4 Biological Environment

4.1 Benthic Ecology

4.1.1 Baseline Information

Introduction

4.1.1.1 This chapter provides baseline subtidal benthic ecological information within the area of the modified offshore transmission infrastructure (modified OfTI). This includes the types and distributions of the different seabed habitats and the communities of macrofauna and macroflora (i.e. animal and plant species which are generally 1 mm in size or larger) that are typically associated with each habitat type (collectively termed biotopes). The information presented here has been drawn from:

- desktop studies;
- a series of site specific benthic ecology field surveys;
- consideration of the relevant key legislative and planning information; and
- consultation with relevant statutory and non-statutory bodies.

4.1.1.2 Site specific information was collected using seabed video surveillance and grab sampling in agreement with Marine Scotland Science (MSS). Methods were comparable to those used during both the previous EIA investigations at both the three consented MORL wind farms (Telford, Stevenson and MacColl) and Beatrice Offshore Wind Limited's (BOWL) wind farms (MORL, 2012; BOWL, 2012; 2013) for which consents have already been granted. Methodologies, results and conclusions for the current site specific field surveys for the modified offshore export cable route corridor are detailed in:

- Technical Appendix 4.1 A - Subtidal Benthic Ecology Characterisation Report.

4.1.1.3 This baseline is used to inform the assessment of the likely significant effects of the installation, operation and decommissioning of the modified OfTI which is presented in:

- Section 4.1.2 – Benthic Ecology impact assessment; and
- Section 4.1.3 – Benthic Ecology – cumulative impact assessment.

4.1.1.4 The intertidal ecology at the modified export cable landfall site at Inverboyndie is described in Chapter 4.5.

4.1.1.5 Note that the benthic ecology of the outer Moray Firth and the potential impacts of the installation and operation of offshore wind farm transmission infrastructure (TI) on seabed habitats and species have already been studied and assessed as part of the previous MORL application and accompanying Environmental Statement (MORL, 2012). Experience gained from these previous studies, including survey methods, baseline descriptions and likely significant effects have been drawn upon to inform this Chapter.

Consultations

4.1.1.6 A full account of the consultation on the current modified TI proposals is presented in the Consultation Report accompanying this ES. Table 4.1-1 below summarises the consultations undertaken to inform the subtidal benthic ecology baseline data gathering and impact assessment.

Table 4.1-1 Summary of Consultations

Organisation	Consultation Response	MORL Approach
Marine Scotland Science (MSS)	Acceptance of survey specifications	The survey comprised collection of grab samples and seabed video and followed previous accepted methods (MORL, 2012, BOWL, 2012; 2013).
Joint Nature Conservation Committee (JNCC) and Scottish Natural Heritage (SNH) **(Scoping Response)**	Agreement with the scope of impacts to be considered. Agreement with initial survey plans. There is the potential for Annex I habitat rocky reef to occur within the cable search area as it approaches shore.	The survey comprised collection of grab samples and seabed video and followed previous accepted methods (MORL, 2012, BOWL, 2012; 2013).. Seabed video was collected to characterize rocky reef habitat and associated species. Acoustic data has been collected to indicate the extent of rocky habitat

Baseline Characteristics

4.1.1.7 This section sets the baseline subtidal benthic ecological conditions within the vicinity of the modified TI.

Desktop Studies

4.1.1.8 The MORL ES (Chapter 4.2: Benthic Ecology, MORL, 2012) described the Moray Firth as an "open system" being an integral part of the wider North Sea thus having common environmental factors. Dominant seabed sediments include moderately to well sorted, fine to medium grained sand and muddy sand, with some shell and are described as relatively homogeneous. Site specific survey found that the sediments of the Smith Bank comprised coarse and medium sands with quantities of fragmented shell and were characterised by typical assemblages of sediment burrowing polychaete worms, bivalve shells and small amphipod crustaceans. Sparse hydroids (sea firs) and bryozoans (sea mats), colonised the larger shell fragments and patches of gravel and cobbles. Corresponding biotopes classifications (Connor *et al.*, 2004) included SS.SSa.OSa.OfusAfil, SS.SSa.IMuSa.FfabMag and SS.SSa.CFiSa.EpusOborApri A range of larger, more mobile species were recorded from trawl sampling and seabed video including a range of flatfish, crabs and starfish species.

4.1.1.9 Previous video surveillance conducted between the BOWL and the proposed BOWL export cable landfall at Spey Bay identified four main seabed habitat types (BOWL, 2012). At the offshore end of the cable corridor on the Smith Bank, the seabed was dominated by coarse and medium sand sediments with varying quantities of shell. These sediments supported a typical suite of infaunal (burrowing) species such as the polychaete worms bivalve shells, sea urchins and small crustacean amphipods. Sponges, tube worms, sea firs and sea mats were found attached to stones, pebbles and larger fragments of shell.

4.1.1.10 Within the deeper waters below the southern flank of the Smith Bank, the seabed is dominated by homogenous muddy sand sediments characterised by seapens together with mounds and depressions created by the activities of sediment dwelling marine organisms, such as the Norway lobster (*Nephrops norvegicus*). This habitat type has been identified as representative of the "burrowed mud" Scottish Priority Marine Feature (PMF) and appears to be extensive throughout the southern half of the outer Moray Firth.

4.1.1.11 Approaching the landfall of the consented BOWL export cables, the seabed comprised fine and medium grade sands and gravel together with coarser, more mixed cobble, pebble and gravel substrates supporting a characteristic encrusting fauna such as tubeworms, barnacles, sea mats, algae and sea firs. Areas of dense cobbles resembled Annex I cobble reef. Outcropping bedrock with dense soft corals, kelps and red algae together with areas of encrusting *Sabellaria spinulosa* communities resembling Annex I *Sabellaria* reef habitat were recorded offshore of the original export cable landfall site at Fraserburgh (Chapter 4.2: Benthic Ecology MORL, 2012). No *Sabellaria* communities were recorded along the BOWL cable corridor (BOWL, 2012).

The Southern Trench

4.1.1.12 The Southern Trench is a distinct bathymetric low within the southern half of the outer Moray Firth. Benthic survey to the east of the trench (MORL, 2012) showed that the sea floor comprised gravelly shelly sand overlaid with a layer of fine silt. Conspicuous species included sea firs and sea mats, soft corals and hermit crabs together with various tube dwelling worms, crabs and starfish. Growths of the tube worm Salmacina or Filograna were identified at one location. No protected cold water corals (*Lophelia pertusa)* were recorded.

Site Specific Surveys

4.1.1.13 Site specific subtidal benthic ecological information was collected via seabed video surveillance and sediment grab sampling in agreement with MSS (see Technical Appendix 4.1 A: Subtidal Ecology Characterisation). Figure 4.1-1 shows the track of the seabed video and grab sampling locations within the modified export cable route corridor. A zig-zag survey pattern and cross lines were adopted in some places along the modified export cable route corridor to increase lateral coverage.

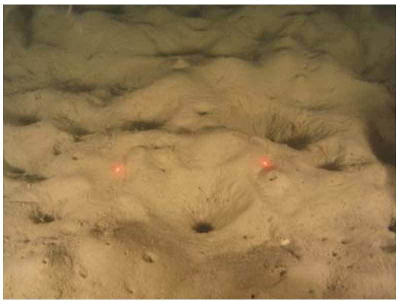
4.1.1.14 Seabed type and associated epifauna and epiflora (surface dwelling) species were used to classify biotopes following the UK Marine Habitat Classification Scheme (Connor *et al*., 2004) with subsequent interpolation and GIS mapping based on geophysical (side scan sonar and bathymetry) data. Figure 4.1-2 shows the distribution and extents of the subtidal biotopes present along the proposed export cable corridor.

4.1.1.15 Seabed sediment samples were analysed within UKAS accredited laboratories for particle size distribution and sediment chemistry. Three samples within inshore areas of the modified export cable route corridor were not collected due to the coarse and hard nature of the ground present.

Results

4.1.1.16 Matching of survey data with the Marine Habitat Classification system identified a total of five biotopes as summarised in Table 4.1-2 below. Given the local complexity of the seabed habitats in some places it is likely that additional finer scale biotope classifications exist within the broader habitat descriptions. Previous grab sampling on the Smith Bank, for instance (MORL, 2012), identified the biotopes SS.SSa.OSa.OfusAfil, SS.SSa.IMuSa.FfabMag and SS.SSa.CFiSa.EpusOborApri which fall under the broader SS.SSa habitat.

Table 4.1-2 Summary of Biotopes Identified Along the Offshore Export Cable Route

Habitat / Biotope Classification	Typical Species	Representative Seabed Image
SS.SSa Sublitoral sand and muddy sediments	*Puguridae* (hermit crabs) *Triglidae* (gurnards) *Pleuronectes platessa* (Plaice) *Pecten maximus* (King scallop) Hydroid/bryozoan turfs *Asterias rubens* (common starfish) *Callionymidae* (Dragonet)	
SS.SSa **SS.SMx.CMx** **SS.SMx.CMx.FluHyd** Sublittoral sand and muddy sands with patches of circalittoral coarse sediments with the hydroids *Flusta foliacea* and *Hydrallmania falcate*.	*Liocarcinus* sp. (harbour crab) *Ammodytidae* (sand eels) *Pecten maximus* (King scallop) *Flustra* and *Hydrallmania* (bryozoans)	
SS.SMu.CFiMu.SpnMeg (coarser variant) Seapens and megafauna in circalittoral fine mud	*Virgularia mirabilis* (seapen) Pleuronectiformes (flatfish) *Asterias rubens* (common starfish) *Chaetopterus* spp. (tubes) (parchment worm) Mounds and burrows	
SS.SSa with **SS.SMx.CMx** Sublittoral sand and muddy sands with circalittoral coarse sediments as waves	Turf forming hydroids and bryozoans *Flustra foliacea*, *Sertularia*, *Abietinaria* and ?*Thuiaria thuja* Pleuronectiformes (flatfish) *Atelecyclus rotundatus* (round crab) *Munida rugosa* (rugose squat lobster) *Pecten maximus* (King scallop)	
SS.SMu.CFiMu.SpnMeg (fine sediment variant) Seapens and burrowing megafauna in circalittoral fine mud	*Pennatula phosphorea* (phosphorescent seapen) *Virgularia mirabilis* (slender seapen) *Nephrops norvegicus* (Norway lobster) *Anseropoda placenta* (goose foot starfish) *Oweniidae* (tubes) (polychaete worm)	

Habitat / Biotope Classification	Typical Species	Representative Seabed Image
CR.MCR.EcCr.FaAlCr.Pom Cobbles boulders and bedrock reef with encrusting and foliose red algae and *Pomatoceros* (now named *Spirobranchus*)	Hydroid/Bryozoan turfs *Alcyonium digitatum* (dead man's fingers) *Urticina* sp. (dahlia anemone) *Metridium senile* (plumose anemone) *Spirobranchus* (keel worm) *Munida rugosa* (rugose squat lobster) *Cancer pagurus* (brown crab) *Echinus esculentus* (edible sea urchin)	

Acoustic Data and Production of the Biotope Map for the Modified OfTI

4.1.1.17 Side scan sonar (acoustic) data were provided after completion of the benthic video survey. These data showed a series of distinct boundaries between different sediment acoustic regions such as changes in reflexivity indicating the different harder and softer seabed types as well as changes between areas of apparent complexity (i.e. boulders and rock outcrop areas) and comparatively more featureless, homogeneous seabed areas. Overlay of these sediment acoustic regions with the biotope classifications and subsequent interpolation was then undertaken to indicate the distribution and extents of the biotopes present throughout the modified offshore export cable route corridor. The resultant biotope map is provided in Figure 4.1-2.

Distribution of the Biotopes within the Modified OfTI Corridor

4.1.1.18 The biotopes found during the current site specific study were comparable with those recorded previously (MORL, 2012; BOWL, 2012). The study area was dominated by largely homogenous sedimentary seabed habitats including muddy sands, fine sandy mud and mixed sandy gravels. These areas are indicated in Figure 4.1-2 by the SS.SSa, SS.SMu.CFiMu.SpnMeg and SS.SMx.CMx classifications respectively. These types of habitats supported little or no conspicuous sessile epifauna with the exception of sparse growths of erect bryozoans and hydroids attached to patches of coarser material, including broken shell. Mobile epifauna, on the other hand, were relatively well represented and included starfish *Asterias rubens, Astropecten irregularis* and *Luidia sarsi*, small spider crabs *Inachinae*, hermit crabs *Paguridae*, whelks *Buccinum undatum*, urchin *Echinus esculentus*, brittlestars *Ophiura ophiura*, squat lobster (*Munida rugosa*) and benthic fish and shellfish such as gurnard Triglidae, sand eels, Ammodytidae, plaice (*Pleuronectes platessa*), brown crab (*Cancer pagurus*). Seapens, *Pennatula phosphorea* and *Virgularia mirabilis*, together with mounds and burrows of larger burrowing fauna, i.e. Norway lobster (*Nephrops norvegicus*), characterised large areas of fine sandy mud. Filamentous growths, thought to be diatomaceous floc (settled plankton), was frequently observed on the seafloor across the sediment areas.

4.1.1.19 Patches of more mixed coarse sand, gravel and shell material occurred occasionally throughout the video study area and were associated with a higher abundance and diversity of sessile bryozoan and hydroid species.

4.1.1.20 Further inshore, the seabed was dominated by comparatively coarser and more mixed sediment types, including areas of cobbles, boulders and exposed bedrock forming stony reefs (SS.SCS.CCS, CR.MCR and IR.MIR). Patches of clean, mobile fine sand of varying thicknesses overlaid these coarser and rockier seabed habitat types creating a complex mosaic of biotopes in places. Sediment tolerant epifaunal communities (SS.SMx.CMx.FluHyd) dominated mixed sediment substrates whilst areas of more stable boulders and bedrock outcrops supported comparatively rich and diverse bryozoan and hydroid assemblages together with the soft coral *Alcyonium digitatum*, the calcareous tube dwelling worm *Spirobranchus* sp. and *anemones Metridium senile* and *Urticina felina* (CR.MCR.EcCr.FaAlCr.Pom and CR.MCR.EcCrFaAlCr.Adig). Conspicuous mobile fauna included urchins *Echinus esculentus*, the sunstar (*Crossaster papposus*), and spiny starfish (*Marthasteria glacialis*) together with brown crab and squat lobster. Encrusting and foliose red and brown algae species, such as *Delesseria sanguinea* and *Saccharina latissima* attached to cobbles.

Features of Nature Conservation Importance within the Modified OfTI Study Area.

4.1.1.21 Table 4.1-3 below presents benthic features of potential nature conservation importance identified within the study area from both the site specific survey and data review.

Table 4.1-3 Habitats and Species of Nature Conservation Importance within the Modified OfTI Study Area

Feature	Indicative Conservation Feature	Importance	Representative Photograph
Habitats			
Cobble and stony reefs.	Annex I Reef	International	
Muddy sand with seapens and burrowing fauna.	Priority Marine Feature (PMF) "burrowed mud"	National	
Species			
Arctica islandica (Ocean quahog)	OSPAR Priority Marine Feature (PMF)	International	

Palinurus elephas Spiny lobster	Priority Marine Feature (PMF)	National	
Arachnanthus sarsi (Mud burrowing anemone)	Priority Marine Feature (PMF)	National	
Maera loveni (mud burrowing shrimp)	Priority Marine Feature (PMF)	National	

Sediment chemistry

4.1.1.22 The sediment contaminants tested as part of the site specific survey were largely at concentrations that were below guideline levels and standards. Concentrations of arsenic and chromium, however, exceeded Cefas / Marine Scotland values for Action Level 1, relating to the disposal of dredged materials to sea, but fell within the more stringent Action Level 2 values. Typically, material containing contaminants at levels between Action Levels 1 and 2 require further testing and consideration prior to permitting their disposal to sea. In this instance, however, there will be no disposal of material to sea. Only temporary disturbance, and subsequent dispersion, of the natural sediments is predicted. No imported material will be added to the local benthic environment. The seabed video survey did not show any significant habitat and community difference or denuded areas associated with sediments with elevated chromium and arsenic levels suggesting no significant effects of current contaminant levels on benthic ecology. All contaminant levels were below OSPAR standards. Disturbance and suspension of sediments into the overlying water column as a result of the action of the cable burial tool would further dilute any associated contaminants within tidal dispersion pathways. Consequently, sediment contaminants have not been considered any further in this assessment.

Legislative and Planning Framework

4.1.1.23 The legislation and guidance which was taken into account in the benthic ecology assessment is summarised below:

- Council Directive 92/43/EEC on the Conservation of natural habitats and of fauna and flora (the 'Habitats Directive'). This was transposed into domestic legislation through the Conservation (Natural Habitats &c.) Regulations 1994, and the Conservation of Habitats and Species Regulations 2010). The Offshore Marine Conservation (Natural Habitats &c.) Regulations 2007 (as amended) (the "Offshore Marine Regulations") extend the provisions of the Habitats Directive to offshore areas;

- Nature Conservation (Scotland) Act 2004 (provides for the conservation of biodiversity and for the conservation and enhancement of Scotland's natural features);
- Marine (Scotland) Act 2010 (provides for the publication of Priority Marine Features); and
- Wildlife and Countryside Act, 1981 (lists species of national nature conservation importance).

4.1.1.24 Specific guidance used in the preparation of both this chapter and its supporting field studies are provided below:

- DTLR (2002). Guidelines for the conduct of benthic studies at aggregate dredging site (now updated see Ware & Kenny, 2011);
- Cefas (2011). Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects;
- Johnston, C.M., Turnbull, C.G. and Tasker, M.L., 2002. Natura 2000 in UK Offshore Waters: Advice to support the implementation of the EC Habitats and Birds Directives in UK offshore waters [online]. JNCC Report No. 325, Joint Nature Conservation Committee, Peterborough;
- OSPAR (2008) Guidance on Environmental Considerations for Offshore Wind Farm Development. 2008-3;
- Wilhelmson *et al*. (2010). International Union for Conservation of Nature (IUCN). Greening Blue Energy: Identifying and managing the biodiversity risks and opportunities of offshore renewable energy;
- Scotland's National Marine Plan (2013) - Consultation Draft; and
- CIEEM 'Chartered Institute of Ecology and Environmental Management' (2010). Guidelines for Ecological Impact Assessment in Britain and Ireland, Marine and Coastal.

4.1.2 Impact Assessment

Summary of Effects and Mitigation

4.1.2.1 This section provides an assessment of the likely significant effects of the installation, operation and decommissioning of the subtidal components of the modified OfTI on the subtidal benthic ecology. Effects on intertidal ecology at the proposed landfall site at Inverboyndie are addressed in Chapter 4.5 (Intertidal Ecology). Likely significant cumulative effects are addressed in section 4.1.3.

4.1.2.2 Information supporting this assessment has been collected from a site specific survey and data review as explained in Section 4.1.1 above.

4.1.2.3 In summary, the effects of the modified OfTI proposals on subtidal benthic ecology are predicted to be of minor significance and include:

- Loss of original habitat as a result of the placement of the two AC OSPs. Note that this effect will be less than that already assessed in the previous ES (MORL, 2012, Chapter 10: Benthic Ecology) because there will be fewer OSPs (two) and associated cable protection material compared to the previous Project Rochdale Envelope (eight). The use of suction bucket foundations in place of GBS foundations further reduces the effect footprint compared to the initial situation (MORL, 2012);
- Temporary seabed disturbances, smothering and suspended sediment effects on fauna and flora as a result of seabed preparatory works, cable laying activities and contact of legs and anchors of construction and

decommissioning vessels on the seabed. This effect will be greater than that previously assessed (MORL, 2012 Chapter 10 Benthic Ecology) as a greater number of trenches will be constructed compared with the previous Project Design (MORL, 2012). However, the modified OfTI does not coincide with potential Annex I (EC Habitats Directive) Sabellaria spinulosa reef, found previously and so no adverse disturbance effects on this international feature will occur as a result of the revised scheme;

- Habitat and associated community change as the result of the introduction of hard structures and subsequent colonisation by encrusting and attaching fauna and flora;
- Temporary fining of particulate habitats, smothering and scour effects on benthic species;
- Seabed contamination and increased bio-availability of pollutants to seabed faunal and floral populations as a result of seabed disturbances;
- Heat and electromagnetic field emissions and associated effects on benthic species.

4.1.2.4 Mitigation will include the application of best practice, including minimising the quantities of scour and cable protection material to reduce effects of loss of original habitat and habitat change, and adherence to the Environmental Management Plan to reduce any risk of accidental spillages of chemicals into the marine environment.

Summary of Effects

4.1.2.5 Overall, the effects of the installation, operation and decommissioning of the modified OfTI on subtidal benthic ecology are predicted to be of **minor** significance. This reflects the highly localised, short term, infrequent and reversible nature of the majority of the predicted effects (BERR, 2008) and the general tolerance and recoverability of the predominately sand and mixed sand and gravel habitats and species within the study area.

4.1.2.6 Muddy sand habitats indicative of the “burrowed mud” Scottish PMF together with cobble and rock habitats indicative of Annex I (EC Habitats Directive) stony reef habitat are widespread throughout the southern Moray Firth, having been recorded during previous EIA investigations (MORL, 2012 and BOWL, 2012). Given the small footprint of the cable burial operation, no significant adverse effects on the wider availability of these features are anticipated. Similarly, the important species for nature conservation are not predicted to be significantly affected by the modified OfTI as significant areas of their habitat will remain in adjacent areas following the installation and operation phases. Recovery of affected areas will occur from adult reproducing populations in adjacent non-affected areas. The spiny lobster PMF species is highly mobile and is likely to be capable of avoiding temporary, localised installation activities. The ocean quahog (PMR and OSPAR species) appears to be distributed on and around the Smith Bank and away from the boundaries of the modified OfTI, although this may, in part, be an artefact of historic sampling effort. Given its current apparent distribution, the population of ocean quahog in the outer Moray Firth is not likely to be significantly affected by the current proposals.

4.1.2.7 Effects of heat and electromagnetic field (EMFs) emissions during the operation of the cable are considered to be **not significant** to subtidal invertebrate benthic ecology. This is due to the shielding of emissions through cable burial, the distance separation provided by any cable protection material and the general insensitivity of benthic invertebrates based on current observations at other wind farm sites. Some mobile species, such as starfish, may be temporally attracted to and aggregate around heat sources although this is not predicted in light of proposed cable burial and placement of cable protection. Effects of EMF and heat emissions on fish and shellfish ecology are presented in Chapter 4.2 Fish and Shellfish Ecology.

4.1.2.8 The provision of hard structures such as foundations of OSPs and scour and cable protection material will provide suitable surfaces for attaching and encrusting indigenous and potential marine invasive non-native species (MINNS).

4.1.2.9 The Environmental Management Plan (EMP) (Technical Appendix 1.3 A within MORL ES, 2012) will control the use and storage of materials during the construction of the wind farms and will mitigate for accidental spillages or releases of chemicals, such as fuels, lubricants and grouting materials, into the marine environment and prevent harm to the benthic ecology. Accordingly, the residual effects from accidental seabed contamination are assessed as being of **minor** significance.

4.1.2.10 It is proposed that the export cables remain in situ during decommissioning. This will reduce the effects on subtidal benthic ecology compared to those that are predicted to occur during installation. Removal of OSP foundations during decommissioning will result in some localised sediment disturbances but these are usually regarded as being no more significant than those that will occur as a result of construction activities. Construction and decommissioning effects on benthic ecology are therefore considered jointly in this assessment.

Proposed Mitigation Measures and Residual Effects

4.1.2.11 Table 4.1-4 below summarises proposed measures to mitigate potential adverse effects on subtidal benthic ecology. This would include the use of best practice during construction such as minimising the quantities of scour and cable protection material to reduce loss of original seabed habitat and habitat change. In addition, a Construction Environmental Management Plan (CEMP) will be in place to control the use and storage of materials to mitigate for accidental spillages or releases of chemicals, such as fuels, lubricants and grouting materials, into the marine environment and prevent harm to the benthic ecology. Regular hull cleaning of construction vessels, maintenance of anti-fouling systems and ballast water management as part of vessel norma;l operating procedures will reduce the risk of introducing and spreading potential marine invasive non-native species.

Table 4.1-4 Impact Assessment Summary

Effect	Receptor	Pre-mitigation Effect	Mitigation	Post-mitigation Effect
Construction & Decommissioning				
Temporary Direct Seabed Disturbance	Sand and gravel sediment habitats and communities (biotopes)	Minor	n/a	minor
	Burrowed mud PMF habitat	minor	n/a	minor
Temporary increased suspended sediment concentration (SSCs) and sediment deposition	Sand and gravel sediment habitats and communities (biotopes)	minor	n/a	minor
	Burrowed mud PMF habitat	minor	n/a	minor
Seabed contamination as a result of accidental spillage of chemicals	Sand and gravel sediment habitats and communities (biotopes) and burrowed mud PMF habitat.	Up to major	Adherence to an EMP	Negligible

Effect	Receptor	Pre-mitigation Effect	Mitigation	Post-mitigation Effect
Operation				
Permanent net reduction of original habitat.	Sand and gravel sediment habitats and communities (biotopes).	minor	n/a	minor
	Burrowed mud PMF habitat	minor	n/a	minor
Habitat and associated community change (MINNS)	Indigenous species	Minor	Good practice (vessel maintenance)	minor
Effects on physical processes and related biological changes	Sand and gravel sediment habitats and communities (biotopes).	Not significant	n/a	Not significant
Effects of EMFs	Electro-magnetic sensitive and migratory invertebrate species	Not significant	n/a	Not significant
Effects of heat	Deep burrowing species such as Nephrops norvegicus	Not significant	n/a	Not significant

Introduction to Impact Assessment

4.1.2.12 This section identifies the potential effects of the installation, operation and decommissioning of the modified OfTI on subtidal benthic ecology in more detail and presents the methods used to evaluate their potential significance.

Details of Impact Assessment

4.1.2.13 A source – receptor – pathway approach was applied to identify the potential effects of the installation, operation and decommissioning of the modified OfTI and the subtidal benthic receptors likely to be affected. Table 4.1-5 shows the source-pathway-receptor model used to identify the pathways through which effects on potentially sensitive benthic ecological features/receptors may occur.

Table 4.1-5 Source-receptor-effect Pathways on Subtidal Benthic Ecology

Activity	Pathway	Receptor	Effect
Construction and Decommissioning			
Dredging, trenching & jetting, piling and cables removal	Seabed disturbances	Species, habitats	Displacement sediment instability, compaction and abrasion
Dredging, trenching & jetting, piling and cables removal	Raised sediment plumes	Species, habitats	Burial, smothering, habitat change (grain size)
Operation and Maintenance			
Foundations, scour and cable protection material	Presence on seabed	Habitats	Reduction in total area of original habitat for life of project and habitat change
	Colonisation	Species	Increase abundance and biomass of sessile fauna and flora
		Environmental quality	Increase risk of spread of marine invasive non-native species (MINNS)
Effects on physical processes and related biological changes	Erosion, scour and smothering	Habitats and species	Change of habitats and species
Cables	Electromagnetic field (EMF) and heat emissions	Species	Re-distribution of species

Rochdale Envelope Parameters Considered in the Assessment

4.1.2.14 The parameters within the Project Description (Chapter 2.2: Project Description) have been used to describe the realistic worst case scenario for each potential effect on benthic ecology (Table 4.1-6). The elements of the modified OfTI considered in this assessment include:

- 2 AC Offshore Substation Platforms (OSPs);
- Inter-platform cabling; and
- Offshore export cables.

Table 4.1-6 Rochdale Envelope Parameters relevant to the Benthic Ecology Impact Assessment

Potential Effect	Rochdale Envelope Scenario Assessed
Construction & Decommissioning	
Temporary Direct Seabed Disturbance	**Maximum footprint = 1.76 km² based on:** • Length of cable corridor from boundary of three consented wind farm sites to landfall site = 52 km (not including micro-siting allowance); • No. of cable trenches = 4; • Width of trench affected area = 6 m; • Length of OfTI cable within three consented wind farms (including inter-platform cabling) = 70 km; • Area of seabed prepared for each OSP = 7,536 m²; • Maximum no. AC OSPs = 2 (installed at least one year apart); • Vessel anchors = 36,000 m²; and • Jack-up vessel footprint of 420 m² per installation. **Rationale** Suction buckets have the largest footprint of any foundation option within the current modified Rochdale Envelope and require the greatest extent of bed preparation prior to installation. Disturbed areas will be subsequently occupied by the turbine foundation and scour protection material. Jack-up barges using up to 6 legs and fixed to the seabed using spud cans with a total area of seabed disturbance for the vessel of 420 m². Maximum length of cabling required within the three consented wind farms area (including inter-platform cabling) is 70 km based upon maximum of two OSPs. Maximum length of export cable corridor from boundary of three consented wind farm sites is 52 x 4 (208 km of cabling not including micro-sitting allowance) under the 220 kV solutions. Area affected by anchors assumes 6 x 12 Te anchors each 4.5 m wide x 3.64 m long, penetrating to a depth of one metre deployed in a radial pattern around barge and re positioned every 200 m and each affecting a nominal area of seabed of 5 m². Upon decommissioning, the seabed will become re-exposed on removal of foundations, scour and cable protection material. Species attached to turbine foundations, scour material and cable protection material will be lost on removal of infrastructure. A full decommissioning plan will be agreed with the relevant government department at the point of decommissioning.
Temporary increases in SSCs and sediment deposition	Fine sediment arising from installation of four export cables from the boundary of the three consented wind farms to landfall (although these will be temporally separated)(total length 208 km), inter-platform cables and cabling up to the boundary of the three consented wind farms (total length 70 km) via jetting and seabed preparatory works for suction bucket foundations for the two OSPs transported and dispersed via tidal currents and wave events as described within Chapter 3.1 Hydrodynamics, Sedimentary and Coastal Processes.
Seabed contamination as a result of accidental spillage of chemicals	The construction window is five years in which time there will be 72 vessel movements and 255 total vessel working days associated with the OSP, inter-platform and export cable installations (indicative vessel movements). Maximum increase in vessel activity over the maximum construction timeframe provides for highest potential for accidental spills.

Potential Effect	Rochdale Envelope Scenario Assessed
Operation	
Permanent net reduction of original habitat	• Total footprint = 0.1 km² based on: • Area per OSP foundation and scour material = 7,536 m²; • Cable protection (assuming protection is required to a distance of 100 m from each OSP foundation to a width of 10 m and up to 20 "J" tubes (or cable connections) per OSP = 20,000 m²; • No. AC OSPs = 2; • Nominal area of cable protection material required along each export cable = 11,000 m²; • No. of export cables = 4; and • Use of rock cutting equipment in water depths <10 m. **Rationale** Net loss of seabed habitat is assessed as the total area of seabed occupied by OSP foundations, scour material and cable protection material on completion of the construction phase. However, it is acknowledged that there will be an incremental loss of seabed habitat throughout the construction phase as the OSPs and associated cable protection will be installed at yearly intervals.
Habitat and associated community change	• No. AC OSPs = 2; • Cable protection (assuming protection is required to a distance of 100 m from the foundation to a width of 10 m and up to 20 "J" tubes (or cable connections) per OSP = 20,000 m²; • No. of export cables = 4; and • Nominal area of cable protection material required along each export cable = 4,000 m². **Rationale** The introduction of OSP foundations, scour and cable protection material will provide localised hard substrata for colonisation by encrusting and attaching species changing the predominately sedimentary communities to hard substrata communities within the footprint of the infrastructure.
Effects on physical processes and related biological changes	• Development of secondary scour • Change in tidal flow and sediment transport rates
Effects of heat and EMF emissions	• Export cables of 52 km each to be laid in 4 trenches (total 208 km); • Cabling within the three consented wind farms area (including inter-platform cabling) of 70 km length; and • Target burial depth is 1 m.

EIA Methodology

4.1.2.15 The impact assessment methodology follows that previously employed (MORL, 2012 Chapter 7.1: Benthic Ecology) and follows Institute of Ecological and Environmental Management (IEEM, 2010) guidelines to define effect **magnitude** and receptor **sensitivity**. The following explains how both effect magnitude and receptor sensitivity is determined and how these two assessment components combine to evaluate overall impact significance.

Magnitude of Effect

4.1.2.16 The magnitude of the effect on benthic ecology is defined in terms of the following criteria;

- Spatial extent - the geographical extent of an effect. Typically this includes consideration of effects at local (i.e. within the boundaries of a wind farm turbine array), regional, (i.e. a specific water body of comparable physical attributes), national and international scales and typically expressed as a percentage of the total area of the development and / or as a distance measure;

- Duration - the temporal aspect of the effect. Guidance offered by Wilhelmsson *et al.* (2010) suggests temporal scales based on the different phases of the actual development thus short term effects are those which occur within the construction phase, long term effects are those that occur through the operational phase whilst permanent effects are those that are still detectable after decommissioning;
- Frequency – the number of occurrences of an activity causing an effect per unit of time; and
- Reversibility (where appropriate) – whether the effect can be reversed i.e., conditions can be returned to that of the baseline prior to the effect occurring either through natural processes or intervention as mitigation.

4.1.2.17 The magnitude of effect is categorised as 'High', 'Medium', 'Low' or 'Very Low' based on the quantification of the above parameters. This process of quantification can necessitate a degree of subjectivity as decisions are based on professional judgement and experience (IEEM, 2010), although underpinned by a strong evidence-base and quantified data where possible. Table 4.1-7 presents the specific parameters used to facilitate the definition of effect magnitude.

Table 4.1-7 Assessment of Magnitude of Effect (Source: from Wilhelmsson *et al.*, 2010 modified)

Characteristic	Description	Categories of effect magnitude	
Spatial extent	The geographic area of influence where the effect is noticeable against background variability	Very Low	Within 10 m from source or < 0.1% of the development area.
		Low	10-100 m from source of <1% of the development area.
		Medium	100-1,000 m from source or <10% of the development area.
		High	>1,000 m from source or >10% of the development area.
Duration	The temporal extent the effect is noticeable against background variability	Very Low	Potential through construction/operation phase
		Low	Through construction phase
		Medium	Through operational phase
		High	Impact persist beyond the operational and decommissioning phases
Frequency	How often the effect occurs	Very Low	Occurs at 5 year intervals or greater.
		Low	Occurs at intervals of between 1 and five years.
		Medium	Occurs on a monthly basis.
		High	Occurs at least on a weekly basis.

Sensitivity of Receptor

4.1.2.18 When a receptor is judged to be exposed to an effect (see Table 4.1-8), its overall sensitivity to that effect is determined. As for magnitude, this process incorporates a degree of subjectivity and expert opinion (IEEM, 2010) to apportion 'High', 'Medium', 'Low' or 'Negligible' categories.

4.1.2.19 The sensitivity of a particular receptor incorporates a variety of criteria including its ability to adapt, its tolerance of the effect and its potential to recover following cessation of an effect. In this assessment, benthic ecological receptors have been classified into biotopes for which considerable quantities of sensitivity information exist via the Marine Life Information Network (MarLIN) website (www.marlin.aco.uk) (see Technical Appendix 4.1 A Subtidal Ecology Characterisation). MarLIN is a charitable organisation funded and supported by the UK statutory nature conservation authorities, DEFRA and associated executive agencies to provide sensitivity assessments for UK marine species and biotopes. The MarLIN sensitivity assessments therefore provide an accepted framework within which effects can be described based on tolerance and recovery criteria to various effects (factors). Evidence/confidence categories caveat the determination of sensitivity within the MarLIN framework although in this assessment a degree of expert judgement and reference to relevant industry experience in other sectors is also made to further refine the overall effect. Importantly, the biotope level allows a degree of flexibility in community structure which might fluctuate in response to natural or anthropogenic influences, i.e. seasonal variations and / or demersal fishing. Observations from other studies including licence monitoring of offshore wind farm and marine aggregates activities are also used here to support assessment of receptor sensitivity.

4.1.2.20 This assessment also considers the value of the receptor as an intrinsic component of its sensitivity, be it in terms of its nature conservation, rarity at a particular geographical scale or functional role within the wider ecosystem as described within Table 4.1-8. IEEM (2010) also attribute social/community and economic values. Valuable ecological assets are usually identified within national and international legislation and/or through local or national nature conservation plans, such as UK Biodiversity Action Plans (UK BAPs). Important species and habitats may be afforded protection through the designation of sites of nature conservation under national and/or international statutes. The presence of a legislative hierarchy relating to nature conservation provides a range of convenient standards on which to assist the evaluation of the sensitivity and associated impact significance of the receptor. Areas which are not currently designated but nevertheless fulfil criteria for designation are assessed and considered in the same way as designated features with respect to assignment of effect significance and mitigation (IEEM, 2010).

4.1.2.21 Many species and biotopes lie outside current policy and legislative frameworks but are considered of importance nonetheless as a result of their functional roles within the wider ecosystem. This is especially relevant where particular features fall under broader habitat classifications with high conservation value, i.e. a sand biotope which forms part of an Annex I sandbank habitat or which falls under the broader "subtidal sands and gravels" UK BAP habitat. Table 4.1-8 presents categories of receptor sensitivity used in this assessment.

Table 4.1-8 Assessment of Receptor Sensitivity (Source : MarLIN, modified)

Characteristic	Description	Sensitivity Categories	
Adaptability	How well a receptor can adapt to an effect	Very Low	The habitat or species can be destroyed or killed (low tolerance) or damaged (medium tolerance) and is expected to recover only partially over a very long period of time (>25 years) and may take >25 years or not at all (negligible recoverability)
		Low	The habitat or species can be destroyed or killed (low tolerance) or damaged (medium tolerance) and is expected to recover over a long period of time (between 10 and 25 years) (low recoverability)
		Medium	The habitat or species can be destroyed or killed (low tolerance) or damaged (medium tolerance) but is expected to recover within 10 years (medium recoverability)
		High	The habitat or species can be destroyed or killed (low tolerance) or damaged (medium tolerance) but is expected to recover within one to five years (high recoverability)
Tolerance	The ability of a receptor to be either affected or unaffected (temporarily and/or permanently) by an effect.	Very Low	Species important for the structure and/or function of the biotope or its identification are likely to be killed and/or the habitat is likely to be destroyed by the impact under consideration
		Low	The population of species important for the structure and/or the function of the biotope or its identification may be reduced or degraded by the impact under consideration, the habitat may be partially destroyed, or the viability of a species population, diversity and function of a community may be reduced.
		Medium	Species important for the structure and/or function of the biotope or its identification will not be killed or destroyed by the impact under consideration and the habitat is unlikely to be damaged. However the viability of a species population or the diversity/functionality in a community will be reduced.
		High	The impact does not have a detectable impact on the structure and/or function of a biotope or the survival or viability of species important for the structure and/or function of the biotope or its identification.

Characteristic	Description	Sensitivity Categories	
Recoverability	A temporal measure of how well a receptor recovers following exposure to an effect	Very Low	Partial recovery is only likely to occur after about 10 years and full recover may take over 25 years or never occur.
		Low	Only partial recovery is likely within 10 years and full recovery is likely to take up to 25 years.
		Medium	Only partial recovery is likely within five years and full recovery is likely to take up to 10 years.
		High	Full recovery will occur over many months or years but should be complete within about five years
Value	The scale of importance (conservation status/importance), rarity (geographical extent relative to the potential area impacted) and worth (socioeconomic, biodiversity)	Very Low	The habitat/species hold no conservation importance, are widespread and play key role in the ecosystem
		Low	The habitat/species hold regional conservation importance, are widespread and play a key role within the ecosystem
		Medium	The habitat/species hold national conservation value
		High	The habitat/species hold international conservation status

Evaluation of Significance of Effects

4.1.2.22 Having described the effect that the proposal has on the benthic ecological receptor, the EIA process requires a level of significance to be assigned to that effect. This is achieved through a synthesis of the magnitude and sensitivity components to determine the significance of effect. A statement of the significance of effect is used to summarise the evaluation process in terms of positive or negative effects and is defined using the following four categories:

- **Not significant:** an effect that is predicted to be indistinguishable from natural background variation using conventional monitoring techniques. The effect is not significant in the context of the nature conservation objectives or legislative requirements;
- **Minor significance**: the effect will be measurable in the short term and/or over local scales (with or without mitigation) using standard monitoring techniques. The effect does not affect nature conservation objectives and falls within legislative requirements. Effects are typically reversible;
- **Moderate significance:** the effect will be measureable in the long term and over a broad to very broad spatial scale and is likely to have a measurable effect on wider ecosystem functioning. It does not affect nature conservation objectives or legislative requirements. Effects may be reversible; and
- **Major significance:** a permanent effect which has a measurable effect on wider ecosystem functioning and nature conservation objectives and exceeds acceptable limits or standards.

4.1.2.23 A conceptual diagram of how effect significance is determined for this assessment is provided below in Table 4.1-9. With respect to this assessment, a significant effect will be any effect that is of moderate significance and above.

Table 4.1-9 Matrix for Determining Significance of Effect from Magnitude and Sensitivity on Benthic Receptors

Magnitude \ Sensitivity	Very Low	Low	Medium	High
Very Low	No Effect	Minor Significance	Minor Significance	Moderate Significance
Low	Minor Significance	Minor Significance	Moderate Significance	Moderate Significance
Medium	Minor Significance	Moderate Significance	Moderate Significance	Major Significance
High	Moderate Significance	Moderate Significance	Major Significance	Major Significance

Uncertainty

4.1.2.24 Uncertainties associated with each assessment are defined using the following criteria:

- **Low uncertainty:** Interactions are well understood and documented. Receptor sensitivity has been investigated in relation to the specific factor under assessment. Predictions relating to effect magnitude are modelled and/or quantified. Information/data have very comprehensive spatial coverage/resolution;
- **Medium uncertainty:** Interactions are understood with some documented evidence. Receptor sensitivity is derived from sources that consider the likely effects of a particular factor. Predictions are modelled but not validated and/or calibrated. Information/data have relatively moderate spatial coverage/resolution; and
- **High uncertainty:** Interactions are poorly understood and not documented. Predictions are not modelled and maps are based on expert interpretation using little or no quantitative data. Information/data have poor spatial coverage/resolution.

Impact Assessment

Construction

4.1.2.25 The following presents the assessments of the identified effects of the construction of the modified OfTI proposals on subtidal benthic ecology. A summary of the significance of the identified effects is presented in Table 4.1-4 above.

Temporary Direct Seabed Disturbances

4.1.2.26 Seabed habitats and their characterising species (collectively termed biotopes) will be directly disturbed as a result of the action of the offshore export cable burial tool during the installation of the export and inter platform cables as well as seabed preparation works associated with the placement of foundations for the AC OSPs. This effect is of interesting as it will increase sediment instability and displace and kill species through crushing, burial and abrasion resulting in the reduction of species diversity, abundance and biomass within the footprint. In addition, the periodic deployment and lifting of anchors to facilitate positioning of the offshore export cable laying barge may dislodge, damage and kill fauna and flora. Mobile species such as crabs, shrimps and benthic fish, including the spiny lobster PMF species, may be able to avoid disturbances or re-position within the sediment profile if buried, but sedentary and sessile fauna and flora may be damaged or dislodged leading to mortality of these species including those of nature conservation importance such as *A. islandica*, *M. loveni*, and *Arachnanthus sarsi*.

4.1.2.27 Direct effects will be highly localised and limited to the footprint of the offshore export cable burial tool, anchors and the dredger draghead. Effects will also be of very short duration lasting as long as the passage of the burial tool, the seabed preparations and anchor deployments, after which habitat recovery and species re-colonisation will occur.

4.1.2.28 Recovery and re-colonisation rates typically depend upon a number of factors including the prevailing hydrodynamic and sediment transport regime, the severity of the original effect and the nature of the baseline community and local re-producing populations. Habitat restoration is facilitated through natural backfilling as part of the cable laying process (BERR, 2008) whilst longer term morphological recovery will take place under the natural wave and tidal driven sediment transport mechanisms. Species recolonisation may be quicker in spring and summer, relative to autumn and winter, due to the greater availability of eggs, spores and larvae from adjacent re-producing populations at these times of year.

4.1.2.29 Sensitivity assessment (Rayment, 2008; Tyler-Watts, 2008) shows that local sand and mixed sand and gravel biotopes are highly intolerant of disturbance but that recovery is high with full recovery expected within a few months to five years following cessation of the disturbance. This reflects the opportunistic traits of the key characterising species, such as high fecundity and rapid larval dispersal.

4.1.2.30 The SpenMeg biotope, which occupies much of the southern half of the outer Moray Firth, on the other hand, may take up to 10 years to recover (Hill, 2008). This is because of the relatively slow growing and long lived nature of the characterising fauna, such as seapens (Hughes, 1998) and Norway lobster, which can take up to five years or more to reach reproductive maturity. Also, this biotope occurs in deeper water where the natural sediment stirring and weathering by large wave / storm events might be comparatively limited so that morphological recovery through natural dynamic process may occur more slowly relative to the recovery of biotopes present on the Smith Bank or in shallower inshore waters.

4.1.2.31 Given its close association with the SpenMeg biotope, recolonisation of affected areas by the mud burrowing amphipod M. loveni may also take more than five years to occur.

4.1.2.32 The reproductive behaviour and longevity of the burrowing mud anemone PMF species, (*Arachnanthus sarsi*) is currently unclear (Wilding & Wilson, 2009) and SNH regard it as rare with low resilience to physical seabed disturbances (see http://www.snh.gov.uk/docs/B988482.pdf). As a precaution, it is considered that this species may take longer than five years to re-colonise affected areas.

4.1.2.33 Trenching and/or dragging of anchors through a stony reef is likely to result in a permanent linear scar as the overlying wave and tidal process will be insufficient to remobilise cobbles and boulders to complete any natural backfilling and habitat restoration. Trenches through these features may instead be in filled by fine transient sediments that are present within the ambient bedload transport resulting in a change in the nature of the seabed to a finer sediment habitat. However, the likelihood of this actually occurring is low. This is because stony and rocky reef areas will be unsuitable for trenching. Instead, installation will be more likely to be achieved using concrete mattressing or rock placement (see below for assessment of habitat and community change).

4.1.2.34 The ocean quahog (*A. islandica*) is very long lived (+100 years) and reaches reproductive maturity at between 5 and 11 years (Sabatini *et al*., 2008). Maximum growth is thought to occur between 3–7 years of age. Recolonisation of disturbed areas and restitution of biomass is thus expected to be partially complete within five years but may take up to 10 years to be restored to pre-construction conditions. However, given its apparent distribution away from the boundaries of the modified TI (see section 'baseline characteristics' above), then no significant adverse effect on the population is forecast.

4.1.2.35 Effects will be highly localised, of short duration and will occur only once. Habitats predicted to be affected occur widely throughout the southern Moray Firth and in this broader scale context, their structure and function is not expected to be affected. Accordingly, the magnitude of effect is predicted to be low. Recovery of habitats and species is generally expected to be complete within five years following cessation of the disturbance although a longer recovery period of up to 10 years for affected parts of the SpenMeg biotope is forecast. Receptor sensitivity is thus judged to be low. Despite their nature conservation importance, the sensitivities of the "burrowed mud" PMF and associated PMF species receptors are also considered to be low given the broad distribution of this habitat type and availability of reproducing populations in adjacent non affected areas. The overall impact is therefore considered to be of **minor** significance.

4.1.2.36 The footprint of the effect is quantified and receptor sensitivity has been assessed through site specific survey and peer reviewed data (MarLIN) and thus uncertainty associated with this assessment is low. Note that significant adverse direct effects have not been identified during licence monitoring of offshore wind farms (MMO, 2014).

Temporary Increases in Suspended Sediment Concentrations and Sediment Deposition

4.1.2.37 Installation of the cables and seabed preparatory work associated with the foundations of the AC OSPs will raise suspended sediment concentrations (SSCs) and increase sediment deposition over adjacent seabed areas. This effect is of potential interest as the re settlement of suspended sediments over surrounding seabed areas and the potential for associated smothering and scour effects on benthic fauna may cause a loss of species diversity, abundance and biomass where effects are significant. Sessile epifaunal species may be particularly affected by increases in SSCs as a result of potential clogging or abrasion of sensitive feeding and respiratory apparatus. Larger, more mobile animals, such as crabs, fish, shrimps and prawns are expected to be able to avoid any adverse SSCs and areas of deposition. Effects will be temporary and will cease on completion of the construction activity.

4.1.2.38 As explained in Chapter 3.1 (Hydrodynamics, Sedimentary and Coastal Processes), local benthic faunal communities may be expected to be naturally exposed to levels of SSCs measuring 100s to 1,000s mg/l during periods of extreme wave events. Numerical modelling of the effects of raising SSCs (Technical Appendix 3.1 A Hydrodynamics, Sedimentary and Coastal Processes) shows that installation activities will increase SSCs by one or two orders of magnitude above the range of that which occurs naturally but only over a very small distance from the point of disturbance (i.e. to 125 m) and for a very short duration (i.e. minutes). Fine sediments are more dispersive and are forecast to remain at levels above the natural variation for up to three hours and for a distance of 2.5 km from the point of disturbance. Sediment thickness of re settled material also exceeds the natural variation but again, this will only occur very close (within 10s of metres) to the disturbance with subsequent wave and tidal driven transport processes further dispersing this material over adjacent areas over time. Sand and gravel sediments will be deposited locally at the point of release and will, therefore, be of the same type as the ambient substrate.

4.1.2.39 The MarLIN benchmark for assessment of the sensitivity of biotopes to raised SSCs and smothering is 100 mg/l for one month and 5 cm depth of burial by sediment for up to one month, respectively. These benchmark criteria are not forecast to be exceeded during the modified offshore export cable installation and OSP seabed preparatory works and so significant effects on receiving biotopes are not, therefore, expected. Sediment biotopes, and associated sediment burrowing species, along the majority of the cable corridor are expected to be tolerant of temporary light sediment effects. Burrowing species will re locate within the sediment profile and re-establish burrow openings if buried. Seapen species are able to retract into the sediment and so may be able to avoid temporary adverse effects of sediment smothering and scour. Important species such as *A. islandica*, *P. elephas*, *A. sarsi* and *M. loveni* are sediment burrowers or mobile species and so are expected to be tolerant to predicted sediment influences or can avoid significant adverse areas.

4.1.2.40 Epifaunal communities, such as those characterising the SS.SMx.CMx.FluHyd biotope, are typical of turbid conditions and so are not expected to be significantly affected by indirect sediment effects unless within a few metres of the disturbance where predicted sediment thicknesses may temporarily bury these species. Soft coral *Alcyonium digitatum* populations, which characterise stony and bedrock reef areas, are similarly tolerant to increases in SSCs and are able to slough off excess fine sediment particles through increased mucus production. Burial up to 5 cm for a prolonged period of time, however, may kill soft coral but such levels are not forecast. Recovery of epifauna populations is, therefore, predicted to be quick (within a few months to five years). Epifauna attached to vertical or sloping rock will not be affected by smothering as fine sediments are unlikely to accumulate on such surfaces.

4.1.2.41 As noted during consultation with the Inshore Fisheries Group (MORL, 2012, Chapter 4.2: Benthic Ecology) bryozoan and hydroid communities are believed to be important for the settlement of the spat of the King scallop (*Pecten maximus*) and squid (*Loligo* spp.) eggs. The localised and temporary nature of the effect and the rapid recovery capability of local bryozoan and hydroid species following sediment disturbances suggest no long term significant effects to important scallop and squid benthic habitat. Furthermore, the SS.SCS.CCS biotope associated with hydroids and bryozoans comprise very coarse gravel and cobble material which is highly unlikely to be ejected into the water column and transported any great distance over surrounding seabed area as a result of the proposed construction activities. Consequently, effects on component sessile epifaunal communities will be highly localised to the point of initial disturbance and will be limited in duration to the period of the activity following which rapid recovery will occur.

4.1.2.42 The effect would be highly localised and of short duration. Effect magnitude is therefore considered to be low. Biotope and species receptors are expected to be tolerant to the predicted sediment effects and/or able to avoid significant adverse areas and recovery is forecast to occur within the short term (five years). Receptors are widely distributed and well represented throughout the region. Receptor sensitivity is therefore considered to be low. Impact significance is therefore predicted to be **minor**.

4.1.2.43 This assessment carries low uncertainty as the effects of raised SSCs have been modelled and the footprint of the effect quantified. Receptor sensitivity has been assessed through site specific survey and peer reviewed data (MarLIN). Note that significant adverse indirect (sediment) effects have not been identified during licence monitoring of offshore wind farms (MMO, 2014).

Operation

Permanent Net Reduction of Original Habitat

4.1.2.44 Permanent net reduction of original habitat will occur as a result of the placement of the foundations of the OSPs and associated scour and cable protection material on the seabed. In addition, any cutting of rock within inshore areas as part of the cable lay operation will result in the loss of an area of this habitat type proportional to the size of the cut. This effect is of potential interest as this will constitute a reduction in the total area of benthic habitat relative to the baseline condition.

4.1.2.45 Based on the worst case design parameters summarised in Table 4.1-6 for the modified OfTI, a total of 0.1 km^2 of habitat will be lost, although in comparison with the previous Rochdale Envelope for the three consented wind farms and TI (MORL, 2012) the effect will be reduced as fewer OSPs will now be constructed.

4.1.2.46 Loss of original habitat will occur at the offshore end of the modified OfTI due to the placement of the foundations of the OSPs and associated cable protection material on the seafloor. Consequently, only those biotopes corresponding to the offshore mixed sand and gravel and fine sand habitats on Smith Bank will be reduced in extent (including the SS.SSa.OSa.OfusAfil, SS.SSa.IMuSa.FfabMag and SS.SSa.CFiSa.EpusOborApri biotopes).

4.1.2.47 Shallow water coarse cobbles and rock habitats closer inshore may be unsuitable for trenching methods and consequently may be subject to concrete mattressing / rock placement (or similar) to achieve successful cable installation resulting in a reduction in the total area of these habitat types. The mattressing / rock placement may replace potential Annex I stony reef but is highly likely to be colonised by fauna and flora that are representative of local populations within a year or two. However, given that it will be a different (artificial) material possibly with reduced complexity, relative to the ambient rocky habitat, the colonising community is expected to be a simpler and less diverse variant of the surrounding communities. This would constitute a negative effect, although its spatial extent would be localised around the area of the mattressing / rock placement.

4.1.2.48 Further rock habitat may be lost on a permanent basis following any cutting of rock as a part of the cable lay process. At this stage the quantity of rock cutting required (if any) is not known. The cutting of rock will remove habitat and the species attached to it. However, it will present new rocky surfaces for colonisation by local species from surrounding unaffected areas once the installation process is complete. Recovery is likely to be very rapid, subject to the presence of nearby reproductive colonies, with establishment and growth of locally occurring foliose red algae, ascidians, bryozoans and the soft coral A. digitatum occurring within one year (Budd, 2008).

4.1.2.49 The spatial extent of the effect will be very low to low as it will relate to the direct footprint of the OSP foundation, rock placement and rock cutting (if any) only. Duration will, however, be medium as the foundations for the OSPs and the scour and cable protection material will be in place throughout the operational phase of the scheme. Furthermore, any rock cutting will leave a permanent localised impact on the seabed but affected areas will be rapidly recolonised. Effect frequency will be very low as the effect will only occur once. Overall, effect magnitude is thus considered to be low. No biotopes or species populations will be lost due to the current proposals. Ecological diversity and functioning across the wider region is therefore not expected as all components of habitat and associated communities will remain post construction. Colonisation of cable protection material and exposed rock surfaces following rock cutting is expected to be rapid although diversity may be lower in comparison to adjacent communities inhabiting the natural rock. Receptor sensitivity is therefore judged to be low. Accordingly, the significance of the loss of original habitat is considered to be **minor**.

4.1.2.50 The footprint of potential habitat loss is quantifiable. MESH data exist to indicate wider context for this assessment. Consequently, uncertainty associated with this assessment is considered to be low.

Habitat and Associated Community Change

4.1.2.51 The foundations of the AC OSPs together with the associated scour and cable protection material will introduce new hard substrate for colonisation by attaching and encrusting species and will change the ambient sedimentary habitats to a more heterogeneous coarse, hard substrate habitat. This effect is of potential interest as it will change benthic ecological conditions relative to the baseline. The increase in the availability of hard substrata is of further potential interest as it increases the risk of enhancing the spread of marine invasive non-native species (MINSS), such as the Japanese ghost shrimp (*Caprella mutica*) and associated loss of indigenous species. Effects of (a) indigenous species and (b) MINNS are assessed separately below.

Indigenous species and habitats

4.1.2.52 Hard structures in predominantly sedimentary biotopes would increase habitat diversity and complexity and would promote local diversity abundance and biomass of epifaunal organisms by providing stable surfaces for attaching and encrusting species. Recent experiences at the Kentish Flats Offshore Wind Farm (EMU Ltd., 2008a), Barrow Offshore Wind Farm (RSK, 2006; EMU Ltd., 2008b), North Hoyle Offshore Wind Farm (Bunker, 2004), Egmond aan Zee Offshore Wind Farm in the Dutch North Sea (Bouma and Lengkeek, 2009) and the Horns Rev Offshore Wind Farm in the Danish North Sea (BioConsult, 2006) show a vertical zonation of epifaunal species colonising turbine columns including high densities of common mussels together with barnacles, common starfish, worms, crabs, bryozoans and hydroid at upper most depths, whilst tube dwelling amphipods, anemones and hydroids dominated surfaces below 10 m. Scour protection rocks supported crab, oyster and slipper limpets and appeared to provide refuge and food for fish such as cod and pouting (BioConsult, 2005; Lindeboom *et al*., 2011). The placement of scour material may provide refuge/micro-niches and increased feeding opportunities for a range of larger more mobile species creating a possible aggregation effect and attracting a variety of fish, molluscs and crustaceans such as wrasse, brown crab, pacific oyster and common mussels (Linley *et al*., 2007).

4.1.2.53 Picken (1986) offers valuable insight into the types of epifaunal organisms that might be expected to colonise the OSP structures as a result of historic studies on the fouling organisms of artificial structures in the Moray Firth, including those within the adjacent Beatrice Field. Structures were initially colonised by barnacles and tubeworms within the first year of placement. Over the following two to three years, these became overgrown with common mussels together with growths of seaweeds in the uppermost 5 m of water. These growths were succeeded after four years by hydroids which dominated surfaces below the seaweeds together with soft corals and the ascidians sea squirts.

4.1.2.54 Krone *et al*. (2013) predicts that introduced hard substrata associated with offshore wind farms will increase stocks of substrata-limited mobile demersal hard bottom species. Predation by these species is expected to be localised around the turbines themselves, where the greatest benefits and feeding opportunities exist, although Krone *et al*. (2013) did notice several hard substrata associated species, such as brown crab and velvet swimming crab venturing onto the surrounding soft bottom seafloor at a wind farm site in the North Sea. This suggests that predation pressure by these species may be increased within a halo beyond each turbine foundation and scour material, although the degree to which this will, if at all, and any associated effect is unclear due to the lack of specific studies.

4.1.2.55 Biogenic material (principally mussel shell) that has grown on and subsequently become detached and fallen from turbines and scour protection rocks (Bouma & Lengkeek, 2012) can accumulate on surrounding seabed areas and within scour pits. Significant accumulation may modify local habitats and associated communities as a result of changes in sediment grain size distribution, organic enrichment and possible attraction and aggregation of scavenging or predatory species such as common starfish, whelks and fish (Love *et al*., 1999; Degreaer *et al*., 2012) although such effects have not been recorded during licence monitoring of offshore wind farms in the UK (MMO, 2014). Localised benthic change has, however, been recorded around the bases of Californian oil platforms (Wolfson *et al*., 1979; Love *et al*., 1999) including deposits of mussel shells, as well as other biological material, supporting very high densities of predatory and scavenging species, particularly starfish at distances of up to 50 m away. The same studies also noted high densities of tube dwelling polychaetes up to 100 m from platforms and attributed this to the availability of biogenic material falling from the platforms for the construction of tubes. In addition, soft sediment communities were found to be modified up to a distance of 50 m from gravity bases at a wind farm in Belgium as a result of changes in sediment grain size distribution and increased enrichment attributable to the presence of turbine structures (Degreaer *et al*., 2012).

Marine Invasive Non-Native Species (MINNS)

4.1.2.56 Offshore renewable developments have been shown to act as stepping stones for several species (Svane and Petersen, 2001, cited in Petersen and Malm, 2006); this has raised concerns about their effect as facilitators for MINNS.

4.1.2.57 Previous examples of offshore wind projects at which MINNS have been recorded include:

- Acorn barnacle (*Elminius modestus*) at Thornton Bank (Kerckhof *et al*., 2009, 2010) and Kentish Flats (EMU, 2008);
- Giant barnacle (*Megabalanus coccopoma*) at Thornton Bank (Kerckhof *et al*., 2009, 2010);
- Slipper-limpet (*Crepidula fornicata*) at Thornton Bank (Kerckhof *et al*., 2009, 2010) and Egmond aan Zee (Bouma and Lengkeek, 2009);
- Pacific Oyster (*Crassostrea gigas*) Egmond aan Zee (Bouma and Lengkeek, 2009);
- Asian sea squirt (*Styela clava*) at Kentish Flats (EMU, 2008);
- Giant midge (*Telmatogeton japonicas*) Thornton Bank (Kerckhof *et al*., 2009, 2010) (Non-marine species); and
- Japanese skeleton shrimp (*Caprella mutica*) at Horns Rev (BioConsult, 2006).

4.1.2.58 MINNS is a qualitative descriptor for determining good environmental status under the Marine Strategy Framework Directive (MSFD). However, their management is still evolving and remains at an early stage mainly due to limited knowledge of the ecology of the species involved.

4.1.2.59 Most of the MINNS have been identified in intertidal and coastal environments with offshore wind farms potentially acting as a corridor for MINNSNIS species to settle and establish (ICES, 2009; Olenin *et al*., 2010). This is because each turbine column creates an intertidal environment offshore and therefore offers favourable conditions. Some of the MINNS classified as problematic (OSPAR, 2010), or as having deteriorating effects (Defra, 2011) have in fact been found at offshore wind farm sites (e.g. *Crassostrea gigas* or *Styela clava*), although not as major components of the faunal community. However, the intertidal environment created by foundation structures including offshore renewables and oil and gas infrastructure, appear to be favourable for some MINNS.

4.1.2.60 The effect of colonisation by indigenous species and MINNS would be highly localised around each installed OSP structure although duration would be medium, lasting throughout the operational phase.

4.1.2.61 The likely significant effects of MINNS on legislative requirements such as MSFD are currently unknown and so the uncertainty associated with this particular assessment is high. Sensitivity is therefore assessed as medium and reflects a precautionary approach in light of apparent uncertainties and previous stakeholder consultation (MORL, 2012). Consequently the significance of the effects of MINNS is regarded as **minor adverse**. Normal vessel maintenance and operating procedures such as hull cleaning, control of ballast water and use of anti-fouling coatings, and as part of the project EMP would reduce the risk of introduction and spread of MINNS.

4.1.2.62 Uncertainty associated with this assessment is high as the effects of the localised increases in predation pressure and accumulation of biogenic material on the seafloor (if any) are unknown and relevant studies are lacking.

Effects on Physical Processes and Related Biological Changes.

4.1.2.63 The effects on physical processes and associated benthic ecological effects within the three consented wind farm sites have been assessed in the previous ES (MORL, 2012 Chapter 10.1:Benthic Ecology).1 in relation to the presence of 339 turbines (maximum number of turbines if the lowest rated turbines are installed). This showed that very small changes in physical process are forecast resulting in no effects on benthic ecology. The presence of only two foundations as part of the modified TI is highly unlikely to raise the significance of this effect or alter the conclusions already made. The cable along the majority of the length of the route will be buried to a target depth of 1 m and so is unlikely to contribute to changes in physical processes. Given the predominately sedimentary nature of the seabed, it is likely that successful cable burial will be achieved throughout the majority of the cable route. This means that the quantity of any new or replacement cable protection material during the operation of the scheme is likely to be very small. Consequently, effects of the modified OfTI on physical processes and associated impacts on benthic ecology are assessed to be of **no significance**.

Effects of EMFs

4.1.2.64 This section addresses potential effects of EMF on benthic invertebrates. Effects of EMFs on fish and shellfish are considered in Chapter 4.2 (Fish and Shellfish Ecology).

4.1.2.65 BERR (2008) explains that sensitivity in benthic organisms, where present, is thought to be related to orientation and direction finding. Therefore, effects of EMFs are of potential interest as these may cause changes in a range of behaviours from local foraging to migration of benthic species depending upon the scale and magnitude of the influence.

4.1.2.66 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 sub marine DC 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). Additionally, the occurrence of apparently healthy and diverse communities on existing offshore wind farm structures provides evidence that EMFs are unlikely to pose a significant threat to the colonising communities (Linley *et al*., 2007). This suggests that receptor sensitivity is low or very low.

4.1.2.67 The offshore export cables will be buried to a target depth of 1 m (see Chapter 2.2, Project Description). This is likely to provide some mitigation for possible impacts associated with EMFs, as a result of the dampening effects of the substrate and the physical separation of the receptors from the EMF source but as pointed out by Gill *et al*. (2005) EMFs may still remain detectable to the most sensitive of species even if the cable was buried to several metres below the seabed. Some dampening of

EMFs may also be achieved through the placement of concrete mattresses or rock protection over the cable, although the effectiveness of this in comparison to burial in sediment is not known.

4.1.2.68 The effect is highly localised around the cable and will be of medium duration lasting throughout the operational phase of the development but will be reversible upon decommissioning. Effect magnitude is therefore considered to be low. These factors coupled with current field observations described above (i.e. very low receptor sensitivity) and the mitigation through burial suggests that EMF effects on subtidal benthic ecology will be **not significant**.

4.1.2.69 This assessment carries medium uncertainty as the number of experimental field studies addressing invertebrate tolerance/sensitivity to EMF is currently rather limited. However, the offshore export cable will be buried so that potential EMF effects will be reduced. Monitoring at other wind farm sites (MMO, 2014, Cefas, 2010; Wilhelmson *et al*.,, 2010) have not detected any significant adverse effects attributable to EMF emissions on benthic ecology.

Effects of Heat

4.1.2.70 The passage of electricity through a cable will generate heat, which will then be dissipated within the overlying water or surrounding sediment substrate. This effect is of interest as it may cause increases in seabed temperatures, which might cause changes in physicochemical conditions of sedimentary substrates. These, in turn, may affect the physiology, reproduction or even mortality of certain benthic species (OSPAR, 2009). Effects of heat from cables laid on the surface of the seabed are considered to be of less concern, as the heat will be rapidly dissipated within the overlying water column. Some mobile species may be temporarily attracted to heat sources resulting in some possible localised re-distribution although observations are lacking.

4.1.2.71 The target cable burial depth is beyond the normal burrowing capabilities of species characterising local biotopes including Nephrops norvegicus. These typically occupy the uppermost few tens of cms of seabed sediment only and are therefore not expected to come on to contact with buried operational cables. In any case, mobile burrowers would be expected to be able to avoid adverse areas.

4.1.2.72 Emissions of heat from cables will be long–term, lasting for the duration of the operation and maintenance phase of the modified OfTI. but reversible on decommissioning. The effect is likely to be highly localised around the cable. The magnitude of this effect is therefore assessed as being very low and the sensitivity of benthic fauna would be very low. Accordingly, the effects of heating from the offshore export cables is assessed to be **not significant**.

4.1.2.73 This assessment carries low uncertainty as the spatial extents of the effects are well understood and licence monitoring at offshore wind farms have not detected any significant adverse effects on benthos due to heat emissions (MMO, 2014).

Decommissioning

4.1.2.74 It is proposed that the export cable will be left in situ and so no effects on benthic ecology will occur during its decommissioning.

4.1.2.75 Removal of the AC OSP foundations will disturb seabed sediments for subsequent re distribution over adjacent areas resulting in potential smothering effects. The dominant sediment habitats and communities will be tolerant to these effects (as assessed above) and the significance of related effects is expected to remain minor.

4.1.2.76 Removal of the OSP foundations will result in the removal of the epifaunal communities attached to them. The protected cold water coral Lophelia pertusa is not expected to colonise OSP foundations during the operation of the wind farm, as the comparatively shallow water conditions locally are thought unsuitable. As such, adverse decommissioning effects on high value benthic ecological receptors are not forecast.

4.1.2.77 Removal of the foundations and scour material will expose the natural seabed previously lost under these structures. These areas are expected to be rapidly re colonised from surrounding reproducing populations with full restitution of the habitats and biotopes expected within five years, subject to the condition of the seabed substrate and stability compared to the baseline situation.

Accidental Spillages of Chemicals

4.1.2.78 Accidental spillages or release of chemicals such as grouting, fuel and oil during the construction, operation and maintenance and decommissioning phases of the wind farms may potentially impact upon the subtidal benthic ecology. The severity of this effect depends upon the quantities and nature of the spillage / release, the dilution and dispersal properties of the receiving waters and the bio-availability of the contaminant to species.

4.1.2.79 In the worst case scenario the magnitude of effect would be high. Depending upon the nature of the spill, sensitivity of receptors would also be high. Impact significance would therefore be major. However, the embedded mitigation measures, which include the development and implementation of construction and operation and maintenance environmental management plans, would reduce the likelihood of such an event occurring so that the magnitude of the effect would be very low and that the impact significance would be **not significant**.

Proposed Monitoring and Mitigation

Construction

4.1.2.80 Development of and adherence to an Environmental Management Plan (EMP) compliant with ISO14001 or BSA 555, will limit the risk of accidental spillages or releases occurring and to ensure that adequate contingency is in place (i.e. spill plan) to resolve any incidents quickly. Also, establishment of an EMP will identify appropriate measures to avoid or minimise adverse effects on marine life.

4.1.2.81 The development and adherence to a protocol to minimise risk of introducing MINNS via attachment to marine plant and/or specialised equipment is recommended by SEPA (MORL, 2012 Chapter 4.2 Benthic Ecology). This may include regular hull cleaning of construction vessels, maintenance of anti-fouling systems and ballast water management as part of vessel normal operating procedures.

4.1.2.82 The use of best practice to minimise the quantities of scour and cable protection material will reduce loss of original seabed habitat and habitat change.

Operation

4.1.2.83 Development of and adherence to an EMP will limit the risk of accidental spillages or releases occurring or ensure that adequate contingency is in place to resolve any incidents quickly.

Decommissioning

4.1.2.84 A decommissioning plan will be developed and agreed with the relevant authority on decommissioning. Development of and adherence to an EMP will limit the risk of accidental spillages or releases occurring or ensure that adequate contingency is in place to resolve any incidents quickly.

4.1.3 Cumulative Impact Assessment

Summary

4.1.3.1 This section presents the results of assessment of the potential cumulative effects upon subtidal benthic ecology arising from the modified OfTI in conjunction with other existing or reasonably foreseeable marine developments and activities. MORL's approach to the assessment of cumulative effects is described in Chapter 1.3: Environmental Impact Assessment.

4.1.3.2 A summary of the likely significant cumulative effects is provided in Table 4.1-10 below. Given the largely static or sedentary nature of benthic ecological receptors, other developments and activities considered here include those which are adjacent to the modified OfTI and which are forecast to give rise to similar effects on benthic ecology. Projects which are distant to the modified OfTI, such as the Hywind Demonstrator Project, are considered to be outside of the potential zone of influence of the modified OfTI with respect to effects on benthic ecology and are thus not considered in this cumulative assessment.

4.1.3.3 In conjunction with other developments and activities within the locale, the modified OfTI will only have minor cumulative effects on benthic habitat loss and introduction of new substrate as a result of the operation of the proposals. Cumulative effects of temporary seabed disturbances arising from the construction phase of the projects are considered to be not significant with regard to benthic ecology.

Table 4.1-10 Cumulative Impact Summary

Effect/Receptor	**Residual significance level for modified TI**	**Whole project assessment:** **Modified TI + Stevenson, Telford and MacColl**	**Mitigation Method**
Construction & Decommissioning			
Temporary increases in SSCs and sediment deposition	Not significant	Not significant	n/a
Total Cumulative Impact Assessment ***(Whole project plus those developments listed in Section 4.1.3.5)***	Effects arising from each scheme will be localised and short term. Sediment plumes will be dispersed along parallel tidal axes. The predominately sedimentary receptors are expected to be tolerant to predicted sediment effects. The cumulative effect is predicted to be not significant.		
Operation			
Habitat loss	Minor	Minor	n/a
Total Cumulative Impact Assessment **(Whole project plus those developments listed in Section 4.1.3.5)**	The footprint of temporary seabed disturbances will be small within the context of the availability of seabed habitat across the outer Moray Firth. No loss of biotope diversity or species populations is forecast. The cumulative effect is predicted to be minor.		
Habitat change	Minor	Minor	n/a
Total Cumulative Impact Assessment **(Whole project plus those developments listed in Section 4.1.3.5)**	The addition of 2 OSP foundations, scour material and cable protection material as part of the modified OfTI will represent a small amount of new habitat within the wider context of the wind farm and oil and gas infrastructure in the outer Moray Firth. The effect is judged to be minor.		

Assessment of Cumulative Effects

4.1.3.4 A whole project assessment has been done for the likely significant cumulative effects of the modified TI in conjunction with the three consented wind farms (Telford, Stevenson and MacColl).

4.1.3.5 The following developments were considered in detail for the total cumulative impact assessment for the whole Project:

- BOWL and transmission infrastructure as consented;
- MORL Western Development Area (WDA);
- Beatrice Demonstrator Turbines;
- SHE-T cable;
- SHEFA telecoms cable;
- Beatrice and Jacky platforms and associated infrastructure; and
- Licence Block 12/27 oil and gas exploration Suncor Energy UK Ltd (Suncor)

4.1.3.6 The spatial context within of this cumulative assessment is set by the expected range of the benthic ecology receptors (habitats and species). These are relatively immobile and will be generally constrained to the respective boundaries of the projects identified above. Some benthic fish and larger crustaceans obviously have the potential to range beyond project boundaries and are considered within Chapter 4.2 Fish and Shellfish Ecology, although the smaller species, which typically fall within the consideration of subtidal benthic ecology, will only range comparatively small distances. Consequently, any direct effects of far field projects and activities beyond the modified offshore export cable route corridor will not contribute to direct cumulative effects on benthic ecology and are thus excluded from this assessment. The exception to this is the perceived incremental loss of original seabed habitat and the introduction of new hard substrata across the wider region as a result of multiple offshore developments, for instance the modified OfTI, three consented wind farms in combination with the BOWL, the MORL Zone Western Development Area (WDA) and existing Beatrice and Jacky platforms. In this respect, the spatial context of the assessment is broadened to encompass other projects within the outer Moray Firth where comparable biotopes serving similar ecosystem functions occur.

4.1.3.7 Indirect effects associated with the movement of sediment plumes from other developments and activities may interact with those arising from the modified Project giving rise to indirect cumulative (sediment) effects. This section therefore considers other local projects and on-going activities within the Moray Firth, which may give rise to sediment plumes. Given that such sediment plume interaction will only occur within the extents of tidal excursions, any projects and activities outside of this tidal range are not considered, as the associated indirect sediment effects on benthic ecology will be insignificant at these greater distances.

Methodology

4.1.3.8 The assessment methodology has followed that outlined in the Moray Firth Offshore Wind Developers Group (MFOWDG) Discussion Document (see Appendix 1.3 D, MORL ES, 2012).

4.1.3.9 The foundations of the OSPs and associated scour and cable protection material of the modified OfTI will be placed within the boundaries of the three consented wind farms (Telford, Stevenson and MacColl). Under MFOWDG, a combined biotope map for both the BOWL and MORL sites was created to inform assessment of the potential incremental cumulative loss of benthic habitat (biotopes) following construction of both offshore wind farms (MORL, 2012).

4.1.3.10 A summary of the realistic worst case parameters of wind farm design for the MORL consented wind farms, the BOWL site as consented and MORL WDA in terms of benthic ecology are provided in Table 4.1-11, Table 4.1-12 and Table 4.1-13 respectively. The worst case parameters for the modified OfTI are provided in Table 4.1-6 above. Note that as the Telford, Stevenson, MacColl and BOWL sites are now consented, their worst case parameters are well understood and will be of a lower magnitude than that applied for. The worst case scenario for the MORL WDA, has assumed a maximum of 500 MW of installed capacity within this area. However, it should be noted that the overall MORL Zone capacity is capped at 1.5 GW as originally assessed in the MORL ES (2012). This means that should MORL successfully construct in excess of 1,000 MW in the three consented wind farm sites then the development in the WDA will be restricted accordingly to ensure the MORL Zone capacity is not exceeded. This restriction of the total capacity of the MORL Zone means that the effects from development in the three consented wind farms and WDA combined will be restricted also.

4.1.3.11 In the MORL ES, cumulative effects were assessed on the basis of a potential capacity of 1,500MW (3 x 500 MW) from the three MORL consented wind farms alone. The predicted effects of a 1,500MW offshore wind farm within the MORL Zone have thus already been assessed and reported (MORL, 2012). The conclusions from that assessment have been assumed in this ES to be representative of the effects of the three MORL consented wind farms and the WDA combined.

Table 4.1-11 Summary of MORL Consented Wind Farms Worst Case Parameters for Benthic Ecology

Realistic Worst Case Parameters	Scenario Assessed
Incremental Loss of Habitat and Habitat Change	
Installation of 186 turbines with gravity base foundations and associated scour material. GBS foundation and scour protection with combined permanent zone of influence of 11,690 m per foundation Cable protection associated with up to 4 J tubes per turbine assuming protection required up to 100 m distance from turbine and at 10 m width = 4,000 m² per turbine.	Total area of loss of original habitat and area of new hard substrata = 2.91 km²
Temporary increases in SSCs and sediment deposition	
Installation of 186 gravity base foundations; Length of inter-array cables = approximately 572 km and trench width = 6 m.	Increases in suspended sediment concentrations arising from worst case parameters.

Table 4.1-12 Summary of BOWL Consented Wind Farm Worst Case Parameters for Benthic Ecology

Worst Case Parameters	Scenario Assessed
Incremental Loss of Habitat and Habitat Change	
Installation of 140 turbines (125 turbines consented as per conditions but with the potential for up to 140 turbines), plus 2 AC OSPs and 1 AC/DC substation GBS foundation and scour protection with combined permanent zone of influence of 11,690 m per foundation Cable protection associated with up to 4 J tubes per turbine assuming protection required up to 100 m distance from turbine and at 10 m width = 4,000 m^2 per turbine. Length of export cable = 65km (up to 3 trenches) requiring 0.26km^2 of cable protection.	Total area of loss of original habitat and area of new hard substrata = 2.49 km^2 equating to 2.04% of the BOWL (turbine site and cable site) development area.
Temporary Increases in SSCs and Sediment Deposition	
Installation of 143 GBS foundations (125 turbines consented as per conditions but with the potential for up to 140 turbines plus 3 OSPs); Length of inter-array cables = 260 km and trench width = 3 m. Length of export cable = 65 km (up to 3 trenches)	Increases in suspended sediment concentrations arising from worst case parameters.

Table 4.1-13 Summary of MORL WDA Worst Case Parameters for Benthic Ecology

Realistic Worst Case Parameters	Scenario Assessed
Incremental Loss of Habitat and Habitat Change	
Installation of 100 turbines and one AC OSP with gravity base foundations and associated scour material. GBS foundation and scour protection with combined permanent zone of influence of 11,690 m per foundation Cable protection associated with up to 100 m distance from turbine and at 10 m width = 2,000 m^2 per turbine.	Total area of loss of original habitat and area of new hard substrata = 2.57 km^2.
Temporary Increases in SSCs and Sediment Deposition	
Installation of 101 gravity base foundations (turbines and OSPs); Length of inter-array cables = approximately 130 km and trench width = 6 m.	Increases in suspended sediment concentrations arising from worst case parameters.

Other Developments

4.1.3.12 Parameters associated with other cable projects within the outer Moray Firth, including the SHE-T cable and the Suncor well installations remain unconfirmed and so individual and cumulative effects are unquantifiable at this stage. This cumulative assessment has therefore taken a more qualitative approach in defining likely effects relating to these developments and associated construction and operational elements. In these instances, it is assumed that other cable projects will result in temporary seabed disturbances including the raising of sediment plumes as a result of trenching or ploughing during installation. These cable projects are also assumed to contribute to the incremental loss of original benthic habitat and to habitat change in the outer Moray Firth as a result of the placement of protection material on the seabed, should this be required.

4.1.3.13 The Suncor well installations are also likely to temporarily disturb seabed sediments resulting in short term increases in suspended sediment concentrations and sediment deposition as a result of the action of the drilling equipment on the seabed. Given the very small size of the footprint of well heads on the seabed (in the order of a few metres), then any contribution to loss of original benthic habitat and habitat change is considered to be negligible.

Cumulative Assessment

4.1.3.14 Effects of EMF and heat emissions have been screened out of the cumulative assessment due to the highly localised spatial extent of the predicted effects around the export cables, the intended target burial depth of 1 m and the mobile nature of potentially sensitive species. Assessment of cumulative effects of EMF on mobile fish and crustaceans is presented in Chapter 4.2 (Fish and Shellfish Ecology).

4.1.3.15 The likely significant cumulative effects on benthic ecology considered include:

- Habitat loss;
- Raised suspended sediment concentrations (SSCs) and sediment deposition; and
- Change in habitat.

4.1.3.16 The receptors identified for consideration in this cumulative assessment are:

- Benthic habitats;
- Benthic species.

Habitat Loss

4.1.3.17 The modified OfTI is predicted to result in the cumulative incremental loss of 0.1 km^2 of original benthic habitat as a result of the placement of the OSP foundations, scour protection and cable protection on the seabed. This equates to just 3.09% of the original benthic habitat that is predicted to be lost as a result of the three MORL consented wind farms. The magnitude of effect is thus judged to be low. There are no habitats or species that are specific to the footprint of the three MORL consented wind farms and modified OfTI developments and so biotope and species diversity will not be reduced. The footprint of the predicted habitat loss is considered to be very small within the context of the benthic habitats available across the wider outer Moray Firth. Sensitivity is thus judged to be low and the effect is predicted to be **minor**.

4.1.3.18 The modified OfTI, MORL consented wind farms, the BOWL site and its associated offshore transmission infrastructure together with development within the WDA and any infrastructure associated with the SHE-T cable will also result in a cumulative incremental loss of seabed habitat in the outer Moray Firth as a result of the successive placements of turbine and OSP foundations and protection material on the seabed.

4.1.3.19 Collectively, the, MORL consented wind farms and MORL WDA turbine foundations, BOWL site and transmission infrastructure will occupy approximately 6.94 km^2 of seabed within the outer Moray Firth. In contrast, the modified OfTI is forecast to only occupy an additional area of 0.1 km^2 (worst case) equating to an additional 1.2 % of the predicted habitat loss. Note that the majority of this additional 1.2 % will actually result in a habitat change (i.e. not habitat loss) as it relates to the placement of rock cable protection material which can be subsequently colonised by local species. Given their, very small footprint on the seabed, the potential Suncor well installations are not expected to contribute to loss of original benthic habitat or habitat change.

4.1.3.20 The spatial extent of this cumulative effect is small within the context of other projects and the wider outer Moray Firth area. The significance of cumulative effects on biodiversity and ecosystem functioning is thus considered **minor**.

4.1.3.21 The maximum footprints of the components of the BOWL, MORL consented sites and WDA developments are understood and so uncertainty associated with this assessment is regarded as low.

Temporary Increases in SSCs and Sediment Deposition

4.1.3.22 Installation of the modified OfTI, the three consented wind farms, the BOWL site and associated OfTI together with the SHE-T and SHEFA offshore transmission infrastructure and the drilling the Suncor well installation will temporarily disturb fine muddy sand sediments resulting in increased SSCs and sediment deposition as assessed above. However, sediment plumes arising from simultaneous installation of the consented wind farms and the modified OfTI proposed are not forecast to interact significantly. This is because of the typically low suspended sediment concentrations (SSCs) predicted, the localised and temporary nature of the effect and the rapid dilution of dispersion of suspended sediments in the receiving waters and the general parallel pathways of plume dispersion so that they are not expected to converge or inter-mingle. Sediment communities are expected to be tolerant to temporary sediment effects as assessed above. The installation of the modified OfTI will not temporally coincide with the installation of the potential Suncor oil and gas wells.

4.1.3.23 Significant cumulative effects relating to temporary increases in SSCs and sediment deposition are therefore not anticipated because of the small spatial scale of the effects, the distances between potential developments, the parallel tidal movements of plumes and the general insensitivity of receiving habitats (see Table 4.1-8 above).

4.1.3.24 Significance of cumulative effects in this regard is therefore considered to be **not significant**.

4.1.3.25 Commercial fishing activities involving mobile demersal gears can also raise suspended sediments into the water column increasing local levels of SSCs. There is therefore the potential for further cumulative sediment effects to arise where this activity occurs within the footprint of indirect construction effects. The magnitude and spatial scale of potential cumulative effects are presently difficult to qualify as the footprint of commercial fishing varies spatially and temporally. However, given the generally rapid dispersion and dilution of raised SSCs, the low intolerance of receiving sediment habitats and the temporary nature of the disturbance, then the significance of any associated cumulative effects is considered to be **not significant**.

Change in Habitat

4.1.3.26 The introduction of new hard substrate in the form of the vertical surfaces of the OSPs and cable protection material in the outer Moray Firth has the potential to increase local species diversity as they will provide suitable areas for colonisation by a range of epifaunal populations. Additionally, scour material will increase the availability of refugia for larger, more mobile epibenthos such as fish and crabs, attracted by the greater availability of food resources (see Chapter 4.2 Fish and Shellfish Ecology). At the local level around each OSP, therefore, there is a potential for increases in biodiversity and productivity. However, at the wider, cumulative level, the perceived positive effects are less certain. This is because any colonising epifaunal populations will probably already be represented within the outer Moray Firth, for example attached to existing platforms within the Beatrice oil field. Consequently, any species colonising the new habitat will already have been recorded elsewhere within the wider area and overall effects on regional biodiversity will be marginal. Accordingly, the effects are judged to be localised and significant cumulative effects in this respect are not predicted.

4.1.3.27 New habitat associated with the two proposed OSPs also has potential for colonisation by marine invasive non-native species (MINNS). However, within the context of the new habitat, represented by existing oil and gas structures and future turbine foundations, scour and cable protection material) already consented in the outer Moray Firth, any contribution from the modified OfTI will be very low and the cumulative effect is considered to be **minor**.

4.1.4 References

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