moray offshore renewables ltd

Environmental Statement

Technical Appendix 4.2 B - Benthic Ecology Characterisation Survey (Transmission Infrastructure)

Telford, Stevenson, MacColl Wind Farms and associated Transmission Infrastructure Environmental Statement

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1. Introduction

1.1. Study Background

1.1.1. Following successful award of exclusive development rights from Crown Estate, Moray Offshore Renewables Ltd. (MORL) (a consortium developer comprising EDP Renovaveis and Repsol Nuevas Energias UK (formerly SeaEnergy Renewables)) commissioned a series of detailed technical studies to support a consent application and associated Environmental Statement (ES) for the three proposed Moray Firth Round 3 wind farm sites named the Telford, Stevenson and MacColl sites.

1.1.2. This document presents a characterisation of the benthic ecology of the offshore transmission infrastructure corridor which is associated with the three wind farm sites. It describes the seabed video survey methods used to acquire characterisation data along the proposed route of the export cable and provides an interpretation of the subtidal benthic environment in terms of the seabed habitats and conspicuous epifaunal communities observed.

1.1.3. The proposed cable route is 103 km long and runs in an approximate south easterly direction between the Moray offshore wind farm zone. Two landfall options were initially considered with the final Fraserburgh beach option being selected following a screening exercise that evaluated environmental, consenting, technical and cost considerations. A full description of the consideration of alternatives is presented within the ES, Chapter 5. Only the final route survey results are therefore presented within this Technical Report as indicated in Figure 1.1. Water depths throughout the length of cable range from <10 to 190m below chart datum.

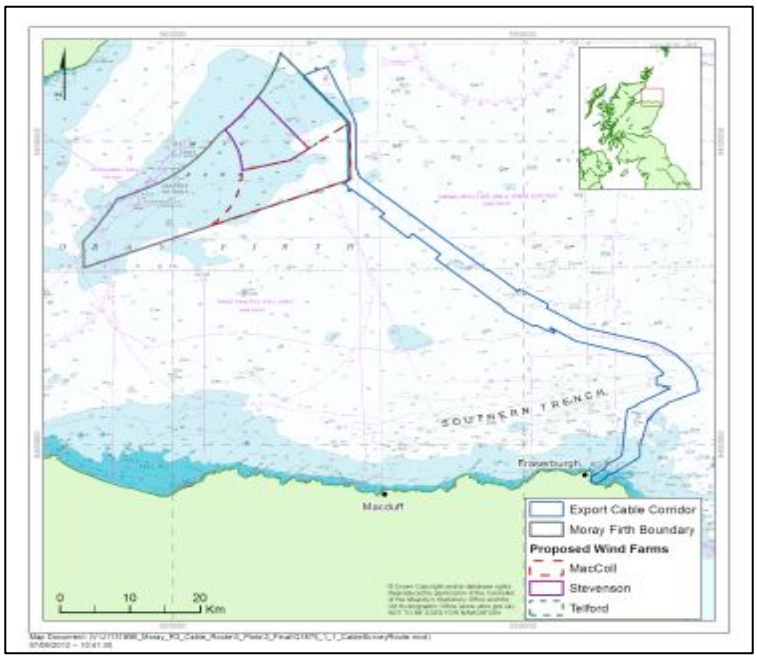

Figure 1.1: Location of the proposed cable route options.

1.2. Aims of the study

1.2.1. Study aims included;

- Characterisation of seabed substrates, features and associated subtidal epifaunal communities within the offshore transmission infrastructure study area.
- Collection of sediment samples for chemistry and particle size distribution (PSD) analyses to further aid assessment of potential wind farm impacts.

1.2.2. Benthic ecological characterisation of the three wind farm sites and the potential cable landfall sites have been reported separately (Technical Appendix 9.2A). This report relates solely to the offshore transmission infrastructure and close environs.

1.3. The background physical and biological environment

1.3.1. Irving (1996) could not provide any great detail for the sublittoral sediments of the Moray Firth stating only that sand and mixed sediments dominate offshore and that the near shore is often a reflection of the littoral environment to certain degrees.

1.3.2. The predictive MESH seabed habitat map for the Moray Firth area (Figure 1.2) provides a guide to broad seabed habitat types likely to be encountered and indicates that along the proposed offshore export cable route deep circalittoral sand dominates with some deep circalittoral and circalittoral / infralittoral coarse sediment particularly in inshore areas to the southeast. However biological community boundaries are unlikely to be so neatly delineated (Eleftheriou *et al.*, 2004).

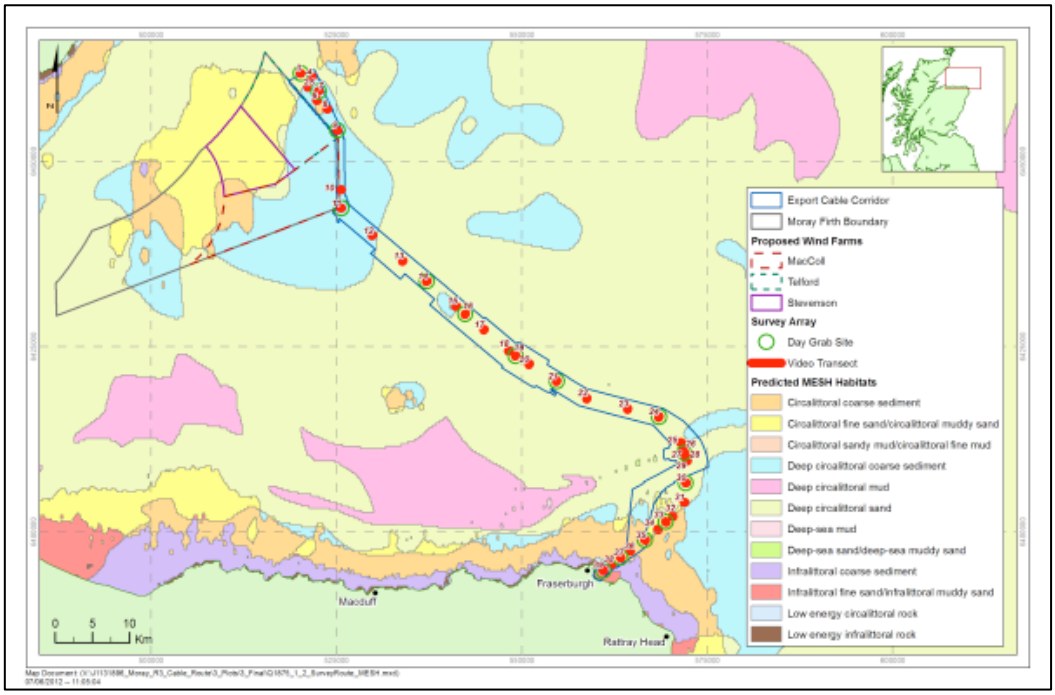

Figure 1.2. Distribution of MESH predicted seabed habitats overlaid with sample locations (Source: www.searchmesh.net).

1.3.3. The Marine (Scotland) Act 2010 makes provision for the publication of certain species and habitats that are considered important for nature conservation. These are referred to as Priority Marine Features (PMFs). There are fourteen invertebrate species referred to in the current draft PMF list (eight in the species list and six associated with a particular biotope in the habitat PMF list). Of those fourteen species only three are regarded to have some likelihood of being found in the area of the offshore infrastructure study area. These include the European spiny lobster *Palinurus elephas*, the Ocean quahog *Arctica islandica* (both PMF species) and the mud burrowing amphipod *Maera loveni* which is associated with a burrowed mud habitat. Figure 1.3 presents the distribution of these species.

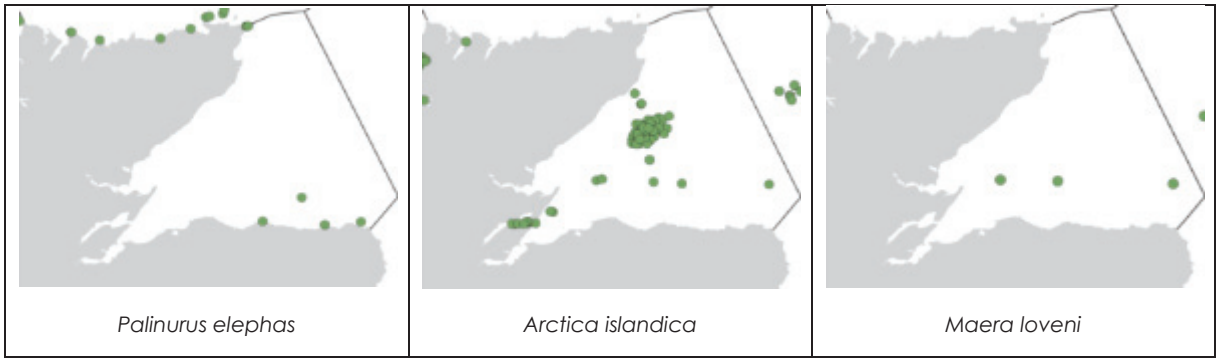

Figure 1.3: Distribution maps of PMF species taken from Scotland's Marine Atlas (2011).

1.3.4. The biotope **SS.CMuSa.SpMeg**, describing deeper water muddy sand with sea pens and burrowing megafauna, is listed as a component biotope of the "burrowed mud" PMF habitat feature. Burrowed mud extends across the southern half of the Moray Firth and as such is likely to intersect with the cable route. Greathead *et al* (2007) also reviewed the distribution of seapens around Scotland with both *Pennatula phosphorea* and *Virgularia mirabilis* found at various locations in the Moray Firth.

1.3.5. Hydrography clearly helps shape the glacially derived sedimentary environment in this area and although sediment plays an important role in defining biological communities (Eleftheriou *et al*, 2004), benthic biotopes can only really be adequately mapped through survey work. Therefore from the EUNIS map (Figure 1.2) the extent of the seapen and burrowing megafauna habitat, typically found in a range of sediments from muddy sands with varying mixtures of shell and gravel to fine, clay-dominated muds (Hughes 1998), might not be predicted (Figure 1.4).

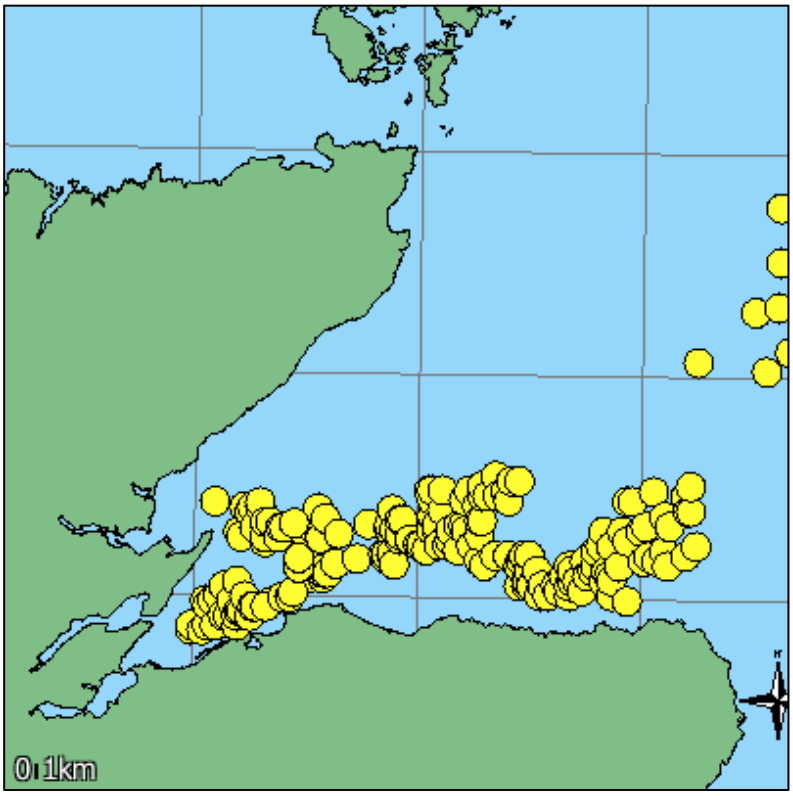

Figure 1.4: OSPAR 'Seapen and burrowing megafauna' habitat as mapped by the NBN Gateway in the Moray Firth Sea Area.

1.3.6. The Southern Trench (see Figure 1.1) is a conspicuous bathymetric feature within the survey area. It is located in the south-eastern part of the outer Moray Firth and 10km north of Fraserburgh. The trench reaches at least 250m in depth and is more than 120 km in length (Holmes *et al*, 2004). Previous surveys have recorded the cold water coral reef *Lophelia pertusa* at this location (Hall-Spencer and Stehfest 2009).

2. Methods

2.1. Survey Design

2.1.1. Following receipt of advice from Marine Scotland a seabed video survey of the proposed cable route was undertaken. Survey specifications, sample analyses and data analyses were agreed with Marine Scotland prior to mobilisation to ensure statutory requirements were addressed (EMU Ltd., 2011a). Table 2.1 summarises the sampling effort. The sampling array is presented in Figure 2.1.

Table 2.1: Summary of sample stations.

Sampling techniques	No. stations	Purpose	Representative photograph of kit
Seabed digital video and stills photography	39	Collection of seabed images to inform habitat and epifaunal community assessment.	
0.1 m^2 Day Grab sampling	15	Collection of seabed sediment samples for sediment chemistry analysis and associated PSD.	

2.1.2. A total of 39 video (drop down) sample locations were selected and visited to acquire sufficient information on seabed habitats and associated epifaunal communities along the proposed route of the cable. Sampling effort was stratified on the basis of the distribution of MESH predicted broad-scale habitats (see Figure 1.2 above) and Admiralty Chart data to ensure sufficient coverage of the range of broad seabed habitats and bathymetry expected.

2.1.3. At 15 of these video locations, a 0.1m^2 Day grab sampler was deployed in an attempt to obtain sediment samples for laboratory chemistry and particle size distribution analyses. However, only 9 samples were successfully collected as a result of the coarse and hard nature of the seabed at some locations.

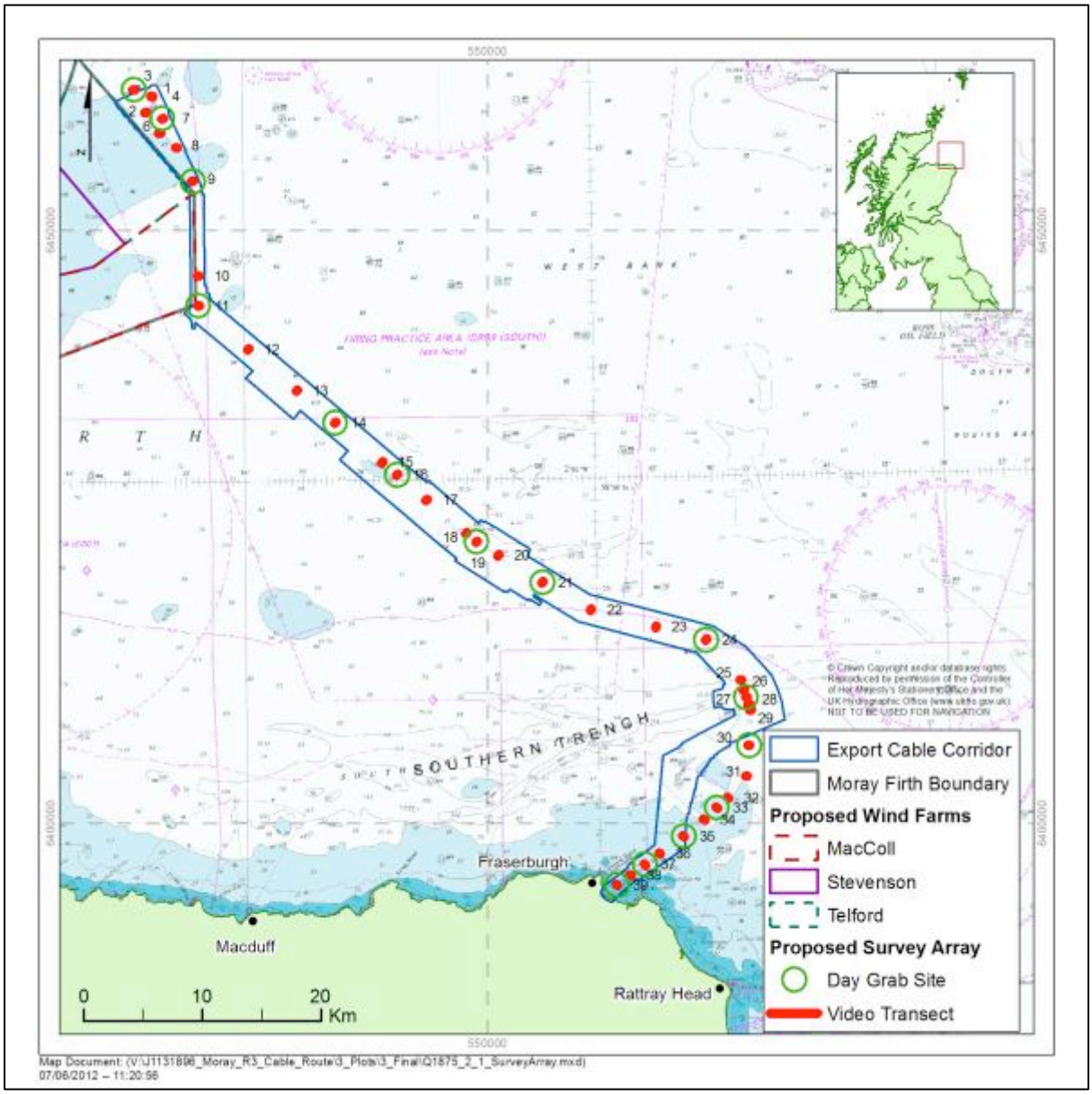

Figure 2.1: Benthic Sampling Array for the Moray Firth Cable Route

2.2. Survey

2.2.1. The survey was conducted over four days (8th - 11th of July, 2011). All survey work was undertaken on board EMU's survey vessel RV Discovery. Summary survey logs are provided in Appendix I.

2.2.2. Survey methods followed standard guidelines (Boyd, 2002 (now updated see Ware & Kenny, 2011) and Cefas, 2004). Sample positioning for each of the grabs and seabed video samples was achieved using EMU's Hemisphere Crescent V100 DGPS which has a stated horizontal accuracy of <0.6 m (95% confidence). Navigation and position recording was achieved using Trimble's HYDROPro software version 2.30.844. The position of the video on the seabed was recorded using a USBL and overlaid onto the digital image to provide real-time positing of the image data.

Subsea video

2.2.3. Digital video footage and still photographs of the seabed at each sample location was undertaken using a combined digital video and stills camera mounted within a drop-down frame. A minimum of five minutes seabed video footage was collected at each station together with a minimum of five photographic stills to allow more in-depth analysis of the substrate during post survey review and to support the observations made using the field deployment of the towed video. In areas of comparative sediment complexity or where a potential marine priority feature was observed, the deployment was extended or repeated to ensure sufficient information was collected to adequately describe the feature observed.

2.2.4. Observer records were collated throughout each video deployment including substrate type and conspicuous epifauna together with any observations of burrows and tubes, (i.e. *Nephrops* burrows).

2.2.5. Upon return from the field, the seabed digital video footage was fully reviewed on EMU's office video editing suite to identify and describe the characterising habitat types and associated epifauna for each transect. Representative seabed photographs for each of the 39 video sampling stations are presented in Appendix II.

2.2.6. Substrate types for each video station were recorded as % cover of the seabed and the species identified were semi-quantified using the industry standard SACFOR abundance scale (see Table 2.2 below). In addition, the digital still images were used to assist identification of species and improve habitat descriptions. All substrate and faunal data were subsequently used to classify the biotopes present at each station.

Table 2.2: SACFOR abundance scales (Source Hiscock, 1996).

Growth Form			Size of individuals/colonies				Density
%cover	Crust/Meadow	Massive/Turf	<1cm	1-3cm	3-15cm	>15cm	
>80%	S		S				>1/0.001m^2
40-79%	A	S	A	S			1-9/0.001m^2
20-39%	C	A	C	A	S		1-9/0.01 m^2
10-19%	F	C	F	C	A	S	1-9/0.1 m^2
5-9%	O	F	O	F	C	A	1-9/ m^2
1-5% or density	R	O	R	O	F	C	1-9/10 m^2
<1% density	R	R		R	O	F	1-9/100 m^2
					R	O	1-9/1000 m^2
						R	<1/1000 m^2

Key: S = Superabundant, A = Abundant, C = Common, F = Frequent, O = Occasional, R = Rare, P = present (used when the abundance of an organism could not be estimated accurately).

Sediment Grab Sampling

2.2.7. Sampling of seabed sediments was achieved using a 0.1 m^2 Day grab with stainless steel bucket at representative seabed locations (see Figure 2.1). Prior to deployment at each station the metal sample bucket of the grab was cleaned with pentane to prevent cross contamination between samples.

2.2.8. Upon retrieval of each sample on board the vessel a sub-sample of between 200 and 500 g was collected for PSD analysis. In addition, the top few centimetres of sediment was also sub-sampled and carefully placed in pre-treated labelled sample jars depending upon the chemical analysis required and stored frozen prior to laboratory testing for the following parameters:

- Metals - Arsenic (As) , Cadmium (Cd), Chromium (Cr), Copper (Cu), Mercury (Hg), Nickel (Ni), Lead (Pb), Tin (Sn), Barium (Ba), Aluminium (Al);
- PAHs – (16 US EPA Priority Pollutants);
- Total PAH;
- Total petroleum hydrocarbons; and
- Total organic carbon.

2.2.9. Sediment samples were successfully collected at 9 out of the 15 stations. Sampling was unsuccessful at some inshore locations as a result of the presence of coarse or hard ground which was not amenable to grab sampling. Unsuccessful grab attempts were relocated, assisted by video review, but sample success was still reduced in areas of coarse or hard seabed.

2.3. Laboratory methods

Particle Size Distribution (PSD) Analysis

2.3.1. PSD analysis was undertaken at EMU's sediment laboratory using in house methods based on BS1377: Parts 1 – 3: 1990 (dry sieving), and BS13320: 2009 (laser diffraction). The latter method was used to analyse the <63 µm sediment fraction.

2.3.2. Representative sub-samples of each sediment sample were oven dried to constant weight at 105 ±5°C before routinely wet sieving to remove silt and clay-sized particles of <63 µm. The remaining coarser material was again oven dried to constant weight at 105 ±5°C followed by dry sieving through a series of mesh apertures corresponding to 0.5 Phi units as described by the Wentworth scale. The <63 µm sediment fraction was routinely subjected to further analysis via laser diffraction at 0.5 Phi intervals to determine the proportion and distribution of the silt/clay components. The weight of the sediment fraction retained on each mesh was subsequently measured and recorded and merged with the laser diffraction data.

Sediment Chemistry analyses

Samples taken for sediment chemistry analyses were sub-contracted to an experienced UKAS accredited chemistry laboratory. Results were compared to standard Cefas and Canadian guideline values to aid assessment of the possible ecological significance of the levels of contaminants found.

2.3.3. Cefas guidelines are represented by a set of non-regulatory Action Levels which form part of a wider body of evidence for assessment of disposal of dredged materials to sea. In general, concentrations of contaminants below Cefas Action Level 1 are of little concern with respect to possible effects on the marine environment. Concentrations above Action Level 2 however suggest that the material is unsuitable for disposal at sea. Values between Levels 1 and 2 may prompt further investigatory work prior to disposal of the material to sea.

2.3.4. Canadian guidelines are presented in the form of Interim Sediment Quality Guidelines (ISQGs) and Probable Effect Levels (PEL). Generally, concentrations above ISQGs may cause some effects in some sensitive species. Concentrations above the PEL are likely to cause effects in a wider range of species.

2.4. Biotope Classification

2.4.1. Biotope code allocations were made using the current UK Marine Classification System V 4.05 (Connor *et al.*, 2004).

2.4.2. Subsequent to video review, the allocation of a biotope code was assisted by the use of the biotope decision making tool BioScribe (Hooper *et al*., 2011). The BioScribe tool was used to match the species list compiled from the video review to the biological communities usually recorded with potential biotope matches. Confidence indicators and direct links to habitat descriptions from the Marine Habitat Classification for Britain and Ireland are provided within BioScribe to facilitate the process. The tool was used in combination with the established Marine Biotope Classification investigative feature via the JNCC website, by an experienced ecologist with codes applied based on the BioScribe outputs and knowledge of the current biotope classification system. It should be noted here that as the survey did not comprise an in-faunal grab sampling element, all biotope allocations were made with video and stills photography review only.

3. Results

3.1. Biological Conditions

3.1.1. Full results of the image analysis including sediment habitat types, conspicuous epifauna and associated biotope classifications for each video location are presented in Appendix III. The Appendix comprises two parts; (1) an initial spreadsheet showing SACFOR species abundance data and sediment data and (2) biotope classifications drawing upon the initial spreadsheet information. Summary seabed habitat, species and biotope information is presented in Table 3.1 below.

Table 3.1: Summary of habitat, species and biotope information from video and static image data.

Sediment habitat type and biotope classification	Characteristic epibenthic species	Locations recorded	Representative seabed image
Muddy sand with some areas of mixed sediment. (Sites 1 to 11) **SS.SSa.CMuSa** **SS.SMx.CMx**	Hydroid/Bryozoan, Paguridae, *Munida rugosa*, *Cancer pagurus*, *Buccinum undatum*.	Recorded at 11 offshore sites on Smith Bank and adjacent to the three proposed wind farm sites.	
Muddy sand with sea pens and burrowing megafauna. (Sites 12 to 14 and 17 to 24) **SS.SMu.CFiMu.SpnMeg**	Hydroid/Bryozoan, *Virgularia mirabilis*, *Pennatula phosphorea*, *Lanice conchilega*, Paguridae, *Munida rugosa*, *Hippasteria phrygiana*, *Porania pulvillus*, *Asterias rubens*, *Echinus esculentus*.	Extensive throughout the mid section of the export cable route between the base of Smith Bank and the northern margins of the Southern Trench.	
Coarse mixed sediments including broken bedrock and boulders. (Sites 15, 16, 25-35) **SS.SMx.CMx** **SS.SMx.CMx.FluHyd** **SS.SMx.CMx.OphMx** **SS.SCS.CCS**	Sponges, hydroids, bryozoans crusts, *Alcyonium digitatum*, *Urticina* sp, *Pomatoceros* worms, various crustaceans including *Munida rugosa*, and echinoderms.	Present inshore of the Southern Trench and as discrete patches along the offshore section of the export cable route. Seabed impacts by demersasl fishing gears are associated with some of these locations (see section 3.4 below.	

Sediment habitat type and biotope classification	Characteristic epibenthic species	Locations recorded	Representative seabed image
Thick *Sabellaria spinulosa* encrustations on rock and boulders overlaid with mobile clean sand. (Sites 36,43,45, and 46) **CR.MCR.CSab.Sspi** **SS.SCS.CCS**	Hydroid/Bryozoan mixed substrate, *Alcyonium digitatum*, *Urticina* sp., *Sabellaria spinulosa*, *Munida rugosa*, *Cancer pagurus*, and echinoderms.	Discrete areas of thicker erect encrustations were present at some locations.	
Bedrock and boulder seabed. Occasionally overlaid with sand. (Sites 37, 38, 39) **CR.MCR.EcCr.FaAlCr** **CR.MCR.EcCr.FaAlCr.Bri** **IR.MIR.KR (IR.MIR.KR.Lhyp.Pk)** **SS.SCS.CCS** **CR.MCR.EcCr.FaAlCr.Flu**	Hydroid/Bryozoans, *Alcyonium digitatum,* *Urticina* sp., *Flustra foliacea,* *Asterias rubens,* *Ophiothrix fragilis,* *Ophiocomina nigra,* *Echinus esculentus,* Corallinaceae, *Laminaria* sp., Red and brown algae.	Extensive throughout shallow inshore waters at Fraserburgh.	
Clean rippled sand. **SS.SSa**	Paguridae, *Asterias rubens,* Ammodytidae.	Inferred from acoustic data.	

3.1.2. A total of 13 biotopes were classified along the proposed offshore export cable route although additional localised sediment biotopes may also be present as fine scale mosaics in areas of high sediment heterogeneity, such as the mixed substrate (**SS.SMx.CMx**) habitats, for example. The **SS.SSa** biotope was inferred from acoustic survey and ground-truthing during earlier EIA investigations at an alternative cable route option.

3.1.3. Figure 3.1 shows the distribution and extent of the classified biotopes (biotope map). It is based on side scan sonar data (collected separately from the current study) and which showed the presence of a number of distinct sediment acoustic regions.

Overlay of the classified biotope information onto the identified sediment acoustic regions side scan sonar data was undertaken as a form of ground truthing to define the extents and boundaries of the different habitats and biotopes present. Biotope classification and interpolation was further supported by benthic survey data gathered elsewhere along the initial cable route survey area.

3.1.4. The biotope map (Figure 3.1) shows that the offshore benthic environment was dominated by fine sand and muddy sand biotopes corresponding to the **SS.SMx.CMx** and **SS.SSa.CMuSa** classifications and describing circalittoral mixed sediments and circalittoral muddy sand sediment types respectively. Further definition of these biotopes was not possible in the absence in infaunal species data. Typical epifauna noted from the seabed video included hermit crab Paguridae, whelk *Buccinum undatum*, brown crab *Pagurus pagurus* and the squat lobster *Munida rugosa*. Sparse growths of bryozoans and hydroids were attached to the occasional stone or larger fragments of shell.

3.1.5. At the base of Smith Bank and along the majority of the offshore section of the export cable route the seabed was classified as **SS.SMu.CFiMu.SpnMeg** describing circalittoral fine mud sediments with sea pens and burrowing megafauna. Conspicuous epifauna associated with this biotope included the sea pens *Virgularia mirabilis* and *Pennatula phosphorea*. As explained in the Chapter 1 above this biotope is reported to occur widely throughout the southern half of the Moray Firth (see Figure 1.4).

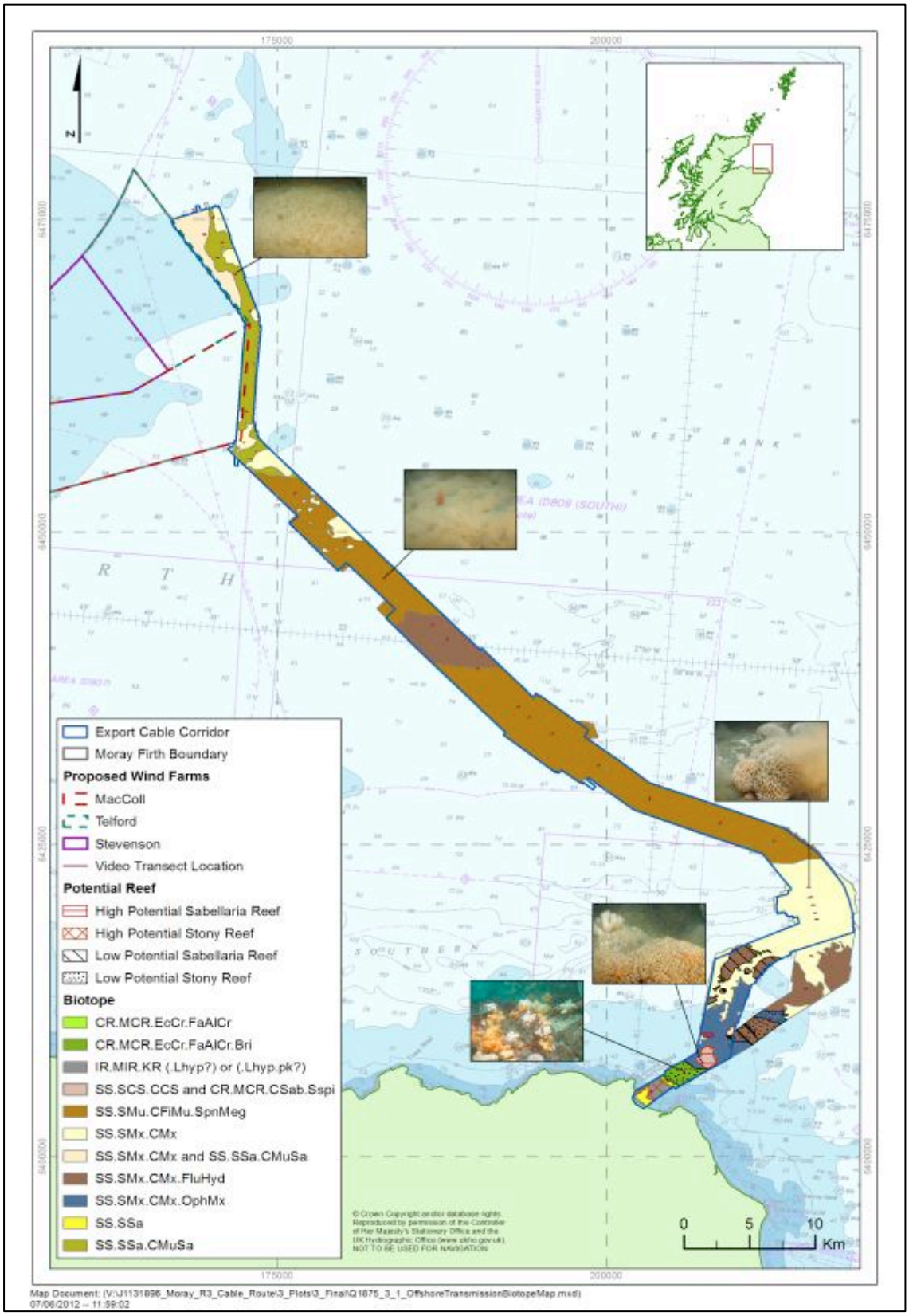

Figure 3.1: Distribution of classified biotopes with example seabed photos of selected habitats.

3.1.6. Further inshore the seabed was dominated by comparatively coarser and more mixed sediment types, including areas of cobbles, boulders and exposed bedrock (**SS.SCS.CCS, CR.MCR** and **IR.MIR**).

3.1.7. Overlying these coarser and rockier seabed habitat types were patches of clean, mobile fine sand in varying thicknesses creating a complex mosaic of mixed rocky/cobble and sand 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* and anemones *Metridium senile* and *Urticina felina* (**CR.MCR.EcCr.FaAlCr** and **CR.MCR.EcCrFaAlCr.Bri**). Dense populations of the epifaunal brittlestar *Ophiothrix fragilis* (**SS.SMx.CMx.OphMx**) colonised the upper surfaces of large cobbles and rocks (see Plate 1 as an example).

Plate 1: Dense brittlestars (*Ophiothrix fragilis*) and soft coral (*Alcyonium digitatum*) on cobbles.

3.1.8. Coarse gravel, cobble and boulders supporting low growing encrustations (thin crusts) of the Ross worm *Sabellaria spinulosa* were recorded in places. These were classified as **CR.MCR.CSab.Spi** describing circalittoral rock supporting *S. spinulosa* (see Plate 2 as an example of this habitat type). These areas are likely to be moderately to strongly influenced by the movement of mobile / transient sands in suspension with which the Ross worm uses to construct and maintain its tubes. Such encrustations can

promote benthic diversity and richness by consolidating seabed sediments thus permitting colonisation by a range of species which are comparatively less tolerant to seabed instability. Consequently, a comparatively high number of fauna were recorded from the video surveillance of these habitats including a range of hydroids, erect bryozoans, tunicates, crustaceans and echinoderms as well as growths soft coral *A. digitatum* and brittlestars *Ophiocomina nigra* and *Ophiothrix fragilis* (Appendix III).

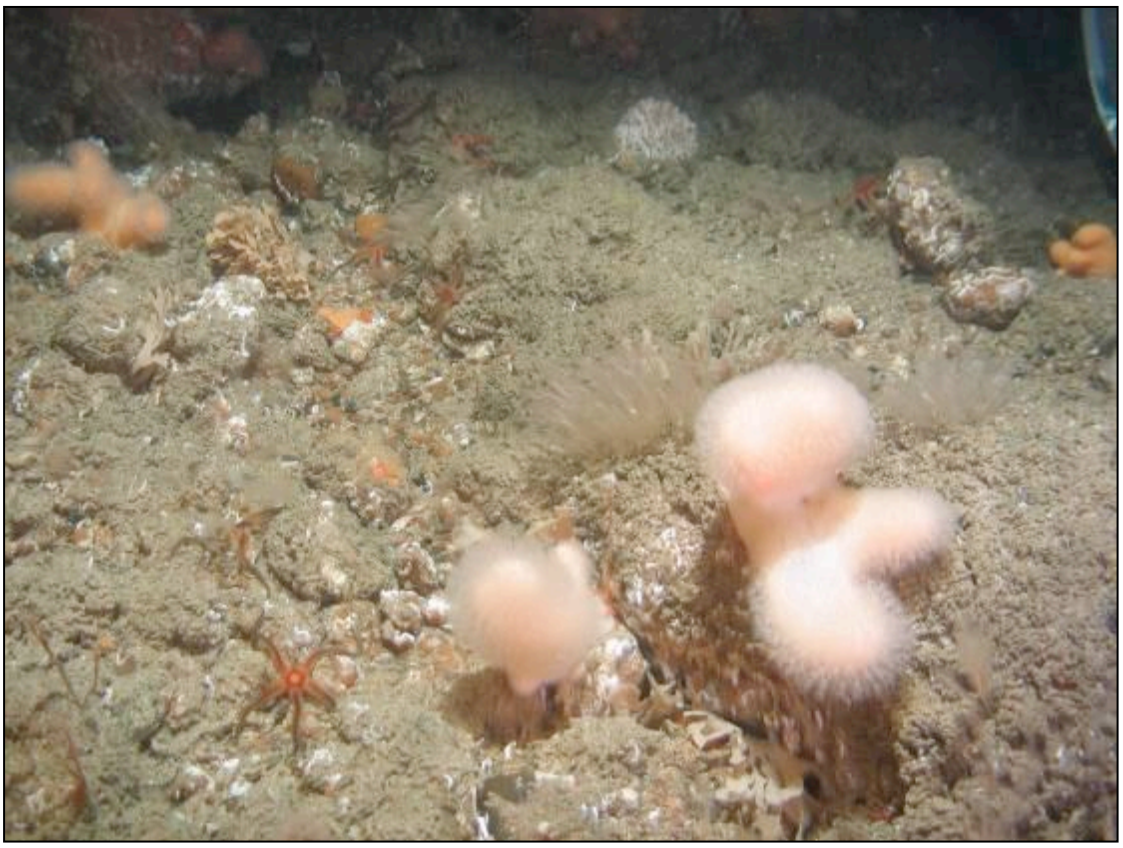

Plate 2: Low growing *Sabellaria spinulosa* encrustations on gravel and cobbles.

3.1.9. In places these encrustations were elevated above the seabed to form topographically distinct reef features resembling EC Habitat Directive Annex I *Sabellaria spinulosa* biogenic reef (see example in Plate 3). An assessment of these potential reef features is presented in section 3.2 below and includes a comparison of selected attributes of the habitat with established criteria for defining Annex I *Sabellaria spinulosa* reef.

3.1.10. Review of the video data showed that these erect reef features were extensive where present but patchy reflecting the patchy nature of the cobbles, boulders and bedrock outcroppings upon which they appeared to encrust.

Plate 3: Potential *Sabellaria spinulosa* biogenic reef (station 36).

3.1.11. Shallower water areas were characterised by cobbles supporting soft coral *Alcyonium digitatum*, urchins *Echinus esculentus* together with a range of bryozoans and hydroids, barnacles, and tube worm *Pomatoceros* sp. and corresponding to the **CR.MCR.EcCr.FaAlCr.Bri** and **CR.MCR.EcCr.FaAlCr** biotope classifications. These describe moderately exposed circalittoral rock with encrusting fauna with algae and brittlestars. Within the shallowest areas where light was comparatively less limiting, the exposed bedrock surfaces were dominated by red algae together with kelp *Laminaria* sp. corresponding to the **IR.MIR.KR** biotope classification describing moderately exposed infralittoral rock with kelp and red algae. As the species of *Laminaria* could not be defined from video data, the biotope was left at a lower designation of **IR.MIR.KR**, but is highly likely to be **IR.MIR.KR.Lhyp.Pk** (*Laminaria hyperborea* and foliose red seaweeds on moderately exposed lower infralittoral rock).

3.1.12. Both the areas of cobbles and exposed bedrock matched the criteria for Annex I geogenic stony and rocky reef (see section 3.2 below). An example of a shallow water rocky habitat resembling Annex I geogenic reef criteria is presented in Plate 4.

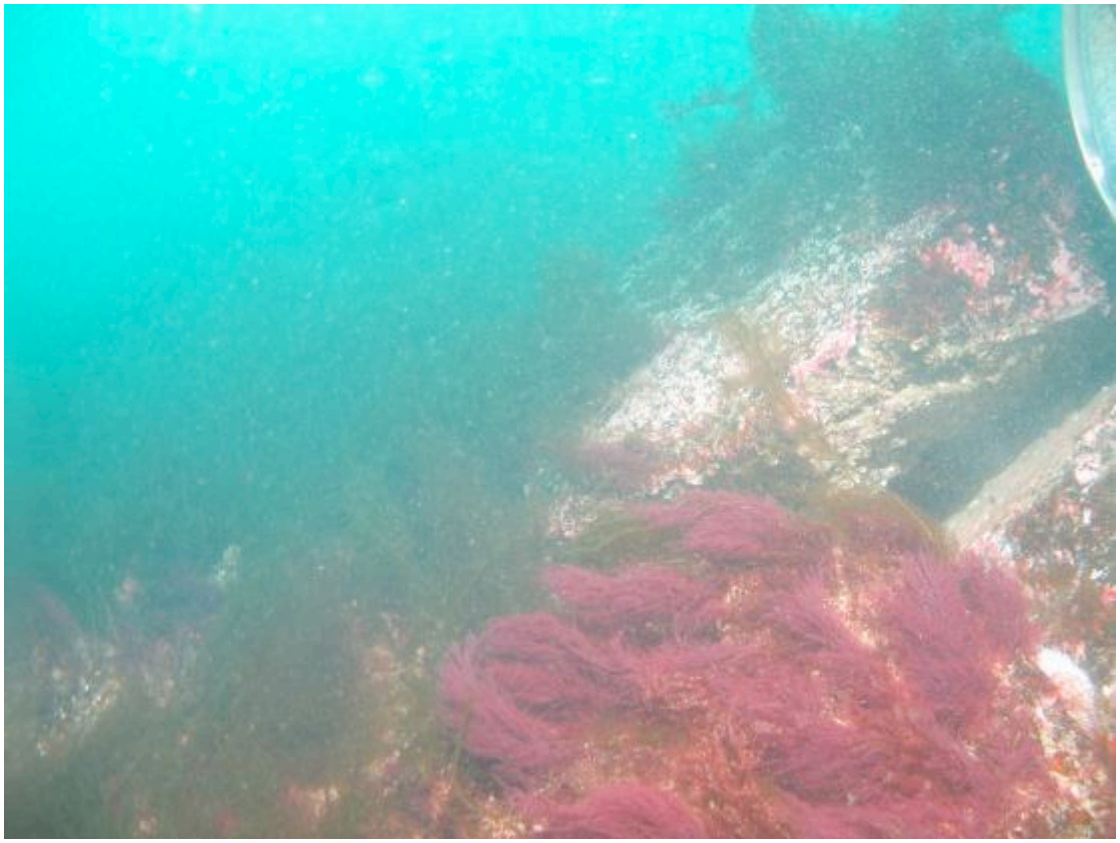

Plate 4: Example of a shallow water stony/ rocky outcropping resembling Annex I geogenic reef (station 39).

The Southern Trench

3.1.13. The Southern Trench is a distinct bathymetric feature which is traversed by the proposed export cable route corridor. A number of video transects were conducted within the area of the trench to identify any specific habitats and communities associated with these distinct depth conditions including the cold water coral species *Lophelia pertusa* previously identified in this area (Hall-Spencer & Stehfest, 2009).

3.1.14. The video data showed that the sea floor of the trench comprised a largely homogenous gravelly shelly sand overlaid with a layer of fine silt (**SS.SMx.CMx**) (Plate 5). Conspicuous species included hydroids and bryozoans, soft corals and hermit crabs together with various tube dwelling worms, crabs and starfish.

Plate 5: Mixed muddy sand substrate within the Southern Trench with Dahlia anemone (*Urticina felina*), common starfish (*Asterias rubens*), soft coral *Alcyonium digitatum* and spider crab (Inachinae).

3.1.15. None of the video transects undertaken in this area identified the deep water coral *Lophelia pertusa* previously recorded here (Hall-Spencer & Stehfest, 2009).

3.1.16. Just to the north of the Southern Trench (station 25), large tube formations were found. These have been created by the growth of Serpulid worms including *Salmacina dysteri* or *Filograna implexa* (see Plate 6). The size of the colonies were unusually large (based on current experience of the contractor of similar features in the UK) (elevated up to 20 – 30 cm above the seabed and up to 30 cm in diameter each) but were only present within a short area of the transect suggesting a highly patchy and sparse distribution. Note that *Salmacina dysteri* and *Filograna implexa* are two separate species of tube building worm but current video data were not sufficient to confirm species identity in this instance. The worm is expected to be *Salmacina dysteri* but would require sampling and closer taxonomical analysis to confirm identity.

Plate 6: Video still of Serpulid colony of either *Salmacina dysteri* or *Filogana implexa*.

3.2. Assessment of Annex I Features

3.2.1. Current data support the presence of potential EC Habitat Directive (92/43/EEC) Annex I biogenic and geogenic reef features at several discrete locations along the route of the proposed export cable. This section compares the physical and biological attributes of some of the observed seabed habitat features with the various criteria currently in use for classifying reef and assessing resemblance to EC Habitats Directive Annex I habitat feature. Consultation with Marine Scotland, Scottish Natural Heritage and Joint Nature Conservation Committee on 18th April 2012 confirmed that any adverse effects on Annex I features will typically not be permitted.

3.2.2. Annex I features are highly protected within Europe under Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Fauna and Flora (transposed into domestic legislation through the Conservation (Natural Habitats &c.) Regulations 1994) and the Offshore Marine Conservation 2007 (Natural Habitats &c.) Regulations (the "Offshore Marine Regulations" as amended 2010) which extends the provisions of the Habitats Directive to offshore areas.

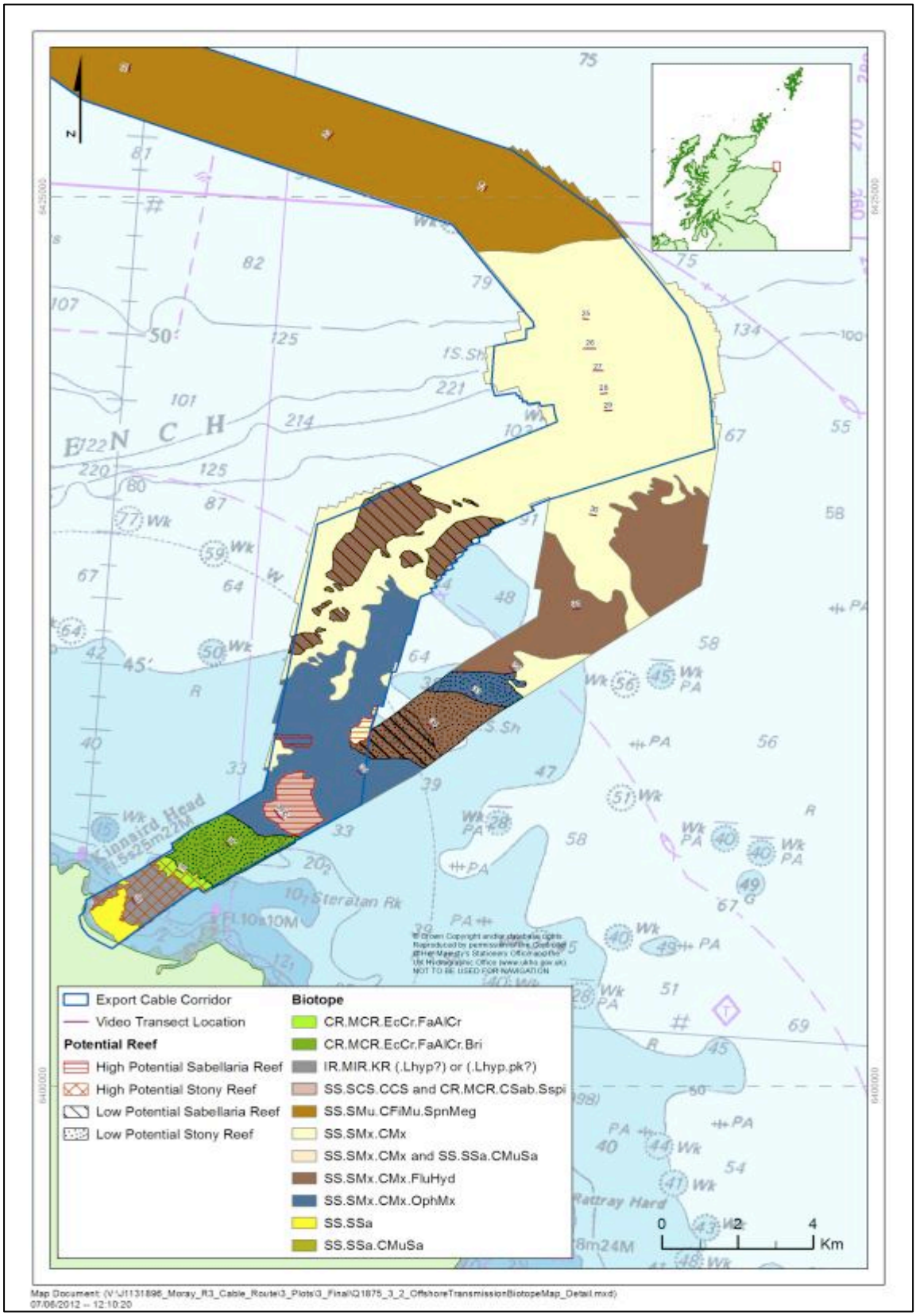

Figure 3.2: Close up of the export cable route showing the southern section and highlighting areas classified as low or high potential stony and *Sabellaria spinulosa* reef.

3.2.3. The extent and distribution of these features are overlaid onto the current biotope map (Figure 3.2 – close up of inshore section) together with an indication as to whether they are of high or low potential in terms of their resemblance to Annex I biogenic (*Sabellaria spinulosa*) or geogenic (stony) reef using the following criteria:

- High potential *Sabellaria spinulosa* reef = the presence of *Sabellaria spinulosa* encrustations have been confirmed by the seabed video and resemble Annex I feature following assessment;
- Low potential *Sabellaria spinulosa* reef = *Sabellaria spinulosa* encrustations have not confirmed by the seabed video (i.e. not surveyed) but acoustic data suggest the presence of suitable seabed types including adjacent mobile sand material;
- High potential stony reef = cobble field and exposed bedrock areas have been confirmed by seabed video and resemble Annex I feature following assessment; and
- Low potential stony reef = cobble field and/or exposed bedrock not confirmed by the seabed video (i.e. not surveyed) but acoustic data suggest the presence of suitable seabed types.

3.2.4. Definitions of biogenic and geogenic reef have been subject to modification since adoption of the Habitats Directive with the most recent international interpretation provided by the European Union in 2007 (CEC, 2007) as follows:

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

- *"Hard compact substrata"* are: rocks (including soft rock, e.g. chalk), boulders and cobbles(generally >64 mm in diameter);
- *"Biogenic concretions"* are defined as: concretions, encrustations, corallogenic concretions and bivalve mussel beds originating from dead or living animals, i.e. biogenic hard bottoms which supply habitats for epibiotic species;
- *"Geogenic origin"* means: reefs formed by non biogenic substrata;
- *"Arise from the sea floor"* means: the reef is topographically distinct from the surrounding seafloor; and
- *"Sublittoral and littoral zone"* means: the reefs may extend from the sublittoral uninterrupted into the intertidal (littoral) zone or may only occur in the sublittoral zone, including deep water areas such as the bathyal.

Such hard substrata that are covered by a thin and mobile veneer of sediment are classed as reefs if the associated biota are dependent on the hard substratum rather than the overlying sediment.

Where an uninterrupted zonation of sublittoral and littoral communities exist, the integrity of the ecological unit should be respected in the selection of sites.

A variety of subtidal topographic features are included in this habitat complex such as Hydrothermal vent habitats, sea mounts, vertical rock walls, horizontal ledges, overhangs, pinnacles, gullies, ridges, sloping or flat bed rock, broken rock and boulder and cobble fields.

Serpulid worms are noted as reef forming animals in the Mediterranean but not in the North Atlantic and North Sea.

3.2.5. In the UK, additional clarifications of the definitions of *Sabellaria spinulosa* reef and 'stony reef' under the Habitats Directive have been attempted during inter-agency workshops and subsequent discussions (Gubbay, 200&, Irving, 2009). In addition, several key parameters to determine "reefiness" have been described within a number of research papers and reports (Johnstone, 2002; Hendrick & Foster-Smith, 2006; Limpenny *et al*., 2010; Houghton *et al*., 2011. Table 3.2 summarises the criteria used in this study to define resemblance to Annex I stony reef and draws upon the outcomes of an inter-agency workshop and subsequently summarised by Irving (2009). Table 3.3 summarises the criteria used to define *Sabellaria spinulosa* "reefiness" and represents a synthesis of the various criteria put forward by various researchers (Gubbay, 2007; Hendrick & Foster-Smith, 2006 & Limpenny *et al*., 2010.

Table 3.2: The main characterising features used to define resemblance of a stony reef to the Annex I feature (source : Irving, 2009).

Characteristic	Not a 'stony reef'	'Resemblance' to being a 'stony reef'		
		Low	Medium	High
Composition:	**<10%**	**10-40% Matrix supported**	**40-95%**	**>95% Clast supported**
Notes: Diameter of cobbles / boulders being greater than 64mm. *Percentage cover relates to a minimum area of 25m².* *This 'composition' characteristic also includes 'patchiness'.*				
Elevation	**Flat seabed**	**<64mm**	**64mm-5m**	**>5m**
Notes: Minimum height (64mm) relates to minimum size of constituent cobbles. *This characteristic could also include 'distinctness' from the surrounding seabed.* *Note that two units (mm and m) are used here.*				
Extent:	**<25m²**	**>25m²**		
Biota:	Dominated by infaunal species			>80% of species present composed of epifaunal species

Table 3.3 Criteria used as a measure of *Sabellaria spinulosa* "reefiness"

Measure of 'reefiness'	NOT a REEF	LOW	MEDIUM	HIGH
Elevation (cm) (average tube height)	<2	2-5	5-10	>10
Patchiness (% cover)	<10	10-20	20-30	>30

3.2.6. In addition to the criteria presented in Table 3.3 the video data was reviewed to determine the types of growth form of *Sabellaria* as follows:

- Absent;
- Moribund loose tubes;
- Crusts;
- Clumps (nodules of reef <10cm in diameter); and
- Potential Reef.

3.2.7. Using these criteria the current survey data have been compared for assessment of the presence and status of Annex I reef features. Appendix IV provides an assessment of selected habitat types for the presence and status of potential Annex I stony reef. Appendix V presents an assessment of selected habitat types for the presence and status of *Sabellaria spinulosa* biogenic reef.

3.2.8. Following these assessments (Appendices IV and V), it has been determined that the habitats at locations 33, 35, 37, 38 and 39 have high resemblance to Annex I stony / rocky "geogenic" reef.

3.2.9. Encrustations of *Sabellaria spinulosa* at location 36 was scored as having high "reefiness" and has therefore been determined to match Annex I *Sabellaria spinulosa* biogenic reef feature.

3.2.10. At present there are no known criteria against which Serpulid reef features can be assessed and statutory advice will be required to confirm its status and sensitivity in this respect.

3.2.11. The side scan sonar data showed that areas supporting both stony / rocky reef and *S. spinulosa* reef were distinct and readily identifiable as areas of coarse, heterogeneous ground with hard reflexivity. This provided a degree of confidence in the interpolation and mapping of other areas of potential reefs where ground truthing data were not collected (see Figure 3.2).

3.2.12. Areas of *Sabellaria* reef were also noted to occur next to areas of mobile sand. This mobile sediment is likely to be important in the development of biogenic reef structures as it is the source of the construction material (in suspension) that *Sabellaria* worms use to build and maintain their tubes that form the reef (see example habitats in Plate 7). The apparent relationship between coarse heterogeneous areas of hard reflexivity and mobile sediment provided further evidence of potential *Sabellaria* reef in areas not covered by the video camera.

3.2.13. Limpenny *et al*. (2011) highlight a good supply of sand which is put into suspension by strong water movement for tube building as the most important environmental requirement of *S. spinulosa*. Thus S. spinulosa reef communities are "*typically associated with weak or moderately strong tidal flows and favour locations such as the edges of sand banks or areas where there are sand waves in the proximity*" Limpenny *et al*. (2011) go on to cite anecdotal evidence which suggests that aggregations of *S. spinulosa* appear more prevalent on the flanks of sandbanks in the

southern North Sea. Clearly, these observations support those made here and provide a degree of validation for the mapping of "low potential" *Sabellaria spinulosa* reef within the current export cable corridor. Ground truthing would be required to confirm the presence of reef in these areas.

Plate 7: *Sabellaria spinulosa* encrustations on rocks with adjacent areas of mobile sand (station 36).

3.3. Grab sampling for seabed sediment types

3.3.1. Full results of the particle size distribution analyses of the grab samples are presented in Appendix VI and are summarised in Figure 3.3. A total of four Folk sediment classifications (Folk, 1954) were identified following laboratory analysis as summarised in Table 3.4 below.

3.3.2. The grab sample data support the distribution of comparatively fine grained sediments offshore with coarser sediments occurring closer inshore as indicated by the seabed video surveillance. The dominant sediment fractions were fine and medium grade sands (particles of diameter between 125 µm and 500 µm).

3.3.3. Levels of fine silt/mud particles (<63 µm diameter) were generally low (<5 %) with increased levels (7 to 22.5 %) along the middle section of the proposed cable route at stations 14, 19 and 21 (Figure 3.3). Video data showed that this more silty sediment (classified as slightly gravelly muddy sand) supported burrowing fauna as evidenced by the density of burrows and mounds. Two species of seapens, *Pennatula*

phosphorea and *Virgularia mirabilis,* also typified the slightly gravelly muddy sand sediments in this area. These observations accord with historic findings of burrowed muddy seabed habitats with sea pens as described in Chapter 1 above. The biotope classification **SS.SMu.CFiMu.SpnMeg** has been attributed to this sediment habitat (which describes sea pens and burrowing megafauna in circalittoral fine mud) and would appear to be supported by the increased mud fraction found. It is a component biotope of the "burrowed mud" Scottish PMF and therefore represents a habitat of potential conservation importance in Scotland.

3.3.4. Results of the analyses of sediment contaminants are presented in Appendix VII. In general, levels of sediment contaminants were below respective guideline values. Arsenic concentrations at station 30 was however, above lower limits but fell within upper Cefas and Canadian values. No obvious sources of arsenic are evident at this location. Total organic carbon (TOC) results for the sediment samples collected were below 0.5%.

Table 3.4 Summary of the grab sample sediment analyses

Folk classification	Number of stations (n=9) Sediment composition	Representative seabed photograph
Slightly gravelly sand (g)S	6 stations Mean % gravel = 0.9 Mean % sand = 95.2 Mean % mud/silt = 3.8	
Gravelly sand gS	2 stations Mean % gravel = 10.9 Mean % sand = 86.6 Mean % mud/silt = 2.5	
Slightly gravelly muddy sand (g)mS	1 station Mean % gravel = 0.0 Mean % sand = 77.5 Mean % mud/silt = 22.5	

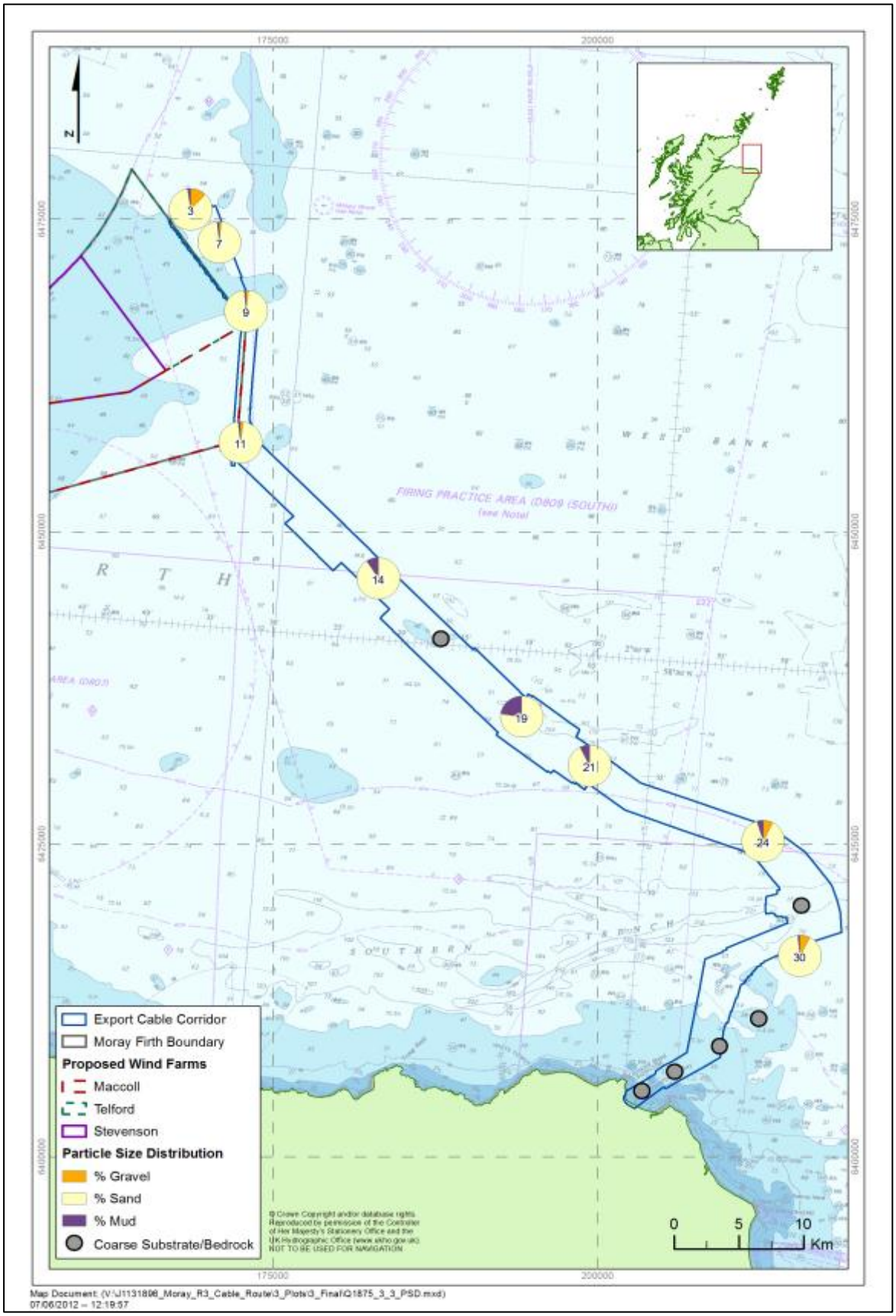

Figure 3.3: Distribution of PSD data using Folk sediment classifications.

3.4 Existing Impacts

3.4.1 Additional side scan sonar data, collected to inform separate geotechnical core sampling and subsequently provided to EMU, showed evidence of physical impacts on the seabed at some locations along the proposed export cable route. The nature of the impacts is not confirmed but it is likely that these are a result of the action of scallop dredges given the characteristic "combing" pattern on the seabed.

3.4.2 Plate 9 presents side scan sonar data for a geotechnical core site where this physical seabed impact type was recorded together with a seabed photograph taken within the general vicinity. Note that the side scan sonar data was collected after the completion of the video survey and so are not accurately ground truthed spatially or temporally. Current survey data (Appendix III) do not support any adverse effects on benthic ecology.

Plate 8 Side scan sonar data showing suspected scallop trawl marks on the seabed together with a seabed photograph taken at station 31 (approximately 500 m away).

3.4.3 As well as the presence of physical impacts, discarded or lost fishing gear was recorded on the seabed over rocky and stony ground at several inshore locations including stations 35, 36 and 39 (Appendix III). Plate 10 shows discarded cables and warps on the seabed at station 36. It is not known whether this activity has or will have significant impacts on benthic ecology. Data collected during the current survey do not support any significant adverse effects in this respect. However, it is noted that station 36 was associated with *Sabellaria spinulosa* reef and may therefore be particularly sensitive to any abrasive effects of discarded fishing gears.

Plate 9 showing discarded cable on the seabed at station 36.

4. Discussion

4.1. Benthic habitats

4.1.1. The underwater video survey has enabled a robust characterisation of the seabed in terms of the distribution of habitats and associated epifaunal communities. Homogenous muddy sand habitats with sea pens and burrowing megafauna dominate the deeper water areas offshore whilst coarser, more heterogeneous substrates and overlying mobile sandy sediments of varying thicknesses occur closer to the coast. Within shallower water, inshore areas, cobbles, boulders and areas of rock outcroppings provide attachment for various sediment tolerant bryozoans, hydroids, soft corals, algae and encrusting worms including the Ross worm *Sabellaria spinulosa*. The survey also confirmed the sandy and slightly gravelly (shelly) sand conditions present at Smith Bank as previously described during grab sampling within and around the proposed turbine arrays (see Appendix 9.2A) (EMU Limited, 2011b).

4.1.2. The key output of this study is the biotope map (Figures 3.1 and 3.2). This represents a valuable summary of the variety, extent and distribution of the benthic habitats and characterising epifaunal communities present within the offshore transmission infrastructure study area.

4.1.3. Biotopes encompass both habitat and species components and are convenient biological units for which high quality and peer reviewed sensitivity data exist via the Marine Life Information Network (www.MarLIN.ac.uk). This means that biotopes are particularly useful for environmental assessment purposes. As such they will be the principal tools for assessing the potential effects of the wind farm proposals on benthic ecology in the subsequent EIA.

4.1.4. Thirteen biotopes were classified and mapped within the study area. A number of these related to habitats of potential nature conservation importance as summarised in Table 4.1 below.

4.1.5. Important habitats identified included "burrowed mud". This is currently on the Scottish draft list of Priority Marine Features (PMF) for which Marine Protected Areas (MPAs) will be recommended. This type of habitat (represented here by the **SpnMeg** biotope) covered extensive areas of the proposed export cable corridor and so impacts upon this draft PMF feature as a result of cable installation activities are expected. Full assessment of this impact is provided within the Environmental Statement and considers the wider distribution of this feature across the southern half of the Moray Firth as indicated by current NBN data (see Figure 1.4 above).

4.1.6. Thick encrustations of *S. spinulosa*, represented by the biotope **CSab.Sspi** matched the criteria used for defining Annex I (EC Habitats Directive) biogenic reef at one location. Subsequent mapping using side scan sonar and interpolation of the sediment acoustic regions indicated that these features may be relatively extensive (although patchy) along the cable route although further ground truthing would be required to confirm distribution and status of reefs in areas of thin crusts and which are currently classified as "low potential". These additional surveys will inform micro-siting

of cables to avoid direct impacts of cable installation on these internationally protected features. Note that despite having been allocated the same biotope classification, the thin encrustations of *Sabellaria* identified elsewhere within the study area have been determined as not reef (see Appendix V).

Table 4.1: Relationship between selected biotopes and habitats of nature conservation importance.

Biotope	Name	Related habitat	Importance
SS.SMu.CFiMu.SpnMeg	Circalittoral muddy sand with seapens and burrowing megafauna	Burrowed mud.	Scottish Priority Marine Feature (PMF).
*** CR.MCR.CSab.Sspi**	*Sabellaria spinulosa* on encrustations on rocks and boulders	*Sabellaria spinulosa* reef.	EC Habitats Directive Annex I (biogenic reef) habitat.
SS.SMx.CMx **SS.SMx.CMx.FluHyd** **CR.MCR.EcCr.FaAlCr** **CR.MCR.EcCr.FaAlCr.Bri** **IR.MIR.KR** **(IR.MIR.KR.Lhyp.Pk)** **SS.SCS.CCS**	Circalittoral and infralittoral coarse sediment, cobbles, boulders and rock with sessile epifaunal and algal communities	Stony and rocky reef	EC Habitats Directive Annex I (geogenic reef) habitat.

*This biotope classification has also been used to describe thin *Sabellaria spinulosa* crusts which have been determined as not reef (see Appendix V).

4.1.7. Holt *et al*. (1998) describe well developed *Sabellaria spinulosa* reefs as relatively unusual. None are identified in Scottish SACs. OSPAR (2010) also discuss well-developed, more stable reefs as appearing to be very scarce and that this apparent rarity suggests that an unusual set of environmental factors and/or circumstances is required for their formation.

4.1.8. Thin crusts, on the other hand, occur more commonly although few examples are known from Scotland (Holt *et al*., 1998). The examples found are probably locally unusual and may be of some ecological interest in Scotland but are unlikely to hold any conservation value. The ecological interest of these encrustations relate to their ability to consolidate sediments and increase substrate stability. This allows colonisation by a range of species including those which may be less tolerant to mobile sediments and disturbed conditions. Consequently, faunal richness and diversity are typically high compared to adjacent areas where encrusting *Sabellaria* is absent.

4.1.9. The third habitat of conservation interest relates to the areas of cobbles, boulders and rocky outcroppings which occurred extensively throughout shallow inshore areas. Matching of the attributes of these habitats with Annex I habitat criteria showed that they had high resemblance to Annex I (EC Habitats Directive) stony and rocky

geogenic reef. These seabed types are unlikely to be suitable for trenching and so it would be expected that cable installation in these areas will involve rock placement or concrete mattresses. These types of material represent suitable hard, stable habitat for colonisation of encrusting and attaching fauna and flora although colonising communities may be comparatively less diverse as a result if the reduced complexity of these artificial substrates. Rock cutting (if used) would result in the loss of rocky biotopes and the habitat upon which they attach although recovery of communities would occur quickly from nearby, unaffected reproductive populations.

4.1.10. It is presently unclear as to the nature conservation status of the small colony of *Salmacina /Filograna* identified at station 25. Consultation with Marine Scotland, SNH and JNCC did not identify any specific concern.

4.2. Effects of cable installation and operation on benthic ecology

4.2.1. Effects of the installation of submarine cables on benthic ecology typically relate to the nature of the method of installation but are usually localised and of short duration (BERR, 2008). Sedimentary seabed habitats may be ploughed or jetted to create a trench of suitable depth to permit burial of the cable. These are energetic processes and will typically release quantities of suspended sediments into the overlying water column for subsequent dispersal and dilution over adjacent seabed areas. Once the cable has been laid and depending upon the cohesiveness of the sediment, the trench will be naturally in-filled over time as a result of the slumping of the trench walls and in-filling with transient sediments present within the ambient bedload transport. Storms and high energy wind and wave events will accelerate the natural erosion of the trenches and associated berms either side of the trench thereby further assisting restoration of the original habitat topography.

4.2.2. Direct effects within the footprint of the cable trench within sediment habitats are therefore usually temporary with habitats reverting to their original condition after cessation of the disturbance. Species re-colonisation will occur following restoration of the habitat and sediment stability to baseline levels and as a result of the import of larvae and migration of adults from adjacent non-affected areas. The rate of species and community recovery may be rapid (within months to a few years) and depends upon the nature of the original communities, availability of reproductive populations nearby and the severity of the initial impact amongst other factors.

4.2.3. Suspended sediments arising from trenching activities will be transported within the tidal water movements and deposited over adjacent areas. The area indirectly affected in this way will depend upon the nature of the disturbed sediment. Larger gravel and sand particles will settle back to the seabed relatively quickly and in close proximity to the original disturbance. Subsequent tidal movements and high energy wave events will further disperse this material until natural background conditions are reached. Finer silt and clay particles are transported and dispersed out of the immediate area. The consequences of the deposition of sediment on sediment habitats are therefore usually localised and sediment dwelling animals will be tolerant to temporary light deposition of sediment. The MarLIN benchmark is 5 cm burial below which animals are capable of re-locating to preferred feeding depths

following burial and significant adverse effects are not therefore expected (www.Marlin.ac.uk). Sessile epifaunal communities however may be more susceptible and may be smothered or scoured by the deposition of sediments or suffer damage or clogging of sensitive feeding and respiratory apparatus in conditions of high suspended sediments concentrations. The magnitude of these effects will be dependent upon the quantities of sediment in suspension and the depth and duration of sediment burial.

4.2.4. In stony or rocky areas, trenching may not be feasible and instead, the cable will be laid directly on the seafloor and secured and protected through careful placement of rock or concrete mattresses. Whilst the original epifaunal habitats will be lost under this material it will be replaced by a comparable hard substrate suitable for colonisation by the epifaunal species originally present. Again, the rate at which these artificial substrates will be colonised will depend upon the nature of the original communities and the availability of nearby reproductive populations but is typically measured in months to a few years. Artificial hard substrates can offer a slightly less complex habitat than those that occur naturally which might result in a comparatively reduced diversity of species.

4.2.5. Operational effects may include electromagnetic field (EMF) emissions and sediment heating.

4.2.6. Effects of EMF on benthic invertebrates have not been documented although there has been no specific monitoring in this regard. Magnetic sensitivity has been detected in some decapod crustaceans which may affect orientation ability of affected individuals (BERR, 2008). Potential influences of EMF on electro-sensitive fish such as sharks and rays and migratory fish species are usually considered within ESs but are outwith this study.

4.2.7. Effects of heat on benthic communities are largely unknown and little empirical field evidence exists (OSPAR, 2008). One example is cited in BERR (2008) and which describes a high voltage DC buried cable system installed between New England and Long Island New York. It was estimated that the cable would result in a rise in temperature at the seabed immediately above it of 0.19^0C and a corresponding increase in seawater temperature of 0.000006^0C. Such effects are considered impossible to detect above the natural variation (BERR, 2008).

4.2.8. Laboratory mesocosm experiments suggest avoidance of areas of high sediment temperature by the polychaete *Marenzelleria viridis* but no correlation with sediment temperature was found for the mud shrimp *Corophium volutator*.

4.2.9. The cable will be buried at depth below the surface of the seabed. As such, benthic fauna dwelling at the sediment / water interface or at shallow burial depths (typically up to around 30 cm below the sediment surface) will be buffered from any heat effects of the cable to a large degree. Deeper burrowing fauna, such as *Nephrops norvegicus* which can burrow up to 0.5 m below the seabed surface, may be comparatively more exposed. A full assessment of the effects of the installation of the export cable and associated infrastructure will be provided within the

Environmental Statement. Given the range of stony and sediment seabed habitats found, cable installation methods are likely to include a mix of trenching (ploughing or jetting) and rock placement and the range of effects discussed above may occur.

4.3. Effects on identified sensitive features

4.3.1. This section briefly considers the potential effects of the installation of the export cable on identified features of nature conservation importance. Note that consultation with the statutory conservation agencies is recommended to confirm the status and importance of these features.

4.3.2. Whilst of conservation importance the "burrowed mud" PMF habitat is very well represented across the southern half of the Moray Firth. The installation of the export cable is therefore predicted to affect only a very small proportion of the total habitat available within the general region. In terms of impact significance, MarLIN assess that partial recovery of the representative **SpnMeg** biotope will occur within 5 years following substrate removal but that full recovery may take up to 10 years. This reflects the slow growth and recovery of sea pens and associated species. However, the biotope has a low intolerance to sediment smothering and recovers immediately (within a few days) following cessation of this type of disturbance (Hill, 2008). Indirect sediment effects over adjacent areas either side of the cable are therefore considered to be negligible.

4.3.3. Trenching through *Sabellaria spinulosa* reefs would result in the loss of the feature within the footprint of the direct impact. Although recovery of the reef is expected, the trenching may not be a permitted activity in areas which are deemed to be of the highest nature conservation value. Mitigation (if needed) might include identification of lower value features and appropriate micro-siting of the cable to avoid direct impacts on core *S. spinulosa* reefs subject to consultation with the statutory agencies. The concept of ''core" reef has successfully been employed at other developments[1] and will be discussed with the nature conservation agencies during micro-siting of cables. Although sensitive to direct impacts, these reefs have high tolerance to sediment effects and *S. spinulosa* is capable of surviving <32 days burial in fine sand with no effect of burial depth (Last *et al*., 2011). Indirect sediment effects are therefore considered to be negligible in this regard.

4.3.4. Ploughing and jetting in rocky substrata supporting stony or rocky geogenic reef will not be appropriate although rock ripping ploughs and mechanical wheel rock cutters are available for subsea cable installations purposes. However, it is likely that in these areas, the export cable will be installed under rock protection material and / mattresses. This material might represent a less complex and artificial proxy habitat and is expected to be colonised by a lower diversity variant of the surrounding faunal and floral communities. The spatial scale of this effect will however be small, limited to the footprint of the material. Peripheral, indirect effects are not expected.

4.3.5. The current survey did not identify any other habitats or species which are sensitive to development and/or which are important in terms of their nature conservation value.

[1] Eastern IFCA, Marine Management Organisation, Natural England. Guide to Ross worm reefs (Sabellaria spinulosa) in the Wash and North Norfolk Special Area of Conservation and Race Bank, Inner Dowsing and North Ridge candidate Special Area of Conservatio

The three PMF species previously found within the general region including the European spiny lobster *Palinurus elephas*, the Ocean quahog *Arctica islandica* and the mud burrowing amphipod *Maera loveni* (the latter is associated with the burrowed mud PMF habitat) were not recorded in the current survey. These species are cryptic or infaunal and so video survey may not be an appropriate technique to record these animals. *Lophelia pertusa* reefs were not encountered within the study area on this occasion despite a number of video deployments in the area of the Southern Trench.

4.4. Sediment sampling

4.4.1. Grab sampling confirmed the results of the video survey and highlighted that the greatest quantities of fine sediments were associated with the deep water muddy sand habitats. Sampling closer inshore was relatively unsuccessful as a result of the hard and coarse ground here.

4.4.2. Sediment contaminants were generally below Canadian (ISQG) and Cefas Action level guideline values. Elevated concentrations of arsenic at stations 30, 44 and 46 are unexplained at present as no obvious sources or distribution patterns were observed. With respect to the Canadian guidelines, effects may be observed insensitive species exposed to the ISQG. In dredged sediments, any contaminants present at concentrations between Action Level I and II requires further consideration before a decision on the disposal of the material to sea can occur. Arsenic concentrations are likely to be rapidly diluted to levels below guideline values if disturbed. Significant ecotoxicological effects on marine life are therefore not expected in the event that sediments containing elevated arsenic levels are disturbed.

4.5 Existing Impacts

4.5.1 Impacts of demersal fishing gears on benthic communities are well studied and appear to be dependant upon a number of factors such fishing intensity, habitiat complexity and consolidation and the nature of the original community. Effects may include a reduction in habitat complexity, loss of long-lived and high biomass species and associated changes in species composition. Sessile epifauna may be particularly susceptible as a result of being dislodged by the passing of demersal gears or by the over-turning of substrates upon which they are attached.

4.5.2 The physical impacts of fishing gears recorded here have not been accurately ground truthed and so assessment of associated effects on the local benthic ecology is not possible. However, it is important to recognise the potential footprint of existing seabed impacts to mitigate for any wind farm effects on benthic ecology and subsequent recovery of habitats and species. Effects of discarded or lost cables and warps on benthic communities is not known but may include abrasion effects on sensitive habitats and species.

5. Conclusions

5.1.1. This study has characterised the benthic habitats and associated epifaunal communities within the proposed Moray offshore wind farm development export cable corridor. These data are used to inform the ES to be provided in support of the development application.

5.1.2. Offshore areas were found to be dominated by homogeneous muddy sand sediment habitats supporting sea pens and burrowing megafauna. Inshore areas were characterised by coarse hard ground comprising cobbles and boulder and rock outcroppings and supported a range of soft coral, bryozoans, hydroids, echinoderms and encrusting worms. Shallow water rocky areas where light availability was not limited were dominated by algal communities including kelp and encrusting and foliose red algal species. *Sabellaria spinulosa* consolidated coarse sediments were present in places and supported comparatively rich and diverse assemblages of epifauna.

5.1.3. A total of 13 sediment and rocky seabed biotopes were classified from the video survey of the export cable corridor. These have been mapped on the basis of side scan sonar data showing the extent and distribution of distinct sediment regions. A number of the classified biotopes related to potential habitats of nature conservation significance including the following:

- Burrowed mud (Scottish draft list priority marine feature);
- *Sabellaria spinulosa* reef (EC Habitats Directive Annex I habitat); and
- Stony and rocky reefs (EC Habitats Directive Annex I habitat).

5.1.4. The ES assesses the significance of any potential impacts on these features within the context of their wider geographical distribution. Mitigation measures to ameliorate possible impacts on sensitive features are described.

5.1.5. Despite a number of seabed video deployments within the area of the Southern Trench, no *Lophelia pertusa* reefs were found. Other PMF species such as *Arctica islandica*, *Palinurus elephas* and *Maera loveni* were not recorded. The latter three species are cryptic or burrowing sediment dwellers so that they may not be detected using the survey techniques agreed by the regulators.

5.1.6. Concentrations of sediment contaminants were generally low. The presence of elevated levels of arsenic at three stations is unexplained at present. No significant effects on benthic communities are expected given the dilution and dispersion that disturbed sediments will receive within the water column.

5.1.7. Impacts of demersal fishing activities on local seabed habitats will need to be considered during assessment and monitoring to mitigate for potential wind farm effects and recovery of the benthic ecology.

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APPENDICES

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Appendix I – Survey Logs

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Appendix I
Moray R3 cable route benthic ecology characterisation
Grab sample locations and field observations

Site No.	Date	Time (UTC)	Depth (m BCD)	UTM WGS84 Z30N		WGS84 (DD)		Inorganics	Organics	PSA	*In-situ* sediment description
				Eastings	Northings	Latitude	Longitude				
3	09/07/11	6:56	54,5	520141	6461899	58.297638°N	2.656410°W	Y	Y	Y	Gravelly sand
7	09/07/11	8:58	56,5	522574	6459459	58.275606°N	2.615141°W	Y	Y	Y	Slightly gravelly shelly sand
9	09/07/11	10:42	55,6	525099	6454175	58.228006°N	2.572657°W	Y	Y	Y	Fine sand
11	09/07/11	12:39	53,8	525608	6443681	58.133728°N	2.565139°W	Y	Y	Y	Silty fine sand
14	09/07/11	15:41	71,0	537148	6433814	58.044289°N	2.370758°W	Y	Y	Y	Silty sand
19	09/07/11	18:56	102,3	549100	6423770	57.952924°N	2.170416°W	Y	Y	Y	Silty sand
21	09/07/11	21:03	76,3	554649	6420336	57.921438°N	2.077457°W	Y	Y	Y	Silty sand
24	09/07/11	23:30	83,0	568465	6415514	57.876228°N	1.845663°W	Y	Y	Y	Fine mud
30	10/07/11	2:37	94,3	572097	6406631	57.795876°N	1.787130°W	Y	Y	Y	Slightly gravelly shelly sand

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Appendix II – Seabed Photographs

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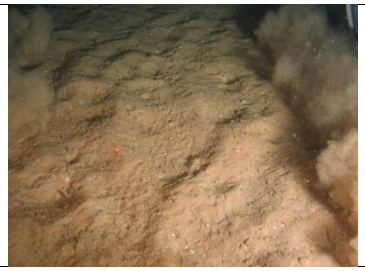
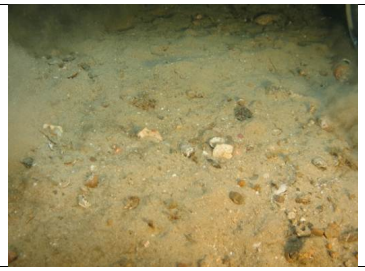
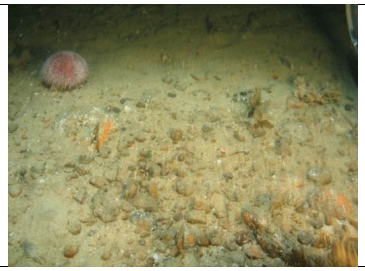
1					
2					
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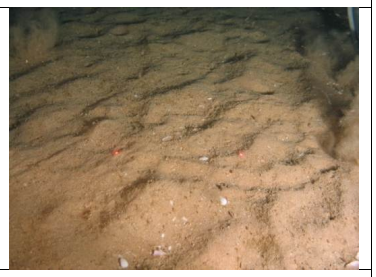
4					

APPENDIX 4.2 B

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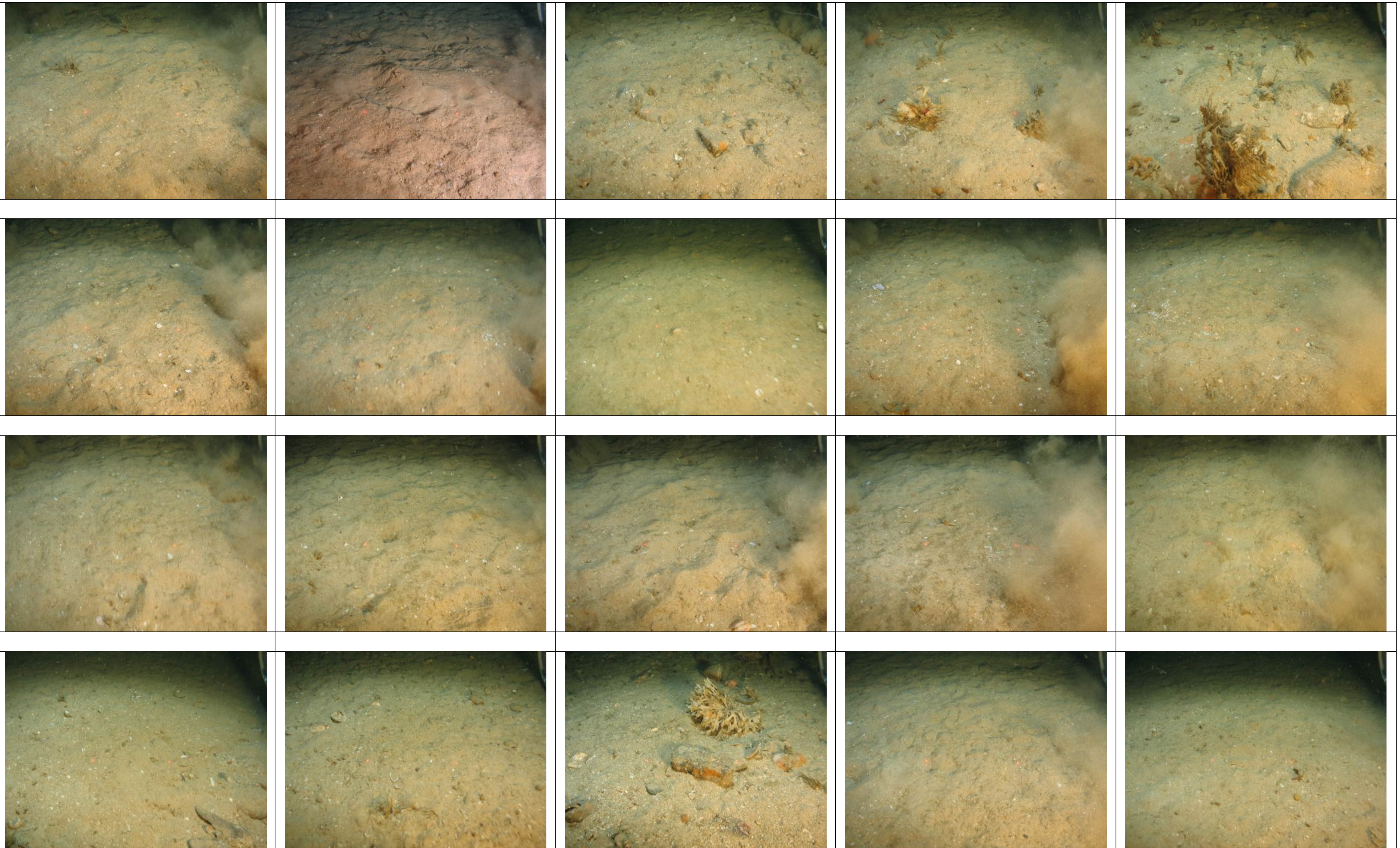

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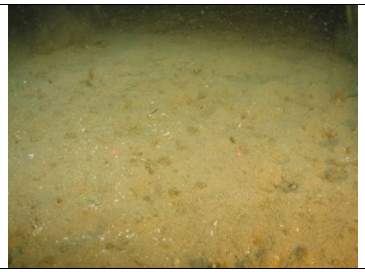
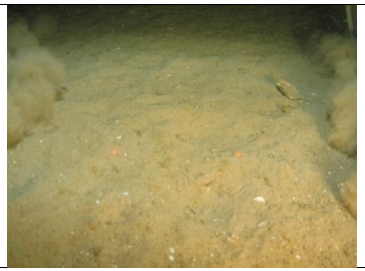
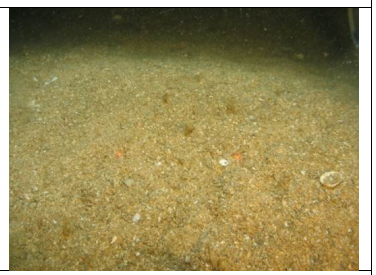
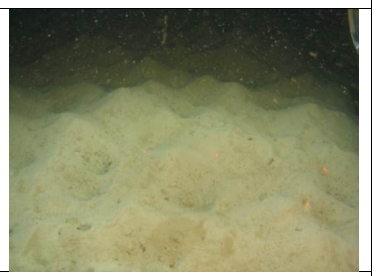
10					
11					
12					

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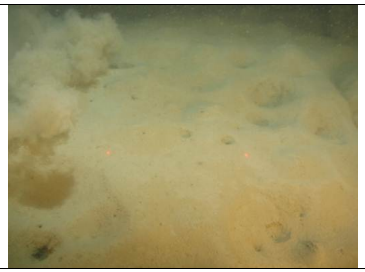
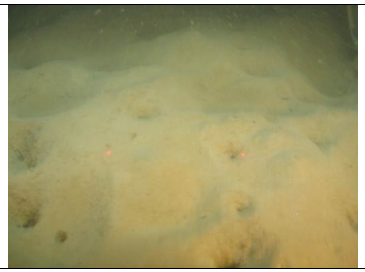
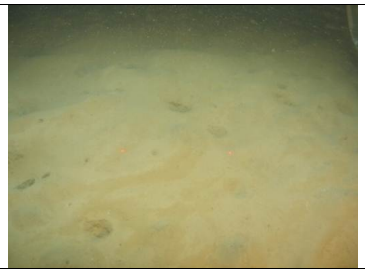
18					
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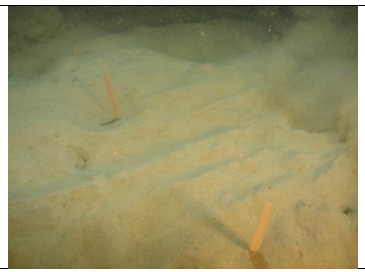
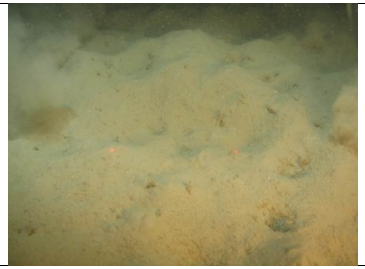
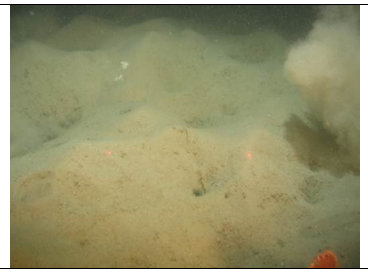
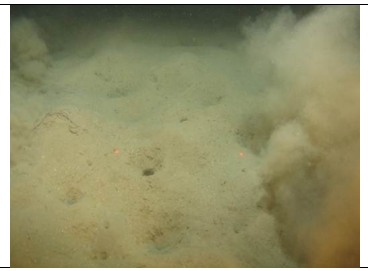
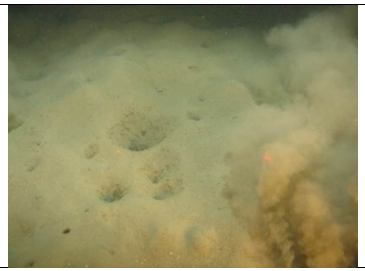
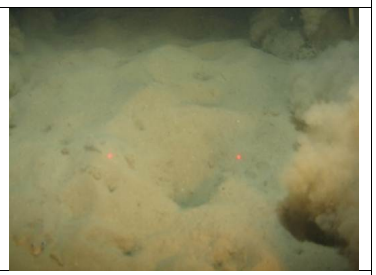
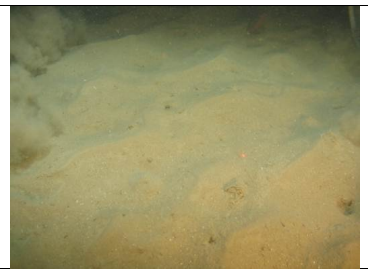
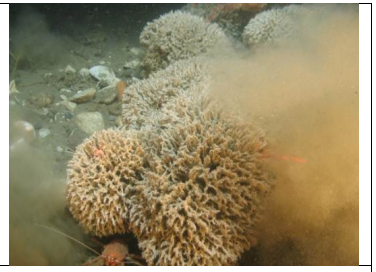
20					

21					
22					
23					
24					

25					
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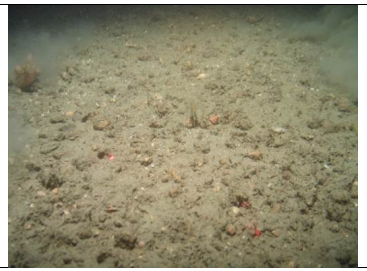
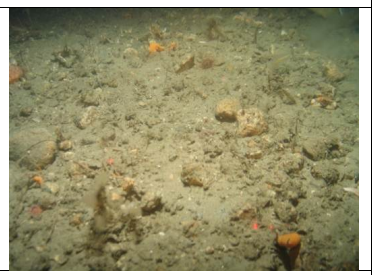
27					
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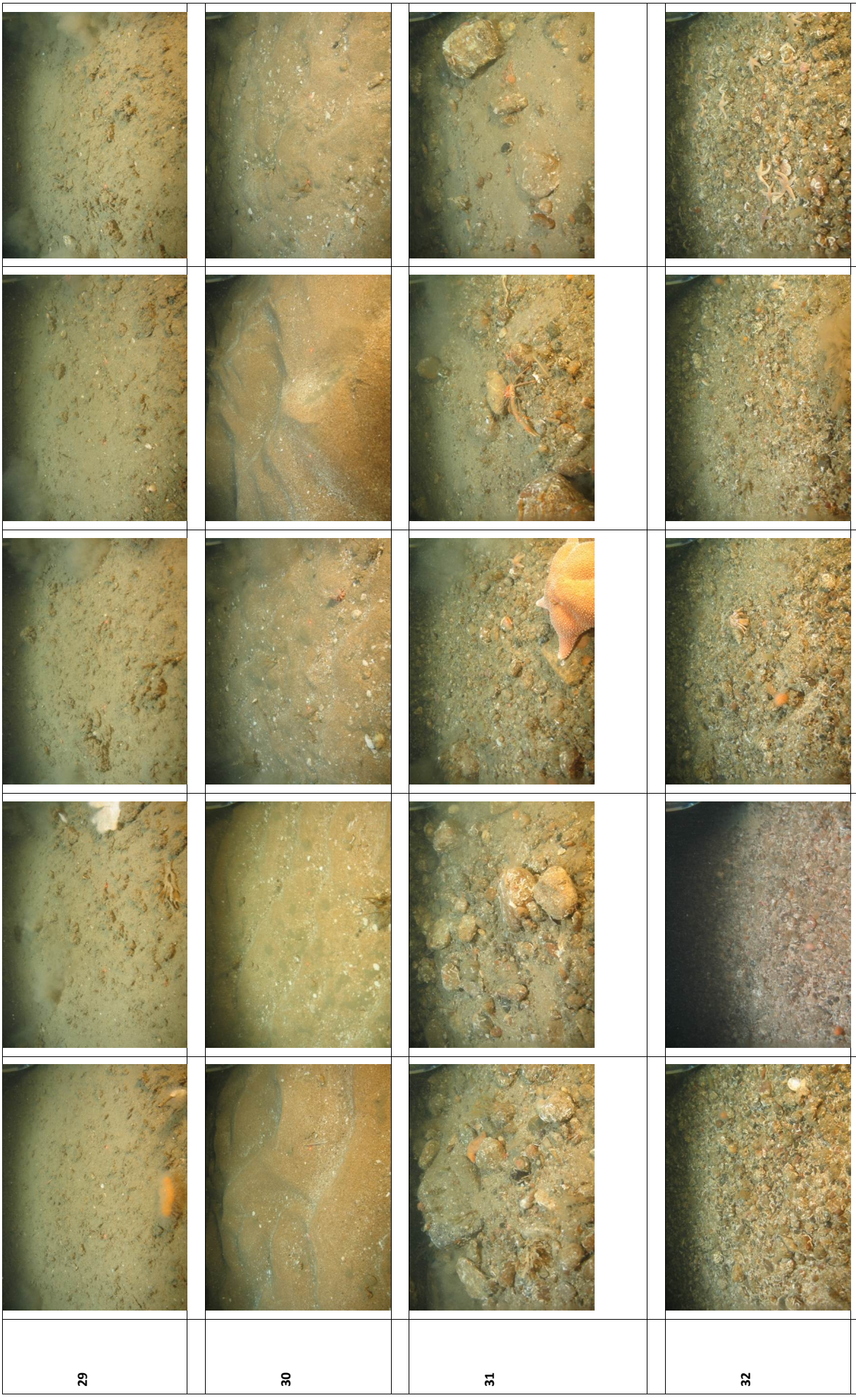
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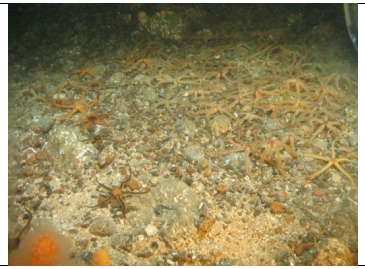
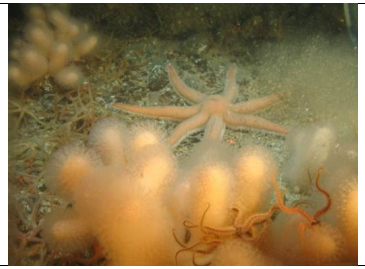
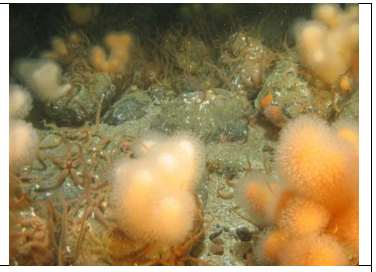
33					
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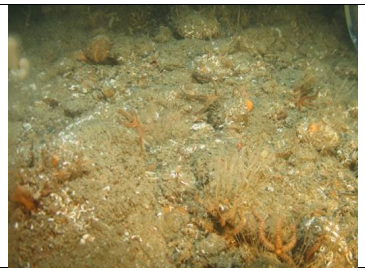
35					
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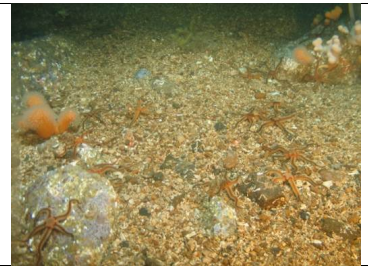
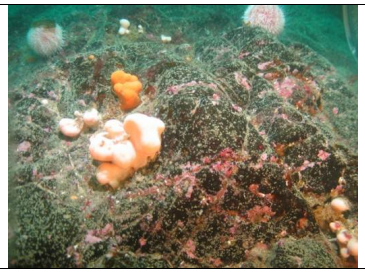
37					
38					
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Appendix III – Biotope Classifications

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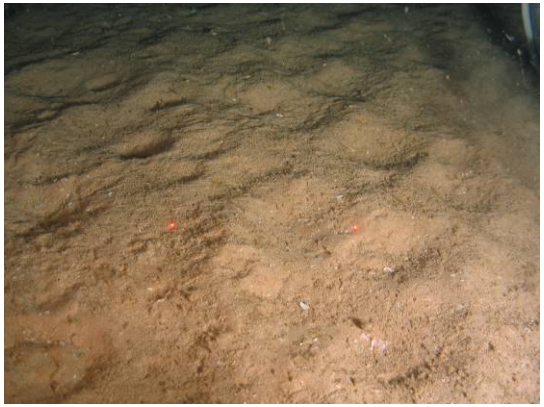
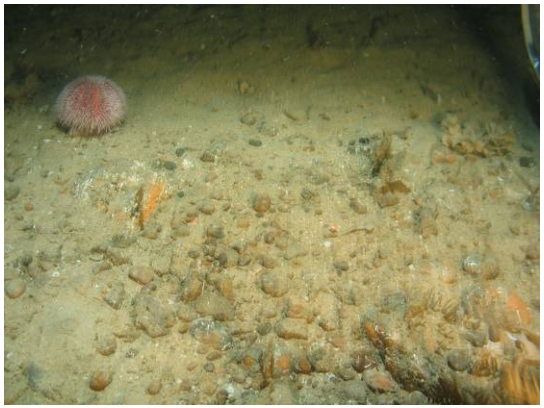
Site Number	Sediment Description	Expanded Sediment Notes	Notable Species	Representative Image	Biotope Code
Site 1	Muddy sand.	Plain of soft sediment of slightly shelly muddy sand. Burrows and holes, with small mounds.	Paguridae, Asteroidea, *Flustra foliacea,* *Buccinum undatum,* PLEURONECTIFORMES, Hydroid/Bryozoan mixed turf.		SS.SSa.CMuSa
Site 2 Video as a continuous transect with Site 5.	Muddy sand with mixed sediment.	Plain of soft sediment of slightly shelly slightly pebbly gravelly muddy sand, with a few cobbles and the occasional small boulder. Burrows and holes, with small mounds.	*Alcyonidium diaphanum,* *Echinus esculentus,* *Flustra foliacea*, Bryozoan crust, Rajidae, Paguridae, *Alcyonium digitatum.* *Munida rugosa,* *Abietinaria abietina,* *Nemertesia antennina,* *Nemertesia ramosa,* *Hydrallmania falcata*, Hydroid/Bryozoan mixed turf.		SS.SSa.CMuSa mixed with areas of SS.SMx.CMx CMX representative image present here.

Site Number	Sediment Description	Expanded Sediment Notes	Notable Species	Representative Image	Biotope Code
Site 3	Muddy sand.	Plain of soft sediment of slightly gravelly, slightly shelly muddy sand. Burrows and holes, with small mounds.	Hydroid/Bryozoan mixed turf, *Hydrallmania falcata,* *Alcyonidium diaphanum,* *Pagurus bernhardus,* CIRRIPEDIA, *Atelecyclus rotundatus,* *Urticina* sp., PLEURONECTIFORMES.		SS.SSa.CMuSa
Site 4	Muddy sand.	Plain of soft sediment of slightly shelly muddy sand. Burrows and holes, with small mounds.	Paguridae , Hydroid/Bryozoan mixed turf, *Flustra foliacea,* *Cancer pagurus.*		SS.SSa.CMuSa

Site Number	Sediment Description	Expanded Sediment Notes	Notable Species	Representative Image	Biotope Code
Site 5 Video as a continuous transect with Site 2.	Muddy sand with mixed sediment.	Plain of soft sediment of slightly shelly slightly pebbly gravelly muddy sand, with a few cobbles and the occasional small boulder. Burrows and holes, with small mounds.	*Alcyonidium diaphanum,* *Echinus esculentus,* *Flustra foliacea,* Bryozoan crust, Rajidae, Paguridae, *Munida rugosa,* *Abietinaria abietina,* *Nemertesia antennina,* *Nemertesia ramosa,* *Hydrallmania falcata,* Hydroid/Bryozoan mixed turf, *Alcyonium digitatum.*		SS.SSa.CMuSa mixed with areas of SS.SMx.CMx CMuSa representative image presented here.
Site 6	Muddy sand.	Plain of soft sediment of slightly shelly muddy sand. Burrows and holes, with small mounds.	*Alcyonidium diaphanum,* *Echinus esculentus,* Paguridae, *Cancer pagurus,* Asteroidea, PLEURONECTIFORMES, Hydroid/Bryozoan mixed turf.		SS.SSa.CMuSa

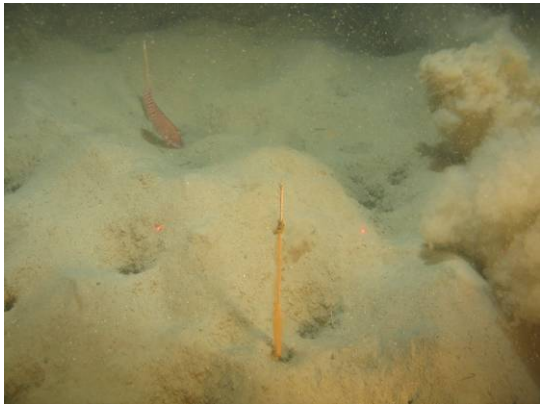
Site Number	Sediment Description	Expanded Sediment Notes	Notable Species	Representative Image	Biotope Code
Site 7	Muddy sand.	Plain of soft sediment of slightly shelly rippled muddy sand. Burrows and holes present.	Hydroid/Bryozoan mixed turf, ASTEROIDEA, PLEURONECTIFORMES.		SS.SSa.CMuSa
Site 8	Muddy sand.	Plain of soft sediment of slightly shelly muddy sand. Small deposits of pebbles and cobbles with the occasional boulder. Burrows and holes, with small mounds.	Hydroid/Bryozoan mixed turf, *Flustra foliacea,* *Metridium senile*, Paguridae *Pecten maximus,* *Echinus esculentus,* *Hydrallmania falcata,* *Abietinaria abietina*, PLEURONECTIFORMES.		SS.SSa.CMuSa
Site 9	Muddy sand.	Plain of soft sediment of slightly shelly rippled muddy sand. Burrows and holes present.	Hydroid/Bryozoan mixed turf, DECAPODA, *Alcyonidium diaphanum*, ASTEROIDEA, Triglidae.		SS.SSa.CMuSa

Site Number	Sediment Description	Expanded Sediment Notes	Notable Species	Representative Image	Biotope Code
Site 10	Muddy sand.	Slightly gravelly, slightly shelly muddy sand. Burrows and holes, with small mounds.	*Hydrallmania falcata,* Hydroid/Bryozoan mixed turf, *Alcyonium digitatum,* *Liocarcinus* sp., Paguridae.		SS.SSa.CMuSa
Site 11	Gravelly shelly sand waves becoming muddy sand.	Start of transect with coarse gravelly shelly sand in waves, becoming slightly gravelly slightly shelly muddy sand with the occasional cobble.	Hydroid/Bryozoan mixed turf, *Lanice conchilega,* DECAPODA, *Crossaster papposus,* Callionymidae, PLEURONECTIFORMES, *Pomatoceros* sp.		SS.SSa.CMuSa
Site 12	Muddy sand.	Muddy substrate with large mounds and dense amounts of holes. High level of bioturbation visible.	*Pennatula phosphorea,* Paguridae, PLEURONECTIFORMES.		SS.SMu.CFiMu.SpnMeg

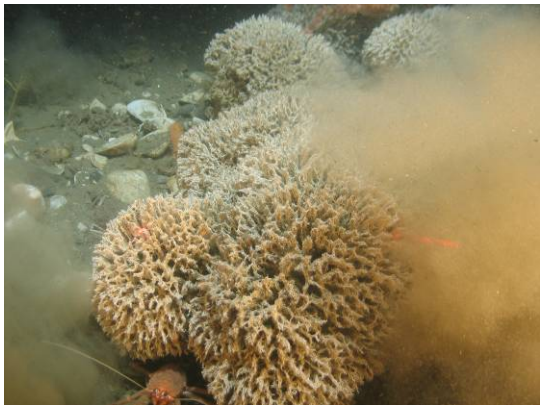
Site Number	Sediment Description	Expanded Sediment Notes	Notable Species	Representative Image	Biotope Code
Site 13	Muddy sand.	Muddy substrate with large mounds and dense amounts of holes. High level of bioturbation visible.	*Pennatula phosphorea, Hippasteria phrygiana.*		SS.SMu.CFiMu.SpnMeg
Site 14	Muddy sand.	Muddy substrate with large mounds and dense amounts of holes. High level of bioturbation visible.	*Pennatula phosphorea, Ophiura albida.*		SS.SMu.CFiMu.SpnMeg

Site Number	Sediment Description	Expanded Sediment Notes	Notable Species	Representative Image	Biotope Code
Site 15	Coarse mixed sediment.	Compacted coarse mixed sediment of shelly, sandy, pebbly gravel with cobbles and the occasional small boulder. Small area with the appearance of broken bedrock and hard ground.	PORIFERA crusts, *Abietinaria abietina,* Hydroid/Bryozoan mixed turf, *Nemertesia antennina,* *Nemertesia ramosa,* Plumulariidae, *Sertularia* sp., *Lanice conchilega,* *Pomatoceros* sp., CARIDEA, *Munida rugosa,* Paguridae, *Asterias rubens,* *Echinus esculentus,* *Hippasteria phrygiana,* *Porania pulvillus,* PLEURONECTIFORMES.		SS.SMx.CMx.FluHyd *Flustra foliacea* and *Hydrallmania falcata* reduced on this substrate but biotope code chosen due to the overall density of hydroids and bryozoans, and accompanying suite of species.
Site 16	Coarse mixed sediment.	Coarse mixed sediment of sandy cobbly pebbly gravel. Areas of dense cobble deposits and some sand dominated substrate or overlay. Becoming coarser along transect with boulders, returning to mixed sediment towards end of transect.	*Echinus esculentus,* *Porania pulvillus,* Paguridae, *Nemertesia ramosa,* *Nemertesia antennina,* *Munida rugosa,* *Pomatoceros* sp., *Tubularia indivisa,* Hydroid/Bryozoan mixed turf, Callionymidae.		SS.SMx.CMx.FluHyd *Flustra foliacea* and *Hydrallmania falcata* reduced on this substrate but biotope code chosen due to the overall density of hydroids and bryozoans, and accompanying suite of species.

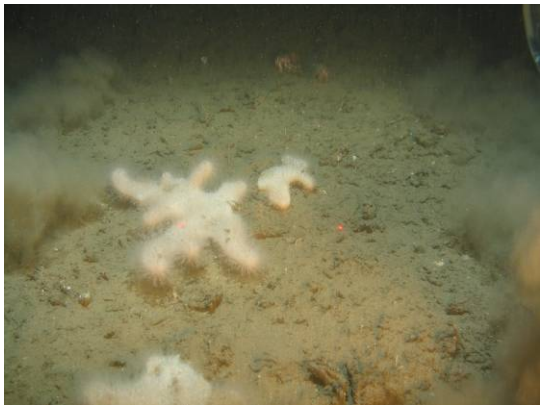
Site Number	Sediment Description	Expanded Sediment Notes	Notable Species	Representative Image	Biotope Code
Site 17	Muddy sand.	Muddy substrate with large mounds and dense amounts of holes. High level of bioturbation visible.	*Pennatula phosphorea,* *Pagurus bernhardus,* *Asterias rubens,* *Porania pulvillus,* Callionymidae.		SS.SMu.CFiMu.SpnMeg
Site 18	Muddy sand.	Muddy substrate with large mounds and dense amounts of holes. High level of bioturbation visible.	*Pennatula phosphorea.*		SS.SMu.CFiMu.SpnMeg
Site 19	Muddy sand.	Muddy substrate with large mounds and dense amounts of holes. High level of bioturbation visible.	*Liocarcinus* sp.		SS.SMu.CFiMu.SpnMeg

Site Number	Sediment Description	Expanded Sediment Notes	Notable Species	Representative Image	Biotope Code
Site 20	Muddy sand.	Muddy substrate with large mounds and dense amounts of holes. High level of bioturbation visible.	*Pennatula phosphorea, Virgularia mirabilis, Nephrops norvegicus,* PLEURONECTIFORMES.		SS.SMu.CFiMu.SpnMeg
Site 21	Muddy sand.	Muddy substrate with large mounds and dense amounts of holes. High level of bioturbation visible.	*Pennatula phosphorea.*		SS.SMu.CFiMu.SpnMeg
Site 22	Muddy sand.	Muddy substrate with large mounds and dense amounts of holes. High level of bioturbation visible.	*Pennatula phosphorea, Bolocera tuediae.*		SS.SMu.CFiMu.SpnMeg

Site Number	Sediment Description	Expanded Sediment Notes	Notable Species	Representative Image	Biotope Code
Site 23	Muddy sand.	Muddy substrate with large mounds and dense amounts of holes. High level of bioturbation visible.	*Pennatula phosphorea,* *? Pachycerianthus multiplicatus* or *Arachnanthus sarsi,* DECAPODA, Paguridae, *Bolocera tuediae,* PLEURONECTIFORMES.		SS.SMu.CFiMu.SpnMeg
Site 24	Muddy sand.	Muddy substrate with large mounds and dense amounts of holes. High level of bioturbation visible.	*Pennatula phosphorea,* Paguridae, *Tubularia indivisa,* Inachinae, *Asterias rubens,* *Alcyonium digitatum,* *Metridium senile,* Hydroid/Bryozoan mixed turf, PLEURONECTIFORMES.		SS.SMu.CFiMu.SpnMeg

Site Number	Sediment Description	Expanded Sediment Notes	Notable Species	Representative Image	Biotope Code
Site 25 Southern Trench site.	Compacted coarse mixed sediment.	Compacted mixed sediment with the appearance of 'gravelly' shelly sand, with a silty overlay, and the occasional cobble.	*?Caryophylliidae,* *Nemertesia ramosa,* *Thuiaria thuja,* *Tubularia indivisa,* *Alcyonium digitatum,* ACTINIARIA, *Cerianthus loydii,* *Urticina* sp., *Lanice conchilega,* *Salmacina/Filigrana* sp., Majidae, *Munida rugosa,* Paguridae, *Alcyonidium diaphanum,* *Asterias rubens,* *Ophiura ophiura.*		SS.SMx.CMx
Site 26 Southern Trench site.	Sand.	Slightly shelly sand with few pebble overlaid by thin silt layer.	Hydroid/Bryozoan mixed turf, *Nemertesia ramosa,* *Tubularia indivisa,* *Alcyonium digitatum,* *Urticina* sp., *Atelecyclus rotundatus,* Paguridae, *Aequipecten opercularis,* Buccinidae, *Alcyonidium diaphanum,* *Flustra foliacea,* *Asterias rubens.*		SS.SCS.CCS

Site Number	Sediment Description	Expanded Sediment Notes	Notable Species	Representative Image	Biotope Code
Site 27 Southern Trench site.	Compacted coarse mixed sediment.	Compacted mixed substrate with the occasional small boulder overlaid by a thin silt layer.	Hydroid/Bryozoan mixed turf, *Nemertesia ramosa*, *Nemertesia* sp., *Tubularia indivisa*, *Alcyonium digitatum*, *Cerianthus lloydii*, HEXACORALLIA, *Urticina* sp., *Salmacina/Filograna* sp., *Atelecyclus rotundatus*, CARIDEA, Majidae, Paguridae, *Omalosecosa ramulosa*, *Asterias rubens*, *Hippasteria phrygiana*, *Ophiura* sp., *Polycarpa/Pyura* sp., Various erect worm tubes.		SS.SMx.CMx
Site 28 Southern Trench site.	Compacted coarse mixed sediment.	Compacted mixed gravelly shelly sand overlaid with a thin silt layer and occasional cobble.	*?Caryophylliidae*, *Alcyonium digitatum*, ACTINIARIA, *Cerianthus lloydii*, *Urticina* sp., Paguridae, *Aequipecten opercularis*, *Flustra foliacea*, *Asterias rubens*, *Ophiura ophiura*, Paguridae.		SS.SMx.CMx

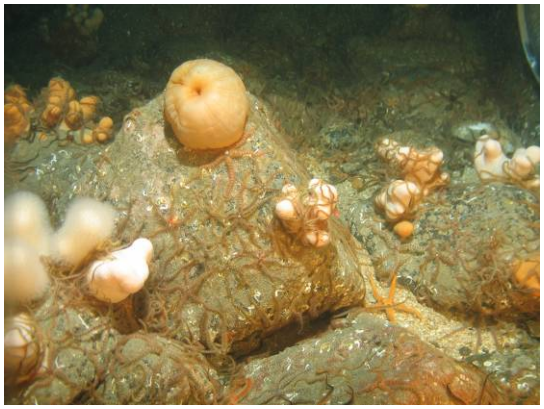
Site Number	Sediment Description	Expanded Sediment Notes	Notable Species	Representative Image	Biotope Code
Site 29 Southern Trench site.	Compacted coarse mixed sediment.	Compacted mixed gravelly shelly sand overlaid with a thin silt layer and occasional cobble.	Hydroid/Bryozoan mixed turf, *Alcyonium digitatum* ACTINIARIA, *Cerianthus lloydii,* *?Corymorpha nutans,* *Urticina* sp., *Sabella* tube, *Salmacina/Filograna* sp., Majidae, *Munida rugosa,* Paguridae, *Aequipecten opercularis,* *Pecten maximus,* *Flustra foliacea,* *Asterias rubens,* ASTEROIDEA, *Hippasteria phrygiana,* *Ophiura* sp., PLEURONECTIFORMES.		SS.SMx.CMx
Site 30	Sand	Slightly gravelly shelly rippled sand with the occasional cobble and small boulder.	Hydroid/Bryozoan mixed turf, *Tubularia indivisa,* *Metridium senile,* *Urticina* sp., *Chaetopterus* tubes, CARIDEA, Paguridae, *Flustra foliacea,* *Ophiura* sp.		SS.SMx.CMx

Site Number	Sediment Description	Expanded Sediment Notes	Notable Species	Representative Image	Biotope Code
Site 31	Coarse mixed sediment with boulders.	Coarse mixed sediment of shelly sandy cobbly gravelly pebbles. Patchy distribution of small boulders and sand forming the occasional open area. Rich epifaunal site densely encrusted with *Pomatoceros* sp.	*Munida rugosa,* *Tubularia indivisa,* *Hippasteria phrygiana,* *Echinus esculentus,* *Pagurus bernhardus,* *Thuiaria thuja,* *Luidia ciliaris,* *Asterias rubens,* *Alcyonium digitatum,* *Pomatoceros* sp., *Urticina* sp., *Nemertesia antennina,* *Nemertesia ramosa,* *Atelecyclus rotundatus,* Majidae, Paguridae, PORIFERA crusts, Bryozoan crust, Hydroid/Bryozoan mixed turf.		SS.SMx.CMx.FluHyd

Site Number	Sediment Description	Expanded Sediment Notes	Notable Species	Representative Image	Biotope Code
Site 32	Coarse mixed sediment.	Coarse mixed sediment of dense shelly sandy cobbly gravelly pebbles. Rich epifaunal site densely encrusted with *Pomatoceros* sp.	*Munida rugosa,* *Sabellaria spinulosa,* *Salmacina/Filograna* sp., *Tubularia indivisa,* *Chaetopterus* tubes, *Neptunea antiqua* *Hippasteria phrygiana,* *Pagurus bernhardus,* *Thuiaria thuja,* *Luidia ciliaris,* *Asterias rubens,* *Alcyonium digitatum,* *Pomatoceros* sp., *Urticina* sp., *Nemertesia antennina,* *Ophiothrix fragilis,* *Ophiocomina nigra,* *Cancer pagurus,* PORIFERA crusts, Bryozoan crust, Hydroid/Bryozoan mixed turf.		SS.SMx.CMx.FluHyd
Site 33	Boulders with mixed sediment and sand.	Sand and gravel substrates with cobbles and boulders.	*Munida rugosa,* *Luidia ciliaris,* *Asterias rubens,* *Crossaster papposus,* *Alcyonium digitatum,* *Pomatoceros* sp., *Nemertesia antennina,* *Echinus esculentus,* *Ophiothrix fragilis,* *Ophiocomina nigra,* *Cancer pagurus,* PORIFERA crusts, Bryozoan crust, Hydroid/Bryozoan mixed turf.		SS.SMx.CMx.OphMx

Site Number	Sediment Description	Expanded Sediment Notes	Notable Species	Representative Image	Biotope Code
Site 34	Coarse mixed sediment.	Coarse mixed sediment comprising shelly gavel with cobbles. Rich epifaunal site densely encrusted with *Pomatoceros* sp.	*Munida rugosa,* *Luidia ciliaris,* *Asterias rubens,* *Crossaster papposus,* *Sabellaria spinulosa,* *Alcyonium digitatum,* *Pomatoceros* sp., *Flustra foliacea,* *Tubularia indivisa,* *Nemertesia ramosa,* *Cancer pagurus,* *Aequipecten opercularis,* *Pecten maximus,* *Tethya citrina,* NUDIBRANCHIA, *Lanice conchilega,* PORIFERA crusts, Bryozoan crust, Hydroid/Bryozoan mixed turf.		SS.SMx.CMx.FluHyd

Site Number	Sediment Description	Expanded Sediment Notes	Notable Species	Representative Image	Biotope Code
Site 35	Dense cobble substrate.	Consolidated coarse sediment with gravel and cobbles with occasional boulders. Very rich epifaunal site. *Sabellaria spinulosa* crust also present.	*Munida rugosa,* *Luidia ciliaris,* *Asterias rubens,* *Antedon bifida,* *Echinus esculentus,* *Ophiothrix fragilis,* *Ophiocomina nigra,* *Crossaster papposus,* *Sabellaria spinulosa,* *Alcyonium digitatum,* *Pomatoceros* sp., *Flustra foliacea,* *Tubularia indivisa,* *Nemertesia ramosa,* PORIFERA crusts, *Chaetopterus* tubes, Plumulariidae, Bryozoan crust, Hydroid/Bryozoan mixed turf.		SS.SMx.CMx.OphMx
Site 36	Bedrock and boulders with rippled sand expanses. Potential *Sabellaria spinulosa* reef.	Exposed rock with boulders and cobbles overlaid with clean mobile sand of varying thicknesses. *Sabellaria spinulosa* varying between thick crust and elevated reef structure, present over approximately 20% of overall transect length.	*Asterias rubens,* *Echinus esculentus,* *Ophiothrix fragilis,* *Ophiocomina nigra,* *Crossaster papposus,* *Sabellaria spinulosa,* *Alcyonium digitatum,* *Pomatoceros* sp., *Tubularia indivisa,* *Alcyonidium diaphanum,* *Chaetopterus* tubes, Plumulariidae, Bryozoan crust, Hydroid/Bryozoan mixed turf.		CR.MCR.CSab.Sspi in a mosaic with SS.SCS.CCS

Site Number	Sediment Description	Expanded Sediment Notes	Notable Species	Representative Image	Biotope Code
Site 36 Transect 2	Bedrock and boulders with rippled sand expanses. Potential *Sabellaria spinulosa* reef.	Exposed rock with boulders and cobbles overlaid with clean mobile sand of varying thicknesses. *Sabellaria spinulosa* varying between thick crust and elevated reef structure, present over approximately 20% of overall transect length.	*Asterias rubens,* *Securiflustra securifrons,* *Flustra foliacea,* *Munida rugosa,* *Cancer pagurus,* *Urticina* sp., *Echinus esculentus,* *Ophiocomina nigra,* *Sabellaria spinulosa,* *Alcyonium digitatum,* *Pomatoceros* sp., *Tubularia indivisa,* Bryozoan crust, Hydroid/Bryozoan mixed turf.		CR.MCR.CSab.Sspi in a mosaic with SS.SCS.CCS
Site 37	Boulder and bedrock with cobbles.	Exposed bedrock and boulders with areas of cobbles. Low lying areas with deposits of pebbly gravelly sand,. Overall area with *Alcyonium digitatum, Echinus esculentus* and brittlestars.	*Asterias rubens,* *Echinus esculentus,* *Ophiothrix fragilis,* *Ophiocomina nigra,* *Thuiaria thuja,* *Crossaster papposus,* *Lanice conchilega,* *Urticina felina,* *Nemertesia ramosa,* *Cellaria* sp., ASCIDIACEA (crust), *Alcyonium digitatum,* *Metridium senile,* Hydroid/Bryozoan mixed turf.		CR.MCR.EcCr.FaAlCr.Bri

Site Number	Sediment Description	Expanded Sediment Notes	Notable Species	Representative Image	Biotope Code
Site 38	Bedrock and boulders.	Beginning of transect with low lying jagged bedrock exposures and wide gullies with cobbly, pebbly gravelly sand. Substrate becomes solid and more consistent raised bedrock and boulder substrate with deep gullies. Cobbly pebbly gravelly sand in the recesses.	*Laminaria* sp., Red and brown algal turf, Corallinaceae, *Echinus esculentus,* CIRRIPEDIA, *Pomatoceros* sp., *Asterias rubens, Clavelina lepadiformis,* PORIFERA crusts, *Bugula* sp., *Alcyonium digitatum, Crossaster papposus,* Hydroid/Bryozoan mixed turf, *Calliostoma zizyphinum.*		CR.MCR.EcCr.FaAlCr
Site 39	Bedrock and boulders.	Bedrock and large boulders with deep gullies. Cobbles, pebbles, gravel and sand present at base of gullies.	*Laminaria* sp., Red and brown turf algae, Corallinaceae, *Echinus esculentus,* CIRRIPEDIA, *Pomatoceros* sp., *Asterias rubens, Clavelina lepadiformis,* PORIFERA crusts, *Bugula* sp., *Alcyonium digitatum.*		IR.MIR.KR Biotope allocation left at level above as unable to confirm species of *Laminaria* present. Potential to be:- IR.MIR.KR.Lhyp or IR.MIR.KR.Lhyp.Pk

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Appendix IV – Assessment of Annex I Stony and Rocky Reef

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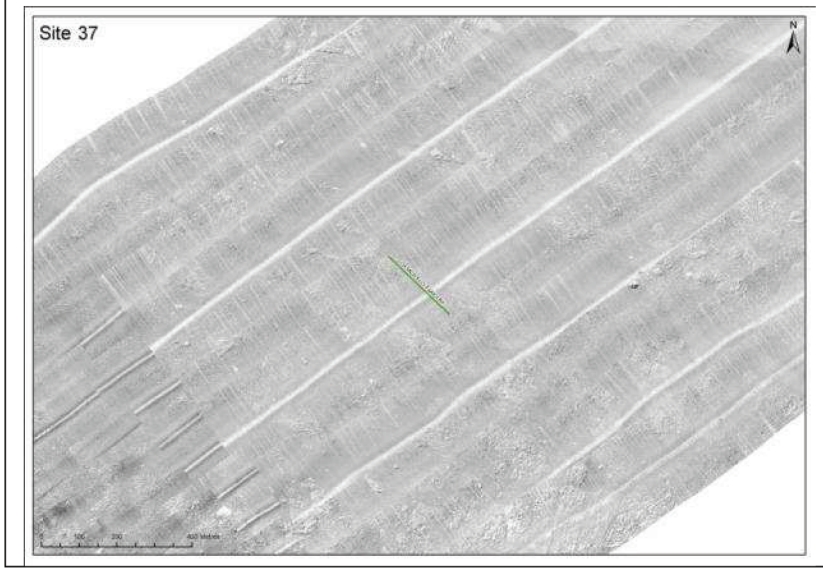
Transect 33

Representative seabed images and associated side scan sonar data. (line shows route of video transect).	Geogenic Classification					Substrate description and associated species
	Composition	Elevation	Extent	% Epibiota cover	Resemblance	
 	40 - 95%	64 – 5 m (distinct from surrounding seabed)	<25 m2	Epifaunal dominated	**High**	**Substrate**: Boulders with dense cobbles over sand and gravel overlain with clean mobile sand. **Cobble / boulder component:** Boulders and cobbles with mixed sediment and sand. **Epibiota community:** Crustose community. **Typical species:** *Munida rugosa, Luidia ciliaris, Asterias rubens, Crossaster papposus, Alcyonium digitatum, Pomatoceros sp., Nemertesia antennina, Echinus esculentus, Ophiothrix fragilis, Ophiocomina nigra, Cancer pagurus, PORIFERA crusts, Bryozoan crust,* Hydroid/Bryozoan mixed turf **Extents:** Present as extensive patches overlain with mobile sand.

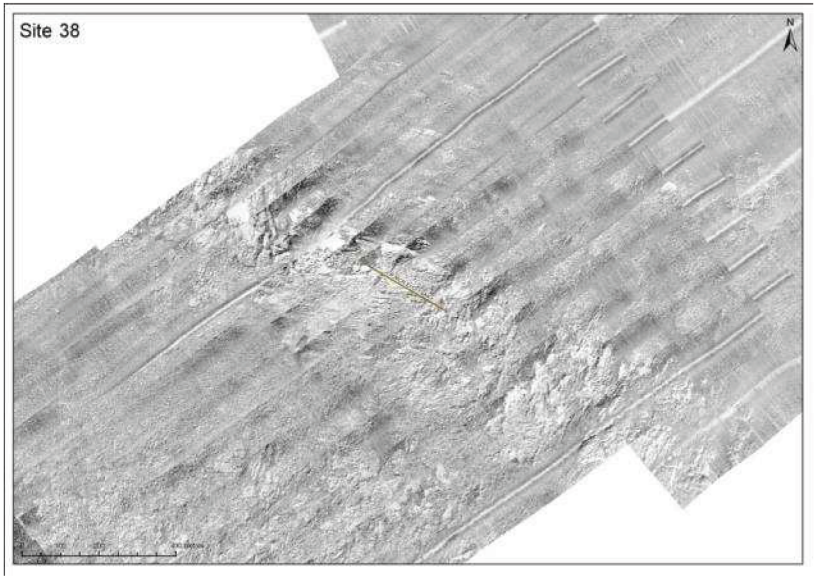
Transect 35

Representative seabed images and associated side scan sonar data. (line shows route of video transect).	Geogenic Classification					Substrate description and associated species
	Composition	Elevation	Extent	% Epibiota cover	Resemblance	
 	40 - 95%	64 – 5 m (distinct from surrounding seabed)	<25 m2	Epifaunal dominated	**High**	**Substrate**: Consolidated substrates comprising cobbles over seabed surface. **Cobble / boulder component:** Dense cobble substrate. **Epibiota community:** Crustose community. **Typical species:** Hydroid/Bryozoan mixed turf *Munida rugosa, Luidia ciliaris, Antedon bifida, Echinus esculentus, Ophiothrix fragilis, Ophiocomina nigra, Crossaster papposus, Sabellaria spinulosa, Alcyonium digitatum, Pomatoceros* sp., *Flustra foliacea, Tubularia indivisa, Nemertesia ramosa,* PORIFERA crusts, *Chaetopterus* tubes, Plumulariidae, Bryozoan crust, **Extents:** Present as extensive patches.

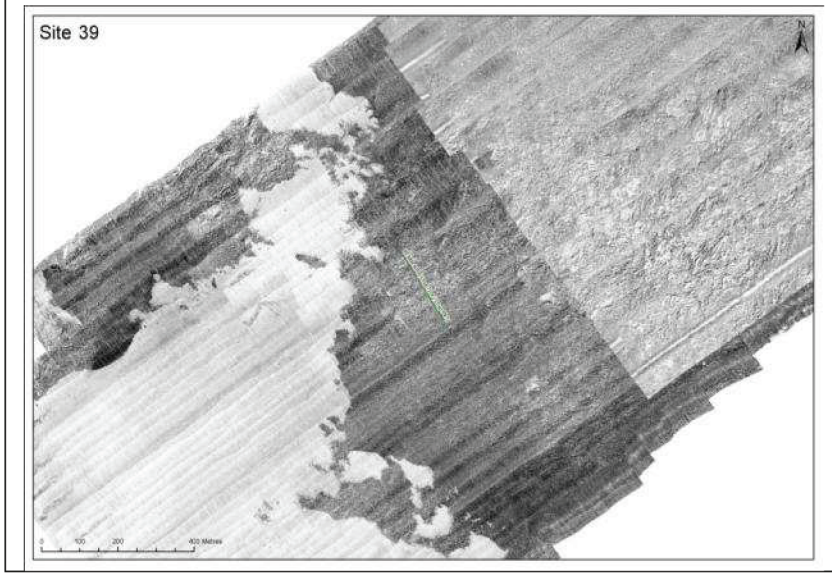
Transect 37

Representative seabed image and associated side scan sonar data. (line shows route of video transect).	Geogenic Classification					Substrate description and associated species
	Composition	Elevation	Extent	% Epibiota cover	Resemblance	
 	40 - 95%	64 – 5 m (distinct from surrounding seabed)	<25 m2	Epifaunal dominated	**High**	**Substrate**: Extensive bedrock and boulder reef with large proportion of cobbles. Low lying areas with pebbly gravelly sand. **Cobble / boulder component:** Boulder and bedrock with cobbles **Epibiota community:** *Alcyonium digitatum, Echinus esculentus* and brittlestars. **Typical species:** *Asterias rubens, Echinus esculentus, Ophiothrix fragilis, Ophiocomina nigra, Thuiaria thuja, Crossaster papposus, Lanice conchilega, Urticina felina, Nemertesia ramosa, Cellaria* sp., ASCIDIACEA (crust), *Alcyonium digitatum, Metridium senile,* Hydroid/Bryozoan mixed turf **Extents:** Present as extensive patches.

Transect 38

Representative seabed image and associated side scan sonar data. (line shows route of video transect).	Geogenic Classification					Substrate description and associated species
	Composition	Elevation	Extent	% Epibiota cover	Resemblance	
 	> 95%	64 – 5 m (distinct from surrounding seabed)	<25 m2	Epifaunal dominated	**High**	**Substrate**: Low lying jagged bedrock with gullies with cobble, pebbly gravelly sand at base of gullies. Substrate becomes solid and more consistently raised bedrock and boulder substrate with deep gullies. Cobbles and pebbly gravelly sand in the recesses. **Cobble / boulder component:** Bedrock and boulders. **Epibiota community:** *Alcyonium digitatum, Echinus esculentus*. **Typical species:** *Laminaria* sp., Red / brown algal turf, *Corallinaceae, Echinus esculentus,* CIRRIPEDIA, *Pomatoceros* sp., *Asterias rubens, Clavelina lepadiformis, PORIFERA crusts, Alcyonium digitatum, Crossaster papposus,* Hydroid/Bryozoan turf, **Extents:** Present as coherent rocky reef throughout width of acoustic survey area (+1 km in width).

Transect 39

Representative seabed image and associated side scan sonar data. (line shows route of video transect).	Geogenic Classification					Substrate description and associated species
	Composition	Elevation	Extent	% Epibiota cover	Resemblance	
 	> 95%	64 – 5 m (distinct from surrounding seabed)	<25 m2	Epifaunal dominated	**High**	**Substrate**: Bedrock and large boulders with deep gullies. Cobbles, pebbles, gravel and sand at base of gullies. **Cobble / boulder component:** Bedrock and boulders. **Epibiota community:** *Alcyonium digitatum, Echinus esculentus*. **Typical species:** *Laminaria* sp., Red / brown turf algae, Corallinaceae, *Echinus esculentus,* CIRRIPEDIA, *Pomatoceros* sp., *Asterias rubens, Clavelina lepadiformis,* PORIFERA crusts, *Bugula* sp., *Alcyonium digitatum* **Extents:** Present as coherent rocky reef throughout width of acoustic survey area (+1 km in width).

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Appendix V – Assessment of Annex I *Sabellaria spinulosa* Reef

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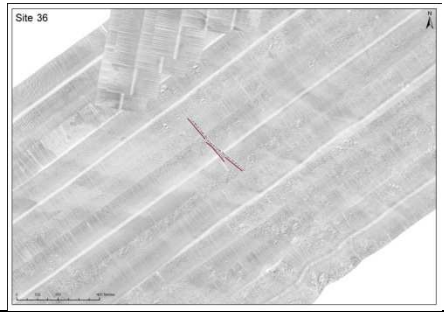
Site	Sediment description	*Sabellaria* form present					*Sabellaria* characteristics				Image acoustic data (line shows route of video transect)	Reefiness
		Absent	Moribund loose tubes	Crusts	Clumps	Potential Reef	Elevation	Patchiness	Brief description of reef	Other conspicuous species		
36	Bedrock and boulders with cobbles overlaid with clean mobile sand.					✓	>10cm	20 -30%	*Sabellaria spinulosa* varying between thick crust and elevated reef structure, present over approximately 20% of overall transect length. Distinct from surrounding seabed	*Asterias rubens*, *E. esculentus*, *O. fragilis*, *O. nigra*, *C. papposus*, *S. spinulosa*, *A. digitatum*, *Pomatoceros T. indivisa*, *A. diaphanum*, *Chaetopterus* Plumulariidae, Bryozoan crust, Hydroid/Bryozoan	 	**HIGH**

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Appendix VI – Results of the Particle Size Distribution Analysis

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Appendix VI
Moray R3 cable route benthic ecology characterisation
Results of the particle size distribution analysis
% Fractional Data

Site Number	3	7	9	11	14
EMU LAB ID	7607	7608	7609	7610	7611
Sieve Aperture (µm)	%	%	%	%	%
64000	0,00	0,00	0,00	0,00	0,00
45000	0,00	0,00	0,00	0,00	0,00
32000	0,00	0,00	0,00	0,00	0,00
22400	0,00	0,00	0,00	0,00	0,00
16000	0,00	0,00	0,00	0,00	0,00
11200	0,00	0,00	0,00	0,00	0,00
8000	1,79	0,00	0,00	1,26	0,00
5600	1,99	0,00	0,12	0,00	0,00
4000	1,19	0,14	0,20	0,24	0,00
2800	3,35	0,39	0,61	0,41	0,00
2000	3,76	0,75	0,84	0,34	0,00
1400	4,29	1,22	1,27	0,51	0,00
1000	3,24	1,45	1,31	0,36	0,04
710	3,53	1,48	1,41	0,34	0,25
500	3,28	1,86	1,77	0,52	1,02
355	3,65	3,11	5,25	1,57	3,13
250	9,50	14,29	27,54	10,91	7,76
180	21,40	42,15	35,33	38,00	13,43
125	27,63	24,69	18,64	33,85	22,64
90	7,43	5,70	3,67	8,36	27,83
63	1,52	1,09	0,66	1,51	14,52
44	0,18	0,12	0,06	0,12	0,84
31	0,23	0,15	0,09	0,13	0,93
22	0,25	0,16	0,11	0,14	0,95
16	0,26	0,17	0,13	0,16	0,96
11	0,25	0,17	0,14	0,18	0,97
8	0,24	0,17	0,15	0,19	0,95
6	0,23	0,16	0,14	0,19	0,88
4	0,20	0,14	0,13	0,17	0,77
3	0,17	0,12	0,12	0,15	0,62
2	0,13	0,09	0,09	0,11	0,46
1,4	0,09	0,06	0,07	0,08	0,31
1,0	0,07	0,05	0,05	0,06	0,22
0,7	0,06	0,04	0,04	0,05	0,21
0,5	0,06	0,04	0,04	0,05	0,19
0,3	0,03	0,02	0,02	0,03	0,12
<0.3	0,00	0,00	0,00	0,00	0,01
TOTAL %	100,00	100,00	100,00	100,00	100,00

Appendix VI
Moray R3 cable route benthic ecology characterisation
Results of the particle size distribution analysis
% Fractional Data

Site Number	19	21	24	30
EMU LAB ID	7613	7614	7615	7617
Sieve Aperture (µm)	%	%	%	%
64000	0,00	0,00	0,00	0,00
45000	0,00	0,00	0,00	0,00
32000	0,00	0,00	7,32	0,00
22400	0,00	0,00	0,00	0,00
16000	0,00	0,00	0,00	0,00
11200	0,00	0,00	0,00	0,41
8000	0,00	0,00	0,00	1,12
5600	0,00	0,00	0,00	1,28
4000	0,00	0,04	0,00	1,66
2800	0,00	0,00	0,01	1,63
2000	0,01	0,00	0,00	1,50
1400	0,01	0,02	0,04	1,57
1000	0,06	0,17	0,13	1,95
710	0,23	0,56	0,43	2,99
500	0,89	1,86	1,81	9,03
355	2,39	3,81	4,72	28,05
250	5,78	9,28	9,72	31,69
180	9,98	13,61	19,63	11,89
125	10,36	28,72	36,06	2,70
90	19,25	26,98	11,46	0,49
63	28,52	7,44	3,71	0,30
44	1,94	0,65	0,33	0,09
31	2,53	0,78	0,42	0,13
22	2,74	0,82	0,48	0,16
16	2,67	0,83	0,53	0,19
11	2,45	0,81	0,55	0,20
8	2,19	0,77	0,55	0,20
6	1,91	0,69	0,51	0,18
4	1,63	0,58	0,44	0,16
3	1,30	0,46	0,35	0,12
2	0,95	0,33	0,26	0,09
1,4	0,63	0,22	0,17	0,06
1,0	0,46	0,16	0,13	0,05
0,7	0,43	0,15	0,11	0,04
0,5	0,40	0,14	0,10	0,04
0,3	0,24	0,08	0,06	0,02
<0.3	0,03	0,01	0,01	0,00
TOTAL %	100,00	100,00	100,00	100,00

Summary Statistics

Site Number	3	7	9	11	14
EMU LAB ID	7607	7608	7609	7610	7611
% Gravel	12,1%	1,3%	1,8%	2,2%	0,0%
%Sand	85,5%	97,1%	96,8%	95,9%	90,6%
% Silt/Clay	2,5%	1,7%	1,4%	1,8%	9,4%
Mean (mm)	0,34	0,21	0,23	0,18	0,13
Md (mm)	0,21	0,20	0,23	0,18	0,12
Mean (phi)	1,54	2,28	2,14	2,45	2,98
Md (phi)	2,24	2,30	2,14	2,44	3,03
Sorting	1,69	0,73	0,73	0,55	1,14
Skq	-0,59	-0,18	-0,16	-0,02	0,15
Kurtosis	1,13	1,83	1,53	1,23	1,97

Descriptive Statistics

Site Number	3	7	9	11	14
EMU LAB ID	7607	7608	7609	7610	7611
% Shell Estimation (Volume)	30 - 40%	25 - 35%	20 - 30%	10 - 15%	5 - 10%
% Shell Description	Predominantly fine-coarse shell hash (63-2800 µm)	Predominantly fine-coarse shell hash (63-2000 µm)	Predominantly fine-coarse shell hash (63-2000 µm)	Predominantly fine-medium shell hash (63-250 µm)	Predominantly fine-medium shell hash (63-250 µm)
Maximum Shell Aperture (µm)	8000	4000	5600	8000	2000
Sample Type	Bimodal, Poorly Sorted	Unimodal, Moderately Sorted	Unimodal, Moderately Sorted	Unimodal, Moderately Well Sorted	Unimodal, Poorly Sorted
Textural Group (Folk & Ward 1954)	Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand
Mean	Medium Sand	Fine Sand	Fine Sand	Fine Sand	Fine Sand
Sorting	Poorly Sorted	Moderately Sorted	Moderately Sorted	Moderately Well Sorted	Poorly Sorted
Skewness	Very Coarse Skewed	Coarse Skewed	Coarse Skewed	Symmetrical	Fine Skewed
Kurtosis	Leptokurtic	Very Leptokurtic	Very Leptokurtic	Leptokurtic	Very Leptokurtic

Summary Statistics

Site Number	19	21	24	30
EMU LAB ID	7613	7614	7615	7617
% Gravel	0,0%	0,0%	7,3%	7,6%
%Sand	77,5%	92,5%	87,7%	90,7%
% Silt/Clay	22,5%	7,5%	5,0%	1,7%
Mean (mm)	0,07	0,15	0,18	0,39
Md (mm)	0,09	0,14	0,17	0,36
Mean (phi)	3,74	2,78	2,45	1,38
Md (phi)	3,52	2,86	2,59	1,48
Sorting	1,70	1,02	1,79	1,02
Skq	0,30	0,06	-0,47	-0,36
Kurtosis	2,15	1,82	4,12	2,13

Descriptive Statistics

Site Number	19	21	24	30
EMU LAB ID	7613	7614	7615	7617
% Shell Estimation (Volume)	5 - 10%	5 - 10%	15 - 20%	75 - 85%
% Shell Description	Predominantly fine-medium shell hash (63-250 μm)	Predominantly fine-medium shell hash (63-250 μm)	Predominantly fine-medium shell hash (63-250 μm)	Predominantly fine-coarse shell hash (63-5600 μm)
Maximum Shell Aperture (μm)	2000	4000	31500	11200
Sample Type	Unimodal, Poorly Sorted	Unimodal, Poorly Sorted	Bimodal, Poorly Sorted	Unimodal, Poorly Sorted
Textural Group (Folk & Ward 1954)	Slightly Gravelly Muddy Sand	Slightly Gravelly Sand	Gravelly Sand	Gravelly Sand
Mean	Very Fine Sand	Fine Sand	Fine Sand	Medium Sand
Sorting	Poorly Sorted	Poorly Sorted	Poorly Sorted	Poorly Sorted
Skewness	Very Fine Skewed	Symmetrical	Very Coarse Skewed	Very Coarse Skewed
Kurtosis	Very Leptokurtic	Very Leptokurtic	Extremely Leptokurtic	Very Leptokurtic

Appendix VII – Results of the Sediment Contaminants Analysis

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Appendix VII
Moray R3 cable route benthic ecology characterisation
Sediment Chemistry Analyses Results

Analyte:	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Tin	Aluminium	Barium.	TOC	TPH	Naphthalene
Method Code:	ICPMSS	ICPMSS	ICPMSS	ICPMSS	ICPMSS	ICPMSS	ICPMSS	ICPMSS	ICPSOIL	ICPSOIL	WSLM59	TPHFIDUS	PAH_MS-SIM_80
Units:	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	% M/M	mg/kg	mg/kg
Station ID													
3	6,8	<0.1	9,7	2,0	5,5	<0.1	3,5	<0.5	1370	15,9	0,5	10,0	<0.08
7	4,9	<0.1	10,8	2,1	5,4	<0.1	3,2	<0.5	1260	12,7	0,3	<10.0	<0.08
9	5,1	<0.1	9,5	2,1	4,7	<0.1	2,9	<0.5	1240	12,5	0,2	<10.0	<0.08
11	2,3	0,2	6,9	2,3	3,3	<0.1	2,6	0,6	1300	14,9	0,1	18,0	<0.08
14	1,7	<0.1	8,4	2,6	3,3	<0.1	4,4	<0.5	2200	21,2	0,3	21,0	<0.08
19	2,1	<0.1	9,3	3,2	4,1	<0.1	5,8	<0.5	2890	27,6	0,4	15,0	<0.08
21	1,7	<0.1	7,8	2,5	3,1	<0.1	4,1	<0.5	2230	23,9	0,2	11,0	<0.08
24	2,6	<0.1	10,5	3,2	4,0	<0.1	4,8	<0.5	2500	30,4	0,3	11,0	<0.08
30	15,4	<0.1	6,0	2,1	6,5	<0.1	5,8	<0.5	1500	15,0	0,4	<10.0	<0.08

Appendix VII
Moray R3 cable route benthic ecology characterisation
Sediment Chemistry Analyses Results

Analyte:	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene
Method Code:	PAH_MS-SIM_80	PAH_MS-SIM_80	PAH_MS-SIM_80	PAH_MS-SIM_80	PAH_MS-SIM_80	PAH_MS-SIM_80	PAH_MS-SIM_80
Units:	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Station ID							
3	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
7	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
9	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
11	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
14	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
19	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
21	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
24	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
30	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08

Appendix VII
Moray R3 cable route benthic ecology characterisation
Sediment Chemistry Analyses Results

Analyte:	Benzo[a]anthracene	Chrysene	Benzo[b]fluoranthene	Benzo[k]fluoranthene	Benzo[a]pyrene	Indeno[1,2,3-cd]pyrene
Method Code:	PAH_MS-SIM_80	PAH_MS-SIM_80	PAH_MS-SIM_80	PAH_MS-SIM_80	PAH_MS-SIM_80	PAH_MS-SIM_80
Units:	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Station ID						
3	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
7	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
9	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
11	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
14	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
19	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
21	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
24	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
30	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08

Appendix VII
Moray R3 cable route benthic ecology characterisation
Sediment Chemistry Analyses Results

Analyte:	Dibenzo[a,h]anthracene	Benzo[g,h,i]perylene	Total (USEPA16) PAHs
Method Code:	PAH_MS-SIM_80	PAH_MS-SIM_80	PAH_MS-SIM_80
Units:	mg/kg	mg/kg	mg/kg
Station ID			
3	<0.08	<0.08	<1.28
7	<0.08	<0.08	<1.28
9	<0.08	<0.08	<1.28
11	<0.08	<0.08	<1.28
14	<0.08	<0.08	<1.28
19	<0.08	<0.08	<1.28
21	<0.08	<0.08	<1.28
24	<0.08	<0.08	<1.28
30	<0.08	<0.08	<1.28