertidal cable may, however be installed through directional drilling, which will limit the footprint of any habitat disturbance.

123 The magnitude of direct disturbance is assessed to be negligible as it is limited in space (within the cable corridor) and in time (during the construction phase) and it is likely to be similar for all installation techniques.

124 The intertidal biotopes recorded at the Thorntonloch are assessed to be of negligible vulnerability to the effects of habitat disturbance associated with cable laying as they are typical of naturally unstable habitats and host animals that have high tolerance and adaptability to this continually disturbed environment (Connor *et al*., 2004). The high growth and reproductive rates of the species characteristic of these biotopes ensures rapid recoverability following cessation of the disturbance.

125 The overall impact of direct habitat disturbance from export cable installation (intertidal) is assessed to be ***not significant*** and this assessment carries low uncertainty.

Source	Pathway	Receptor	Magnitude of effect	Vulnerability of receptor	Significance of impact	Qualification of significance
Installation of export cables	Direct habitat disturbance	Export cable route intertidal biotopes including **LS.LSa.MoSa**, **LR.FLR.Eph.EntPor** and **LR.MLR.BF.Rho**	Negligible	Negligible	Not significant	Probability is high, uncertainty is low. The magnitude of the effect, as outlined in Chapter 9: Physical Processes, is negligible. Most intertidal receptors in the export cable route are highly tolerant to changing environments.

Table 14.12: Impact assessment of habitat disturbance from construction on biotopes in the export cable route (intertidal)

Increased SSC and Sediment Settlement/Smothering

126 Cable installation within the intertidal area is likely to be undertaken during low tide; therefore, the potential for re-suspension of sediment as a result of construction activities and subsequent sediment settlement is very low. The degree of sediment re-suspension likely to occur with the flooding tide is expected to be low because of the coarse nature of the sediment, which will settle back very rapidly. The spatial extent of any sediment settlement is expected to be very localised and short term and the overall magnitude of the effect is considered negligible.

127 The intertidal biotopes recorded at Thorntonloch are considered to have negligible vulnerability to the effects of sediment re-suspension and smothering by 5 cm of sand (MarLIN benchmark), owing to their high tolerance and adaptability to the continual turbulence naturally occurring within this zone from storm events and/or hydrodynamic exposure (tides and wave action). In addition, owing to the ephemeral nature of the floral and faunal organisms typically found in this intertidal zone, recoverability of these biotopes is likely to be very rapid following cessation of disturbance.

128 Overall, the effect of increased SSC and sediment settlement is likely to be ***not significant*** and this assessment carries low uncertainty.

Source	Pathway	Receptor	Magnitude of effect	Vulnerability of receptor	Significance of impact	Qualification of significance
Installation of export cables	Increase in SSC and sediment settlement/ smothering	Export cable route intertidal biotopes including **LS.LSa.MoSa**, **LR.FLR. Eph.EntPor** and **LR.MLR.BF.Rho**	Negligible	Negligible	Not significant	Probability is high, uncertainty is low. The magnitude of the effect, as outlined in Chapter 9: Physical Processes, is negligible. Most intertidal receptors in the export cable route are highly tolerant to changing environments.

Table 14.13: Impact assessment of increased SSC and sediment settlement/smothering from construction on biotopes in the export cable route (intertidal)

14.7.2 Operation and Maintenance

129 The environmental effects (Table 14.10) arising from the operation and maintenance relevant to benthic ecology are:

- Permanent habitat loss directly under turbine foundations, scour protection and substation structures;
- Temporary habitat disturbance (displacement, physical disturbance and abrasion) from jack-up barge and vessel anchoring used during maintenance activities;
- Introduction of new subsea structures and subsequent substrates from the turbine and other structures in the offshore site and rock armouring of the intra-array and export cables;
- Changes in hydrodynamics caused by the presence of new structures, including scour and changes in sediment transport; and
- Electromagnetic fields (EMF) and heating generated by the intra-array and export cables.

14.7.2.1 Offshore Site

Permanent Habitat Loss

130 The biotopes recorded within the offshore site have low tolerance to habitat loss as this involves the removal of the substratum and any attached benthic community. Long term habitat loss will occur directly under all turbine foundations and associated structures including scour protection. Based on the Rochdale Envelope the maximum total area of habitat loss is estimated to be 0.25 km^2 (0.05%) of the Neart na Gaoithe offshore site (this does not include an estimate for loss due to substation foundations, however this is not expected to increase this estimate by any more than 10%). Removal of the substratum would result in removal of the community and its associated species; therefore, all biotopes have low tolerance to this effect or none at all.

131 However most biotopes in the offshore site are widely represented within the southeast Scotland region and any loss that may occur within the offshore site is considered of low magnitude within the wider geographical context. In addition, the recoverability of most biotopes is likely to occur within five years, should the wind turbines be removed, e.g., at the end of the wind farm lifespan. Therefore, their vulnerability to habitat loss is considered low (Table 14.14). The overall impact of habitat loss on the structure and functioning of the benthic biotopes is assessed to be of ***minor significance*** (Table 14.14). This assessment carries low uncertainty.

Source	Pathway	Receptor	Magnitude of effect	Vulnerability of receptor	Significance of impact	Qualification of significance
Presence of turbine foundations and inter-array cabling with scour protection	Direct habitat loss	**SS.SMu.CFiMu.SpnMeg SS.SMx.CMx.OphMx SS.SMu.CSaMu SS.SCS.CCS SS.SSa.OSa.(OfusAfil) CR.MCR.EcCr**	Low	Low	Minor significance	Probability is high, uncertainty is low. The magnitude of the effect, as is considered low overall given the area of habitat lost. The biotopes present have varied tolerance, adaptability and recoverability but overall give the presence of the biotopes in the wider region, vulnerability is assessed as low.

Table 14.14: Impact assessment of habitat loss in the operational stage of the offshore site on benthic ecology

Temporary Habitat Disturbance

132 The maintenance of the wind farm involves use of jack-up vessels for intermittent maintenance. This will create habitat disturbance of approximately 0.04 km^2 over 25 years. This is expected to be an underestimate given the use of other vessels which may have anchoring systems. However due to the limited duration, extent frequency and severity the magnitude of the effect is assessed to be negligible and the significance of this impact is considered to be ***not significant.***

Changes in Hydrodynamic Regime

133 The biotopes recorded within and surrounding the Neart na Gaoithe site are found in moderately strong (e.g., **SS.SMx.CMx.OphMx** and **SS.SCS.CCS**) to weak and very weak (e.g., **CR.MCR.EcCr, SS.SMu.CFiMu.SpnMeg** and **SS.SMu.CSaMu**) tidal streams and are likely to be intolerant to significant changes in water flow rates (MarLIN, 2011). Although an increase in water flow rate may result in higher nutrient availability in the water columns, some species may be unable to feed in very strong currents. In addition, increases in flow rate will change the surface layer of the seabed sediment, removing the mud fraction to leave the coarser particles behind. This in the long term may change the nature of the top layers of sediment, making it unsuitable for some shallow burrowing species. Conversely, if water movement becomes negligible, suspended organic particles available to filter feeders will decline impairing growth and fecundity in the long term.

134 The tolerance of the biotopes is reported to be low at the MarLIN benchmark (MarLIN, 2011), which assumes a change in water flow of two categories, e.g., from moderately strong to very weak. These values are significantly higher than those predicted to occur within the site during the operational phase. Results of the modelling study (see Chapter 9: Physical Processes) indicate that the predicted changes to water level caused by the presence of the wind turbines and their foundations are very small (<0.025% of water depth) and generally localised to the near-field with the exception of a small change (<0.02%) of spring tidal range in the upper reaches of the Firth of Forth. Changes to the tidal currents are predicted to be quite small (between 3 and 6% of peak spring tidal velocities), and restricted to the immediate vicinity of the offshore site. Similarly, the predicted changes to the wave climate are considered to be small (<3% of average waves) and restricted to the immediate vicinity of the offshore site. The predicted changes to the sediment transport process are considered to be very small with the frequency of the exceedance of the critical sheer stress changing typically by 1-3% (with a maximum difference of 6%). These changes are also restricted to the immediate vicinity of the offshore site. Chapter 9: Coastal Processes provides additional data on the change in the physical conditions.

135 Impacts of scour were also assessed as part of the modelling study, the results of which indicate that if jacket structures are employed, the estimated equilibrium scour depth will be between 2.20 and 3.26 m; the lateral extent of the scour pit will be between 3.98 and 7.99 m; and the scoured area will between 284 and 1063 m^2. The actual dimensions of the scour pits around each leg of the structure will depend on the size of turbine installed. However, scour pits will not overlap regardless of turbine size, and, therefore, the scour will be relatively localised. The volume of scoured material will be between 196-1,100 m^3, depending on the size of the turbines. The resulting elevated SSC would be small and localised, with peak concentrations between 100-300 mg/l, and concentrations beyond about 250 m of the structures reducing to <10 mg/l. The resulting deposition footprints will be very localised around the turbine base, with a maximum thickness of 0.1 m and the extent of the footprint with a thickness >1 mm reaching up to 500 m. The impacts from the scoured material around the structures is, therefore, considered to be small and localised within the near-field.

136 In view of these results, the magnitude of the potential hydrodynamic changes is assessed to be negligible (Table 14.15) and the vulnerability of the biotopes to the predicted changes is assessed to be low (Table 14.15). The overall impact of a change in hydrodynamic regime in the operational phase is considered to be of ***minor significance*** (Table 14.15) and this assessment carries low uncertainty.

Source	Pathway	Receptor	Magnitude of effect	Vulnerability of receptor	Significance of impact	Qualification of significance
Presence of turbine foundations and inter-array cabling with scour protection	Changes in hydrodynamic conditions	**SS.SMu.CFiMu.SpnMeg SS.SMx.CMx.OphMx SS.SMu.CSaMu SS.SCS.CCS SS.SSa.OSa.(OfusAfil)**	Negligible	Low	Minor significance	Probability is high, uncertainty is low. The magnitude of the effect is predicted to be negligible (see Chapter 9: Physical Processes) and changes limited to the near field. Although some biotopes present are intolerant to change, the values that affect them are much higher than predicted at the Neart na Gaoithe site and as such the impact is considered not significant.

Table 14.15: Impact assessment of change in hydrodynamic conditions in the operational stage of the offshore site on benthic ecology

Introduction of New Substrates

137 The presence of turbine foundations, towers and associated turbine and inter-array cable scour protection may lead to increased heterogeneity and consequently to new different biological communities particularly in areas of soft sediment seabed. Monitoring studies of offshore wind farms to date indicate that in areas of soft sediment seabed, the addition of turbine foundations is not likely to have a significant effect on the native communities, at least in the short term (Dong Energy *et al*., 2006). These studies indicate that the benthic communities of the soft sediment areas occurring within the turbine array were not considerably different from those occurring within reference areas (Lindeboom *et al*., 2011). Conversely, turbine foundations and associated scour protection are reported to support faunal assemblages which differ significantly not only from those typical of soft sediment seabed, but also from those occurring on natural hard substrate (Wilhelmsson and Malm, 2008).

138 The colonisation of the turbine foundations by the epibenthic macrobiota is influenced by physical and biological factors, as well as by the position and orientation of the substrate in the water column (Wilhelmsson *et al*., 2010). Therefore, the assemblages on the vertical turbine foundations may differ from those on the scour protection around them (Lindeboom *et al*., 2011). Post-construction studies of offshore wind farms show that turbine foundations support dense populations of filter feeders, typically blue mussels *Mytilus edulis*, which has also been recorded on other structures projecting from the sea floor, such as oil platforms and pier pilings (Wilhelmsson and Malm, 2008). Surveys of operational wind turbines on the Danish coast have recorded two principal assemblages, i.e., mussels, dominating the upper zone, and tubeworms, anemones, hydroids and solitary sea squirts on the lower zone (Dong Energy *et al*., 2006; Lindeboom *et al*., 2011).

139 It is likely that the presence of new substrates may result in a localised increase of biological diversity, as observed for the Torness artificial reef constructed in 1984, south of Torness powerstation (Irving, 1997). Similarly, the colonisation succession studied on a range of material (concrete, rubber and steel) on the west coast of Scotland, indicated that after 12 months of immersion the colonisation of all materials became increasingly similar, showing a dominance of tunicates (Linley *et al*., 2007). Similarly, observations on the succession of animals and plants on an artificial reef in Poole Bay showed that after 18 months of submergence the biological communities on the artificial reef were similar to those developed on local rocky patch reefs after five years of submergence (Linley *et al*., 2007). Therefore, biological succession can result in the establishment of communities similar to those already naturally present; the rate that this biological succession from colonisation to climax community occurs is influenced by the local physical (e.g., hydrographic regime) and biological conditions (e.g., larval supply) (Linley *et al*., 2007).

140 Within the context of the Neart na Gaoithe development, the abundance of epibenthic assemblages, e.g., those associated with the biotopes **SS.SCS.CCS** and **CR.MCR.EcCr**, is likely to increase, as more hard substrate will be available with an estimated total surface area of 0.43 km^2. Other marine organisms will also colonise the turbines, but the extent to which this may affect the overall biodiversity in the longer term (more than 10 years) is currently difficult to estimate. The magnitude of the effect is assessed to be low and the vulnerability of biotopes (in terms of likelihood of a switch in community structure and composition) is low. The overall impact is likely to be of ***minor significance***. The uncertainty of this assessment is medium as although the effect is likely to be localised, no estimate can presently be made on how any habitat alteration may affect species diversity and biomass within the area as a whole in the long term.

141 The addition of turbine foundations may act as stepping stone for alien species brought in as larvae by ballast waters (Wilhelmsson *et al*., 2010). The introduction of non-native species may impair the ecosystem equilibrium as artificial structures are reported to be more suitable for non-native species than natural reefs by changing the competitive interactions (Wilhelmsson *et al*., 2010). However, no specific information is available to suggest that reefs associated with offshore wind farms will provide uniquely beneficial opportunities not currently available to alien species to assist their invasion in UK waters (Linley *et al*., 2007).

142 There are no records of non-native species invading the biotopes recorded within the offshore site and the likelihood of non-native species establishing and dominating on wind turbines within the Neart na Gaoithe offshore site is reduced by the existing (long term) presence in the region of both natural and man-made hard substrata (e.g., Torness breakwater) which already support established epibenthic communities (Lindeboom *et al*., 2011). In light of this the vulnerability of the biotopes to colonisation of alien species is considered negligible. The magnitude of the effect is considered to be negligible and the overall impact assessed to be ***not significant*** with low uncertainty (Table 14.16).

Source	Pathway	Receptor	Magnitude of effect	Vulnerability of receptor	Significance of impact	Qualification of significance
Presence of turbine foundations and inter-array cabling with scour protection	New substrate materials	Biotopes in offshore site, e.g., those with epibenthic assemblages **SS.SCS.CCS** and **CR.MCR.EcCr**	Low	Low	Minor significance	Probability is high, uncertainty is medium. Additional hard substrate will result in colonisation, but the extent to which this may affect the overall biodiversity in the longer term unknown.
	Pathway for alien or invasive species	Biotopes in offshore site	Negligible	Negligible	Not significant	Probability is low, uncertainty is low. There are no records of non-native species invading the biotopes recorded within the offshore site. Additionally, presence of a number of existing novel substrata (e.g., breakwaters) without non-native invasion reduces this possibility.

Table 14.16: Impact assessment of introduction of new substrate in the operational stage of the offshore site on benthic ecology

14.7.2.2 Export Cable Corridor - Subtidal Assessment

143 Subsea cables need protection in order to reduce the risk of damage to the cable and to ensure the safety of other users of the sea. Two methods are currently used to provide protection to subsea cables, the most common of which is cable burial within the seabed sediment. When cable burial is not achievable the cable is laid

directly onto the seabed and measures taken to protect the cable, for example, rock dumping or the use of grout / sand bags. Additional information on the methods of cable protection can be found in Chapter 5: Project Description.

144 The environmental impacts associated with the use of outer cable protective measures or scour protection are permanent habitat loss and introduction of new substrate.

Permanent Habitat Loss (Cable Protection)

145 Permanent habitat loss will occur directly under the cable protection measures. The current anticipated cable protection method uses an assumed scour protection dimensions of 3 m by 5 m and 0.3 m thick (refer to Chapter 5: Project Description and BERR, 2008). The habitat loss along the two 33 km long export cables is estimated to be 0.07 km^2. This represents a small spatial extent compared to habitat loss from the presence of turbine foundations and the magnitude of the effect is assessed to be negligible.

146 The biotopes recorded along the export cable route have low tolerance to substratum loss as this involves the removal of the substratum and the associated communities. The ability of the biotopes to recover (e.g., following removal of the cable and associated protection measures as part of decommissioning) varies from moderate to high depending on the species specific growth patterns and reproductive strategies which have been discussed in the offshore site section. The fact that these biotopes occur over a large area outside the study area can facilitate the recovery process. In view of this, the vulnerability of the biotopes to habitat loss occurring along the export cable route is assessed to be negligible and the overall impact on the structure and functioning of the benthic biotopes is assessed to be ***not significant*** and this assessment carries low uncertainty (Table 14.17).

Source	Pathway	Receptor	Magnitude of effect	Vulnerability of receptor	Significance of impact	Qualification of significance
Presence of export cable with cable/scour protection	Direct habitat loss	Export cable route subtidal biotopes including **SS.SMu.CSaMu.ThyNten**, **AfilMysAnit, AfilNten** and **SS.SMu.CFiMu.SpnMeg**	Negligible	Negligible	Not significant	Probability is high, uncertainty is low. Biotopes are common outside the cable route corridor, and given the magnitude of the effect the impact is assessed as not significant.

Table 14.17: Impact assessment of permanent habitat loss in the operational stage of the export cable route on benthic ecology

Introduction of New Substrates (Cable Protection)

147 The introduction of cable protection may lead to increased heterogeneity as already discussed within the offshore site section. Photographic and sampling surveys at the Torness artificial reef, south of the export cable route, indicated that a local enhancement of the cod and European lobster populations around the reef (Irving, 1997). Some large invertebrates such as the sea urchin *Echinus esculentus*, the common starfish and encrusting bryozoans had also colonised the reef (Irving, 1997). Given the relatively limited spatial extent of the cable protection, the magnitude of this effect is considered to be negligible and the overall impact likely to be ***not significant***. This assessment carries low uncertainty (Table 14.18).

Source	Pathway	Receptor	Magnitude of effect	Vulnerability of receptor	Significance of impact	Qualification of significance
Presence of export cable with cable/scour protection	New substrate materials	Export cable route subtidal biotopes including **SS.SMu.CSaMu.ThyNten**, **AfilMysAnit, AfilNten** and **SS.SMu.CFiMu.SpnMeg**	Negligible	Negligible	Not significant	Probability is high, uncertainty is low. Additional hard substrate will result in colonisation (as observed at the nearby artificial reef), but the extent to which this may affect the overall biodiversity in the longer term unknown.

Table 14.18: Impact assessment of introduction of new substrate in the operational stage of the export cable route on benthic ecology

Electromagnetic Fields (EMF)

148 Studies on the effects of EMF on benthic invertebrate fauna are limited and those that are available indicate that geomagnetic orientation is not a unique characteristic of fish and marine mammals, but it also occurs in molluscs (e.g., nudibranchs (Cain *et al*., 2005), chitons and crustaceans (sandhoppers)) (Bochet and Zettler, 2006).

149 The survival and physiology of selected species of prawns, crabs, starfish, marine worms and blue mussels have been studied in relation to EMF levels corresponding to the intensity on the surface of ordinary submarine direct current cables in the Baltic Sea. Results showed no significant effects for any of the species under consideration after three months of exposure (Bochert and Zettler, 2004). In addition, a visual survey of benthic communities on wind power cables and the peripheral areas, showed no differences in assemblage structure (Wilhelmsson *et al*., 2010).

150 In general, the occurrence of apparently healthy and diverse communities on existing offshore wind farm structures provides evidence that EMF is unlikely to pose a significant threat to the colonising communities on turbine bases in the longer terms (Cefas, 2009; Linley *et al*., 2007). However, in the absence of more comprehensive evidence, uncertainty remains when predicting potential impacts of EMF on benthic invertebrate communities.

151 The magnitude of the effect of EMF is considered to be low (Table 14.19) based on the relatively small footprint of the cables within the offshore site. The vulnerability of the invertebrate species associated with the biotopes recorded within the Neart na Gaoithe is considered to be negligible (Table 14.19) (based on current knowledge). The overall effect of EMF from subsea cables on marine benthic invertebrates within the Neart na Gaoithe site is assessed to be of ***minor significance*** (Table 14.19). This assessment carries medium uncertainty as the number of experimental field studies addressing invertebrate tolerance/sensitivity to EMF is currently limited.

Source	Pathway	Receptor	Magnitude of effect	Vulnerability of receptor	Significance of impact	Qualification of significance
Presence of export cables	EMF	Export cable route subtidal biotopes including **SS.SMu.CSaMu.ThyNten**, **AfilMysAnit, AfilNten** and **SS.SMu.CFiMu.SpnMeg**	Low	Low	Minor significance	Probability is high, uncertainty is medium. Experimental filed studies on the survival and physiology of selected species of marine benthic invertebrates have to date shown no significant effects from EMF.

Table 14.19: Impact assessment of EMF in the operational stage of the export cable route on benthic ecology

Heating Effects

152 The heat dissipation created by transmission losses for Alternating Current (AC) cables may result in temperature rise of the surrounding sediment (OSPAR, 2009). The literature reports one set of field measurements of seabed temperature near power cables at Nysted offshore wind farm; however, the results are not considered to be robust enough to draw conclusions applicable to other cases (OSPAR, 2009).

153 It is currently assumed that a permanent increase in the seabed temperature will lead to changes of seabed characteristics (e.g., alteration of redox, O_2, sulphide profiles, changes of nutrient profiles and increase in bacterial activity) (Meißner and Sordyl, 2006). These in turn may impact on the physiology, reproduction or even mortality of certain benthic species, but also alter benthic communities because of changes in emigration/immigration patterns (OSPAR, 2009).

154 Theoretical calculations of the temperature effects of operational buried cables currently reported in the literature predict significant temperature rise of the surrounding sediment (OSPAR, 2009). However, in the absence of robust field data, the assessment of effects of increased temperature associated with subsea cables on marine habitats and species remain highly uncertain (OSPAR, 2009).

155 Within the Neart na Gaoithe site, the magnitude of the effect of heating from subsea cables is considered to be low (Table 14.20) in view of the low number and small spatial extent of the cables. Similarly, the vulnerability of the invertebrate species associated with the biotopes recorded within the offshore site is considered to be negligible (Table 14.20) and the overall impact from potential heating effects of operational power cables is assessed to be ***not significant*** (Table 14.20). This assessment carries high uncertainty because of the lack of robust data from field studies.

Source	Pathway	Receptor	Magnitude of effect	Vulnerability of receptor	Significance of impact	Qualification of significance
Presence of export cables	Seabed sediment heating	Export cable route subtidal biotopes including **SS.SMu.CSaMu.ThyNten**, **AfilMysAnit, AfilNten** and **SS.SMu.CFiMu.SpnMeg**	Negligible	Negligible	Not significant	Probability is medium, uncertainty is high. No data are currently available on the amount of heat dissipation.

Table 14.20: Impact assessment of heating effects in the export cable route during operation for benthic ecology

14.7.2.3 Export Cable Route - Intertidal

156 The potential ecological effects associated with the operational phase are expected to be minimal as the cable is most likely to be buried in the sediment. Limited physical disturbance may occur during maintenance but this is predicted to be limited in space and time and not pose risks to the intertidal habitats (Tables 14.14-14.15).

14.7.3 Decommissioning

157 The life span of the Neart na Gaoithe development is estimated to be 50 years with repowering after approximately 25 years (refer to Chapter 5: Project Description). Current decommissioning plans approved in the UK provide for detailed decommissioning techniques to be approved closer to the time of decommissioning to allow for changes in available technologies. Hence, at present, there is uncertainty on what decommissioning process will be employed at the end of the lifetime of any development. To date, little evidence is available on the environmental effects of decommissioning, but where available, it is mostly based on experience from the oil and gas sector (Wilhelmsson *et al.*, 2010). In order to carry out the assessment it has been assumed that all structures will be removed at the end of the wind farm's life, apart from buried cables, which will be left *in situ*.

14.7.3.1 Offshore Site

158 The options available at the end of the wind farm life span are either complete removal or repowering. As discussed in Chapter 5: Project Description, under various international obligations (most notably the OSPAR convention), as well national legislation and guidance (including Sections 105 to 114 of the Energy Act 2004), it is unlikely that any project structures would remain in place above the seabed. Repowering of the wind farm would require new consents and full environmental impact assessment to be carried out and is, therefore, outside of the scope of this chapter.

159 If the wind farm were to be completely removed, physical disturbances very similar to those occurring during the construction phase may occur, including displacement, physical abrasion and increase in SSC. In addition, it is expected to result in the destruction of the new habitats that may have developed on the hard substrate associated with the turbines and scour protection measures. These new habitats may constitute islands of comparatively undisturbed hard substrata and, if the wind farm has effectively protected an area from the effects of fishing, this protection will disappear (Wilhelmsson *et al*., 2010).

14.7.3.2 Export Cable Route - Subtidal and Intertidal

160 Cables are likely to be disconnected after being isolated offshore. The subsea cables would probably also be left buried and notified as being disused and out of service. Leaving cables *in situ* would avoid significant disturbance to the seabed.

161 Cables could be removed, however, the depth of the cable burial plays a role in the ease of cable removal, as only cables buried to a shallow depth in sandy seabed can be removed using an under-runner. This device is put on the cable and 'under runs' the cable while being towed from a line from a host vessel. However, this procedure will not work if cables are buried to ≥1 m (BERR, 2008). In such cases removal would involve the use of a subsea plant capable of cutting large open trenches to access the buried cables, thus resulting in sediment disturbance. The sections of cable likely to be removed include the beach section down to the low water point and the sections close to the offshore wind turbine generators, as these are not expected to be deeply buried. If cable protection measures are present, these may have provided substrate for new habitats to develop that may also be disturbed/destroyed during cable removal (BERR, 2008). Whilst the placement of this material may be viewed initially as change, the habitat will become integrated over time, and its subsequent loss may displace associated species that have become resident.

162 Impacts of the decommissioning phase are expected to include temporary habitat disturbance and associated species displacement from the removal of the cable and decommissioning vessel footprints e.g., jack-up barges and increases in SSC and sediment deposition from the cutting and dredging works. The impacts of these activities on subtidal habitats and benthic communities are estimated to be similar to, or less than (for example, if cables are left *in situ*), those occurring as a result of construction. Therefore, the impacts of decommissioning are considered to be analogous to those described for the construction phase.

14.8 Mitigation and Residual Impacts

14.8.1 Offshore Site

14.8.1.1 Mitigation for Heating Effects from Cables

163 Mitigation measures to minimise the potential heat generated by operating subsea cables include an appropriate trenching depth to limit the rise in sediment temperature (Table 14.16). This will prevent macrozoobenthic fauna from direct harm as well as limit physical changes that may impair the ecological functioning of benthic communities.

14.8.1.2 Mitigation for Electromagnetic Fields Emitted from Subsea Cables

164 The burial of cables may mitigate the effects of EMF on sensitive species (Table 14.16), although such mitigation may be less relevant to benthic habitats, particularly as the sediment layer itself has no influence on the magnitude of the EMF (Gill *et al.*, 2009), however, it does provide additional distance between the cable and receptor (Gill *et al.*, 2005).

14.8.1.3 Sediment Disturbance from Cable Laying

165 No reefs or shellfish beds have been recorded to occur along the Torness cable corridor during the site specific survey, therefore, no micro-siting of the cable route beyond that within the 300 m cable corridor is currently proposed for these reasons. However, a formal pre-construction cable route survey will be undertaken that will seek to identify any sensitive seabed habitats. Should any such habitats be recorded, the cable route will be micro-sited, via consultation with SNH and stakeholders. Although no significant impact arising from the installation of the cables is predicted, it is considered good practice to minimise the extent of any unnecessary habitat disturbance. On this basis, material displaced as a result of cable burial activities should, where techniques allow, be back-filled in order to promote recovery. This also reduces the potential for re-mobilisation of sediments and enables recovery of benthic organisms to occur within a much quicker timescales (BERR, 2008).

14.9 Cumulative and In-Combination Impacts

166 The cumulative impact assessment scenario has taken into account the proposed Inch Cape and the Firth of Forth Round 3 offshore wind farms and the Neart na Gaoithe project, as described in Table 14.2. Chapter 5: Project Description discusses these other projects in more detail.

14.9.1 Cumulative Construction Impacts

14.9.1.1 Cumulative Direct Physical Disturbance to Habitats

167 Habitat disturbance associated with the turbine and met masts installation, cable installation and supporting infrastructure (e.g., offshore services platforms) is estimated to be up to 14.04 km^2 for the other developments, based on the worst case Rochdale scenario for each development. This is in addition to the values assessed at a project level for Neart na Gaoithe, at 2.11 km^2 and 0.75 km^2 respectively for the offshore site and export cable route. The biotopes impacted are varied with varied vulnerabilities but none are unique to the region and all are widespread across the southern North Sea region (see Figure 14.6).

168 This is of low spatial extent and duration; therefore, the overall impact is assessed to be ***not significant.***

14.9.1.2 Cumulative Increase in Suspended Sediment Concentrations and Settlement

169 The worst cumulative impact scenario assumes that construction operations would occur simultaneously at all three proposed developments. It is noteworthy that the Firth of Forth Round 3 Zone will encompass parts of the Wee Bankie Formation and Marr Bank which lie approximately 40 km off the coast of southeast Scotland. Both are within the feeding range of many seabirds breeding at colonies in and around the Firth of Forth (Wanless *et al.*, 1998). These offshore areas are known to support large population of sandeels which are a critical prey of many top predators in the North Sea, including birds (Wanless *et al.,* 1998; Greenstreet *et al*., 2010). The highly specific habitat requirement of sandeels, i.e., sandy sediments with negligible amounts of mud (Greenstreet *et al*., 2010; see also Chapter 15: Fish and Shellfish Ecology), means that any physical changes, e.g., an increase of mud percentage, following sedimentation of SSC, could make these habitat unsuitable for sandeel. This could potentially reduce the sandeel population size and in turn affect other predators including birds and marine mammals (Wanless *et al.*, 1998).

170 Cumulative changes to the far-field suspended sediment transport pathways resulting from the three proposed developments were modelled assuming a continuous discharge of a neutrally buoyant plume over a spring-neap cycle with all developments scenario hydrodynamic mode (details in Chapter 9: Physical Processes). Comparison of the results of the predicted cumulative impacts and those generated using the baseline model shows no noticeable differences. This result indicates that the proposed developments will not cause net changes to the regional sediment transport regime or sediment dynamics along the nearby coastline, even when the three sites are considered cumulatively. In view of these results, and taking into account the vulnerability of biotopes assessed and presented in Section 14.7: Impact Assessment, the potential cumulative impact of increased SSC (including impacts on the sandeel population) is assessed to be ***not significant*** with low uncertainty. The individual projects' site specific field and modelling studies will provide more detailed information and any potential risk identified will be highlight and addressed in those projects' environmental statements.

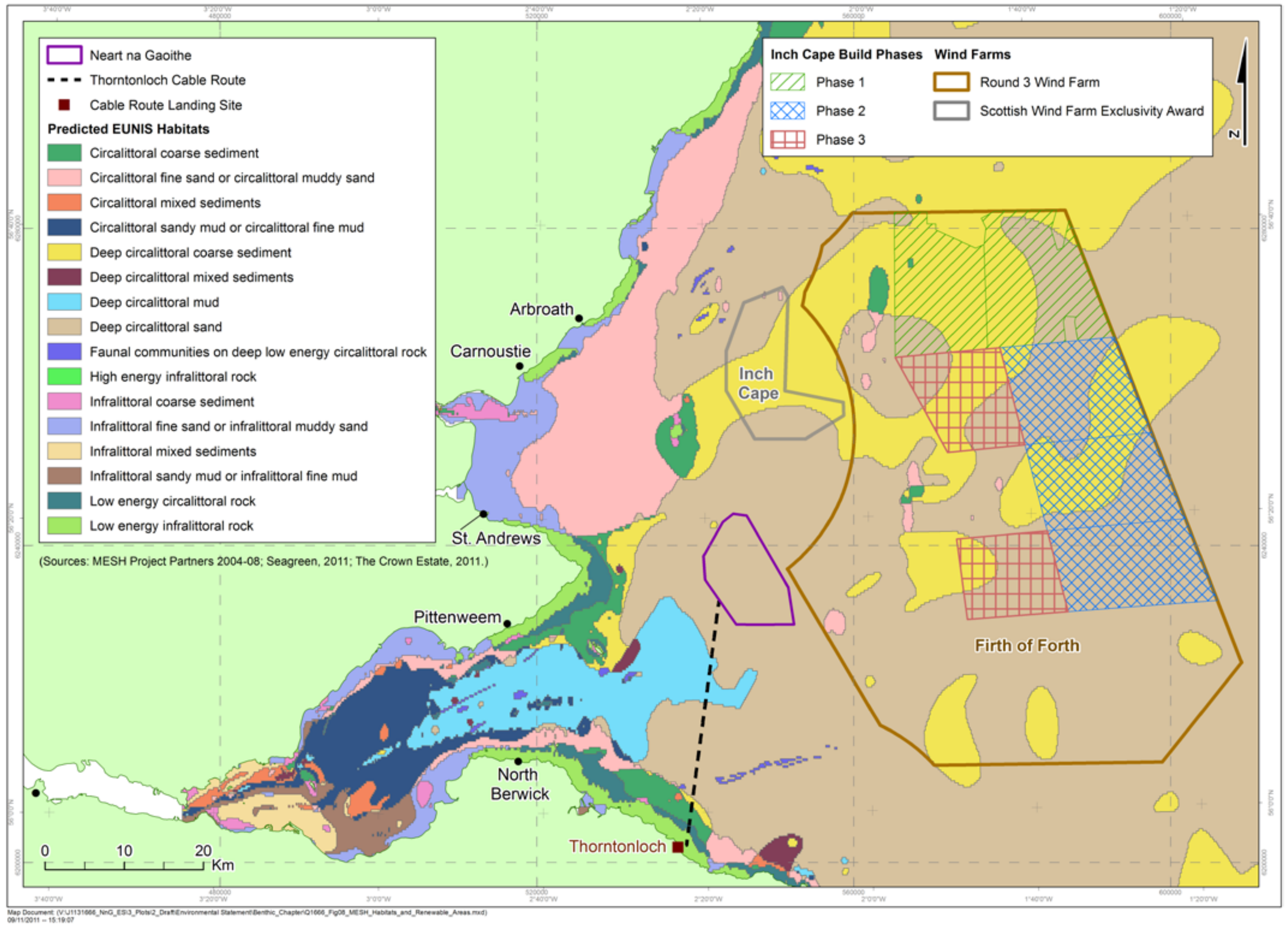

Figure 14.6: Predicted MESH habitats within the south east Scotland offshore region

14.9.2 Cumulative Operation and Maintenance

14.9.2.1 Cumulative Habitat Loss

171 In the absence of results from site specific surveys not yet undertaken at Inch Cape nor the Firth of Forth Round 3 Zone 2 developments, the habitats likely to occur within the development sites have been derived from the MESH programme. Results of the Neart na Gaoithe site specific survey accorded well with the broad-scale MESH classification (EMU, 2010), therefore, the MESH predictions are considered to be a good indication of the habitats likely to occur within the wider region (Figure 14.6). The habitats predicted to occur within Inch Cape and the Firth of Forth Round 3 site include 'deep circalittoral coarse sediments' and 'deep circalittoral sand'. The former occurs over large areas of the offshore continental shelf and is characterised by robust infaunal polychaete and bivalve species (Connor *et al*., 2004). The latter are characterised by sands or non-cohesive muddy sands and are likely to host a diverse range of polychaetes, amphipods, bivalves and echinoderms (Connor *et al*., 2004).

172 Habitat loss beneath the turbine and met mast installation, associated scour protection, and supporting infrastructure (e.g., offshore services platforms) is estimated to be up to 9.25 km^2 for the two additional developments and 0.28 km^2 for the Neart na Gaoithe (offshore site and export cable route), based on the worst case Rochdale scenario for each development, which assumes the largest gravity base foundations (and scour protection) in all cases. This represents a small proportion of the total area of the three sites. Therefore, the overall impact is assessed as ***not significant***. However, results of the site specific surveys may identify features of ecological and/or conservation interest, which may need further consideration and will be assessed in detail in the individual projects' ES.

14.9.2.2 Cumulative Changes in Hydrodynamic Regime

173 The cumulative effects of the proposed Neart na Gaoithe, Inch Cape and Firth of Forth Round 3 offshore wind farms on the sediment regime have been modelled in combination with analyses of the seabed sediment characteristics (Chapter 9: Physical Processes). Results of the modelling study indicate that the predicted cumulative changes to sediment transport processes resulting from the Neart na Gaoithe and other surrounding developments are expected to be small (predicted frequency of exceedance of the critical shear stress changing typically by 1-3% (with a maximum difference of 6%) and restricted to the immediate vicinity of the development sites. The biotopes occurring within the Neart na Gaoithe development and those expected to occur at Inch Cape and the Firth of Forth Round 3, based on the MESH habitats, are likely to be of negligible vulnerability to the predicted cumulative changes in flow rates. Based on this information the likely impact on benthic habitats and their associated biological communities is assessed to be ***not significant*** with low uncertainty.

14.9.2.3 Cumulative Introduction of New Substrate

174 The potential scale of the three offshore wind farms developments may offer opportunities for the colonisation of areas of new substrate. Habitat complexity is difficult to quantify and qualify with a host of characteristics (e.g., surface texture, rugosity, degree of lacunarity and angularity) being potentially relevant. The scale of the complexity offered by a given habitat is of crucial importance in determining which animals, or size of animals, can exploit the space offered.

175 However, even when considered cumulatively, the magnitude of the habitat enhancement resulting from the introduction of artificial structures is considered low particularly when put into the wider geographical context. Therefore, the impact of artificial reefs benthic habitats and faunal communities is assessed to be of ***minor significance*** and this assessment carries medium uncertainty.

14.9.2.4 Cumulative Electromagnetic Field Generated by Offshore Cables

176 Cumulative effects from export and inter-array cables are of relevance to electro-sensitive species that will tend to respond to the EMF emitted by these cables, although this would be expected over very small areas and local only to the area where the cables are buried. Reference to the available data on the proposed cable lengths for each of the proposed offshore wind farms in the southeast Scotland region, including the Neart na Gaoithe site, indicates a total length for export and interconnector cables of approximately 261 km and up to 1,540 km of inter-array cables (see Table 14.2 for assumptions).

177 It is assumed that the cables will be relatively well spaced (e.g., at minimum of 70 m for the Neart na Gaoithe development); however, the inter-array cables could come together in relatively close proximity at offshore sub-stations. Cable spacing in itself can influence the strength and extent of the EMF emitted. In addition, cable loading will affect the fields emitted. Evidence from the current literature indicates that EMF may be measurable within circa 17–20 m of a buried subsea cable. However, there is no current evidence of detrimental effects on marine invertebrates from EMF associated with subsea cables. On the contrary, the presence of dense epibenthic communities occurring on the hard structures of operating wind farms, suggests that any effects are unlikely, but further focussed research is needed in this field. The potential cumulative impact from EMF of subsea cables on benthic habitats and faunal communities is assessed to be of ***not significant.***

14.10 Monitoring

178 The main purpose of monitoring is to verify the predictions on environmental impacts identified by the ES. Standard monitoring for offshore wind farms includes a preconstruction benthic / epibenthic survey to provide a baseline for subsequent monitoring and also to identify any potential Annex I habitats that may require micro-siting of project infrastructure. This is followed by three annual surveys on consecutive years following construction (Cefas, 2009). Each survey should take into account the following:

- Sample locations determined by factors such as precise foundation and cable locations. Sample locations should also take full account of factors such as coastal process modelling outputs (for sediment transport/ deposition information) and geophysical surveys (to ensure adequate coverage of seabed habitats);
- Sample number and replicates, identifying the appropriate number of replicates on the basis of the habitat type being sampled. The number and location of stations should be determined making use of the data used to characterise the site as part of the ES. This monitoring should include a suitable baseline dataset and make adequate use of control sites;
- Colonisation of turbines and scour protection should be determined by diver-operated video observations and analyses with some accompanying sample collection for verification and identification; and
- Intertidal invertebrate sampling and biotope verification should be undertaken at lower, mid and upper shore sampling stations along three transects running perpendicular to the shore in the area of the cable landfall at appropriately low spring tides.

179 Longer term datasets are required to ascertain the long term effects of offshore wind farm installation, as three years, which is the average length of studies to date, is too short a timescale to detect the extent of natural variability against potential changes induced by the wind farm. In terms of infaunal monitoring, less frequent surveys over a longer period of time may be recommended, with more frequent monitoring concentrating on the known 'near-field' and colonisation impacts (Cefas, 2009).

180 Statistical analyses employed will depend on the properties and quality of the data and what hypotheses are to be tested. The quality of these analyses should be certified through a quality assurance/quality control procedure employed on data analyses (e.g., peer reviewed and signed off) and supplied with the monitoring reports. These procedures would allow comparisons between studies and standardising of investigation of future spatial and temporal trends (Cefas, 2009).

14.11 Summary and Conclusions

181 A total of 13 biotopes were recorded within and peripheral to the proposed Neart na Gaoithe development during the site specific survey. These are considered to be typical of the region and are widely distributed. Of particular significance, because of their conservation importance, are the biotopes **SS.SMu.CFiMu.SpnMeg** (seapens and burrowing megafauna in circalittoral fine mud) and **CR.MCR.EcCr** (echinoderms and crustose communities). The latter is of particular importance associated with the Annex I feature: 'cobble or stony reefs'. Although small areas within the site have characteristics similar to those of 'stony reef', further analyses revealed that none of these areas fully met the criteria to satisfy the assessment of reefs, therefore, they could not conclusively be classified as Annex I features.

182 The intertidal habitats of Thorntonloch are typical of the regions exposed coasts and included, but not limited to, **LS.LSa.MoSa** (barren or amphipod-dominated mobile sand shores) and **IR.MIR.KR.Ldig** (*Laminaria digitata* on moderately exposed sublittoral fringe rock) in the lower shore infralittoral.

183 The potential impacts of the Neart na Gaoithe wind farm development were considered in relation to the construction and operational phase, with regard to the subtidal environments within the turbine array and the cable corridor and the intertidal habitats at Thorntonloch landfall. Cumulative impacts were considered taking into account the proposed Inch Cape and The Firth of Forth Round 3 offshore wind farms development. A summary of the impact assessment, mitigation and cumulative impact assessment is provided in Table 14.21 below.

Source	Pathway	Receptor	Impact significance pre-mitigation	Mitigation	Residual impact significance	Cumulative and in-combination impact	Qualification of significance
Construction							
Installation of turbines, subsea cables and associated structures	Habitat disturbance	**SS.SMx.CMx.OphMx**	Minor significance	None identified	Minor significance	Not significant	Probability is high, uncertainty is low. The majority of species in this biotope are tolerant of displacement and burrowing infaunal species are able to re-burrow after displacement.
		SCS.CCS **SS.SSa.OSa.(OfusAfil)** **SS.SMu.CSaMu** **(ThyNten; AfilMysAnit and AfilNten)**	Minor significance				Probability is high, uncertainty is low. Some infauna within the biotopes are able to rebury following displacement. Permanently attached species would not be able to reattach following displacement and hence there would be a temporary minor decline in sessile fauna.
		SS.SMu.CFiMu.SpnMeg)	Minor significance				Probability is high, uncertainty is low. The biotope has some intolerance but can recover. It is of high value due to its importance for conservation and supporting Nephrops, a commercially targeted species.
		CR.MCR.EcCr (FaAlCr.Pom and Adig)	Minor significance				Mobile scavengers and epibenthos, e.g., crabs and brittlestars are likely to survive displacement and return to suitable substrata. Abrasion (e.g., by anchor chains) is likely to result in loss of spines and some damage to tests species.
Installation of gravity base foundations	Increase in SSC and sediment settlement/smothering	**SS.SMu.CFiMu.SpnMeg**	Minor significance	None identified	Minor significance	Not significant	Probability is high, uncertainty is low. Increase in SSC is predicted to be at a low level. Constituent species have low vulnerability.
		SS.SMx.CMx.OphMx	Minor significance				Probability is high, uncertainty is low. *O. fragilis* need suspended material so are likely to tolerate different SSC levels. Levels are unlikely to be that high in the development area.
		SS.SMu.CSaMu **SS.SCS.CCS** **SS.SSa.OSa.(OfusAfil)**	Minor significance				Probability is high, uncertainty is low. Smothering may result in temporary cessation of feeding/ respiration.
		CR.MCR.EcCr	Minor significance				Probability is high, uncertainty is low. An increase in SSC may reduce feeding efficiency, and be detrimental to hydroids, bryozoans and juvenile sea urchins.
Installation of export cables (subtidal)	Direct habitat disturbance	Export cable route subtidal biotopes including **SS.SMu.CSaMu.ThyNten, AfilMysAnit, AfilNten** and **SS.SMu.CFiMu.SpnMeg**	Minor significance	Backfilling where possible to enable biotope recovery and minimise impacts	Minor significance	Included in offshore site cumulative impacts above.	Probability is high, uncertainty is low. The magnitude of the effect is expected to be lower beyond 1-2m trench width. Although some biotopes in the export cable route have some insensitivity to disturbance, many are generally tolerant and adaptable and of low value.
	Increase in SSC and sediment settlement/smothering	Export cable route subtidal biotopes including **SS.SMu.CSaMu.ThyNten, AfilMysAnit, AfilNten** and **SS.SMu.CFiMu.SpnMeg**	Not significant				Probability is high, uncertainty is low. The magnitude of the effect, as outlined in Chapter 9: Physical Processes, is negligible. Most receptors in the export cable route are tolerant to levels of increased SSC.
Installation of export cables (intertidal)	Direct habitat disturbance	Export cable route intertidal biotopes including **LS.LSa.MoSa, LR.FLR.Eph.EntPor** and **LR.MLR.BF.Rho**	Not significant	None identified	Not significant		Probability is high, uncertainty is low. The magnitude of the effect, as outlined in Chapter 9: Physical Processes, is negligible. Most intertidal receptors in the export cable route are highly tolerant to changing environments.

Source	Pathway	Receptor	Impact significance pre-mitigation	Mitigation	Residual impact significance	Cumulative and in-combination impact	Qualification of significance
	Increase in SSC and sediment settlement/smothering	Export cable route intertidal biotopes including **LS.LSa.MoSa, LR.FLR.Eph.EntPor** and **LR.MLR.BF.Rho**	Not significant				Probability is high, uncertainty is low. The magnitude of the effect, as outlined in Chapter 9: Physical Processes, is negligible. Most intertidal receptors in the export cable route are highly tolerant to changing environments.
Operation and Maintenance							
Presence of turbine foundations and inter-array cabling with scour protection	Direct habitat loss	**SS.SMu.CFiMu.SpnMeg SS.SMx.CMx.OphMx SS.SMu.CSaMu SS.SCS.CCS SS.SSa.OSa.(OfusAfil) CR.MCR.EcCr**	Minor significance	None identified	Minor significance	Not significant	Probability is high, uncertainty is low. The magnitude of the effect, as is considered low overall given the area of habitat lost. The biotopes present have varied tolerance, adaptability and recoverability but overall give the presence of the biotopes in the wider region, vulnerability is assessed as low
Presence of turbine foundations and inter-array cabling with scour protection	Changes in hydrodynamic conditions	**SS.SMu.CFiMu.SpnMeg SS.SMx.CMx.OphMx SS.SMu.CSaMu SS.SCS.CCS SS.SSa.OSa.(OfusAfil)**	Minor significance	None identified	Minor significance	Not significant	Probability is high, uncertainty is low. The magnitude of the effect is predicted to be negligible (see Chapter 9: Physical Processes) and changes limited to the near field. Although some biotopes present are intolerant to change, the values that affect them are much higher than predicted at the Neart na Gaoithe site and as such the impact is considered not significant
Presence of turbine foundations and inter-array cabling with scour protection	New substrate materials	Biotopes in offshore site, e.g., those with epibenthic assemblages **SS.SCS.CCS** and **CR.MCR.EcCr**	Minor significance	None identified	Minor significance	Minor significance	Probability is high, uncertainty is medium. Additional hard substrate will result in colonisation (at a project and cumulative level), but the extent to which this may affect the overall biodiversity in the longer term unknown.
	Pathway for alien or invasive species	Biotopes in offshore site	Not significant		Not significant	Not assessed explicitly	Probability is low, uncertainty is low. There are no records of non-native species invading the biotopes recorded within the offshore site. Additionally presence of a number of existing novel substrata (e.g., breakwaters) without non-native invasion reduces this possibility.
Presence of export cable with cable/scour protection (subtidal)	Direct habitat loss	Export cable route subtidal biotopes including **SS.SMu.CSaMu.ThyNten, AfilMysAnit, AfilNten and SS.SMu.CFiMu.SpnMeg**	Not significant	None identified	Not significant	Included in offshore site cumulative impacts above.	Probability is high, uncertainty is low. Biotopes are common outside the cable route corridor, and given the magnitude of the effect the impact is assessed as not significant.
	New substrate materials	Export cable route subtidal biotopes including **SS.SMu.CSaMu.ThyNten, AfilMysAnit, AfilNten and SS.SMu.CFiMu.SpnMeg**	Not significant				Probability is high, uncertainty is low. Additional hard substrate will result in colonisation (as observed at the nearby artificial reef), but the extent to which this may affect the overall biodiversity in the longer term unknown.
Presence of export cable with cable/scour protection (intertidal)	EMF	Export cable route subtidal biotopes including **SS.SMu.CSaMu.ThyNten, AfilMysAnit, AfilNten and SS.SMu.CFiMu.SpnMeg**	Minor significance	None identified	Not significant		Probability is high, uncertainty is medium. Experimental filed studies on the survival and physiology of selected species of marine benthic invertebrates have to date shown no significant effects from EMF. Also stands for offshore site.
	Seabed sediment heating	Export cable route subtidal biotopes including **SS.SMu.CSaMu.ThyNten, AfilMysAnit, AfilNten and SS.SMu.CFiMu.SpnMeg**	Not significant				Probability is medium, uncertainty is high. No data are currently available on the amount of heat dissipation In the absence of robust field data, the assessment of effects of increased temperature associated with subsea cables on marine habitats and species remain highly uncertain highly speculative.

Table 14.21: Summary of the impact assessment, mitigation and cumulative impact assessment

14.12 References

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Appendices

Appendix 14.1: Benthic Ecology Characterisation Survey

Appendix 14.2: Preliminary Assessment of Coarse Sediment Habitats