10 BENTHIC HABITATS AND ECOLOGY

10.1 The table below provides a list of all the supporting studies which relate to the benthic habitats and ecology impact assessment. All supporting studies are provided on the accompanying CD.

Details of study	Location on supporting studies CD
Benthic survey for Phase 1 of the MeyGen tidal stream energy project, Inner Sound, Pentland Firth (ASML, 2011)	OFFSHORE\Seabed interactions
MeyGen EIA Coastal Processes Modelling – Modelling setup, calibration and results (DHI, 2011)	OFFSHORE\Seabed interactions
Report of Survey for Atlantis Resources Corporation for Site Survey Stroma. JN3475 (IXSurvey Limited, 2009)	OFFSHORE\Seabed interactions

10.1 Introduction

10.2 This section assesses the effects of the Project on benthic habitats and ecology. A number of different specialists have contributed to this assessment:

- Aquatic Survey and Monitoring Limited (ASML) – seabed survey, video footage analysis, biotope mapping, seabed survey reporting;
- Hebog Environmental Limited - macrobenthic analysis Particle Size Analysis (PSA) and Loss on Ignition analysis;
- Health Protection Agency laboratory (Radiation and Environmental Monitoring Scotland) - assessment of radioactive contamination; and
- Xodus Group – baseline description, impact assessment and Environmental Statement (ES) section write up.

10.2 Assessment Parameters

10.2.1 Rochdale Envelope

10.3 In line with the Rochdale Envelope approach, this assessment considers the maximum ('worst case') Project parameters. Identification of the worst case scenario for each receptor (i.e. Environmental Impact Assessment (EIA) topic) ensures that impacts of greater adverse significance would not arise should any other development scenario be taken forward in the final scheme design. Table 10.1 describes the detail of the project parameters that have been used in this assessment and explains why these are considered to be worst case. The potential impacts from potential alternative Project parameters have been considered in Section 10.9.

Project parameter relevant to the assessment		'Maximum' Project parameter for impact assessment	Explanation of maximum Project parameter
Turbine	Physical parameters	N/A	Physical turbine parameters do not directly influence benthic ecology, however potential effects on water flow from the presence of the turbines is considered under the physical processes and sediment dynamics impact assessment and the results of this impact assessment are used to inform the benthic ecology impact assessment.
	Oil fluid inventory	1,500 litres	The tidal turbines will contain an inventory of fluids including oil, hydraulic fluid and coolant. Turbine inventories will be between 645 and 1,500 litres.
Turbine support structure	Maximum amount of drill cuttings released into the marine environment	86 monopile Turbine Support Structure (TSS)	The drilled monopile TSS will result in the maximum release of drill cuttings to the marine environment. Assuming the maximum number of 86 TSSs, the maximum amount of drill cuttings that can be generated from turbine support installations is 17,200m^2 (total for 86 TSSs).
	Maximum seabed footprint	86 Gravity Based Structure (GBS) TSS	The GBS TSS will result in the largest seabed footprint. Each GBS TSS has a maximum footprint of 40m x 30m. The total footprint for 86 turbines is 0.103km^2.
	Operations and Maintenance	No removal of TSSs required for routine operations and maintenance	It is assumed that no replacement or major TSS overhaul involving removal is required during the operational life of the Project.
	Decommissioning	86 Monopile	86 Monopile TSSs will be cut at the seabed. The bottom on the piles below the seabed will remain in-situ.
	Maximum amount of compressor lubricant released into the marine environment	86 monopile TSS	Monopile drilling operations will take approximately 4 hours per pile. A compressor is used to pump air into the drilled holes to lift cuttings clear. The lubricant will be discharged to sea along with the cuttings at a maximum rate of 5 litres per hour, i.e. 20m^3 per monopile and 1,720m^3 for all 86 installed over 3 years.
Cable connection to shore	Maximum cable footprint on seabed	86, 120mm unbundled cables each 1,300m in length with split pipe armouring	The maximum physical area of the seabed occupied by the cables has been calculated as 0.027km^2. Based on a maximum 1.3km of cable from Horizontally Directional Drilled (HDD) bore exit to turbine, and a cable diameter of 120mm (x2 to account for split pipe armouring) for 86 turbines. This assumes that the cables will emerge from the bores 700m from the shore.
	Decommissioning	86, 120mm unbundled cables, each 1,300m in length	All cables laid on the seabed will be fully removed at decommissioning.
	EMF (Electromagnetic Fields)	0.013km^2 of 6.6kV cables	The maximum area of the seabed affected by the magnetic field of the cables is 0.013km^2. Based on a maximum 1.3km of cable from HDD bore exit to turbine and maximum cable diameter of 120mm for 86 turbines.
Cable landfall	Maximum drill cuttings released into marine environment	29, 0.6m HDD bores, drilled from either Ness of Quoys or Ness of Huna	The majority of drill cuttings generated from the drilling of the HDD bores will be returned to shore and not discharged to sea; however it is estimated that the contents of the last 10m of each bore could be discharged to sea at the seabed breakthrough. Of the two potential HDD scenarios, the greatest potential volume of cuttings discharged to sea at breakthrough will result from last 10m of 29 boreholes of 0.6m diameter (82m^2).
Onshore Project components	-	N/A	As there are no proposed works in the intertidal area along the coast the onshore aspects of the Project do not influence the benthic habitats and ecology impact assessment.

Table 10.1: Rochdale Envelope parameters for the benthic habitats and ecology assessment

10.2.2 Area of assessment

10.4 It is also important to define the geographical extent of the assessment area. The focus of the benthic habitats and ecology assessment is potential impacts on seabed habitat and ecology of the offshore Project area and adjacent seabed (see Figure 10.2).

10.5 It should be noted that at the time of undertaking the assessment the exact distance from shore at which the HDD bores would emerge was considered to be between 700 and 2,000m, although the exact distance was unknown. The assessment here is based on the worst case where the cables emerge 700m from the shore.

10.3 Legislative Framework and Regulatory Context

10.3.1 Legislation

10.6 In addition to the EIA Regulations, the following legislation is relevant to the assessment of benthic habitats and ecology:

- Marine (Scotland) Act 2010;
- EU Habitats Directive (Directive 92/43/EEC);
- The Habitats Regulations 1994 (as amended in Scotland) implements species protection requirements of the Habitats Directive in Scotland, on land and in inshore waters; and
- UK Biodiversity Action Plan (UKBAP) – the UK Governments Response to the Convention on Biological Diversity (CBD), which the UK signed up to in 1992 in Rio de Janeiro.

10.7 The following sections provide further details on the specific types of marine habitats covered by the above list of conservation and management legislation.

10.3.2 European Habitats Directive

10.8 The European Habitats Directive lists 13 marine habitats and eight marine species in Annexes I and II respectively. To meet the requirements outlined in Article 3 of the European Habitats Directive, Special Areas of Conservation (SACs) have been designated in UK waters to contribute to the European network of important high-quality conservation sites that will make a significant contribution to conserving these species and habitats. Of those benthic habitats and species listed in Annex I and II of the Directive, there are three that have the potential to occur in the vicinity of the MeyGen Inner Sound Crown Estate Agreement for Lease (AfL) area:

- Sandbanks which are covered by sea water all the time;
- Large shallow inlets and bays; and
- Reefs (rocky and biogenic).

10.9 There are no SACs within a 40km radius of the MeyGen Inner Sound AfL area in the Inner Sound that have been designated for the presence of benthic habitats or species.

10.3.3 UK Biodiversity Action Plan (UKBAP)

10.10 The current list of UK Biodiversity Action Plan (UKBAP) priority habitats was published following a two-year review of the BAP process and priorities (Maddock, 2008). The Orkney Local Biodiversity Action Plan 2002-2007 (OLBAP) has been reviewed following its expiration and a further Plan (2008-2011) has been published which sets out to guide the conservation and enhancement of key features of biodiversity in Orkney over the coming years (OLBAP Steering Group, 2008). In addition a Caithness Local Biodiversity Action Plan (CLBAP) was published in 2003 by the Caithness Biodiversity Group (2003), where it states that “the plan attempts to set out what can be done in the next five to ten years”.

10.11 Those habitats and species previously recorded in the vicinity or with the potential to occur in and around the Pentland Firth include:

- Littoral caves and overhangs;
- Fragile sponge and anthozoan communities on subtidal (sublittoral) rocky habitats;
- Subtidal (sublittoral) sands and gravel;
- Tide-swept channels;
- Wave surge gullies and caves
- Blue mussel (*Mytilus edulis*) beds;
- Fan mussel (*Atrina fragilis*);
- Horse mussel (*Modiolus modiolus*) beds;
- Maerl beds;
- The molluscs *Devonia perrieri, Hydrobia elongata, Manzonia crassa* and *Simnia patula*;
- The sea-slugs *Hancockia unicinata* and *Okenia leachii;* and
- Native oyster (*Ostrea edulis*).

10.3.4 Priority Marine Features

10.12 The Marine Working Group of the Scottish Biodiversity Forum, responsible for the coordination of action in Scottish waters, was keen that the work already undertaken at a UK level (through the UKBAP review) be developed further. Scottish Natural Heritage (SNH) has reviewed a large number of marine habitats and species to identify those considered to be of greatest marine nature conservation importance in Scottish territorial waters; these have been termed Priority Marine Features (PMF). A draft list of PMF in inshore Scottish waters, including those for which future Marine Protected Areas (MPA) will be designated under the Marine (Scotland) Act 2010, has recently been drawn up and circulated for consultation (SNH, 2011). The list, which is provisional and thus subject to future revision, includes a number of marine habitats that may be present in the region of interest:

- Blue mussel beds;
- Burrowed mud;
- Flame shell beds;
- Horse mussel beds;
- Kelp and seaweed communities on sublittoral sediment;
- Maerl beds;
- Maerl or coarse shell gravel with burrowing sea cucumbers;
- Native oyster beds;
- Northern seafan communities;
- Seagrass beds;
- Shallow tide-swept coarse sand with burrowing bivalves; and

- Tide-swept algal communities.

10.3.5 The Convention for the Protection of the Marine Environment of the North East Atlantic

10.13 The Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR) is the mechanism by which 15 governments of western Europe work together to protect the marine environment of the North-East Atlantic. In 2003, the UK government committed to establishing a well-managed, ecologically coherent network of Marine Protected Areas (known as the OSPAR MPA commitment). Marine SACs designated under the European Habitats Directive have been submitted as the UK's initial contribution to the OSPAR network. A list of marine habitats and species considered to be under threat or in decline within the north-east Atlantic has been produced by OSPAR (OSPAR, 2008) and a number of the marine habitats and species on the list may also be present in the Pentland Firth area:

- Maerl beds;
- *M. modiolus* beds;
- *Ostrea edulis* beds;
- Sea-pen and burrowing megafauna communities; and
- Zostera beds.

10.4 Assessment Methodology

10.4.1 Scoping and consultation

10.14 Since the commencement of the Project, consultation on benthic ecology and habitats issues has been ongoing. Table 10.2 summarises all consultation relevant to benthic ecology and habitats. In addition, relevant comments from the EIA Scoping Opinion are summarised in Table 10.3, together with responses to the comments and reference to the ES sections relevant to the specific comment.

Date	Stakeholder	Consultation	Topic / specific issue
7th April 2011	Marine Scotland and SNH	Pre-Scoping meeting	EIA surveys and studies required and the data needs for each EIA study.
6th May 2011	Marine Scotland	Teleconference	Conference call to discuss scope of the baseline survey and potential requirements for future monitoring. Including consideration of aligning the baseline survey with future monitoring needs.
27th May 2011	Marine Scotland, statutory consultees and non statutory consultees	Submission of EIA Scoping Report	Request for EIA Scoping Opinion from Marine Scotland and statutory consultees and request for comment from non statutory consultees.
30th June – 2nd July 2011	Local stakeholders	Public Event - EIA Scoping	Public event to collate information/opinions on proposed EIA scope.
23rd June 2011	Marine Scotland	Marine Licence for seabed survey	Application for a Marine Licence to undertake a seabed survey. Licence (04233/11/0) received 22nd July 2011.
7th July 2011	Marine Scotland and SNH	Submission of document for comment	Submission of proposed seabed survey scope for review and comment by Marine Scotland and SNH.
22nd July 2011	Marine Scotland and SNH	Receipt of comments on seabed survey scope	Receipt of comments on the seabed survey scope from Marine Scotland and changes made to scope in order to address comments.
25th July 2011	Marine Scotland and SNH	Submission of response to seabed survey comments	Response to comments received on the seabed survey, addressing specific issues and responding to issues raised by Marine Scotland and SNH.
31st September 2011	Marine Scotland, The Highland Council, statutory consultees and non statutory consultees	Receipt of EIA Scoping Opinion	Receipt of response to EIA Scoping Report and other comments from non statutory consultees.
3rd October 2011	Marine Scotland	Project update meeting	Report on EIA progress including presentation of seabed survey results.
6th – 7th December 2011	Local stakeholders	Public Event – pre application consultation	Public event to communicate the findings of the EIA to local stakeholders.

Table 10.2: Details of consultation meetings undertaken in relation to benthic habitats and ecology

Name of organisation	Key concerns	Response	ES section within which the specific issue is addressed
Scottish Environment Protection Agency (SEPA)	A baseline assessment of existing subtidal (sublittoral) habitats and species should be submitted. This should include any UK Biodiversity Action Plan habitats and species.	Baseline subtidal (sublittoral) habitats survey undertaken to include UKBAP species and habitats.	Section 10.5 Baseline Description
SEPA	The ES should consider how the risks of introducing marine non-native species (MNNS) will be minimised.	MNNS will be considered within the ES and if required appropriate mitigation measures identified.	Section 10.6.5 Impact 10.4: Marine Non-Native Species (MNNS)
Scottish Natural Heritage (SNH)	Other potential impacts which should be considered include disturbance due to EMF and the barrier effect. Benthic and demersal species are more likely to be vulnerable to the potential barrier effects of EMF than pelagic species and should be considered accordingly. The ES should consider the vulnerability of different species (e.g. benthic/demersal/ pelagic/migratory), their likely levels of sensitivity, and to what extent cable protection or armouring can limit exposure to EMF.	Impact assessment includes consideration of EMF impacts, including reference to ongoing Marine Scotland research. Results form the research is currently unavailable and so have not been used to undertake the impact assessment.	Section 10.7.1 Impact 10.5 Electro-Magnetic Effects
SNH	We recommend that benthic ecology survey methodologies are submitted to Marine Scotland (MS) and Scottish Natural Heritage (SNH) for comment. The applicant should check for Annex I habitats, and/or Priority Marine Features during survey work as well as any BAP habitats and species.	Benthic survey undertaken and proposed scope sent to Marine Scotland and SNH for comment prior to the survey. Any annex I habitats and priority marine features highlighted through survey work have been considered.	Section 10.4.6 Aquatic Survey and Monitoring Ltd (ASML) Survey Section 10.5 Baseline Description
SNH	Consideration should be given to future seabed monitoring during the phasing of the proposed development. The ES should identify and where possible seek to mitigate any significant negative impacts on any protected habitats and species identified.	Mitigation measures and future seabed monitoring strategies will be presented in the ES.	Section 10.6 Impacts During Construction and Installation Section 10.7 Impacts during Operation and Maintenance, Section 10.8 Impacts during Decommissioning
SNH	Bedrock, boulder and cobble reefs would fit under Annex I 'reefs' and a major element of the benthic survey should be establishing the flora and fauna associated with these areas.	Comment noted and taken into account during the impact assessment.	Section 10.4.6 Aquatic Survey and Monitoring Ltd (ASML) Survey Section 10.5 Baseline Description

Name of organisation	Key concerns	Response	ES section within which the specific issue is addressed
SNH	We recommend that the ES presents clear information on, and identification of, the main biotopes found on-site. We note that MS survey details were not available for inclusion in the EIA Scoping Report. Key results and interpretation of data from this survey should be included within the ES.	Biotope map has been produced and will be used to inform ongoing design/array layout. The Marine Scotland data is now available for use and has been used to inform the EIA.	Section 10.5.3 Species and Biotopes

Table 10.3: Scoping and consultation relevant to benthic ecology

10.4.2 Desk based study

10.15 To inform both this assessment and the scope of the seabed survey that feeds into this assessment, a desk-based review of existing data sources was conducted. The ultimate aim of this exercise was, in association with significant local experience of the area, to provide advice on the habitats and species that may be present in the Project development area and wider region. This review has been used as the basis of the summary of key sensitivities provided in the Baseline Description (Section 10.5). This review relied on a number of published data sources, which include:

- Preliminary assessment of the conservation importance of benthic epifaunal species and habitats of the Pentland Firth and Orkney Islands in relation to the development of renewable energy schemes (Moore, 2009, 2010);
- Assessment of the conservation importance of species and habitats identified during research cruises within the Pentland Firth and Inner Sound (Moore and Roberts, 2011);
- Marine Scotland Interactive (Marine Scotland, 2011);
- Scottish Marine SEA (Scottish Executive, 2007); and
- UKSeaMap interactive map (JNCC, 2010).

10.4.3 Field studies

10.4.4 Marine Scotland

10.16 To support the development of wave and tidal energy developments in the Pentland Firth and Orkney waters, the Scottish Government through Marine Scotland conducted a number of seabed surveys in the area. These include a number of surveys conducted by the Fisheries Research Services (FRS), now Marine Scotland Science, in the Pentland Firth and Orkney Waters between 2006 and 2008, where both video footage and stills images were collected (Hayes, 2009). Analysis of the footage and photographs was reported by Moore (2009; 2010) and Moore and Roberts (2011). Footage taken by FRS is available to download from the Marine Scotland Website (Marine Scotland, 2011) and view through Google Earth. The coverage of these surveys is shown in Figure 10.1.

10.4.5 iXSurvey

10.17 In addition to these wider surveys of the Pentland Firth, Atlantis Resources Corporation (a Joint Venture partner within MeyGen) contracted iXSurvey Limited to undertake a geophysical site survey of the Inner Sound (iXSurvey, 2009). The results of this survey have been used to provide an indication of the seabed substratum present in the Project development area (Section 9, Figure 9.12, Figure 10.4).

10.4.6 Aquatic Survey and Monitoring Ltd (ASML) Survey

10.18 MeyGen appointed Aquatic Survey and Monitoring Ltd (ASML) to undertake a benthic seabed survey. The survey approach was based on a combination of remote video/stills photography, grab and dredge sampling, developed using the geophysical survey outputs (iXSurvey, 2009), from which the benthic habitats and species of the Project development area could be described using the biotope classification system of Connor *et al* (2004). The survey comprised the following:

- A drop down video and photographic survey to note seabed type (substratum) and the epibenthic biotopes present by collecting information from a number of video transects and drops, This approach was used over the whole survey area, and in particular those areas known from iXSurvey (2009) to consist predominantly of rock and which could therefore not be sampled in any other way;
- A grab survey to sample the infaunal community types in any sediment that exists in the vicinity and to determine baseline sediment particle size distribution. Additional grabs were also taken to collect sediment samples for analysis of radioactivity;
- A qualitative pipe-dredge survey was undertaken in locations where gravel beds were predicted, in order to sample any epifauna and interstitial fauna present in these ‘hard to sample’ substrates; and
- Collection of sediment bedload samples (along with water samples) for analysis and reporting by the DHI.

10.19 The geographical extent of the survey in relation to the offshore Project development area is shown in Figure 10.2. The shallowest depth reached during the survey was 15m. The survey area covers the whole of the turbine deployment area and extends to the point at which the boreholes for the export cables will emerge form the seabed (700m offshore) if the worst case scenario is considered[1].

[1] Worst case in this context refers to the shortest distance to the shore at which cables may emerge. Working with this shortest distance results in the longest possible length of cable and thus the largest likely area of seabed impact.

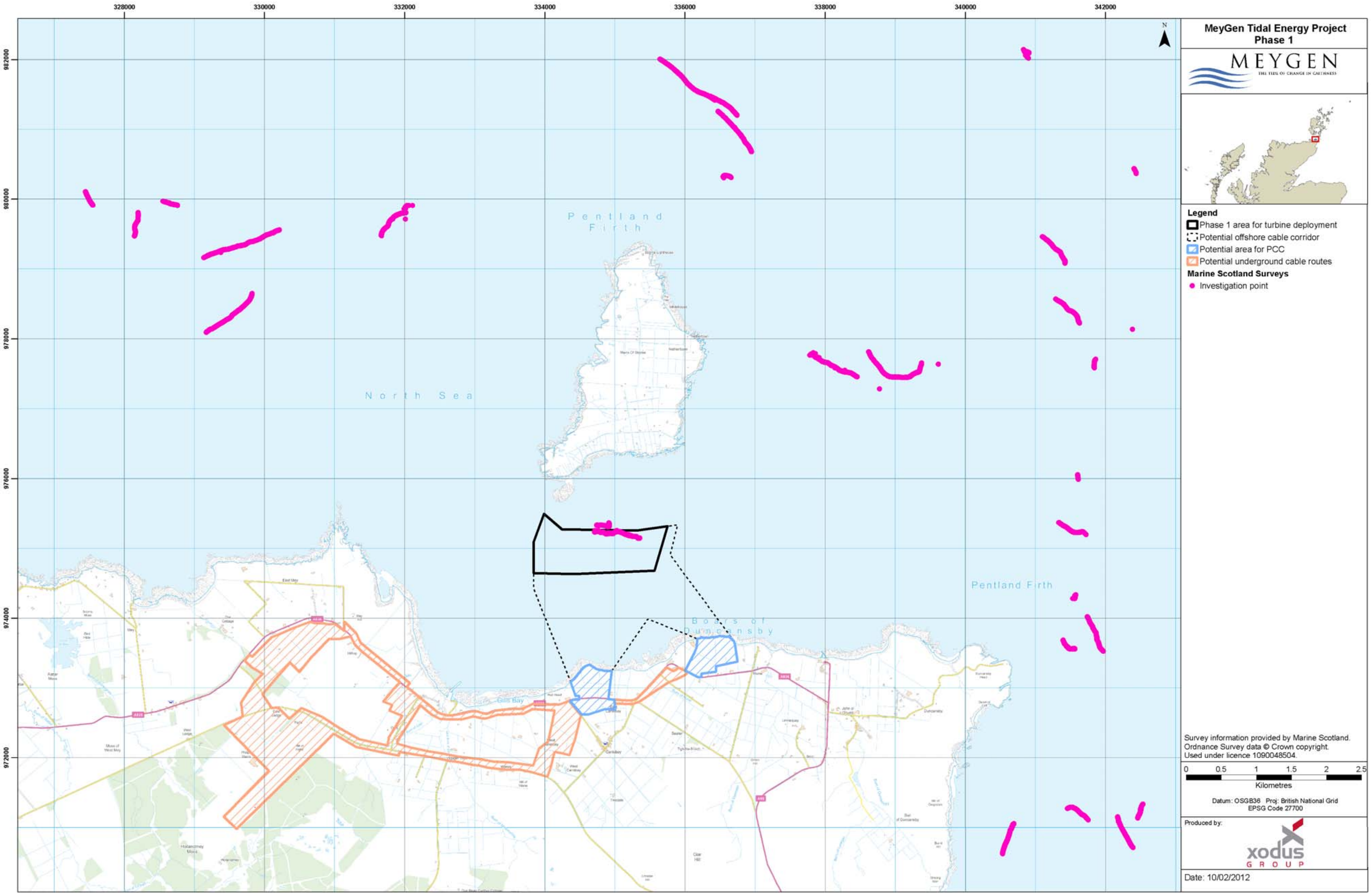


Figure 10.1: Coverage of the Marine Scotland surveys in relation to the offshore Project development area (Marine Scotland, 2011)

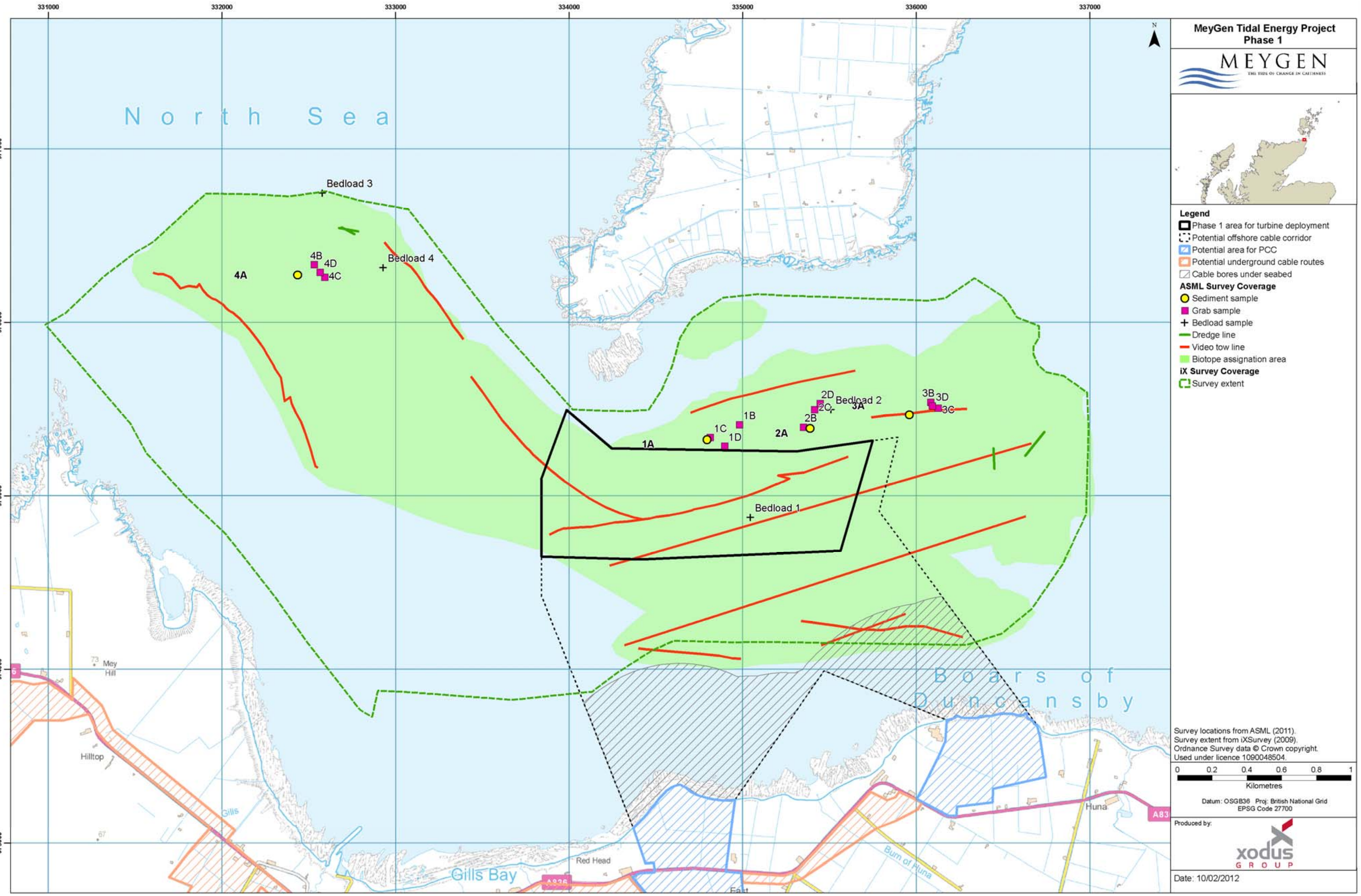


Figure 10.2: Extent of benthic environmental survey coverage and sample stations (ASML, 2011)

10.4.7 Significance criteria

10.20 The EIA process and methodology are described in detail in Section 8. Each assessment section is, however, required to develop its own criteria for the 'sensitivity of receptor' and 'magnitude of impact' aspects since the definition of these will vary between different topics. For benthic ecology, the significance criteria used in this section is based on the methodology described in Section 8 but the sensitivity of the receptor and magnitude of impact are defined in Table 10.4 and Table 10.5 respectively.

10.21 The consequences of impacts are then considered by reference to the relevant criteria in the EIA Regulations. The significance of impacts in relation to the EIA Regulations is defined in Section 8, Table 8.2.

Sensitivity of receptor	Definition
Very High	▪ Sites of international designation (e.g. SAC) or species/assemblages which form qualifying interests of internationally designated sites. ▪ Globally threatened species or habitats (e.g. IUCN list). ▪ Species which are considered to be present in internationally important numbers or habitats comprising an internationally important proportion of that habitat. ▪ Site contains high density of numerous PMF species or habitats.
High	▪ Nationally important sites (e.g. SSSI) or species/assemblages which form qualifying interests of nationally designated sites. ▪ Species/assemblages which contribute to an international site but which are not listed as qualifying interests. ▪ Ecologically sensitive species/habitat (e.g. rare) or present in nationally important numbers/area. ▪ Site contains moderate density of numerous PMF species or habitats.
Medium	▪ Sites of local value. ▪ Presence of Annex I habitats or Annex II species of the European Habitats Directive. ▪ Species present in regionally important numbers. ▪ Species/assemblages which contribute to a national site but which are not listed as qualifying interests. ▪ Species occurring within international/national sites but are not crucial to the integrity of the site. ▪ Species listed as priority species in the UKBAP. ▪ Site contains one or more PMF species or habitats.
Low	▪ Sites not containing features that would meet the criteria for sites of local value, but nevertheless having some biodiversity value. ▪ Any other species of conservation interest (e.g. LBAP species).
Negligible	▪ Habitat/species of no conservation concern.

Table 10.4: Definitions for sensitivity of receptor

Magnitude of impact	Definition
Severe	▪ Widespread total loss or very major alteration to species and habitat such that the condition of features of qualifying interest will be fundamentally altered. ▪ Little or no recovery anticipated. ▪ Impact highly likely to occur.
Major	▪ Widespread change to characterising species or lasting change to habitat leading to medium-term damage. ▪ Recovery anticipated after several years following decommissioning. ▪ Impact likely to occur.
Moderate	▪ Change to benthic species in a localised area (confined to project footprint and immediate locality) for project duration, but no lasting change to habitat. ▪ Good recovery potential following decommissioning (approximately 2 years). ▪ Impact will possibly occur.
Minor	▪ Change from baseline conditions measurable but within scale of natural variability, and confined to project footprint. ▪ Temporary alteration or effects confined to a small percentage of available habitat, with rapid recovery likely. ▪ Impact unlikely to occur.
Negligible	▪ Imperceptible or no changes to the baseline condition. ▪ Impact extremely unlikely to occur.
Positive	▪ An enhancement of an ecosystem or population parameter.

Table 10.5: Definitions for magnitude of impact

10.4.8 Data gaps and uncertainties

10.22 The seabed of much of the Inner Sound was surveyed to provide a comprehensive baseline, encompassing the maximum area possible for the offshore project footprint (for both direct and indirect impacts). The seabed survey was undertaken during neap tides to enable good quality data to be collected and to ensure maximum time available on location by suitably qualified and experienced consultants. It is therefore likely that the majority of species and habitats were visible and could be enumerated. However, the survey was constrained by the environmental conditions at the site, including poor weather conditions on the first day and the change in tidal conditions as the survey progressed.

10.23 Where tidal currents increased above a certain threshold the footage became less clear. However, in most instances it was still possible to identify the biotopes, species and habitats present. When the footage became unclear recording was stopped and a suitable tidal window was selected for restarting the survey. This constraint may have contributed to some limitations in the recording of habitats and species, with some biotopes surveyed in more detail than others.

10.24 The actual delineation of the different biotopes was made based on the seabed types recorded from the geophysical survey (iXSurvey, 2009) in combination with the footage from the benthic survey (ASML, 2011). Instead of being discrete boundaries between biotopes it is more likely that these boundaries represent broader transition zones. In addition, it is likely in some areas that the biotopes are a mosaic of two or more similar biotopes rather than the monoculture described from the benthic survey.

10.25 With regards to the impact assessment, information on the specific sensitivity of a number of the biotopes to a number of the possible impacts and on the recovery rates following impact is not available. Instead, a combination of expert knowledge and the known sensitivities of similar habitats have been used, with information from similar developments considered to corroborate conclusions on possible impact.

10.5 Baseline Description

10.5.1 Introduction

10.26 A desk-based review of existing data sources was conducted in order to identify habitats and species of conservation concern that may be present over the offshore Project development area and surrounding waters. Other publications and survey reports relevant to the region have also been reviewed which, when combined with the site-specific surveys, provide a comprehensive baseline of the offshore Project development area.

10.5.2 Seabed and sediments

Regional context

10.27 BGS (1990) indicates that the sea floor between Helmsdale (to the south) and Dunnet Head (to the west) slopes away from the coast to a depth of approximately 60m at a distance between 5km and 10km from shore. RPS Energy (2009) indicates that the seabed depth ranges from 30m to 40m with a shallower slope angle on the Caithness shore than the Stroma shore. Depths greater than 30m are found within 500m of the Stroma shoreline.

10.28 Very little historical information exists to describe the seabed and sediments present in the offshore Project development area and surrounding waters. There are a number of wide scale sediment and habitat mapping programmes that have been conducted in UK, one of which is the JNCC UKSeaMap programme that provides an overview of the sediments and habitats likely to be present in areas of the North Sea and northern Scotland (JNCC, 2010), building upon previous datasets on sediment and habitats distribution from the MESH (Mapping European Seabed Habitats) programme. The predictive habitat mapping conducted by the UKSeaMap programme is not at a resolution that includes the Inner Sound. However, for the wider Pentland Firth JNCC UKSeaMap predictive habitats data (JNCC, 2010) suggests the habitat present to be composed of rock.

10.29 The high velocity tidal currents within the sound (maximum mean flow of four to five ms^{-1}) have scoured the Quaternary deposits and seabed soils from the study area. In consequence, seabed sediments are largely restricted to cobble and boulder grade sediments, which are too heavy to transport far (RPS Energy, 2009).

10.30 Following review of the Marine Scotland footage (Section 10.4.4) that was analysed and reported by Moore (2009; 2010) and Moore and Roberts (2011) analysis suggests that the seabed of the wider Pentland Firth consists of rock or a mix of bedrock and boulders, where the boulders often lie on coarse shelly sand (or gravel) or the coarse sediment is trapped between boulders.

Site-specific details

10.31 Five video transects and associated stills images were taken by Marine Scotland within the Inner Sound in 2009 and 2010 (Figure 10.3). A review of this footage indicates that the seabed at the northernmost stations (e.g. Gills Bay Run 2, Figure 10.3) is heterogeneous and composed of shell gravel with small outcrops of scour-polished rock. The more southerly stations (e.g. Gills Bay TV 1, Figure 10.3) show a markedly different seabed, with complex, uneven, fissured bedrock and boulders in gulleys and lows. Occasional pockets of sediment are present in these fissures with one extensive area of shell gravel with adjacent rock polished by scour. The Marine Scotland surveys are discussed further in the Physical Environment and Sediment Dynamics section (Section 9). Moore and Roberts (2011) analysed this data and the results demonstrated that the area mainly consisted of uneven, fissured bedrock with boulders collecting in gulleys and lows. There were also areas of shell gravel and coarse sand, with coarse material also collecting in rock fissures and lows. Rock adjacent to major sediment pockets was observed to be polished smooth by the scour.

10.32 The iXSurvey, the results of which are fully summarised in the Physical Environment and Sediment Dynamics section (Section 9), covered an area of 11.4km^2 between Duncansby Head and Stroma (Section 9, Figure 9.12). iXSurvey (2009) reported that the majority of the seabed comprised current-scoured bedrock that exhibits a “saw tooth” profile. Within the area surveyed, approximately 70% of the seabed (7.8km^2) consisted of bedrock with an irregular topography, considered to be a result of differing rock types and the different rates of erosion that these rock types show. This confirms the British Geological Society (BGS) report that the geology of the Inner Sound is composed largely of exposed Devonian (Old Red Sandstone) bedrock (BGS, 1990). This seabed type was present throughout the central portion of the survey area. Subrock, defined as rock at or near the seabed surface, contributed a further 12% (1.4km^2) of the seabed in the survey area. This seabed type was found in a number of patches both directly south of and to the southwest of Stroma. These results are similar to those gained from video and still images collected by Marine Scotland within the Inner Sound in 2009 and 2010.

10.33 As outlined above, the more detailed information from the geophysical site survey (iXSurvey, 2009) indicates that the majority of the seabed is comprised of current-scoured bedrock with patches of sand, megarippled sand and sandbanks with coarse gravel only present in isolated patches directly south and south-west of Stroma. Specifically, 10% (1.1km^2) of the seabed is made of isolated megarippled sand or sandbanks whilst coarse gravel forms the remaining 7% (0.8km^2) of the survey area (Section 9, Figure 9.12).

10.34 Areas of sand accumulation and migration are present in the north-eastern regions of the geophysical survey area (Section 9, Figure 9.12) as well as a localised area in the north-west. These sand bodies rest upon underlying bedrock which is otherwise exposed at the seabed in the remainder of the site. These regions commonly exhibit numerous megaripples, with wavelengths of up to 20m and heights of between 0.2 and 0.5m. In the far north-east of the survey area two discrete sand waves occur within a large sandbank, with wavelengths up to 140m and heights of 10m (Section 9, Figure 9.12). The maximum sediment thickness observed at this sandbank was approximately 15.5m. In the lee of Mell Head (Section 9, Figure 9.12) on the Island of Stroma sediments have accumulated to form an extensive sandbank.

10.35 Deposits of coarse gravel are present in the north-western, north-eastern and eastern parts of the survey area (Section 9, Figure 9.12). These deposits directly overlie bedrock and vary in thickness from a thin veneer, to ridges up to 5m deep in the far east of the survey area (Section 9, Figure 9.12). Numerous seabed anomalies were identified to occur throughout the survey area. These could be interpreted as either seabed irregularities or isolated glacial erratic boulders up to 1.1m in height (Section 9, Figure 9.12).

10.36 The seabed over the area where the current speeds are highest consists of scoured bedrock platform. There is a series of low ridges or steps within and around this area that comprise extensive areas of smooth, fissured rock which dipped down towards the east and had small vertical faces on the western side. The vertical faces of these are approximately 2m high and they had large numbers of crevices, fissures and overhangs likely to provide a variety of microhabitats for fauna. At the base of each face are boulders, cobbles and lumps of broken bedrock with occasional patches of clean shell gravel; these boulders generally cover the lower part of the next ridge. This seabed topography in the centre of the Sound (including the turbine deployment area) can be expected to create localised areas of shelter behind and below the rock faces whereas the tops of the ridges are exposed to the strongest currents.

10.37 The ASML survey (ASML, 2011) conducted in the offshore Project development area and surrounding waters collected sediment samples at four sites (Figure 10.2) and results of the associated analysis are presented in Figure 10.4 and Table 10.6. The results of the particle size analysis (PSA) suggest that the sediment at the sample sites is largely composed of very coarse sand or very fine gravel, with three of the four sites showing a predominance of gravel over sand. From observations made during sampling, the sediment collected for this analysis was made up completely of shell material (carbonate) and appeared devoid of organic matter. As the PSA samples consisted of clean shell fragments a very low organic content was expected; indeed, ASML (2011) state that laboratory techniques were unable to quantify the organic content due to the content of the sediment being so low. The ASML grab sampling (ASML, 2011) appears to confirm the interpretation of the geophysical data collected by iXSurvey (2009).

Sediment	Size	Phi	1A	2A	3A	4A
Medium pebble (gravel)	>8mm	< -3	5.3	0	0	8.4
Small pebble (gravel)	4 to 8mm	-2 to -3	21.52	2.46	8.82	20.93
Granule (very fine gravel)	2 to 4mm	-1 to -2	50.66	36.8	44.03	45.26
Sand (very coarse)	1 to 2mm	0 to -1	22.47	56.07	43.8	24.77
Sand (coarse)	500 to 999µm	1 to 0	0.02	4.59	3.31	0.61
Sand (medium)	250 to 499µm	2 to 1	0.01	0.04	0.02	0.02
Sand (fine)	125 to 249µm	3 to 2	0.01	0.01	0.01	0.01
Sand (very fine)	63 to 125µm	4 to 3	0	0.01	0.01	0.01
Silt & Clay	<63µm	>4	0	0.01	0	0

Table 10.6: PSA results from the benthic survey (ASML, 2011)

10.38 Preliminary suspended sediment results from the ASML survey data suggest a range of between 10 and 14mgl^{-1} (Table 10.7). The bedload (that is the particles transported along the seabed by water movement) is comprised almost exclusively of very fine sand upwards with a near absence of silt and clay (ASML, 2011).

Measurement	Station			
	1	2	3	4
Water Volume (ml)	2,000	1,930	1,895	1,960
Suspended sediment mass (mg dry weight)	20.9	26.5	21.5	23.1
Suspended sediment (mgl^{-1})	10	14	11	12

Table 10.7: Suspended sediment results from the benthic survey (ASML, 2011)

10.5.3 Species and biotopes

Regional context

10.39 The communities identified on rock (or a mix of bedrock and boulders) during the Marine Scotland surveys in the wider Pentland Firth area are generally of low diversity and are strongly dominated by current and scour-resistant species such as the acorn barnacle (*Balanus crenatus*) and the dahlia anemone (*Urticina felina*). The species distribution is strongly influenced by the variation in current conditions, creating a mosaic of assemblages. The communities to the west of Stroma (sampling stations for which are shown in Figure 10.1) presented an exception to the general pattern of extremely tideswept circalittoral rock communities in the main channel of the Pentland Firth. Here, the seabed is predominantly medium or coarse sand, often formed into waves and sometimes with a surface scatter of pebbles, cobbles and small boulders; these stations were assigned the biotope code of SS.SCS.CCS (circalittoral coarse sediment). In his analysis of the footage, Moore (2009, 2010) and Moore and Roberts (2011) recorded that the sand is likely to be highly mobile and that the video evidence suggests it supports little life. In this same area, where occasional large boulders were present, the sand-scoured habitat supported large *U. felina* as well as scattered patches of the bryozoan hornwrack (*Flustra foliacea*) and hydroid clumps, described by the biotope designation CR.MCR.ECCR.UrtScr (*U. felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock).

10.40 The communities reported by Moore (2009) to the west of Stroma were also identified by additional review and analyses of FRS footage to the west and east of Stroma by Moore (2010). One video to the west of Stroma (sampling stations for which are shown in Figure 10.1) was also assigned the biotope SS.SCS.CCS (circalittoral coarse sediment), where the substratum of shelly medium sand formed into waves had no evidence of infauna. Analyses of one video run approximately 2.5km to the east of Stroma found that the seabed consisted of sand-scoured bedrock outcrops and boulders on shell gravel (Moore, 2010). The community there was considered to be a patchwork of biotopes but most similar to CR.HCR.FaT.CTuB (*Tubularia indivisa* and cushion sponges on tide-swept turbid circalittoral bedrock). The biota varied according to localised differences in sand scour and current strength, but was characterised by profuse numbers of *U. felina*. Elevated upward facing rock was generally species-poor with a barnacle crust, scattered *U. felina*, bryozoans, hydroid clumps, *T. indivisa* and sparse occurrences of the sponge *Pachymatisma johnstonia*.

Site-specific details

10.41 The above surveys give a summary of what is present in surrounding waters and provides for an initial, crude assessment of what may be present in the offshore Project development area. However, it is only site-specific surveys that can confirm these initial hypotheses; the results of these surveys are described herein.

10.42 In addition to the footage interpreted and reported by Moore (2009; 2010) and described above, a further five videos and associated stills images were taken by Marine Scotland within the Inner Sound, south of Stroma. A review of this footage indicates that the seabed to the southeast of Stroma is heterogeneous in nature and consists of uneven, fissured bedrock with boulders collecting in gulleys and lows (Moore & Roberts, 2011). There are also extensive areas of shell gravel and coarse sand, with coarse material also collecting in rock fissures and lows, whilst rock adjacent to major sediment pockets was observed to be polished smooth by the scour (Moore & Roberts, 2011). Over most of the area the rock was dominated by a crust of *B. crenatus* (although mostly dead in places) and abundant *U. felina* (Moore & Roberts, 2011). Young *Cancer pagurus* was locally abundant[2] but *Nucella lapillus* was observed as sparse in distribution (Moore & Roberts, 2011). At some sites there was extensive coverage of the rock by a yellow encrusting sponge, with lesser quantities of other sponges such as *Esperiopsis fucorum* and *Hymedesmia paupertas* (possible) and a patchy bryozoan turf (Moore & Roberts, 2011). Apparently sparse members of the community included polyclinid cushions, dead men's fingers (*Alcyonium digitatum*) and hydroid patches (Moore & Roberts, 2011). Other more mobile fauna included the common sea urchin (*Echinus esculentus*), and the starfish *Asteroidea* spp. indet, and *Henricia* sp. The biotope has been referred to CR.HCR.FaT.CTub (*Tubularia indivisa* and cushion sponges on tide-swept turbid circalittoral bedrock), although the characterising species *T. indivisa*, appeared to be only present at low density (Moore & Roberts, 2011). Areas of coarse sediment SS.SCS.CCS (circalittoral coarse sediment) are expected to be highly mobile and show no evidence of life (Moore & Roberts, 2011).

10.43 The biotopes across the survey area have been defined and described based on the ASML (2011) data. A list of the biotopes found in the offshore Project development area, including title, description of the main species present, depth range and a photograph, is given in Table 10.10. The distribution of biotopes over the offshore development area and surrounding waters in Inner Sound is shown in Figure 10.5. As would be expected from the large areas of exposed bedrock, the largest biotopes by coverage are those associated with exposed and broken rock surfaces. The largest biotope by area in the offshore Project development area is CR.HCR.FaT.BalTub (*B. crenatus* and *T. indivisa* on extremely tide-swept circalittoral rock), which is very similar to the CR.HCR.FaT.CTub (*Tubularia indivisa* and cushion sponges on tide-swept turbid circalittoral bedrock) biotope found in the area by the Marine Scotland surveys. CR.HCR.FaT.CTub (*Tubularia indivisa* and cushion sponges on tide-swept turbid circalittoral bedrock) was also recorded by the ASML survey, although not in exactly the same areas found by the Marine Scotland survey; this is a result of the likely patchy nature of the biotopes in that the seabed will at times be a mosaic of two or more closely related biotopes, especially around the limits (e.g. depth, water flow) of the biotope. It does not signify any major difference in communities present and has no bearing on the conservation significance of the area. The SS.SCS.CCS (circalittoral coarse sediment) biotope recorded by ASML (ASML, 2011) in the north east of the Project area was also recorded from the wider area by the Marine Scotland surveys and is certainly not locally restricted to the AfL area. ASML (2011) report that the observations made from the five MarineScotland surveys by Moore & Roberts (2011) tallied very closely with those of the present survey.

2 Note that the Pentland Firth and Orkney Waters area has been identified as a possible important nursery ground for this species (Moore, 2009).

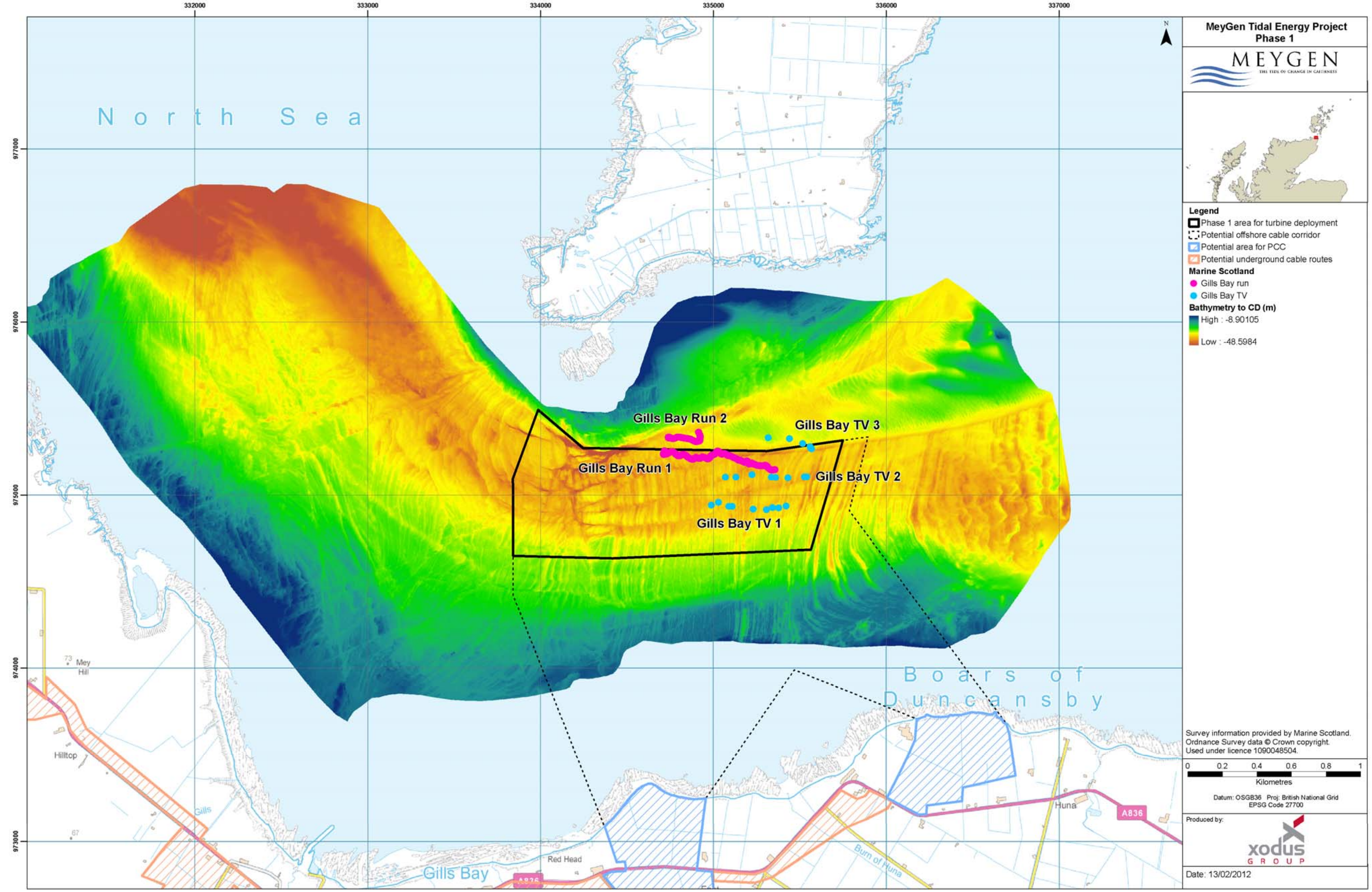


Figure 10.3: Marine Scotland coverage and relevant survey positions (Marine Scotland, 2011)

10.44 Within the cable corridor, south of the turbine deployment area where the seabed shoals towards the mainland shore, upward-facing bedrock and boulders becomes characterised by large brown seaweeds of the genus *Laminaria*, or kelp. The deepest water in which kelp was recorded was approximately 25m (ASML, 2011) but it will be the shallower waters within which the kelp plants form 'kelp forests' that are characteristic of exposed shallow waters in Scotland and much of the UK (note that the ASML survey did not differentiate between kelp forest and kelp park biotopes). The specific kelp biotope identified in Inner Sound (IR.HIR.KFaR.LhypFa) is found often on exposed and very exposed wave-surged, upper infralittoral bedrock and massive boulders. It is characterised by a dense forest of the kelp *Laminaria hyperborea* and a high diversity of seaweeds and invertebrates (Connor *et al*., 2004). The shallowest kelp plants are often short or stunted, while in deeper water the plants are taller with stipes[3] heavily covered with foliose red seaweeds, some of which are found on the rock below the canopy. Encrusting coralline algae can cover any bare patches of rock (Connor *et al*., 2004) in between kelp plants. The faunal composition of this biotope varies markedly between sites, but commonly occurring are the soft coral *A. digitatum* and the anthozoans *Sagartia elegans* and *Corynactis viridis* (Connor *et al*., 2004). The hydroid *Obelia geniculata*, the ascidian *Botryllus schlosseri* and the bryozoan *Membranipora membranacea* compete for space on the kelp fronds, whereas the bryozoan *Electra pilosa* can be found on the holdfasts and on the epiphytic foliose red algae. Similar 'kelp forest' biotope is found on suitable rocky habitat around the entire Scottish coastline but is particularly extensive around Skye and the adjacent mainland, along the west coast of the Outer Hebrides, and around Orkney and Shetland. The biotope is also found on the west coast of England, Wales and Ireland (JNCC, Undated).

10.45 Other biotopes have been described associated with the areas of boulders and sediment; these, along with the other biotope designations, are described in Table 10.10. The proportion of the Project area covered by differing biotopes and the percentage of the offshore Project area (turbine deployment and cable route areas) that is covered by each of the biotopes, as well as the infrastructure that may be coincident with those, is shown in Table 10.11. The conservation status of the biotopes is noted also. Results for macrofaunal analysis from the MeyGen commissioned environmental survey (ASML, 2011) show that nearly 8,000 individuals belonging to 104 species were recorded from 12 grab samples (Table 10.8), all from the SS.SCS.CCS (circalittoral coarse sediment) biotope. This biotope is the only sedimentary biotope found in the survey area and is only found in a small area in the northeast of the turbine and cable area. However, it is not found within the location within which the turbines will be deployed and as such, it can be used to consider the wider area but is not an indication of what will specifically be found at the turbine locations. An average of around 600 individuals and 23 species were found at each station, although the values at each ranged between 222 and 999 individuals and 16 and 38 species (Table 10.8). Of the 104 different species found, 30 belong to the annelids, 22 to the bryozoans and 18 to the crustaceans. Other notable contributions by species number included the molluscs (11) and cnidarians (8). The remainder (porifera, platyhelminthes, nemertea, nematoda, chaetognatha. chelicerata, echinodermata, tunicate and pisces) contributed up to three species to the overall total.

	Station												Average
	1B	1C	1D	2B	2C	2D	3B	3C	3D	4B	4C	4D	
Individuals	547	349	439	1,269	358	222	815	713	547	280	999	788	611
Species	29	21	19	24	25	22	18	16	17	19	38	31	23
Top five species by individual number	*Socarnes erythrophthalmus* Turbellaria *Saccocirrus papillocercus* *Spadella cephaloptera* Nematoda			Turbellaria *Saccocirrus papillocercus* *Spadella cephaloptera* *Socarnes erythrophthalmus* *Leptocheirus pectinatus*			*Saccocirrus papillocercus* Turbellaria *Leptocheirus pectinatus Spadella cephaloptera* Nematoda			Turbellaria *Liljeborgia pallida* *Microcharon harrisi* *Spadella cephaloptera* *Leptocheirus pectinatus*			

Table 10.8: Species results from the sediments surrounding the offshore Project development area (ASML, 2011)

3 The holdfast anchors the kelp plant to the seabed whilst the stipe extends upwards like a plant's stem and supports the fronds (leaf-like structures).

10.46 The communities in each of the grab samples were all found to be very similar, being dominated by interstitial organisms In numerical terms, the platyhelminthe Turbellaria (1,921 individuals) and annelid *Saccocirrus papillocercus* (1,662 individuals) dominated. Other characteristic species included unidentified nematoda, the arrow worm *Spadella cephaloptera*, the polychaete *Ophryotrocha* sp., the amphipods *Socarnes erythrophthalmus*, *Liljeborgia pallida*, *Leptocheirus pectinatus* and the isopod *Microcharon harrisi*. Most of these taxa are characteristic of coastal benthic habitats, and the amphipods and isopod in particular are known from coarse sandy and shelly substrata around the UK. In the UK, the polychaete genus *Ophryotrocha* has been associated with an opportunistic lifestyle in organically enriched areas of oil-contaminated sandy mud around oil and gas installations (e.g. Connor *et al*., 2004). Worldwide, this genus is also associated with opportunistic occurrence, often in high numbers in low diversity communities, in a variety of habitats (Thornhill *et al*., 2009). Its occurrence in the coarse tidally swept sediments of Inner Sound may be linked more to inhospitability of the habitat to most other species, than to organic enrichment.

10.47 Many small fragments of sponges, bryozoans and ascidians were also present, but these were assumed to be transient drift material and continually swept in from the nearby reef biotopes by the strong tidal currents in the Sound (ASML, 2011).

10.48 There were very few species recorded in each of the dredge samples, with a total of 51 species from nine phyla recorded (Table 10.9). The samples were dominated by bryozoans, particularly encrusting bryozoans on dead shells, crustaceans, hydroids and molluscs with one tunicate *Polyclinum aurantium* found in all the samples. Species found included the hydroid *Sertularia argentea*, an amphipod *Gammaropsis* sp., a small mussel *Modiolula phaseolina* and the encrusting bryozoans *Parasmittina trispinosa*, *Celleporella hyalina* and *Cellepora pumicosa*. The erect bryozoans *Flustra foliacea* and *Securiflustra securifrons* were both present in two samples in moderate quantities, confirming the video results

Phylum	Dredge Station				Total species
	D1A	D1B	D2A	D2B	
Cnidaria	1	6		1	6
Nemertea		1			1
Annelida		4	3	1	6
Chelicerata		1			1
Crustacea	2	9	5	2	13
Mollusca	3	4		5	7
Bryozoa	6	9	6	4	14
Echinodermata		2			2
Tunicata	1	1	1	1	1
Total species	13	37	15	14	51

Table 10.9: Species results from the dredge samples surrounding the offshore Project development area (ASML, 2011)

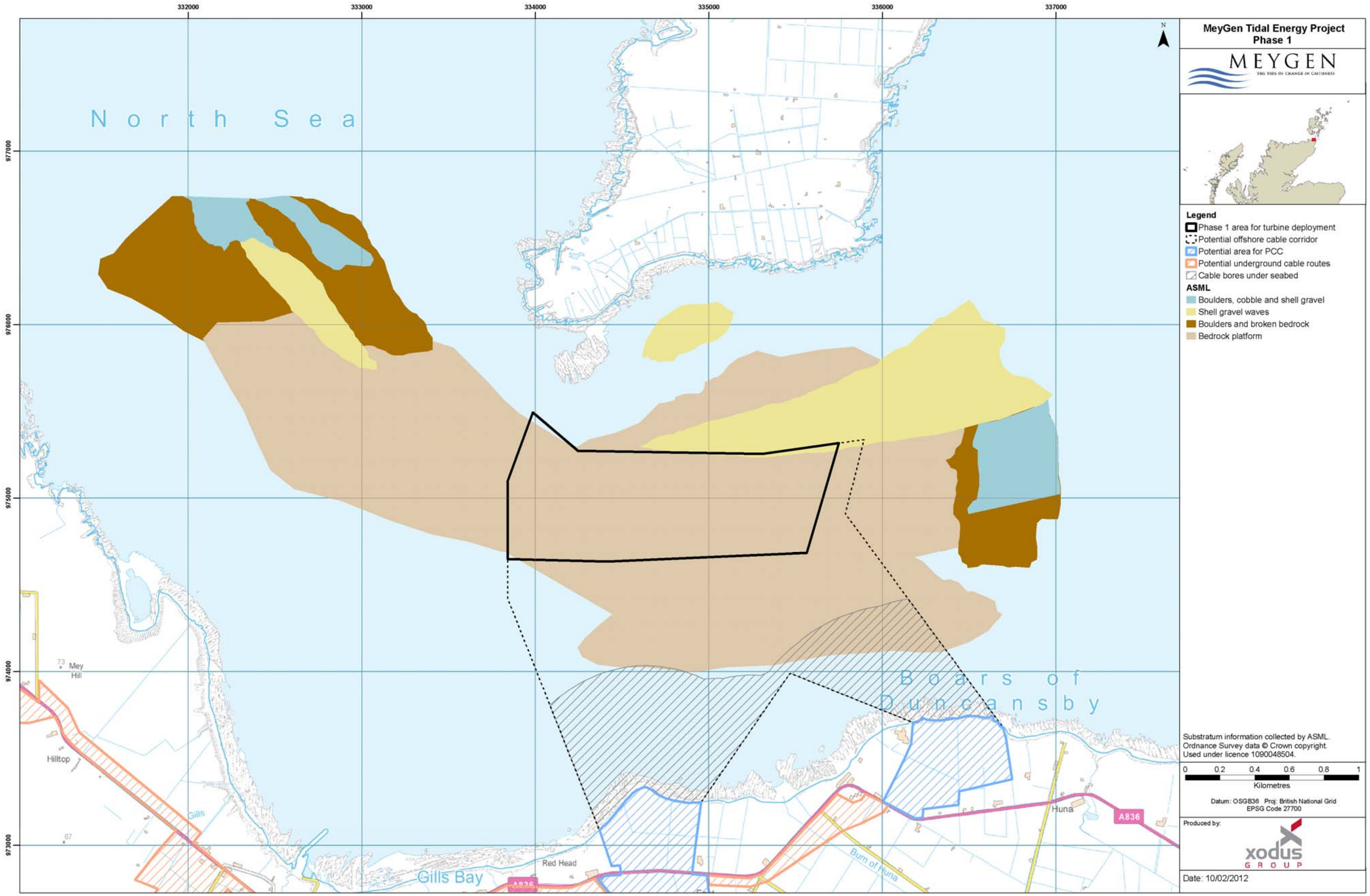


Figure 10.4: Substratum type for the offshore Project area and surrounding seabed (ASML, 2011)

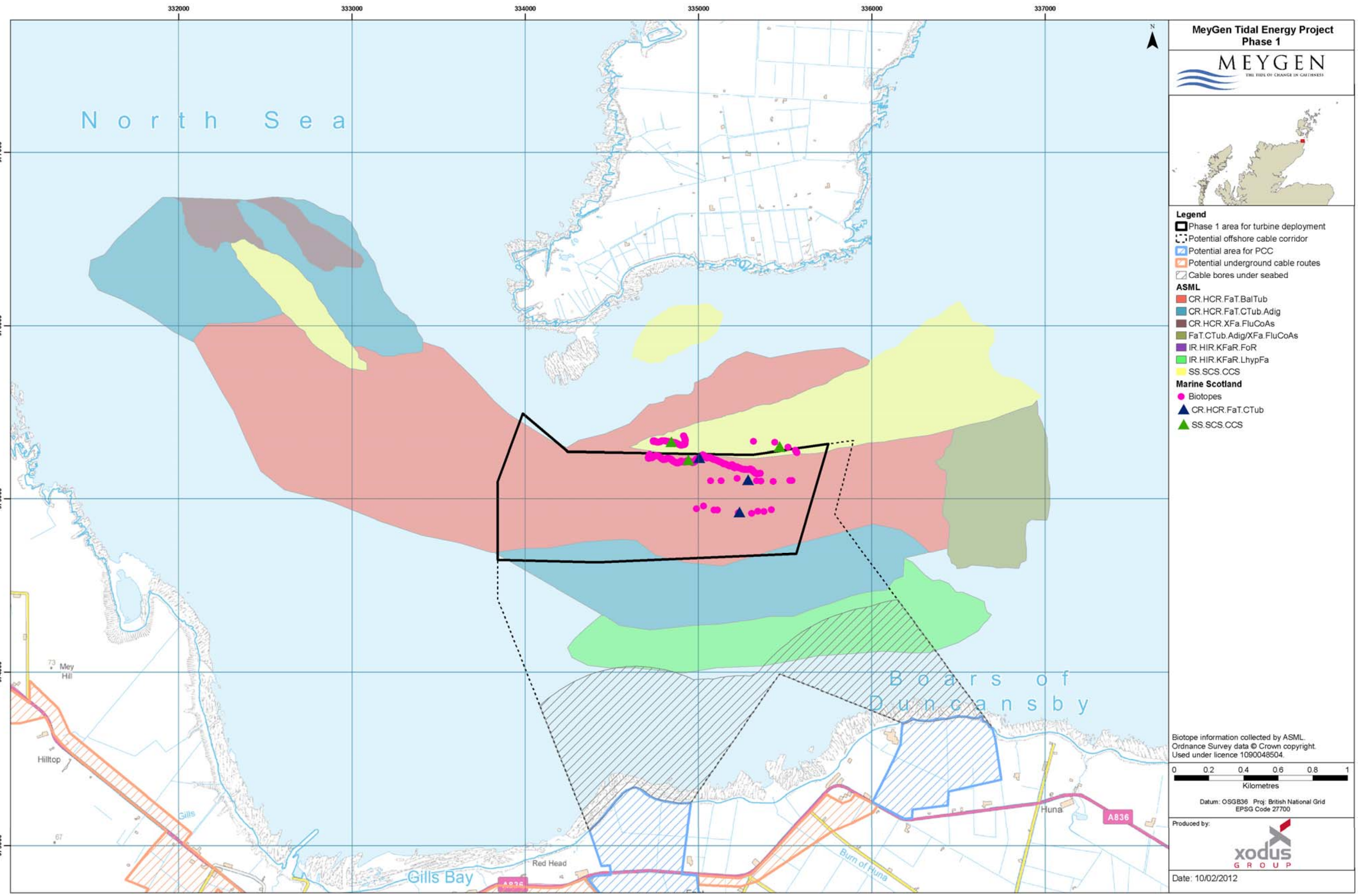
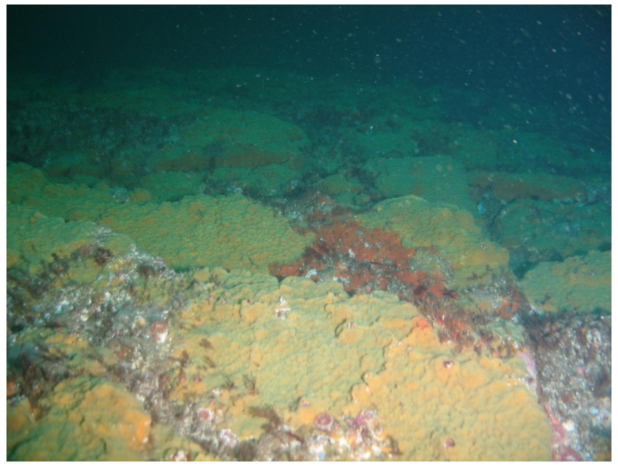
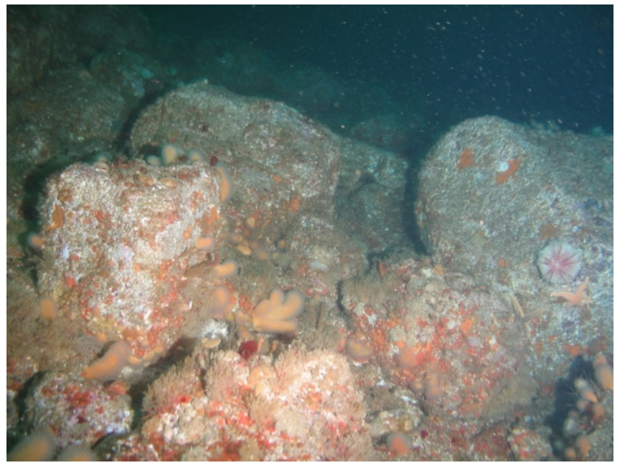


Figure 10.5: Biotope codes for the offshore Project area and surrounding seabed (ASML, 2011)

Biotope	Description	Project area images
CR.HCR.FaT.BalTub *B. crenatus* and *T. indivisa* on extremely tide-swept circalittoral rock Recorded at approximately 30 to 40m water depth	Scoured bedrock platform with steps, ledges and some broken rock and boulders. Coarse shell gravel patches and occasional cobbles and boulders. The rock platforms were tilted with a vertical face with crevices and overhangs running below the highest edge. Rock heavily encrusted with a rich scour-tolerant fauna. Dominant and highly characteristic species include *T. indivisa*, *B. crenatus*, *Chirona hameri/Balanus balanus*, superabundant *U. felina*, sheets of *Halichondria panicea*. Patches of foliose red algae on higher parts of rock platforms. *E. esculentus*, *A. rubens*, *Henricia* sp., *Cancer pagurus* all frequent. Numerous other ascidians, anemones, sponges, hydroids and bryozoans present. This biotope dominated the circalittoral rock platforms in the strongest tidal streams. There were pockets of other biotopes sheltered behind verticals or in small gullies.	 
CR.HCR.FaT.CTub.Adig *Alcyonium digitatum* with dense *Tubularia indivisa* and anemones on strongly tide-swept circalittoral rock Recorded at approximately 25 to 45m water depth	Broken and irregular bedrock, boulders and cobble with some bedrock platform. Coarse shell gravel patches. Rock heavily encrusted with a rich scour-tolerant fauna. Dominant *A. digitatum*, *T. indivisa*, *B. crenatus, U. felina*¸ *Sagartia elegans*, *Alcyonidium diaphanum*, *Polyclinum aurantium*, *Nemertesia* spp., *Flustra foliacea*, *Securiflustra securifrons*. Patches of foliose red algae on higher parts of rock platforms. *E. esculentus*, *A. rubens*, *Henricia* sp., *C. pagurus* all frequent. Numerous other ascidians, anemones, sponges, hydroids and bryozoans present.	

Biotope	Description	Project area images
	This biotope dominated more broken and irregular rock and was just out of the strongest tidal streams. It was particularly characterised by abundant *A. digitatum*.	
IR.HIR.KFaR.LhypFa *Laminaria hyperborea* forest with a faunal cushion (sponges and polyclinids) and foliose red seaweeds on very exposed upper infralittoral rock Recorded at approximately 15 to 25m water depth	Bedrock and boulders with dense kelp forest and park. Rock surfaces were completely covered with kelp forest/park, dense foliose red algae and encrusting fauna such as *A. digitatum*, *H. panicea*, anemones and sponges. The animal components were particularly prominent on vertical faces and kelp stipes. There was no division attempted in the mapping between kelp forest and kelp park, particularly as there is only one biotope available in the classification for this very tide swept habitat.	
IR.HIR.KFaR.FoR Foliose red seaweeds on exposed lower infralittoral rock Recorded at approximately 20 to 30m water depth	Bedrock and boulders with dense foliose red algae. It was difficult to distinguish individual species from the video and photographs. This biotope formed a zone along the deeper edge of the kelp park, to depths of about 20 to 29m. Smaller patches of the biotope, which were not mapped separately, were seen on the shallower parts of rock platforms within circalittoral biotopes.	No good photo/screen grab available

Biotope	Description	Project area images
SS.SCS.CCS Circalittoral coarse sediment Recorded at approximately 15 to 30m water depth	Clean shell gravel waves with little or no organic matter and a particle size distribution dominated by shell granules and very coarse shell sand. The fauna was dominated by interstitial organisms such as turbellarians, the polychaete *S. papillocercus*, amphipods such as *Socarnes erythrophthalmus*, *Leptocheirus pectinatus* and *Liljeborgia pallida* as well as the chaetognath *Spadella cephaloptera*. Many small fragments of sponges, bryozoans and ascidians were also recorded, but these are assumed to have been transient and swept in from the nearby reef by the constant strong tidal currents.	

Table 10.10: Biotopes observed in the offshore Project area (ASML, 2011)

10.49 It is important to reference the survey results against the conservation priorities identified in Section 10.2. The regional and site survey results suggest that the seabed on which the turbines and cables to shore will be placed could be classified as Annex I Rocky Reef. Indeed, three of the biotopes identified from these areas are listed under the European Habitats Directive as indicative of Reef habitat (Table 10.11).

10.50 Such rocky, tidally influenced habitat may fall under the UKBAP classification of 'tide-swept channels', especially when it is considered that the 'CR.HCR.FaT very tide-swept faunal communities' biotope (a higher level code containing two of the biotopes recorded from the surveys) is one of the illustrative biotopes for this designation. Similarly, the SS.SCS.CCS (circalittoral coarse sediment) biotope, found elsewhere in this region, is listed as illustrative of the subtidal (sublittoral) sands and gravel biotope. The presence of some sponges means that the UKBAP 'fragile sponge and anthozoan communities on subtidal (sublittoral) rocky habitats' may be found in the area. However, as sponges were found only occasionally (ASML, 2011) and as the UKBAP description notes this habitat as being dominated by sponges and sea fans, it is not considered that this biotope is present. No UKBAP species were recorded during the environmental survey (ASML, 2011). The Caithness LBAP does not list any marine species other than fish (detailed in Section 13) and consequently none of the species reported from the survey can be classified as LBAP species.

10.51 In terms of Priority Marine Features (PMF), the kelp biotope found during the survey does not match the specifics of the 'kelp and seaweed communities on sublittoral sediment' or that of the 'tide-swept algal communities' listed in Section 10.2.2.4 above. As such, no PMF habitats are likely in the area, and no PMF species have been recorded either. This concurs with the Marine Scotland survey results for this region. Similarly, none of the OSPAR habitats or species that could be present in the area have been recorded by any of the recent surveys that cover the AfL area and the wider area. The species observed were generally common and widespread (ASML, 2011).

Biotope	Area (km^2)	% of Area[4]	Conservation importance
Turbine deployment area			
CR.HCR.FaT.BalTub (*B. crenatus* and *T. indivisa* on extremely tide-swept circalittoral rock)	1.03	90.3	Indicative of Annex I habitat. Indicative of UKBAP tide-swept communities.
CR.HCR.FaT.CTub.Adig (*Alcyonium digitatum* with dense *Tubularia indivisa* and anemones on strongly tide-swept circalittoral rock)	0.09	7.9	Indicative of Annex I habitat. Indicative of UKBAP tide-swept communities.
SS.SCS.CCS (circalittoral coarse sediment)	0.02	1.8	None.
Cable route to shore			
CR.HCR.FaT.BalTub (*B. crenatus* and *T. indivisa* on extremely tide-swept circalittoral rock)	0.026	1.87	Indicative of Annex I habitat. Indicative of UKBAP tide-swept communities.
CR.HCR.FaT.CTub.Adig (*Alcyonium digitatum* with dense *Tubularia indivisa* and anemones on strongly tide-swept circalittoral rock)	0.418	30.07	Indicative of Annex I habitat. Indicative of UKBAP tide-swept communities.
IR.HIR.KFaR.FoR (Foliose red seaweeds on exposed lower infralittoral rock)	0.088	6.33	Indicative of Annex I habitat.
IR.HIR.KfaR.LhypFa (*L. yperborean* forest with a faunal cushion (sponges and polyclinids) and foliose red seaweeds on very exposed upper infralittoral rock)	0.689	49.57	Indicative of Annex I habitat.
Area not surveyed (but assumed to be CR.HCR.FaT.CTub.Adig and IR.HIR.KfaR.LhypFa)	0.169	12.16	Indicative of Annex I habitat. Indicative of UKBAP tide-swept communities.

Table 10.11: Biotope coverage and conservation status for the offshore Project development area (ASML, 2011)

[4] 45% of the cable route corridor was surveyed for the biotope mapping as the shallowest area could not be covered. Considering the inshore location of this part of the cable route corridor, the biotopes here are likely to be a continuation of (or possibly variants of) the kelp biotope found in the 15 to 25m depth range further offshore. It should also be noted that the HDD bores will emerge on the seabed a minimum of 700m from shore (see Figure 10.2).

10.5.4 Shellfish

10.52 Consultation with local fishermen has confirmed that the area of the Project is targeted for lobster (effort concentrated to the west of the Project area), brown crabs and velvet crabs. The strong and rapidly changeable tidal conditions in the turbine deployment area mean it is not intensively fished since fishermen are reluctant to use static gear in such conditions.

10.53 Given the largely rocky seabed found within the turbine deployment area and the known preference of scallops for mixed sediment habitats, along with the lack of targeted fishing (Section 14), it is unlikely that scallops will be encountered in significant numbers. There are no historic or active aquaculture sites located within the study site.

10.54 Both the benthic site survey (ASML, 2011) and the Marine Scotland regional surveys (Marine Scotland, 2011) have recorded the presence of the brown crab (ASML, 2011).

10.6 Impacts during Construction and Installation

10.6.1 Introduction

10.55 Some areas of significant sediment cover were found to be present by the geophysical survey (iXSurvey, 2009). Comparing the distribution of this shell and gravel material against the proposed layout of the potential 86 turbines suggests that only a small proportion of the turbine deployment area (1.8%) has any sediment (Table 10.11). This area is unlikely to be affected as turbines are to be located within the areas of bedrock which make up most of the turbine deployment area. It should also be noted that the models in Section 9 suggest that there is no net transport of sediment from these areas and the natural sediment transport within the Project area will be unaffected. As a result, issues related to sediment, such as sediment suspension and consequent smothering of benthic species through re-settlement, are not likely consequences of installation of the tidal turbines and discussion of such impacts are not considered necessary in this document. Similarly, the devices and cables will make use of the natural seabed topography and no seabed levelling, rock removal operations or trenching or dredging will be undertaken. This section will consequently focus on assessing the impact on the benthic environment (including shellfish) of placing structures on the seabed and ensuring suitable attachment, as well as any clearance of kelp required along the cable routes. Considering the lack of sediment in the area, the footprint of the installation activities is therefore not expected to extend much outwith the area on which structures are placed. Where such impacts may occur, these will be related to the discharge of drill cuttings from the directional drilling of the cable bores and for pile drilling for the TSS and potential kelp clearance during cable installation, both of which are discussed below. In addition, the possible issue of non-native marine species introductions from vessels has been considered.

10.6.2 Impact 10.1: Direct physical impact and loss of habitat

10.56 The placement of the turbines and cables on the seabed will be likely to impact on any benthic species present within the footprint of the structures themselves, the areas of which are shown in Table 10.12. Any small sessile species present on the seabed on which such infrastructure will be placed would potentially be damaged or destroyed; more mobile species, including some of the shellfish species, retain the ability to move away from affected areas during the installation process. The placement of the turbines and cables onto the seabed will also exclude the seabed habitats directly beneath from use by species found in the region for the life of the development. As there is little sediment in the Project area then there are not expected to be any indirect effects through sediment suspension and re-settlement. As noted in the baseline description, the surveys in the Project area and wider AfL area showed that there are no species considered to be of specific conservation significance recorded at the site and that there are no large aggregations of species that would suggest elevated numbers compared to other sites in the vicinity of the survey area.

10.57 In addition, it may be necessary to clear the cable route of kelp to facilitate cable installation. Based on the ASML survey data, kelp habitats may extend to approximately 1km from the shore. To calculate a worst case value for this kelp clearance, it has been assumed, as above, that all 86 turbines will require a separate cable to shore and that this cable will pass through 300m of kelp biotope once it has emerged from the bore. Each cable will require a 1m corridor to be cleared of kelp within which the cable can be placed. With these assumptions an area of kelp of approximately 0.027km^2 would be cleared. Such an area of clearance corresponds to a very small percentage of the total kelp forest habitat available locally in the Pentland Firth and an even smaller percentage of that available regionally and nationally (as kelp forest and park biotopes are widespread on Scottish coastlines); indeed, it accounts for less than 4% of kelp in the area surveyed by ASML (2011). The presence of kelp (both forest and park) around the cables means that this habitat is certainly locally available to any species displaced by installation activities. Thus, a large area of undisturbed habitat will continue to be available directly adjacent to the cables to any species that relies on the kelp habitat. The kelp removal is also likely to be insignificant in comparison to available standing crop levels and natural loss processes; for example, storm events may dislodge up to 25% of standing kelp crop (Chapman, 1948) in some environments.

10.58 Regarding the fate of the kelp that is cut, the practical disposal route is to leave the cut plant on the seabed onsite in the vicinity of the cutting operation, where it can join the major storm cut weed pathway into the kelp/coastal ecosystem. This is likely to be the most environmentally sensible option, particularly when the cut kelp quantities are compared with the storm cut/cast weed from the area. This method will retain the detritus contribution to the forest environment rather than the energy/emission costs associated with shipping to shore for land use/disposal. Some of this cut kelp may be washed onto shore but the small volume of kelp likely to be cut against the loss of kelp that will occur from the wider area during storm events (up to 25% of standing crop) means any amount washed ashore is likely to be small and only temporary in nature.

Removal Reason	Dimensions	Area of seabed affected (km^2)
Maximum surface of 86 turbines	40m x 30m x 86 turbines	0.103
Surface area of export cables	1.3km x (120mm x2) x 86 turbines	0.027
Total	-	0.130
Assumptions	▪ The horizontally drilled bores that will carry the export cables beneath the littoral zone and much of the shallow sublittoral zone will breakthrough 700m from shore; ▪ The greatest distance from a turbine offshore to the start of the subsurface cable bores 700m from shore is approximately 1.3km, and this has been assumed for all cables; ▪ Some weighting (using cast iron split pipes) to ensure cable stability is required but the extent is currently unknown - to account for this, the diameter of all the cables has been doubled; and ▪ Turbines will require one cable each.	

Table 10.12: Estimated area of direct physical impact

10.59 Kelp, a perennial[5] with regard to the holdfast and stipe, experiences rapid blade growth between December and June when a completely new blade develops from the meristem[6] (UK Marine SACs Project, 2001). Plants that are damaged can therefore return to a viable state over a period of only months. In the first few years of the life of kelp, the blade area and stipe length increase each year until the kelp is over five years old (UK Marine SACs Project, 2001). The growth rate and length of the stipe is elevated in shallower waters relative to deeper waters (UK Marine SACs Project, 2001); the cable route will pass through such shallow waters (as well as deeper waters) and in some areas the recovery rates will therefore likely be at the upper end of the scale.

10.60 The tidal rapid habitat that dominates the Project area is reported to demonstrate a high degree of sensitivity in relation to habitat loss (Scottish Executive, 2007). For the kelp habitat through which the cables pass sensitivity is rated as moderate. The specific biotope that is likely to experience the largest impact by area from turbine placement is CR.HCR.FaT.BalTub (*B. crenatus* and *T. indivisa* on extremely tide-swept circalittoral rock), with CR.HCR.FaT.CTub.Adig (*Alcyonium digitatum* with dense *Tubularia indivisa* and anemones on strongly tide-swept circalittoral rock) and SS.SCS.CCS (circalittoral coarse sediment) experiencing some impact also. Where cables are concerned, it will be the same biotopes including IR.HIR.KFaR.FoR (Foliose red seaweeds on exposed lower infralittoral rock) and IR.HIR.KFaR.LhypFa (*L. hyperborea* forest with a faunal cushion (sponges and polyclinids) and foliose red seaweeds on very exposed upper infralittoral rock).

10.61 As the area of impact is so small and the shellfish recorded in the area are mobile, the impact on this species group is expected to be small.

10.62 Given the low level of conservation importance of the benthic habitats within the Inner Sound, the receptor sensitivity is defined as medium. Although direct impact will occur in the localised area of the development (that is, where structures are placed on the seabed) which would lead to a moderate ranking, the impact is not expected to extend outwith that immediate footprint to the wider Project area and, since recovery is expected to be rapid, the magnitude is therefore defined as minor.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Medium	Minor	Minor	Not Significant

[5] Lasting for more than one year.
[6] The point from which new growth emerges.

MITIGATION IN RELATION TO IMPACT 10.1
▪ Although no significant impact has been identified, mitigation measures have been provided on a precautionary approach to ensure this remains the case. ▪ The area of kelp that may need cleared will be restricted to as small as practicable around the cable and only larger plants will be removed if possible. ▪ Installation layout will be clearly defined and communicated to any personnel involved in kelp clearance.

10.6.3 Impact 10.2: Release of drill cuttings and fluid

Pile drilling

10.63 Monopile drilling operations will generate rock cuttings and these will be discharged from the drilling rig into the marine environment. Drilling operations will take approximately 4 hours per pile and a total of 30 hours to complete the preparations for each TSS. Seawater (with no additives) will be used as the drilling fluid to lubricate the drill bit and aid in the removal of cuttings from the hole. A compressor will be used to pump air into the drilled holes in order to lift the cuttings clear as required. This compressor will use a lubricant which will be discharged to sea along with any cuttings to a maximum of 5 litres per hour (i.e. 20m^3 per TSS, or 1,720m^3 for all 86 turbines installed over a 3 year period). The total volume of cuttings will be 17,200m^3 over a 3 year period.

HDD drilling

10.64 The cables to shore will be routed through bores directionally drilled through the cliffs onshore. Assuming a worst case scenario of 29, 600mm bores, 700m in length. These will generate approximately 195m^3 of drill cuttings per bore; a total volume of 5,655m^3 for 29 bores. These will be collected from the bore at the drilling site onshore. As drilling is occurring from the onshore end, there may be some loss of cuttings to the marine environment upon breakthrough to the seabed. In the worst case scenario, the final 10m of the bore will be lost into the marine environment; a total of 82m^3 for all 29 bores. Note that the loss of the entire bore is considered an accidental event and covered in Section 24.

10.65 The HDD drilling operation will use bentonite as a lubricant. Bentonite is non-toxic the main potential environmental impact is likely to result from the physical settlement of rock cuttings onto the seabed and associated biological communities.

10.66 The drill cuttings from the piles and HDD bores are likely to consist predominantly of a fluid paste (incorporating the finest silt and clay-sized particles) with occasional larger fragments up to pebble-sized flakes, all of which are mobile in the marine environment. The largest and heaviest particles will settle relatively quickly to the seabed in the close vicinity of the drilling centre, whilst in this energetic locality the finest particles will remain in suspension for some time.

10.67 The likely initial result of such discharges will most likely include physical disturbance and smothering of rocky habitat and associated species close to the discharge locations, together with raised turbidity levels in the water column over a slightly wider area. Turbidity levels will then decline following discharge, as the result of dispersion, dilution and gradual settlement of the finer fractions. As a result of the distance to shore and the high tidal flow rates through Inner Sound, there is little likelihood of the cuttings being washed ashore, although this will depend on prevailing sea and weather conditions at the time of discharge. There will also be a length of time between each pile being drilled which will allow for additional dispersion time between each discharge event.

10.68 The dynamic environment (resulting from intense wave action and tidal activity) into which the operational discharge will be released means that drill cuttings will be dispersed into the wider marine area; the Pentland Firth is one of highest energy coastal environments in the UK. The lack of sediment across almost all the turbine deployment area and the likely cable corridor indicates a dynamic environment in which solids are unlikely to accumulate. Natural turbulent conditions should ensure any deposition on the seabed is quickly dispersed and does not accumulate into large deposits. Naturally occurring material (including rock and other debris) is constantly moved around by tide and wave action ordinarily and, as such, the addition of rock debris is unlikely to be an unusual event. The bedload information collected by ASML (2011) and presented in Section 10.5 confirms that such material is present under usual conditions and that the introduction of small rock material (the cuttings) will not be a novel event.

10.69 Evidence from shallow waters of the southern North Sea, where wave and tidal movements greatly influence the marine environment, suggests that erosion rates are greater than natural sedimentation rates and that cuttings piles[7] are readily dispersed (e.g. Kjeilen *et al.*, 1999).

10.70 Should some localised accumulation of cuttings result in negative impacts to the benthic environment, affected species (as a group or individually) will regenerate successfully where damage has not been extensive. Where damage is such that recovery is not expected, species will be replaced through reproductive activity and inward migration or spread from the surrounding environment. Whilst it is possible that a thin layer of cuttings could inhibit attachment to the bedrock by such species, this is unlikely and cuttings are not expected to remain for any period of time. It is especially important to note that the suite of surveys undertaken in the Project area and the wider region (including the AfL area) have reported that the habitat within the offshore Project area is similar to that surrounding it. This is important as, in the unlikely event of negative impacts to the benthic environment of the offshore Project area, the resources for recovery exist in the surrounding area.

10.71 Although information is not available on the specific sensitivities of all the biotopes recorded from the site surveys, the sensitivity of the UKBAP habitat 'tidal rapids' that includes biotopes that cover around 61% of the Project area has previously been described. That review suggests that the vast majority of the Project area is unlikely to be affected by the release of the drill cuttings, demonstrating as it does low sensitivity to smothering, increased turbidity and changes in suspended sediment levels (Scottish Executive, 2007). With regards to the kelp habitat through which the cables may pass, this type of environment is not particularly sensitive to smothering (low) or an increase in suspended sediment (not sensitive) or turbidity (very low) (Hiscock, 2008).

10.72 As any increase in turbidity or suspended sediment levels is expected to be temporally and spatially restricted and as many of the shellfish species in the area are mobile, significant impact by this mechanism seems unlikely; the restricted element of any impact means that the number of sessile mollusc species impacted will be low, even though these species are generally more susceptible to increased sedimentation as the filter feeding apparatus can become clogged and ineffectual.

10.73 Given the lack of conservation importance of the benthic habitats within the Inner Sound, the receptor sensitivity is defined as medium. Although increased turbidity/suspended sediment levels may occur in the localised area of the development (that is, around where drilling operations occur) which would lead to a moderate ranking, the impact is not expected to extend outwith that immediate footprint to the wider Project area and, since recovery is expected to be rapid, the magnitude is therefore defined as minor.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Medium	Minor	Minor	Not Significant

MITIGATION IN RELATION TO IMPACT 10.2
▪ Although no significant impact has been identified, mitigation measures have been provided on a precautionary approach to ensure this remains the case. ▪ Minimise as far as practicable the depth and diameter of the turbine foundation piles (without compromising technical performance).

[7] These observations related to drill cuttings discharged during oil and gas industry drilling operations which generate significantly greater volumes of cuttings (>100x).

▪ Lubricant used in the compressor to drive air into the drilled piles will be non-toxic and seawater will be used as a drilling fluid, negating the need for any additional chemical input.
▪ Minimise as far as practicable the volume of drill cuttings released into the marine environment during breakthrough of HDD bores, by implementing a closed loop recycling system to return drill cuttings and fluid from the HDD to shore.

10.6.4 Impact 10.3: Release of sediment bound contaminants

10.74 The release of contaminated sediments during device and cable installation may cause potentially detrimental effects on species (and habitats) that are sensitive to contamination. However there is no indication that any of the limited sediments present in the Project area have been contaminated. There is a general lack of development in the wider area, with the Dounreay reactor representing the only major potential contamination pathway within the vicinity of the Project. Radiochemical analysis of grab samples from the benthic survey, showed no evidence of contamination from artificial radioactivity in any of the samples (ASML, 2011). There is a dredge spoil disposal site located in the proposed turbine deployment area but this has not been in use since the 1970s. The seabed surveys identified the whole area to be composed of bedrock, indicating that in the high energy tidal environment sediments disposed at the site have since dispersed away from the site.

10.75 The sediment adjacent to the turbine deployment area will settle very close to where it was disturbed as it consists of large sized particles that are likely to travel a very short distance. The models in Section 9 Physical Environment and Sediment Dynamics suggest that there is no net transport of sediment from the area and the natural sediment transport within the Project area will be unaffected. As a result it is unlikely that contaminated sediments (if, despite what available evidence suggests, they are present) will be disturbed in a manner that may affect the benthic species or habitats present in the Project area. The magnitude of impact is therefore defined as negligible.

10.76 The potential impacts on water quality have been discussed further in Section 9 Physical Environment and Sediment Dynamics.

10.77 Given the lack of conservation importance of the benthic habitats within the Inner Sound, the receptor sensitivity is defined as medium.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Medium	Negligible	Negligible	Not Significant

MITIGATION IN RELATION TO IMPACT 10.3
▪ No mitigation measures proposed as no significant impact predicted.

10.6.5 Impact 10.4: Marine non-native species

10.78 Invasive Marine Non-Native Species (MNNS) pose a significant threat to biodiversity as they may have negative impacts on native species and threaten regional ecosystems; SNH reports a growing problem with marine invasive non-native species in Scotland (SNH, 2011). Non-native species have the potential to be introduced in the Inner Sound environment through the use of vessels and equipment that has been used in other parts of the world; this is a particular risk with the use of ballast water. Should a non-native species be introduced into the marine environment of Inner Sound there is no guarantee that the species will be tolerant of the conditions and it is in fact more likely that the species will be unable to reproduce and initiate a local population. For such a population to develop the species would need to be tolerant of the environmental conditions of the Inner Sound (e.g. temperature, salinity, suspended sediment), make use of existing food sources (e.g. organic content of sediment, prey species) and be able to outcompete the native species. Alternatively it must be able to exploit a previously unfilled ecological niche. Where these conditions are met then the native populations may experience a reduction in numbers or a complete failure. Note that Hiscock (2008) reports some of the biotopes in the region to be a no risk from non-native species at all (e.g. the kelp habitat), although information is lacking in support of conclusions for other biotopes on which assessments have been made. Note that the use of local or UK-based installation vessels would limit the potential for introduction of non-native marine species.

10.79 Given the low level of conservation importance of the benthic habitats within the Inner Sound, the receptor sensitivity is defined as medium. The impact of MNNS could in theory extend, in the long term, over a large area. This could lead to a high ranking for magnitude of impact. However, the impact is considered extremely unlikely to occur and to balance the scale of impact against the likelihood of impact occurring, a magnitude of impact of minor is assigned.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Medium	Minor	Minor	Not Significant

MITIGATION IN RELATION TO IMPACT 10.4
▪ Although no significant impact has been identified, mitigation measures have been provided on a precautionary approach to ensure this remains the case.
▪ All vessels involved in all stages of the Project will adhere to all relevant guidance (including the IMO guidelines) regarding ballast water and transfer on non-native marine species.

10.7 Impacts during Operation and Maintenance

10.7.1 Impact 10.5: Electro-magnetic effects

10.80 The electricity produced by the turbines will be transmitted to shore using a series of cables laid on the seabed. The electric current that is carried in these cables generates magnetic fields that have the potential to interact with marine species and to affect their behaviour since, in addition to visual cues, some species also use the magnetic field of the earth to orient (Fisher & Slater, 2010). The magnetic component of EMF will be of similar strength to that of the Earth in close proximity to the cables, and so will have the potential to affect magnetosensitive species such as bony fish, elasmobranchs, marine mammals, sea turtles (Inger *et al*., 2009), barnacles and sea urchins (Fisher & Slater, 2010). Section 13 describes the possible effects of EMF in greater detail.

10.81 At a worst case the cabling for the array will include 1.3km of subsea cabling from the devices to the subsea boreholes which cover a maximum of 0.013km^2 of the Project area and a considerably smaller proportion of the wider Inner Sound. The cables to be used are up to 6.6kV significantly reducing the fields surrounding the cables when compared to the 132kV cables used in most offshore wind farms. This in itself will considerably reduce the EMF impacts compared to other offshore power cables. The cables are designed with a screen completely surrounding the conductor, resulting in the E-field being present between the conductor and the screen such that the i-field outside the cable will be zero. Directly surrounding the cable the magnetic field may be up to 6μT (micro tesla). However, at 2m from the cable this would decrease to approximately 2μT which is well below that of the earths magnetic field (which is between 30 and 70 μT) and may not be detectable. It is not known to what extent the exact magnitude of the iE-field emissions will be from the cables used for the array but it is considered likely to be below the predictions made in the COWRIE reports (CMACS, 2003, Gill *et al*., 2005).

10.82 Benthic and demersal species are more likely to be vulnerable to the potential barrier effects of the electromagnetic fields (EMF) than pelagic species as their lifestyle brings them into closer contact with the seabed cables. The species most sensitive to the EMF and most likely to be attracted or repelled by the electrical fields generated by submarine cables are the electrosensitive elasmobranchs, a species group which is dealt with in Section 13.

10.83 However, other benthic species are potentially still vulnerable. Bochert & Zettler (2004) report the outcome of experimental analysis on several benthic species (including a number of crustaceans) exposed to static magnetic fields of 3.7mT for an extended period of time. These results obtained no differences in survival rates between the experimental and control populations. Similarly, the mussel *M. edulis* exposed to the static magnetic fields for three months did not demonstrate recordable changes. Bochert & Zettler (2004) conclude thus: Static magnetic fields of power cable transmissions do not appear to influence the orientation, movement or physiology of benthic species. In addition, even under the influence of anthropogenic fields, no negative impacts have been observed in crustaceans; for example, no ill effects were detected in western rock lobster (*Panulirus cygnus*) after electromagnetic tags, emitting a 31kHz signal, were attached to them (Jernakoff 1987). Although there are studies that demonstrate some species may be susceptible (e.g. Rosario & Martin, 2010), the Marine Renewable SEA does not list any specific benthic species as having demonstrated a response to EMF.

10.84 As noted in Section 13, there are insufficient data available with which a judgement can be made about the potential for EMF to impact on a particular species but it can be concluded that the potential for impact is highest for species that depend on electroreception to detect benthic prey (CMACS, 2003); this will not be the case for any of the benthic species identified in the baseline description.

10.85 Given the low level of conservation importance of the benthic habitats within the Inner Sound, the receptor sensitivity is defined as medium. Although the impact of EMF could extend across part of the Project area, turbines will be operational for only approximately three quarters of the time, meaning that EMF will be present for only approximately three quarters of the time. Combined with the fact that the impact is, based on the discussion above, considered unlikely to occur, a magnitude of impact of minor is assigned.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Medium	Minor	Minor	Not Significant

MITIGATION IN RELATION TO IMPACT 10.5
▪ Although no significant impact has been identified, mitigation measures have been provided to ensure this remains the case. ▪ Where cables are not within boreholes attempts will be made to lay cables within natural crevices and cracks in the seabed to reduce cable wear. This will ensure that the majority of the cable is not exposed. ▪ The voltage of the cables will be up to 6.6kV (as opposed to the 132kV) which will considerably reduce the EMF emitted by the cables. ▪ The length of the drilled boreholes for the cable will be maximised (as far as technically and commercially practicable) to increase the length of cable under the seabed. ▪ Ongoing research by Marine Scotland and their advisors will be monitored for potentially successful mitigation strategies.

10.7.2 Impact 10.6: Hydrodynamic change

10.86 The introduction of structures into the water column has the potential to alter the movement of water in an area, both at a very local and more regional level. This possibility is increased when the structures installed are designed to capture the energy in the marine environment. Species will have flow tolerance limits within which they are able to exist; these will relate to the oxygen delivered by the water, by food availability or by simple flow forces moving animals from the seabed. A change in the water flow, be it an increase or decrease in rate or direction or some other consequence, could affect the species composition of an area if the species present had a small range of flow rates in which they could survive.

10.87 As noted above, although information is not available on the specific sensitivities of the biotopes recorded from the site surveys, the sensitivity of the UKBAP habitat 'tidal rapids' that includes biotopes that cover around 61% of the Project area has previously been described. This habitat exhibits low tolerance to a decrease in water flow and could consequently experience a degradation in quality should the water flow be affected by the tidal device (Scottish Executive, 2007). Modelling indicates that mean flow through Inner Sound during calm conditions could be reduced by between 0 and $0.4ms^{-1}$ after the installation of the final 86-turbine array (see Section 9, Figure 9.14). At the same time, the flow rates could be increased immediately to the north by between 0.1 and $0.2ms^{-1}$ for the final 86 turbine array. The conclusions are much the same for storm conditions except that, as would be expected, the extent and magnitude or the differences are greater under storm conditions. This small change in flow rates mean the impact is likely to be minimal and the magnitude of impact is therefore defined as negligible.

10.88 The above is backed up by findings of research associated with the SeaGen tidal turbine development in Strnagford Narrows, Northern Ireland (Royal Haskoning, 2011). CR.HCR.FaT.BalTub (*B. crenatus* and *T. indivisa* on extremely tide-swept circalittoral rock), dominant at the MeyGen site is the dominant biotope throughout the SeaGen tidal turbine development site in the Strangford Narrows, Northern Ireland (Royal Haskoning, 2011) whilst CR.HCR.FaT.CTub.Adig (*Alcyonium digitatum* with dense *Tubularia indivisa* and anemones on strongly tide-swept circalittoral rock) is also present at both sites. Studies associated with the SeaGen development indicate that although some changes were observed in the benthic community, these changes were as expected in a high energy environment (they were reflected in control stations away from the SeaGen device) and all of the available data support the conclusion that there appears to be no deleterious effect of the installation of the marine current turbine.

10.89 The two biotopes closest to shore, which the cables may pass through, should be unaffected by changes in water flow and both exhibit a low sensitivity in any case (e.g. Budd, 2008).

10.90 Given the lack of conservation importance of the benthic habitats in Inner Sound, the receptor sensitivity is defined as medium.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Medium	Negligible	Negligible	Not Significant

MITIGATION IN RELATION TO IMPACT 10.6
▪ No mitigation measures proposed as no significant impact predicted.

10.7.3 Impact 10.7: Sediments

10.91 The alteration in water flow across the area of the turbine installation (as outlined above) could affect suspended sediment levels in the water. If the effect was sufficiently large, then this could result in a change in sediment erosion and deposition patterns locally with follow-on changes to the habitats and species present. The impacts of increased sedimentation are described above but it should be noted that reducing the available sediment can also result in changes. For example, most polychaete worms burrow or build tubes from the available sediment; restricting this supply or causing changes in particle size could affect the ability of such species to undertake such tasks.

10.92 The morphology modelling study (detailed in Section 9) predicted that there would be no significant impacts to the sediment dynamics and bedforms following the installation of the tidal array. There is a natural movement of sediments as would be expected in a tidal flow receiving wave action, but the array is not predicted to affect these processes significantly. The results (given in Section 9) show that even under calm conditions and with no turbines the bedforms show evidence of movement, but not in a way which is significant. The sand present in the area will shift backwards and forwards under the flooding and ebbing tide, but with no evidence of bedform migration or net sediment transport. Under calm conditions, the addition of the array is predicted to make little or no difference to the existing bedform structures. The conclusions for storm conditions are much the same as for the calm conditions except that, as would be expected, the extent and magnitude or the differences are greater.

10.93 For the habitats for which information is available, varying degrees of sensitivity to altered sediment levels in the water column are observed. For example, CR.HCR.XFa.FluCoAs (*F. foliacea* and colonial ascidians on tide-swept moderately wave-exposed circalittoral rock) shows intermediate sensitivity to increased sediment (Budd, 2008) but this biotope is found well away from the areas in which sediment load might be increased, being as it is well outside the Project and cable route areas. Kelp habitats show a high tolerance to increased sediment and are tolerant of decreases in suspended sediment (Hiscock, 2008); however, neither of these changes are expected in the areas where kelp is found. Overall the impact magnitude is considered to be negligible.

10.94 Given the lack of conservation importance of the benthic habitats in Inner Sound, the receptor sensitivity is defined as medium.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Medium	Negligible	Negligible	Not Significant

MITIGATION IN RELATION TO IMPACT 10.7
▪ No mitigation measures proposed as no significant impact predicted.

10.7.4 Impact 10.8: Introduction of new hard structures

10.95 The physical presence of the turbine structures will provide new, stable, hard substrata. In areas where the seabed is comprised of sediment then this would be presented as a novel habitat. However, these hard structures will be installed in rocky areas and will present a habitat similar to that already present, potentially being colonised by epifaunal and encrusting animals typical of the area. The presentation of additional hard structures into the environment will not change the type of habitat available and is thus unlikely to affect the species composition of the immediate or wider region.

10.96 Information from the SeaGen tidal device in Strangford Lough shows that some, but not all, of the hard structures below the surface experienced marine growth. Royal Haskoning (2011) report that the parts of the SeaGen device which most closely represented a seabed type habitat (the shoe structures on the seabed) have become colonised by the biotope CR.HCR.FaT.BalTub (*B. crenatus* and *T. indivisa* on extremely tide-swept circalittoral rock) which was found to be dominant prior to installation of SeaGen, indicating that the device (or at the least some parts of the device) present a similar habitat to that which exists pre-installation.

10.97 The cylindrical turbine structures (legs, struts and lower tower) were, however, colonised by the blue mussel biotope CR.MCR.CMus.CMyt (*Mytilus edulis* beds with hydroids and ascidians on tide-swept exposed to moderately wave-exposed circalittoral rock) (Royal Haskoning, 2011). This biotope was not recorded in the Narrows during previous SeaGen surveys. Royal Haskoning (2011) report that this biotope provides a food source for some fish species, echinoderms and crustaceans and that its addition to the Narrows is considered to be positive. Note that similar structures on the MeyGen devices are likely to be subject to antifouling measures (see Impact 10.9) and growth of this sort may be restricted.

10.98 The impact from colonisation of new hard structures is likely to be limited to the Project footprint, possibly extending to the surrounding area if the structures were to act as an artificial reef, promoting a raised density of species and out from which these species could move to settle. However, as colonising species are likely to be the same as already found in the Inner Sound and as some of the structures deployed for this Project are likely to be treated with antifouling to limit colonisation, a magnitude of impact of minor is assigned.

10.99 Given the lack of conservation importance of the benthic habitats in Inner Sound, the receptor sensitivity is defined as medium.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Medium	Minor	Minor	Not Significant

MITIGATION IN RELATION TO IMPACT 10.8
▪ No mitigation measures proposed as no significant impact predicted.

10.7.5 Impact 10.9: Antifouling

10.100 The introduction of new structures presents a second concern; the degree to which antifouling treatment will be applied which, by its nature, may be toxic to species found in the area. MeyGen recognises that the prevention of marine growth on the turbine structures is an important consideration, even in a fast flow environment. Different approaches, including antifouling paints and copper coatings, are being explored on the prototype devices at EMEC and this experience will inform the need for and type of antifouling system to be deployed. Any toxic effect of the antifouling treatment or impact from any other method of limiting biofouling (e.g. copper coating, water blasting) will be limited to the device itself and exert no effect on the surrounding marine environment and therefore the impact magnitude is defined as negligible.

10.101 Given the lack of conservation importance of the benthic habitats in Inner Sound, the receptor sensitivity is defined as medium.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Medium	Negligible	Negligible	Not Significant

MITIGATION IN RELATION TO IMPACT 10.9
▪ No mitigation measures proposed as no significant impact predicted.

10.8 Impacts during Decommissioning

10.102 The tidal turbines will be removed from the support structures to a DP vessel and returned to shore and no impact on the benthic environment is expected. The cables will be recovered to a vessel (with the potential for some destructive impact) as the cables are moved over the seabed and the HDD bores capped at the breakthrough location. If piled foundations are used, the piles will be cut at the seabed. Any impacts these operations may have on the seabed will occur in an area that experienced an effect during the installation operations and at similar or lesser magnitude the impacts described for the installation and operation phases.

10.103 Although information on the potential for recovery is not available for all the habitats found in the area, evidence that does exist for some of the habitats suggests a high or very high capacity to recover from all relevant impacts (e.g. Hiscock, 2008, Budd, 2008). Although this recovery may be delayed in some cases until after decommissioning (e.g. the recovery of the seabed onto which the devices will be placed), there will be a degree of recovery starting immediately following the installation of the devices (e.g. kelp recovery along the cable routes).

10.9 Potential Variances in Environmental Impacts

10.104 The impact assessment above has assessed the worst case Project options with regards to impact to benthic ecology. This section provides a brief overview of the potential variances between the worse case Project option assessed and alternative Project options.

10.105 Not considered worst case for benthic ecology was the option for pin pile TSS. The installation methods for pin pile TSS would have a lesser impact compared to the installation of the monopile TSS since it would produce less drill cuttings. It also has a smaller footprint than the GBS TSS and therefore the potential direct habitat loss would be lower.

10.106 In addition should the export cable boreholes be drilled closer to the array site (less than the worst case assessed) this has the potential to reduce the impact of loss of seabed habitat and reduce the area and volume of kelp that would need to be removed form the cable corridor. This would also reduce the potential for impact from EMF as the length of cable placed on the seabed would be lessened.

10.10 Cumulative Impacts

10.10.1 Introduction

10.107 MeyGen has in consultation with Marine Scotland and The Highland Council identified a list of other projects (MeyGen, 2011) which together with the Project may result in potential cumulative impacts. The list of these projects including details of their status at the time of the EIA and a map showing their location is provided in Section 8; Table 8.3 and Figure 8.1 respectively.

10.108 Having considered the information presently available in the public domain on the projects for which there is a potential for cumulative impacts, Table 10.13 indicates those with the potential to result in cumulative impacts from a benthic habitats and ecology perspective. The consideration of which projects could result in potential cumulative impacts is based on the results of the project specific impact assessment together with the expert judgement of the specialist consultant.

Project title	Potential for cumulative impact	Project title	Potential for cumulative impact	Project title	Potential for cumulative impact
MeyGen Limited, MeyGen Tidal Energy Project, Phase 2	✓	SHETL, HVDC cable (onshore to an existing substation near Keith in Moray)	✗	OPL, Ocean Power Technologies (OPT) wave power ocean trial	✗
ScottishPower Renewables UK Limited, Ness of Duncansby Tidal Energy Project	✓	Brough Head Wave Farm Limited, Brough Head Wave Energy Project	✗	MORL, Moray Offshore Renewables Ltd (MORL) offshore windfarm	✗
Pelamis Wave Power, Farr Point Wave Energy Project	✗	SSE Renewables Developments (UK) Limited, Costa Head Wave Energy Project	✗	SSE and Talisman, Beatrice offshore Windfarm Demonstrator Project	✗
Sea Generation (Brough Ness) Limited, Brough Ness Tidal Energy Project	✗	EON Climate & Renewables UK Developments Limited, West Orkney North Wave Energy Project	✗	BOWL, Beatrice Offshore Windfarm Ltd (BOWL) offshore windfarm	✗
Cantick Head Tidal Development Limited, Cantick Head Tidal Energy Project	✗	EON Climate & Renewables UK Developments Limited, West Orkney South Wave Energy Project	✗	Northern Isles Salmon, Chalmers Hope salmon cage site	✗
SSE, Caithness HVDC Connection - Converter station	✗	ScottishPower Renewables UK Limited, Marwick Head Wave Energy Project	✗	Northern Isles Salmon, Pegal Bay salmon cage site	✗
SSE, Caithness HVDC Connection - Cable	✗	SSE Renewables Developments (UK) Limited, Westray South Tidal Energy Project	✗	Northern Isles Salmon, Lyrawa salmon cage site	✗
RWE npower renewables, Stroupster Windfarm	✗	EMEC, Wave Energy test site (Billia Croo, Orkney)	✗	Scottish Sea Farms, Bring Head salmon cage site	✗
SSE, Gills Bay 132 kV / 33 k V Substation Phase 1: substation and overhead cables (AC)	✗	EMEC, Tidal energy test site (Fall of Warness, Orkney)	✗	Northern Isles Salmon, Cava South salmon cage site	✗
SSE, Gills Bay 132 kV / 33 k V Substation Phase 2: HVDC converter station and new DC buried cable	✗	EMEC, Intermediate wave energy test site (St Mary's Bay, Orkney)	✗	Scottish Sea Farms, Toyness salmon cage site	✗
SHETL, HVDC cable (offshore Moray Firth)	✗	EMEC, Intermediate tidal energy test site (Head of Holland, Orkney)	✗	Northern Isles Salmon, West Fara salmon cage site	✗

Table 10.13: Summary of potential cumulative impacts

10.109 The following sections summarise the nature of the potential cumulative impacts for each potential project phase:

- Construction and installation;
- Operations and maintenance; and
- Decommissioning.

10.10.2 Potential cumulative impacts during construction and installation

10.110 Cumulative impacts arising from installation of multiple marine renewable projects at the same time as the proposed installation are not anticipated as the majority of impacts are expected to localised (e.g. increased turbidity, smothering and release of drill cuttings and fluids[8]). The Ness of Duncansby Tidal Energy project is the only project that may potentially be constructed at the same time as the MeyGen Tidal Energy Project, Phase 1 and would not act in combination to cause significant cumulative impacts.

10.10.3 Potential cumulative impacts during operations and maintenance

10.111 It is possible for cumulative and in-combination impacts to arise from operation and maintenance of the MeyGen Project and the construction, installation operation and maintenance of these other marine renewable projects in the Pentland Firth; the main impact in this respect will be the loss of currently available seabed habitat for the life of the developments.

10.112 The installation of additional marine renewable devices in the Pentland Firth has the potential to contribute to increased loss of seabed habitat and species associated with those lost areas. However, previous area wide surveys show Pentland Firth and Orkney waters coastline as displaying low diversity circalittoral tideswept rocky communities, dominated by a sessile fauna of *B. crenatus* and *U. felina* (although other predominantly sandy, sand-scoured rock or mixed substrates of sand and stones have been recorded). As the area in which we consider cumulative impacts expands and consequently the area of impact from marine renewables also increases, so does the habitat available and the relative magnitude of impact remains the same. As the current assessment rates the possible impact from this Project as minor, it is

[8] Cumulative impacts from discharges of drill cuttings would only be a potential impact if other developers used piled foundations.

expected that the cumulative impact from the various currently proposed projects would be insignificant also.

10.113 The installation of additional marine renewable projects in the Pentland Firth and their associated cabling increases the sources from which EMF could be emitted. However, as outlined above, the possible negative effects of EMF are considered to be extremely localised in nature and of little actual consequence to the benthic species found in the area. Similarly localised impacts predicted from the above assessment, such as on water flow and sediment transport and the introduction of hard structures and antifouling agents, have been assessed as applicable only to the immediate vicinity of the development and in a non-significant manner above and are not expected to act in any cumulative fashion with other developments.

10.114 The likelihood of the introduction of non-native marine species to the marine environment will increase with each additional project since the number of vessels entering and exiting the area will also increase. However, assuming that other projects in the area make the same commitments to follow relevant guidelines as made herein, that likelihood will remain low and there should be no cumulative impact.

10.10.4 Potential cumulative impacts during decommissioning

10.115 Although it is possible that a number of the impacts that may occur during decommissioning (e.g. noise emissions, seabed impact) could act cumulatively with other developments, there is limited scope for much of this since it is highly unlikely that the Ness of Duncansby development (the only development other than MeyGen Phase 2 expected to offer the potential for cumulative impact) would be decommissioned at the same time as this development, or that of the MeyGen Phase 2 development (which would likely be decommissioned at the same time as the proposed development).

10.10.5 Mitigation requirements for potential cumulative impacts

10.116 No mitigation is required over and above the Project specific mitigation.

10.11 Proposed Monitoring

10.117 Monitoring of benthic habitats and ecology is proposed in order to confirm impact predictions made in the ES in particular in relation to:

- Dispersion of drill cuttings from potential TSS pile installation and HDD bore breakthrough; and
- To detect any significant changes in habitats due to the presence of the turbines.

10.118 Surveys are expected to be required post installation and post decommissioning.

10.119 Based on current knowledge of the site (extensive baseline surveys and hydrodynamic modelling) and building on the pre installation surveys, it is likely that the benthic monitoring programme would be based primarily on drop down video upstream / downstream of the project such that potential changes to the biotope mosaic in the area could be detected. Reference areas to either side of the turbine array and cable routes could also be sampled.

10.12 Summary and Conclusions

10.120 The biotopes across the turbine deployment area are dominated by CR.HCR.FaT.BalTub (*B. crenatus* and *T. indivisa* on extremely tide-swept circalittoral rock), which is very similar to the CR.HCR.FaT.CTub biotope found in the area by the Marine Scotland surveys. The SS.SCS.CCS (circalittoral coarse sediment) biotope recorded in the turbine deployment area (ASML, 2011) was also recorded from the wider area by the Marine Scotland surveys and is certainly not locally restricted to the AfL area. As would be expected from the large areas of exposed bedrock, the largest biotopes by coverage are those associated with exposed and broken rock surfaces. Within the cable corridor, where the seabed shoals towards the mainland shore, upward-facing bedrock and boulders becomes characterised by large brown seaweeds of the genus *Laminaria*, or kelp. The deepest water in which kelp was recorded was approximately 18m (ASML, 2011) but it will be the shallower waters within which the kelp plants form ‘kelp forests’ that are characteristic of exposed shallow waters in Scotland and much of the UK. The specific kelp biotope identified form the cable route in Inner Sound (IR.HIR.KFaR.LhypFa Foliose red seaweeds on exposed lower infralittoral rock) is found often on exposed and very exposed wave-surged, upper infralittoral bedrock and massive boulders. It is characterised by a dense forest of the kelp *Laminaria hyperborea* and a high diversity of seaweeds and invertebrates (Connor *et al*., 2004).

10.121 Three of these biotopes are listed under the European Habitats Directive as indicative of Reef habitat (Table 10.11) whilst the rocky, tidally influenced habitat, is likely to fall under the UKBAP classification of ‘tide-swept channels’. Similarly, the SS.SCS.CCS (circalittoral coarse sediment) biotope, found elsewhere in this region, is listed as illustrative of the subtidal (sublittoral) sands and gravel biotope. No UKBAP or LBAP species were recorded during the environmental survey (ASML, 2011) and no PMF habitats or species have been recorded either. This concurs with the Marine Scotland survey results for this region. Similarly, none of the OSPAR habitats or species that could be present in the area have been recorded by any of the recent surveys that cover the lease option area and the wider area. To summarise, although some of the habitats may represent those listed under various protection mechanisms, the areas do not represent outstanding examples of these habitats and are unlikely to qualify for any protection through site designation. In addition, these habitats are common throughout the wider Pentland Firth and Orkney waters.

10.122 A number of potential impacts associated with the construction, installation, operation, maintenance and decommissioning of the Project on benthic ecology have been assessed. This assessment identified a number of key issues including loss of habitat and associated species, removal of kelp, discharge of drill cuttings and the potential for the introduction of MNNSs.

10.123 The area of seabed habitat which will be impacted by the Project is considered to be extremely small and similar to that present in the Inner Sound and wider area. It is also expected to demonstrate a capability of recovery following the installation and decommissioning stages. The conservation importance of the habitats that may be directly impacted, although represented on some lists of conservation significance, is relatively low and there will be no impact on any areas of protected seabed habitat. The areas from which kelp may be removed and the volumes required to be cut are not expected to be significant in terms of that lost during storm events and natural renewal processes. Species which rely on the seabed habitats excluded from use or on the kelp that is removed will be able to relocate to identical habitats in the immediate vicinity of any impacted area.

10.124 The relatively small volume of drill cuttings and fluid associated with monopile drilling and the HDD bores at seabed breakthrough have been assessed as unlikely to significantly impact the marine environment into which they will be discharged, especially when the high energy nature of that environment is taken into account. Similarly, non-native marine species are unlikely to be a significant issue with regards to the Project.

10.125 Considering these conclusions, the installation of the turbines and associated cables is not expected to have a likely significant effect on the benthic environment.

10.126 With regards to the operation of the device, the EMF emitted by the cables has been noted as of concern to some marine species; the effect on benthic species, including shellfish, is, however, not expected to be significant in the case of the Project. Water flow and sediment transport will also be relatively unaffected by the operation of the devices and no impact on seabed habitats or species is therefore expected. The introduction of the turbines as possible hard substrate for colonisation by benthic species is of little concern since it presents a similar habitat to that already present in the turbine deployment area and parts of the cable corridor. The necessity of antifouling to combat any potential growth is also not considered to exert a negative impact since that area of habitat loss has been considered likely in the installation operation assessment and as the possible toxic effect of any antifouling solution will be limited to species making contact with the devices themselves.

10.127 Considering the conclusions, the operation of the turbines and associated cables is not expected to have a likely significant effect on the benthic environment.

10.128 Any impacts that decommissioning operations may have on the seabed will occur in an area that has experienced an effect during the installation operations and at similar or lesser magnitude than the impacts described for those installation and operation phases. In conjunction with an agreed decommissioning plan, the decommissioning of the turbines is not expected to impact significantly on the benthic environment.

10.129 The scale of the individual effects of the installation, operation and decommissioning of the devices are not expected to combine with those from other projects in the wider area to produce likely significant negative cumulative impacts.

10.130 MeyGen has committed to undertaking monitoring of the benthic environment to determine that the impact is as assessed above. This plan will be developed with the relevant authorities and will consider all available guidance and best practice.

10.131 Overall through the implementation of proposed mitigation strategies and commitments the impact of the proposed development on benthic habitats and ecology is considered to be not significant.

10.13 References

ASML (2011). Benthic survey for Phase 1 of the MeyGen tidal stream energy project, Inner Sound, Pentland Firth. Report to MeyGen Ltd, London, by Aquatic Survey & Monitoring Ltd, Frosterley.

British Geological Survey (BGS) (1990). United Kingdom offshore regions report: The geology of the Moray Firth. British Geological Survey, Nottingham.

Bochert, R. & Zettler, M.L. (2004). Long-term Exposure of Several Marine Benthic Animals to Static Magnetic Fields. Bioelectromagnetics. **25**, 498-502.

Budd, G.C. (2008). Foliose red seaweeds on exposed or moderately exposed lower infralittoral rock. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online at http://www.marlin.ac.uk/habitatsensitivity.php?habitatid=65&code=2004 [Accessed 04/11/11].

Caithness Biodiversity Group (2003). The Caithness Biodiversity Action Plan. February 2003. Available online at http://www.highlandbiodiversity.com/htm/counties/caithness/caithness.pdf [Accessed 19/04/11].

Chapman, V.J. (1948). Seaweed resources along the shores of Great Britain. Economic Botany. **2,** 363-378.

CMACS (2003). A baseline assessment of electromagnetic fields generated by offshore windfarm cables. COWRIE Report EMF -01-2002 66.

Connor, D.W., Allen, J.H., Golding, N., Howell, K.I., Lieberknecht, L.M., Northen, K.O. & Reker, J.B. (2004). The Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough. ISBN 1 861 07561 8.

Fisher, C. & Slater, M. (2010). Effects of electromagnetic fields on marine species: A literature review. Available online at http://www.oregonwave.org/wp-content/uploads/1-Effects-of-electromagnetic-fields-on-marine-species-A-literature-review.pdf [Accessed 04/11/11].

Gill, A.B., Gloyne-Phillips, I., Neal, K.J. & Kimber, J.A. (2005). The potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically and magnetically sensitive marine organisms – a review. COWRIE 1.5 Electro-magnetic fields review. COWRIE-EM FIELD 2-06-2004.

Hayes, P. (2009). Summary of the Fisheries Research Services (FRS) seabed survey work within the Pentland Firth and Orkney Waters 2006 – 2008. Fisheries Research Services Internal Report No 01/09.

Hiscock, K. (2008). *Laminaria hyperborea* forest with a faunal cushion (sponges and polyclinids) and foliose red seaweeds on very exposed upper infralittoral rock. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online at http://www.marlin.ac.uk/habitatsensitivity.php?habitatid=44&code=2004 [Accessed 04/11/11].

Inger, R., Attrill, M.J., Bearhop, S., Broderick, A.C., Grecian, W.J., Hodgson, D.J., Mills, C., Sheehan, E., Votier, S.C., Witt, M.J. & Godley, B.J. (2009). Marine renewable energy: potential benefits to biodiversity? An urgent call for research. Journal of Applied Ecology. **46(6),** 1145-1153.

IXSurvey Limited (2009). Report of Survey for Atlantis Resources Corporation for Site Survey Stroma. JN3475.

Jernakoff, P. (1987). An Electromagnetic Tracking System for use in Shallow Water. Journal of Experimental Marine Biology and Ecology. **113,** 1-8.

JNCC (2010). UKSeaMap 2010 interactive map. Available online at http://www.jncc.gov.uk/page-5534 [accessed 21.4.11].

JNCC (Undated). IR.HIR.KFaR.LhypFa. Available online at http://www.jncc.gov.uk/marine/biotopes/biotope.aspx?biotope=JNCCMNCR00000678 [Accessed 04/11/11].

Kjeilen, G., Cripps, S.J., Woodham, A., Runciman, D. & Olsen, S. (1999). Natural degradation and estimated recovery time-scales. UKOOA Drill Cuttings Initiative Research and Development Programme, Project 2.3.

Maddock, A. (2008). UK Biodiversity Action Plan; Priority Habitat Descriptions. Available online at

http://www.ukbap.org.uk/library/UKBAPPriorityHabitatDescriptionsfinalAllhabitats20081022.pdf [Accessed 04/11/11].

Marine Scotland (2011). Marine Scotland Interactive. http://www.scotland.gov.uk/Topics/marine/science/MSInteractive/datatype/TV [Accessed 09/05/11].

MeyGen (2011). Projects for consideration in the cumulative (and in combination) impact assessment.

Moore, C. G. & Roberts, J. M. (2011). An assessment of the conservation importance of species and habitats identified during a series of recent research cruises around Scotland. Scottish Natural Heritage Commissioned Report No. 446.

Moore, C.G. (2010). Preliminary assessment of the conservation importance of benthic species and habitats off the west coast of Orkney and in the Pentland Firth in relation to the development of renewable energy schemes. Scottish Natural Heritage Commissioned Report No. 352.

Moore, C.G. (2009). Preliminary assessment of the conservation importance of benthic epifaunal species and habitats of the Pentland Firth and Orkney Islands in relation to the development of renewable energy schemes. Scottish Natural Heritage Commissioned Report No. 319.

OLBAP Steering Group (2008). The Local Biodiversity Plan 2008 - 2011. Available online at http://www.orkney.gov.uk/Files/Planning/Biodiversity/Local_Biodiversity_Action_Plan_2008-2011.pdf [Accessed 14/11/11].

Rosario, J.C & Martin, E.R. (2010). Behavioral Changes in Freshwater Crab, Barytelphusa Cunicularis after Exposure to Low Frequency Electromagnetic Fields. World Journal of Fish and Marine Sciences. **2.6**, 488-492.

Royal Haskoning (2011). SeaGen Environmental Monitoring Programme. Final Report. MCT, 16th January 2011, 9S8562/R/303719/Edin.

RPS Energy (2009). Geohazard Assessment - Stroma Sound, Inner Pentland Firth. Prepared for Atlantis Corporation.

Saunders, G., Bedford, G.S., Trendall, J.R. & Sotheran, I. (2011). Guidance on survey and monitoring in relation to marine renewables deployments in Scotland. Volume 5. Benthic Habitats. Unpublished draft report to Scottish Natural Heritage and Marine Scotland.

Scottish Executive (2007). Scottish Marine SEA: Environmental Report Section C SEA Assessment: Chapter C6 Benthic Ecology. Available online at http://www.seaenergyscotland.net/public_docs/ER_C6_BenthicEcology_Final.pdf [Accessed 04/11/11].

SNH (2011a). Priority marine features in Scottish territorial waters (draft list). Available online at http://www.snh.gov.uk/docs/B874876.pdf [Accessed 04/11/11].

SNH (2011b). Marine non-native species. Available online at http://www.snh.gov.uk/land-and-sea/managing-coasts-and-sea/marine-nonnatives/ [Accessed 04/11/11].

Thornhill, D.H., Dahlgren, T.G. & Halanych, K.M. (2009). Evolution and Ecology of Ophryotrocha (Dorvilleidae, Eunicidae). Chapter 13 in: Shain, D. H. (ed) Annelids in Modern Biology. Wiley-Blackwell.

UK Marine SACs Project (2001). Growth rates of kelp. Available online at http://www.ukmarinesac.org.uk/communities/infralittoral/ik3_2.htm [Accessed 04/11/11