



SCOTTISH EXECUTIVE

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Glossary & Abbreviations

Benthic	The bottom or lowest level of a large water body such as an ocean or a lake.
Biogenic	Produced by life processes
Biotope	Refers to a specific, uniform set of environmental conditions in which a particular assemblage of organisms live.
CCW	The Countryside Council for Wales
EIA	Environmental Impact Assessment
JNCC	Joint Nature Conservation Committee
Leaching	Corrosion in which one element is preferentially corroded, leaving a residue (often porous) of the elements that are more resistant to the particular environment.
M	Metres
M ²	Metres Squared
MarLIN	The Maritime Life Information Network
MCT	Marine Current Turbines
MNCR	Marine Nature Conservation Review
SAC	Special Areas of Conservation
Sacrificial anode	Metal which corrodes readily in order to protect its corresponding cathode.
Sessile	Unable to move; fixed to a point
SPA	Special Protection Area. Site designated to protect certain rare or vulnerable bird species under the 1979 EC Birds Directive. The sites generally support significant numbers of internationally important species.
SSSI	Site of Special Scientific Interest. Site designated by Scottish Natural Heritage under the Wildlife and Countryside Act 1981 (as amended) to protect nationally important ecosystems
Steering group	A group of experts in fields of knowledge relevant to the assessment who are appointed to guide the process
Substratum	the base or material on which an organism lives or grows
WaveHub	A renewable energy project in the South West of England that aims to create the UK's first offshore facility for the demonstration and proving of the operation of arrays of wave energy generation devices

C6 Benthic Ecology

C6.1 Introduction

Benthic habitats and species are protected under both UK and European legislation. The EU Habitats Directive lists marine and intertidal habitats of conservation importance (Annex 1), and marine species of conservation importance (Annex 2), and allows for the designation of Special Areas of Conservation (SACs).

The UK has also identified a series of important benthic ecological sites under the Wildlife and Countryside Act 1981, under which Sites of Special Scientific Interest (SSSIs) are designated. Unlike SAC sites, SSSI sites are exclusively intertidal, extending only as far as Mean Low Water.

The UK Biodiversity Action Plan (BAP) identifies important habitats and species and identifies means for protecting and improving their biodiversity, but does not designate specific sites for protection.

Whilst these initiatives combine to designate and protect important benthic and intertidal habitats in Scottish waters, the way in which habitat types have been defined differs for each designation type. Annex 1 habitats have a generally broad definition and may contain certain UK BAP habitats, and SSSIs as sub-habitats, but there is not a direct relationship between the habitats identified. In addition, some UKBAP or SSSI habitats may occur in several Annex 1 Habitats. Tables C6.1 and C6.2 give details of the UKBAP and Habitats Directive habitats likely to be present in the study area.

The assessment has been undertaken at the habitat level and has focussed on the priority habitats identified in the UKBAP. Protected species are addressed in Chapter C5.

Figures C6.1-6.5 accompany this chapter.

C6.2 Baseline Environment

C6.2.1 *General Overview of Benthic Ecology of the Study Area*

An overview of the benthic characteristics of the study area is given, highlighting areas of key importance and/or sensitivity. A more detailed description of the benthic ecology of the study area is given in Appendix C6.A.

The temperate west coast of Scotland, from Burrow Head, Galloway to Unst, Shetland, hosts several areas that may be suited for the placement of devices designed to extract the energy contained in wind-induced waves or tidally induced currents. These areas are, by their very nature, exposed to waves or strong tidal currents and support quite different biological communities.

Within the region under review, the wave-exposed shorelines are characteristically steep, rocky and backed by cliffs. Such exposed shorelines are typically poor in terms of species diversity, a trend that continues sub-tidally where sediments are coarse and mobile. These environments are likely to be resilient to the types of changes that could occur during and following the construction of marine renewable energy devices.

However, habitats that experience rapid tidal flows, but not extremes of wave action, often host particularly diverse communities of sessile suspension-feeders such as sponges, bryozoans and hydroids. As a consequence of the diversity of such tidally-swept habitats, and their relative scarcity, they have been designated under the UKBAP as deserving of particular protection.

C6.2.2

Priority Habitats, Site Designations and Habitat Descriptions

The marine and coastal SAC habitats likely to be present within the study area are listed in Table C6.1 below. UKBAP priority habitats do not have any legal sites status, but, whilst SAC designation is not dependent on the presence of specific UKBAP habitats, examples of these habitats may be found within SAC or SSSI sites. Table C6.2 identifies sites where the priority habitats are expected to be found, based primarily on their status as qualifying features within designated areas. These areas are shown on Figure C6.1 which shows specific areas that have been identified as being of ecological importance as a result of their status as SACs, SSSIs (see Table C6.2).

Table C6.1: Marine UKBAP Habitats in the Study Area

SAC Feature	UK Biodiversity Action Plan Priority Habitat Types Likely to be Found Within the Relevant SAC Feature
Sublittoral Habitats	
Sandbanks which are slightly covered by seawater at all times	Maerl beds Sublittoral sands and gravels
Large shallow inlets and bays	Maerl beds Tidal rapids Mud habitats in deep water Mudflats Sheltered muddy gravel
Estuaries	Maerl beds Tidal rapids Mudflats
Lagoons	Tidal rapids Mudflats
Reefs	<i>Modiolus modiolus</i> beds <i>Sabellaria alveolata</i> reefs <i>Sabellaria spinulosa</i> reefs <i>Lophelia pertusa</i> reefs <i>Serpula vermicularis</i> reefs Tidal rapids
Intertidal and Coastal Habitats	
Coastal lagoons (Priority Habitat)	Saline lagoons Tidal rapids Mudflats
Mudflats and sandflats not covered by seawater at low tide	Mudflats Seagrass beds

The following habitat descriptions have been taken primarily from the UKBAP website (<http://www.ukbap.org.uk/>).

C6.2.2.1

Maerl Beds

Maerl is a collective term for several species of calcified red seaweed. It grows as unattached nodules on the seabed, and can form extensive beds in favourable conditions. Maerl is slow-growing, but over long periods its dead calcareous skeleton can accumulate into deep deposits (an important habitat in its own right), overlain by a thin layer of pink, living maerl.

Maerl beds typically develop where there is some tidal flow, such as in the narrows and rapids of sea lochs, or the straits and sounds between islands. Beds may also develop in more open areas where wave action is sufficient to remove fine sediments, but not strong enough to break the brittle maerl branches. Live maerl has been found at depths of 40 m, but beds are typically found much shallower, above 20 m and extending up to the low tide level.

Maerl beds are found off the southern and western coasts of the British Isles, but are particularly well developed around the Scottish islands and in sea loch narrows, around Orkney.

Maerl beds are an important habitat for a wide variety of marine animals and plants which live amongst or are attached to its branches, or burrow in the coarse gravel of dead maerl beneath the top living layer. Maerl beds, because of the wide geographical range over which they occur, have a wide range of associated animals and plants, with species diversity tending to be greater in the south and west. Due to the fragility of maerl, the beds are easily damaged and may have declined substantially in some areas.

Maerl beds rely on water movement to disperse fine sediment particles, which would otherwise accumulate between the maerl fragments and smother the bed. Any obstruction to the water flow can be expected to have adverse effects on the maerl and its associated fauna and flora.

Maerl beds may be found within four different priority habitat types in Annex I of the EU Habitats Directive: 'Sandbanks which are slightly covered by seawater at all times'; 'large shallow bays and inlets'; 'Estuaries' and 'Lagoons'.

C6.2.2.2

Tidal Rapids

In the UKBAP, the term 'tidal rapids' is used to cover a broad range of high energy environments including deep tidal streams and tide-swept habitats. The Joint Nature Conservation Committee's (JNCC) Marine Nature Conservation Review (MNCr) defined rapids as 'strong tidal streams resulting from a constriction in the coastline at the entrance to, or within the length of, an enclosed body of water such as a sea loch. Depth is usually shallower than five metres.' In deeper situations, defined in this plan as being more than five metres, tidal streams may generate favourable conditions for diverse marine habitats (e.g. the entrances to fjordic sea lochs, between islands, or between islands and the mainland, particularly where tidal flow is funnelled by the shape of the coastline). Wherever they occur, strong tidal streams result in characteristic marine communities rich in diversity, nourished by a constantly renewed food source brought in on each tide.

These habitats are abundant in animals fixed on or in the seabed, and typically include soft corals, hydroids (sea fans), bryozoans (sea mats), large sponges, anemones, mussels and brittlestars in dense beds. In shallow water, bedrock and boulders often support kelp and sea oak plants, which grow very long in the tidal currents, and have a variety of animals growing on them. Other smaller red and brown seaweeds grow on cobbles and pebbles, many of these being characteristic of tide swept situations. Coarse gravel is a more difficult habitat for animals to colonise, as it is constantly moving, yet even here there are typical animals, such as sea cucumbers, worms and burrowing anemones.

The richness and variety of marine life in tidal rapids relies primarily on the strong water currents to carry food in, and waste materials and fine sediments away.

Rapids can be included in protected sites as Special Areas of Conservation (SACs) under the EU Habitats Directive as 'reefs' (if the seabed is of rock or a biogenic reef, such as a mussel bed); under 'large shallow inlets and bays', or in the priority habitat 'lagoons'. However, rapids with mixed sediments occurring in sea lochs and sounds (many are of this type) do not qualify under the present habitat definitions.

C6.2.2.3 Modiolus modiolus Beds

The horse mussel *Modiolus modiolus* forms dense beds at depths of 5-70 m in fully saline, often moderately tide-swept areas off northern and western parts of the British Isles. *M. modiolus* can occur as relatively small, dense beds of epifaunal mussels carpeting steep rocky surfaces, as in some Scottish sea lochs, but is more frequently recessed at least partly into mixed or muddy sediments in a variety of tidal regimes. In some areas of very strong currents extensive areas of stony and gravelly sediment are bound together by more or less completely recessed *M. modiolus*, creating waves or mounds with steep faces up to one metre high and many metres long. These areas of semi-recessed and recessed beds may in some cases extend over hundreds of hectares, and in many cases may be considered as 'biogenic reefs', though they are all referred to here as beds.

Modiolus modiolus is a long-lived species and individuals within beds are frequently 25 years old or more. Juvenile *M. modiolus* are heavily preyed upon, especially by crabs and starfish, until they are about 3-6 years old, but predation is low thereafter. Recruitment is slow and may be very sporadic; there may be poor recruitment over a number of years in some populations.

There have been no studies of the recovery of damaged beds but full recovery after severe damage would undoubtedly take many years at best and may not occur at all. Some beds may be self maintaining relict features.

The composition of the biotopes is variable, and is influenced by the depth, degree of water movement, substrate, and density of *M. modiolus*. Sponges, ascidians, soft corals, anemones, hydroids, bryozoans, tubeworms, brittlestars, urchins, starfish, barnacles, crabs, spider crabs and other decapods, whelks and other gastropods, scallops and fish all tend to be abundant as epifauna, while there may also be coralline algae and other red seaweeds in shallower areas. Infauna often includes the Purple Heart urchin *Spatangus purpureus* and numerous bivalves.

There is currently no statutory protection for known examples of this sublittoral habitat in the UK, as the marine SACs list is incomplete with respect to biogenic reefs. However, reefs are an Annex I habitat under the EC Habitats Directive and the definition of 'reef' habitats' includes biogenic reefs or 'concretions' which arise from the sea floor and support communities such as those formed by *Modiolus modiolus*, *Serpula vermicularis*, *Sabellaria spinulosa* and *Sabellaria alveolata*.

C6.2.2.4 Sabellaria spinulosa Reefs

Sabellaria spinulosa reefs comprise dense subtidal aggregations of this small, tube-building polychaete worm. *Sabellaria spinulosa* can act to stabilise cobble, pebble and gravel habitats, providing a consolidated habitat for epibenthic species. They are solid (albeit fragile), massive structures at least several centimetres thick, raised above the surrounding seabed. Whilst *Sabellaria* reefs can potentially persist for many years, they can also be ephemeral in nature, potentially washed away during winter storms. They provide a biogenic habitat that allows many other associated species to become established. The *S. spinulosa* reef habitats of greatest nature conservation significance are those which occur on predominantly sediment or mixed sediment areas. These enable a range of epibenthic species, with their associated fauna and a specialised 'crevice' infauna, which would not otherwise be found in the area, to become established.

One of the most important environmental factors that *S spinulosa* requires seems to be a good supply of sand grains for tube building, put into suspension by strong water movement (either tidal currents or wave action). *S. spinulosa* also appears to be very tolerant of polluted conditions. The worms need some form of hard substratum to which their tubes will initially be attached, whether bedrock, boulders, artificial substrata, pebbles or shell fragments. However, the presence of extensive reefs in predominantly sediment areas indicates that, once an initial concretion of tubes has formed, additional worms may settle onto the colony enabling it to grow to considerable size without the need for additional 'anchorage' points.

There is currently no statutory protection for known examples of this sublittoral habitat in the UK, as the marine SACs list is incomplete with respect to biogenic reefs. However, reefs are an Annex I habitat under the EC Habitats Directive and the definition of 'reef' habitats' includes biogenic reefs or 'concretions' which arise from the sea floor and support communities such as those formed by *Modiolus modiolus*, *Serpula vermicularis*, *Sabellaria spinulosa* and *Sabellaria alveolata*.

Sabellaria spinulosa reefs may also represent important sub-features of other Annex I habitats for which a site was selected. None of the candidate Special Areas of Conservation (cSACs) were selected specifically for biogenic reefs, although they may represent important sub-features of other Annex 1 habitats ('Sandbanks which are covered by seawater at all times'; 'Large shallow bays and inlets', and 'Estuaries'), for which a site was selected.

C6.2.2.5 *Sabellaria alveolata* Reefs

Sabellaria alveolata reefs are formed by the honeycomb worm *Sabellaria alveolata*, a polychaete which constructs tubes in tightly packed masses with a distinctive honeycomb-like appearance. These reefs can be up to 30 or even 50 cm thick and take the form of hummocks, sheets or more massive formations. Reefs are mainly found on the bottom third of the shore, but may reach mean high water of neap tides and extend into the shallow subtidal in places. Reefs form on a variety of hard substrata, from pebbles to bedrock, in areas with a good supply of suspended sand grains from which the animals form their tubes, and include areas of sediment when an attachment has been established. The larvae are strongly stimulated to settle by the presence of existing colonies or their dead remains. *S. alveolata* has a very variable recruitment and the cover in any one area may vary greatly over a number of years, although in the long term reefs tend mainly to be found on the same shores.

S. alveolata reefs occur as sub-features of non-reef Annex 1 habitats (e.g. intertidal mudflats and sandflats) under the Habitats Directive and are present in a number of cSACs. However, many examples of *S. alveolata* reefs lie outside of these designated areas.

C6.2.2.6 *Lophelia pertusa* Reefs

Lophelia pertusa is a colonial bank-forming species of coral, found in deep, dark, cold waters. *L. pertusa* grows in oceanic water of 4-12°C and is typically found offshore, on the continental shelf and shelf break, most commonly between 200-400 m depth.

L. pertusa is found in current-swept areas, where the local topography or hydrography accelerates the current flow or encourages the development of internal waves in the water column, and where sediment accumulation is low. Currents keep the corals free from settling silt, carry suspended food and remove waste.

Hydrography and current-topography interactions appear to play an important role in *L. pertusa* distribution. Recent studies on a *L. pertusa* reef off the coast of Norway suggest that *L. pertusa* reefs might be associated with hydrocarbon seeps, specifically methane seeps. However, the consensus is that deep water corals occur where the local topography induces current acceleration or the development of internal waves and where sediment accumulation is low.

L. pertusa and other deep water corals are generally found in areas of low sediment accumulation. Corals are generally very sensitive to the effects of sedimentation, which can result in slowed growth or death and may reduce the diversity of associated species.

As there were no known *L. pertusa* reefs within territorial waters during the selection process for cSACs, *L. pertusa* reefs have not been designated. However, the move to extend designation of marine SACs offshore of 12 nm, may lead to future designation.

C6.2.2.7 Serpula vermicularis Reefs

Serpula vermicularis is a marine worm which makes a hard, calcareous tube 9 mm in diameter and up to 200 mm long. In most places the worms are solitary with the base of the tube attached to stones or shells, and the feeding end growing up into the water. In the UK, reefs have only been found in Loch Creran, and the Linne Mhuirich arm of Loch Sween, both sea lochs on the west mainland coast of Scotland. The reefs in Loch Sween are now reported to be dead.

The Serpulid reefs in Loch Creran begin as single tubes on stones or shells on a sandy mud seabed. As more worms settle and grow on already established ones the reef grows upwards and outwards to form a rounded clump of white tubes, similar to a coral head. The worms extend their feeding fans, which are about 2 cm across and a range of colours, from white through orange to bright red, from the ends of the tubes. The larger reefs, over 1 m in diameter, tend to collapse outwards from the centre but the collapsed sections continue growing. The reefs are best developed in a relatively narrow vertical zone in the loch, at a depth between 6-10 m.

The reefs are a haven for other marine wildlife on the muddy seabed where there is little other solid attachment, and become covered with orange sponges, colonial and solitary sea squirts, hydroids and seaweeds. Mobile animals live between the tubes in the centre of the reef; particularly common are brittlestars, terebellid worms, small spider crabs, squat lobsters, hermit crabs, starfish and a range of marine snails.

The reefs at Loch Creran, at least in the sublittoral fringe, have declined over the last 100 years (together with eelgrass *Zostera marina* beds), while those in Loch Sween apparently died between 1982 and the mid 1990s.

Serpulid reefs are fragile and vulnerable to mechanical disturbance. The worms rely on water movement to feed; in both Loch Creran and Loch Sween this is a relatively gentle flow.

There is currently no statutory protection for known examples of this sublittoral habitat in the UK, as the marine SACs list is incomplete with respect to biogenic reefs. However, reefs are an Annex I habitat under the EC Habitats Directive and the definition of 'reef' habitats' includes biogenic reefs or 'concretions' which arise from the sea floor and support communities such as those formed by *Modiolus modiolus*, *Serpula vermicularis*, *Sabellaria spinulosa* and *Sabellaria alveolata*.

C6.2.2.8 Sublittoral Sands and Gravels

Sublittoral sand and gravel sediments are the most common habitats found below the level of the lowest low tide around the coasts of the United Kingdom.

Sublittoral sand and gravel habitats occur in a wide variety of environments, from sheltered (sea lochs, enclosed bays and estuaries) to highly exposed conditions (open coast). The particle structure of these habitats ranges from mainly sand, through various combinations of sand and gravel, to mainly gravel. While very large areas of seabed are covered by sand and gravel in various mixes, much of this area is covered by only very thin deposits over bedrock, glacial drift or mud. The strength of tidal currents and exposure to wave action are important determinants of the topography and stability of sand and gravel habitats.

Sand and gravel habitats that are exposed to strong tidal currents or wave action, have low diversity and are inhabited by robust, errant fauna specific to the habitat such as small polychaetes, small or rapidly burrowing bivalves and amphipods. The epifauna in these habitats tends to be dominated by mobile predatory species. Upper estuarine mobile sands, subject to very low fluctuating salinity, are species poor. This habitat is characterised by mysids (*Neomysis integer*) and amphipods (*Gammarus* spp).

Coarse sand sediment can occur in sand-wave formations in shallow water, wave exposed and tide-swept coasts. The infauna in this type of habitat is highly impoverished and is typified by small opportunistic capitellid and spionid polychaetes and amphipods (*Pontocrates arenarius*, *Haustorius arenarius* and *Eurydice pulchra*) that are adapted to living in a highly perturbed environment. The epifauna is characterised by mobile predators such as crabs (*Carcinus maenas* and *Liocarcinus* spp), hermit crabs (*Pagurus bernhardus*), whelks (*Buccinum undatum*), and occasionally sand eels (*Ammodytes* spp). Similar habitats also occur in estuaries where the marine fauna is replaced with a sparse low salinity tolerant fauna (e.g. Solway Firth).

Well sorted medium and fine sands on exposed coasts subjected to frequent wave action and variable tidal currents are typified by errant polychaetes such as *Nephtys cirrosa* and amphipods such as *Bathyporeia* spp (common in full salinity areas of many estuaries).

Mobile, coarse sand habitats fully exposed to wave action and swept by strong tidal streams are dominated by small or highly mobile polychaetes, thick shelled and rapidly burrowing bivalves (*Spisula elliptica* and *S. subtruncata*) and mobile amphipods that are adapted to periodic disturbance. It is a common habitat with examples found from Shetland to the Scilly Isles.

Sand mixed with cobbles and pebbles that is exposed to strong tidal streams and sand scour is characterised by conspicuous hydroids (*Sertularia cupressina* and *Hydrallmania falcata*) and bryozoans (*Flustra foliacea* and *Alcyonidium diaphanum*). These animals increase the structural complexity of this habitat and may provide an important microhabitat for smaller fauna such as amphipods and shrimps. Examples of the habitat are to be found in Shapinsay Sound, Cromarty Firth, and in numerous Scottish sea lochs.

In contrast, those biotopes found in full salinity in sheltered or deeper waters that are less perturbed by natural disturbance are among the most diverse marine habitats with a wide range of anemones, polychaetes, bivalves, amphipods and both mobile and sessile epifauna. These habitats are therefore unlikely to occur in the high energy environments likely to be exploited for marine renewable energy development. Clean stone gravel habitats are characterised by the sea anemones *Halcapa chrysanthellum* and *Edwardsia timida*, associated with hydroid/bryozoan turfs and red seaweeds. This habitat type has limited recorded distribution: Loch Creran, Loch Eynort (Skye).

Sublittoral sands and gravels included covered by "sandbanks slightly covered by seawater at all times" habitat under Annex I of the EU Habitats Directive.

C6.2.2.9 UKBAP Priority Habitats (Sheltered Waters)

Priority habitats that exist in areas sheltered from wave and tidal action such as: sheltered muddy gravel, seagrass beds and mudflats, and mud habitats in deep water are not considered in any detail here, as such low energy environments are unlikely to be exploited for wave and tidal energy. However, they are included in the GIS mapping and impact assessment as they are potentially impacted by export cable installation.

C6.2.3 *Areas of Known Importance*

The following areas have been identified as key sites of importance for marine benthic ecology in the study area. They have been identified based on their designated status, or whether they are specifically named in the UKBAP for the relevant priority habitat. However, important habitat types will certainly exist outside of these key areas, and the benthic ecology will need to be assessed in more detail on a project specific level for specific developments. These areas are shown in Figure C6.1, and a more detailed description of the benthic ecology within these areas is given in Appendix C6.A.

Table C6.2: Sites Designated for Benthic Ecology in the Study Area

Study Area	Site Name	Habitat Directive Primary Reason for Site Designating	Qualifying (but not primary) Features	Potential Resource Area	Protected Status	UKBAP Features
Northern Isles	Papa Stour	Reefs Submerged/partially submerged sea caves	None	Wave	SAC SSSI	Sublittoral sands and gravels
	Sanday	Reefs	Sandbanks which are slightly covered by sea water all the time Mudflats and sandflats not covered by seawater at low tide	Wave and tidal	SAC SSSI	Reefs Intertidal mudflats and sandflats Sublittoral sands and gravels <i>Modiolus modiolus</i>
	Loch of Stenness	Coastal lagoons (priority feature)	None	Outside main interest area	SAC SSSI	Saline lagoons
	Sullom Voe	Large shallow inlets and bays	Coastal lagoons Reefs	Tidal	SAC SSSI	Reefs Saline lagoons
	Mousa	Species	Reefs Submerged or partially submerged sea caves	Outside main interest area	SAC SSSI	Reefs Sublittoral sands and gravels Sea caves
	The Vadills	Coastal lagoons	None	Outside main interest area	SAC SSSI	Reefs Tidal Rapids Saline lagoons Maerl beds
North Coast	Invernaver	Coastal habitats	None	Wave	SAC	Intertidal mudflats and sandflats
	Durness	Coastal habitats (dunes)	None listed	Wave	SAC	Intertidal mudflats and sandflats
	Loch An Duin (south Sound of Harris)			Tidal	SSSI	Tidal rapids Saline lagoons Maerl beds
	Sound of Barra	sandbanks which are slightly covered by seawater all the time	None	Wave and tidal	pSAC	Sublittoral sands and gravels <i>Zostera marina</i> Maerl beds
	Loch Roag Lagoons	Coastal lagoons	None	Wave	SAC	Saline lagoons Tidal rapids Reefs
	Loch Laxford	Large shallow inlets and bays	Reefs	Wave	SAC SSSI	Reefs
	South Uist Machair	Terrestrial habitats	Coastal lagoons	Wave	SAC SSSI	Intertidal mudflats and sandflats Saline lagoons
	Loch nam Madadh (Loch Maddy)	Coastal lagoons Large shallow inlets and bays	Sandbanks which are slightly covered by sea water all the time Mudflats and sandflats not covered by seawater at low tide Reefs	Outside main area of interest	SAC SSSI	Intertidal mudflats and sandflats Seagrass beds Reefs Saline lagoons Maerl beds
Outer Isles	St Kilda	Reefs Sea caves	None	Wave	SAC SSSI	Reefs Sublittoral sands and gravels Sea caves

Study Area	Site Name	Habitat Directive Primary Reason for Site Designating	Qualifying (but not primary) Features	Potential Resource Area	Protected Status	UKBAP Features
	North Rona	Species	Reefs Submerged or partially submerged sea caves	Wave	SAC SSSI	Reefs Sublittoral sands and gravels Sea caves
Inner Isles	Lochs Duich, Aish and Long Reefs Marine SAC	Reefs	None	Not within main interest areas	SAC	Reefs Subtidal sandbanks <i>Modiolus modiolus</i> <i>Phellia Gausapata</i> (nationally scarce species)
	Sound of Arisaig	Sandbanks which are slightly covered by sea water all the time	None	Wave	SAC	Reefs Sublittoral sands and gravels Maerl beds
Argyll and Bute	Firth of Lorn	Reefs	None	Wave and tidal	SAC	Reefs
	Moine mhor	Terrestrial habitats	Mudflats and sandflats not covered by seawater at low tide Atlantic salt meadows (<i>Glaucopuccinellietalia maritima</i>)	Not within main interest areas	SAC SSSI	Intertidal mudflats and sandflats
	Treshnish Isles	Reefs	None	Wave	SAC	Reefs
	Loch Sunart	Terrestrial habitats	Reefs	Wave	SAC SSSI	Reefs Intertidal mudflats and sandflats Seagrass beds
	Loch Creran	Reefs	None	Wave	SAC	<i>Serpula vermicularis</i> reefs <i>Modiolus modiolus</i> reefs
North Channel	Luce Bay	Large shallow inlets and bays	Sandbanks which are slightly covered by sea water all the time Mudflats and sandflats not covered by seawater at low tide Reefs	Outside main area of interest	SAC SSSI	Reefs Intertidal mudflats and sandflats Subtidal mudflats and sandflats Shallow inlets and bays
	Solway Firth	Sandbanks which are slightly covered by sea water all the time Estuaries Mudflats and sandflats not covered by seawater at low tide	Reefs	Outside main area of interest	SAC	Intertidal mudflats and sandflats Sublittoral sands and gravels <i>Sabellaria alveolata</i> reefs

C6.2.4

Rare and Scarce Species

Several marine species listed in the UKBAP are likely to be located within the study area. In addition, within the UK's territorial waters Government agencies have identified species that are considered rare or scarce although they may have no formal designation or protection under the EU Habitats Directive or UKBAP. Some of these species inhabit high energy environments such as those proposed as sites for wave, and particularly tide, electricity generation schemes.

Table C6.3: Rare and Scarce Species Likely to be found in the Study Area

Species	Type	Habitat	Status
<i>Tethyspira spinosa</i>	Sponge	Wave exposed sub-tidal rock	Nationally rare or scarce
<i>Plocamilla coriacea</i>	Sponge	Vertical, subtidal rock or on other sponges	Nationally rare or scarce
<i>Arachnanthus sarsi</i>	Anemone	Shell-sand	Nationally rare or scarce
<i>Phellia gausapata</i>	Anemone	Rocks in kelp zone	Nationally rare or scarce
<i>Austroscyrrhoe fimbriatus</i>	Amphipod	Possibly associated with maerl	Nationally rare or scarce
<i>Synoicum incrustatum</i>	Ascidian	Horizontal surfaces subject to sand-scour	Nationally rare or scarce
<i>Ophiopsila annulosa</i>	Brittlestar	Subtidal, coarse gravel	Nationally rare or scarce
<i>Gelidiella calcicola</i>	Red alga	Maerl beds	Nationally rare or scarce
<i>Scmitzia hiscockiana</i>	Red alga	Sublittoral on tide-swept cobbles	Nationally rare or scarce
<i>Carpomitra costata</i>	Brown alga	Epilithic on small stones and shells in strong currents	Nationally rare or scarce
<i>Funiculina quadrangularis</i>	Sea Pen	Soft undisturbed mud below about 15m depth in fully marine conditions	UKBAP listed
Native Oyster (<i>Ostrea edulis</i>)	Bivalve Mollusc	Coastal water habitats on firm bottoms of mud, rocks, muddy sand, muddy gravel with shells and hard silt.	UKBAP listed
Fan Mussel (<i>Atrina fragilis</i>)	Bivalve Mollusc	Mud, sand or fine gravel	UKBAP listed

Source: Plaza and Sanderson 1997; UKBAP website

C6.3**Potential Effects**

C6.3.1

Introduction

The following is a description of the potential effects that the installation and operation of wave and tidal devices could have on benthic ecology.

C6.3.1.1

Installation Effects

During installation of devices and cables, benthic communities in the vicinity of installation operations would be impacted in the following ways:

Substratum loss of species located within the installation area as a result of cable trenching, installation of piles, gravity bases or clump weights, and deployment of anchors and jack-up rigs if used. Indirect effects (increased turbidity and smothering) on the surrounding area would also result from the re-distribution of sediment into the water column. These impacts will be localised and temporary and are likely to be most significant for installation of export cables, and devices which require structures to be piled into the seabed (one wave and two tidal devices currently propose piled foundations). Devices which use gravity bases, anchors and clump weights will cause a much smaller impact resulting from disturbance of the seabed and sediment suspension.

Smothering can occur within the immediate vicinity of the seabed disturbing works, as the coarser fraction of the sediment disturbed is likely to be re-deposited on the seabed within about 50 m of the works. This impact is only expected to be temporary, as material deposited will be re-suspended and distributed by natural hydrodynamic processes, and will only affect those species/habitats that are sensitive to smothering.

Increased suspended sediment and turbidity can occur as finer particles travel further from the disturbed area, swept by tidal currents, with potential effects on sessile filter feeders. It is not possible to quantify this impact because of the high number of variables involved in determining background and project caused suspended sediment levels. However, given that the wave and tidal turbines will be placed in high energy environments, it is likely that the small amounts of sediment released into the water column during turbine and cable installation will be rapidly dispersed into the surrounding environment, and will have a negligible impact on background suspended sediment and turbidity levels. This conclusion will of course have to be re-assessed on a case-by-case basis for specific developments.

Disturbance of contaminated sediments is also possible during cable and device installation, should seabed disturbing works be undertaken within an area of contaminated seabed, which may cause potential effects on nearby species that are sensitive to contamination. Areas of potential contamination risk and the associated implications for water quality are assessed in Chapter C2.

C6.3.1.2

Operation Effects

During device operation the following impacts are possible:

Substratum loss due to the presence of piles, gravity bases, clump weights and anchors on the seabed, or scouring associated with structures piled into the seabed. The area of seabed lost is impossible to quantify at the strategic level, as it is dependent on many project specific factors.

Based on discussions with developers, typical array sizes are likely to be 4 km² for wave (7 – 100 devices) and 0.5 km² for tidal arrays (approximately 30 devices). Depending on design devices are expected to each occupy a seabed area of between approximately 12m² (piles) and 40 m² (gravity bases). These numbers give an indication of the scale of impact per device/array, but it is not possible, given the wide range of device types and seabed attachments being considered in this SEA to make estimates of the actual area of seabed that would be lost

Decrease in water flow resulting from extraction of tidal energy, will potentially impact on habitats and species which are sensitive to changes to tidal flows and wave exposure (See Table C6.6). The richness and variety of marine life in tidal rapids relies primarily on the strong water currents to carry food in, and waste materials and fine sediments away. Therefore, interruptions of tidal flows are likely to have implications for fauna and flora. Benthic habitats are also potentially affected by changes in sediment patterns as a result of reduction in tidal flows. Whether significant changes in community structure would occur and whether they would be considered deleterious would depend on the degree of change and the nature of the receiving environment. For example, proposed developments resulting in significant reductions in water exchange within a sea-loch system supporting mussel farmers, or in fjardic systems, are likely to find opposition from mussel growers and conservationists respectively.

Based on limited existing projects and modelling studies, it is estimated that the extent of measurable impact on tidal energy can extend up 0.5 km from the tidal device (for further details see Chapter C3). Maerl beds, *Modiolus* beds and *Lophelia pertusa* reefs, and some deep mud habitats are highly sensitive to changes to tidal flows.

Decrease in wave exposure resulting from extraction of wave energy. Wave exposed habitats, particularly those facing the full force of the Atlantic swell, and those consisting of mobile sediments, generally show reduced species diversity. These environments are likely to be resilient to the removal of wave energy. Based on limited existing projects and modelling studies, it is estimated that the extent of impact on wave energy can extend up to 20 km from the wave device. Maerl beds and *Modiolus* beds are highly sensitive to decreases in wave energy.

Changes in suspended sediment levels and turbidity may be caused by changes to sedimentation patterns resulting from extraction of tide and wave energy. Depending on the specific environmental parameters at a given location this may result in increases or decreases of both sediment suspension and deposition. High confidence estimates, based on expert knowledge can be given for the extent of impacts on sediment processes of up to 50 m from devices (Bryden, 2006) (see Chapter C3: Metocean Marine Processes).

Maerl beds are particularly sensitive to impacts associated with changes to suspended sediment levels.

Whether changes to wave and tidal energy, and sedimentation patterns would cause significant changes in community structure, and whether they would be considered deleterious would depend on the degree of change and the nature of the receiving environment. Reduction of downstream water flow, if it occurs, is expected to be more significant in straits, tidal rapids and other constricted areas (such as Kyle Rhea and the Falls of Lora) than along broad areas of open coastline such as the Rhinns of Galloway.

There is also the potential for **leaching of toxic compounds** from sacrificial anodes, antifouling paints or hydraulic fluids (if present) from a device. A small number of both wave and tidal devices are expected to use antifouling coatings, and whilst organotins are now banned, the use of copper is still permitted. Most of the priority habitats likely to be present in the study area for which there is relevant sensitivity information are not particularly sensitive to heavy metal contamination that could result from use of copper based antifoulants or from sacrificial anodes. However, several of the benthic habitats under consideration are known to be sensitive to synthetic chemical contamination that could result from the leaching of hydraulic fluids used for some wave and tidal devices. *Modiolus* beds in particular, are identified as being highly sensitive to synthetic chemical contamination, with very low recoverability rates. The UKBAP for tidal rapids states that species inhabiting tidal rapids may be sensitive to water pollution.

As discussed in Section 3, the quantities and toxicities associated with sacrificial anodes and antifouling coatings are generally expected to be extremely small, and it is therefore considered that this potential effect will be of negligible significance. The potential for leakage of hydraulic fluids through accidental storm or collision damage could potentially present a significant impact if it occurred, but it is considered that there is a very low likelihood of such a leakage occurring. Potentially more significant still are the possible impacts that could result from leakage of cargoes or fuel carried by a vessel involved in a collision with renewable device arrays. This impact is impossible to quantify due the number of variables such as vessel cargo, risk of vessel collision, etc. It is not possible to make any realistic estimate of the geographical extent of this impact, due to the large numbers of variables involved (quantities leaked, metocean conditions, etc) and it is therefore not included in the significance mapping.

There is also potential for **colonisation of structures** causing increased biodiversity and leading to increased food availability for fisheries. Whilst this therefore has potential to be a positive impact, species colonising underwater structures may lead to undesirable changes in community structure, giving rise to negative impacts. On balance, colonisation of underwater structures is generally considered to be of neutral significance.

Table C6.4: Summary of Potential Effects on Benthic Ecology

Effect	Development Phase	Direct/Indirect	Duration	Extent
Substratum loss (construction)	CC CD	Direct	Temporary (during installation)	Cable and device installation area
Smothering	CC CD	Direct	Temporary (during installation)	50m
Increased turbidity	CC CD	Indirect	Temporary (during installation)	Negligible
Increased suspended sediment	CC CD	Indirect	Temporary (during installation)	Negligible
Decrease in wave exposure	OD	Direct	Long term (device life)	Up to 20km
Decrease in water flow	OD	Direct	Long term (device life)	Up to 500m
Substratum loss (operation)	OD	Direct	Long term (device life)	Within array area: wave - 4 km ² ; tidal - 0.5 km ²
Changes in turbidity	OD	Indirect	Long term (device life)	Negligible
Changes in suspended sediment	OD	Indirect	Long term (device life)	Negligible
Disturbance of contaminated sediments	CC CD	Indirect	Long term (device life)	Negligible
Contamination from anti-fouling paints and sacrificial anodes	OD	Direct	Temporary (during installation)	Negligible
Accidental contamination (Hydraulic Fluids or vessel cargo/fuel)	OD	Direct	Long term (device life)	Impossible to quantify

CD = Construction/decommissioning impact – devices

CC = Construction/decommissioning impact - cables

OD = Operation impact – devices

OC = Operation impact – cables

C6.4

Sensitivity of Receptors

The sensitivity of the priority habitats likely to be found within the study area are given in Table C6.6. The sensitivity information and subsequent assessment of impact significance has been undertaken on the basis of the priority UKBAP habitats known to be present within the study area. The species present within each habitat type are described in sub-section C6.2.2.

Where there were a number of biotope codes for a given habitat type, the worst case (i.e. greatest sensitivity / lowest recoverability) has been used, to ensure that a precautionary approach can be used to assess impacts. In addition, where a site designated under the Habitats Directive potentially contains several types of UKBAP priority habitats, the sensitivity used in the significance assessment and mapping is based on the most sensitive habitat.

The sensitivity information has been taken directly from the MarLIN website, and the sensitivity assessment rationale was developed by the MarLIN team in consultation with the Biology & Sensitivity Key Information Sub-programme Technical Management Group and ratified by the MarLIN programme Steering Group. The assessment rationale involves judging the intolerance of a species to change in an external factor arising from human activities or natural events. The rationale then assesses the likely recoverability of the species following cessation of the human activity or natural event. Intolerance and recoverability are then combined to provide a meaningful assessment of their overall sensitivity to environmental change. The definitions of the different sensitivity ratings used by Marlin are given in Table C6.5:

Table C6.5: MarLIN Definitions of Habitat Sensitivity

Sensitivity Scale	Sensitivity Definition or Scenario
Very High	The habitat or species is very adversely affected by an external factor arising from human activities or natural events (either killed/destroyed, 'high' intolerance) and is expected to recover only over a prolonged period of time, i.e. >25 years or not at all (recoverability is 'very low' or 'none').
	The habitat or species is adversely affected by an external factor arising from human activities or natural events (damaged, 'intermediate' intolerance) but is not expected to recover at all (recoverability is 'none').
High	The habitat or species is very adversely affected by an external factor arising from human activities or natural events (killed/destroyed, 'high' intolerance) and is expected to recover over a very long period of time, i.e. >10 or up to 25 years ('low' recoverability).
	The habitat or species is adversely affected by an external factor arising from human activities or natural events (damaged, 'intermediate' intolerance) and is expected to recover over a very long period of time, i.e. >10 years (recoverability is 'low', or 'very low').
	The habitat or species is affected by an external factor arising from human activities or natural events (reduced viability, 'low' intolerance) but is not expected to recover at all (recoverability is 'none'), so that the habitat or species may be vulnerable to subsequent damage.
Moderate	The habitat or species is very adversely affected by an external factor arising from human activities or natural events (killed/destroyed, 'high' intolerance) but is expected to take more than 1 year or up to 10 years to recover ('moderate' or 'high' recoverability).
	The habitat or species is adversely affected by an external factor arising from human activities or natural events (damaged, 'intermediate' intolerance) and is expected to recover over a long period of time, i.e. >5 or up to 10 years ('moderate' recoverability).
	The habitat or species is affected by an external factor arising from human activities or natural events (reduced viability, 'low' intolerance) but is expected to recover over a very long period of time, i.e. >10 years (recoverability is 'low', 'very low'), during which time the habitat or species may be vulnerable to subsequent damage.
Low	The habitat or species is very adversely affected by an external factor arising from human activities or natural events (killed/destroyed, 'high' intolerance) but is expected to recover rapidly, i.e. within 1 year ('very high' recoverability).
	The habitat or species is adversely affected by an external factor arising from human activities or natural events (damaged, 'intermediate' intolerance) but is expected to recover in a short period of time, i.e. within 1 year or up to 5 years ('very high' or 'high' recoverability).
	The habitat or species is affected by an external factor arising from human activities or natural events (reduced viability, 'low' intolerance) but is expected to take more than 1 year or up to 10 years to recover ('moderate' or 'high' recoverability).
Very Low	The habitat or species is very adversely affected by an external factor arising from human activities or natural events (killed/destroyed, 'high' intolerance) but is expected to recover rapidly i.e. within a week ('immediate' recoverability).
	The habitat or species is adversely affected by an external factor arising from human activities or natural events (damaged, 'intermediate' intolerance) but is expected to recover rapidly, i.e. within a week ('immediate' recoverability).
	The habitat or species is affected by an external factor arising from human activities or natural events (reduced viability, 'low' intolerance) but is expected to recover within a year ('very high' recoverability).
Not Sensitive	The habitat or species is affected by an external factor arising from human activities or natural events (reduced viability, 'low' intolerance) but is expected to recover rapidly, i.e. within a week ('immediate' recoverability).
	The habitat or species is tolerant of changes in the external factor.
Not Sensitive	The habitat or species may benefit from the change in an external factor (intolerance has been assessed as 'tolerant').
Not Relevant	The habitat or species is protected from changes in an external factor (i.e. through a burrowing habit or depth), or is able to avoid the external factor.

Source: www.marlin.ac.uk

Table C6.6: Sensitivity of Benthic Habitats (based on UKBAP marine priority habitats)

Habitat Type	Smothering	Increased Turbidity	Decrease in Wave Exposure	Decrease in Water Flow	Substratum Loss	Change in Suspended Sediment	Contamination (synthetic compound)	Contamination (heavy metals)
Maerl Beds ¹	v high	high	high	High	v high	v high	moderate	insufficient info
Tidal Rapids ^{2,3,4}	low	low	high	High	high	low	high	low
<i>Modiolus Modiolus</i> Beds ²	high	low	high	High	v high	v low	v high	low
<i>Sabellaria spinulosa</i> Reefs ²	low	not sensitive	moderate	moderate	moderate	low	low	insufficient info
<i>Sabellaria alveolata</i> Reefs ²	v low	v low	moderate	low	moderate	low	v low	low
<i>Lophelia Pertusa</i> Reefs ²	v low	tolerant	tolerant	high	v high	v low	insufficient info	insufficient info
<i>Serpula vermicularis</i> Reefs ²	low	v low	tolerant	v low	v high	not sensitive	insufficient info	insufficient info
Sublittoral Sands and Gravels ¹	v low	moderate	low	low	moderate	v low	moderate	moderate
Seagrass ¹	v high	v low	low	moderate	v high	moderate	moderate	low
Sheltered Muddy Gravel ³	low	v low	moderate	tolerant	moderate	not sensitive	moderate	moderate
Mud Habitats in Deep Water ³	moderate	low	moderate	moderate	moderate	low	moderate	low
Saline Lagoons ⁴	low	low	not relevant	not relevant	low	v low	low	v low
Mudflats ⁵	low	v low	tolerant	tolerant	moderate	v low	moderate	moderate
Coastal Saltmarsh	low	tolerant	moderate	moderate	moderate	moderate	moderate	low

Source: www.marlin.ac.uk

1Habitat included in SAC habitat1110 Sandbanks which are slightly covered by sea water all the time; 2 Habitat included in SAC habitat1170 Reefs 3 Habitat included in SAC habitat1160 Large shallow inlets and bays; 4 Habitat included in SAC habitat1150 Lagoons (priority habitat) 5 Habitat included in SAC habitat1140 Mudflats and sandflats not covered by seawater at low tide

C6.5 Potential Significance of Effects

C6.5.1 Assessment Criteria

The assessment of effect significance has been undertaken based on the criteria below. These have been developed specifically for the SEA, and take into account the information available to inform the assessment of significance. Due to the strategic nature of this assessment, it has not been possible to quantify magnitude of impacts, and the assessment of significance is therefore based primarily on the sensitivity and importance of receptors, as described in Table C6.7:

Table C6.7: Significance Assessment Criteria - Benthic Ecology

Significance Level	Determining Criteria
High	Impact on a known area of ecological importance designated as a cSAC or pSAC under the habitats directive, where a species/habitat that has a high to very high sensitivity to the impact in question is within the zone of influence of that impact.
Moderate	Impact on a potential area of ecological importance (possible Annex I Habitat - pAIH), or on a UKBAP priority habitat where a species/habitat that has a high – very high sensitivity to the impact in question is within the zone of influence of that impact, or, Impact on a known area of ecological importance designated as a cSAC or pSAC under the habitats directive, or a UKBAP priority habitat where a species/habitat that has a low to moderate sensitivity to the impact in question is within the zone of influence of that impact.
Minor	Impact on a potential area of ecological importance (pAIH), where a species/habitat that has a low - moderate sensitivity to the impact in question is within the zone of influence of that impact.
Negligible/No Impact	No species/habitats that are sensitive to the impact in question are within the zone of influence of that impact.
Unknown	Impact on an area of unknown importance for benthic ecology

C6.5.2 Mapping of Effect Significance

The significance of key effects on benthic ecology has been mapped and the results are shown on Figures C6.2 – C6.5).

It should be noted that the assessment of significance has been undertaken at a strategic level, based on the worst case scenario for impacts on the key known locations important or protected habitats in the area.

Significance of benthic ecological impacts has been determined by creating a buffer drawn around the known locations of the key benthic habitat. The size of the buffer is equivalent to the estimated maximum distance from a marine renewable energy device that specific impacts are considered likely, and the level of significance is based on the sensitivity to a specific impact (see Table C6.8). Where an area is known to contain a number of key habitats, the habitat with the greatest sensitivity to the impact in question is used to assess significance.

C6.5.3 Results of Significance Assessment

C6.5.3.1 Installation Effects

During installation of devices and cables, benthic communities in the vicinity of installation operations would be impacted in the following ways:

Substratum loss: Installation impacts will be localised and temporary and are likely to be most significant for installation of export cables, and devices which require structures to be piled into the seabed (one wave and two tidal devices currently propose piled foundations). Devices which use gravity bases, anchors and clump weights will cause a much smaller impact resulting from disturbance of the seabed and sediment suspension. Maerl beds, tidal rapids, *Modiolus* reef, *serpula vermicularis* reef and seagrass beds have all been identified as having a high - very high sensitivity to substratum loss, and therefore major significance impacts on these habitats are potentially expected should seabed disturbing works be undertaken where these species occur. Moderate effects are expected on *Sabellaria* reef, sublittoral sands and gravels, sheltered muddy gravel and, mud habitats in deep water which have a low to moderate sensitivity to this impact. Impact mitigation through avoidance of protected sites could be expected to reduce impacts to negligible. Much of the benthic habitats within the study area however, remains unknown, and therefore impacts on the majority of the study area remains unknown.

Smothering: This impact is only expected to be temporary, as material deposited will be re-suspended and distributed by natural hydrodynamic processes, and will only affect those species/habitats that are sensitive to smothering. Maerl beds and *Modiolus* beds and seagrass beds are of high or very high sensitive to smothering impacts, and major potential significance impacts are expected to affect these species. The other UKBAP priority habitats known to be present in the study area have a low, very low or moderate sensitivity to this impact and impacts therefore have a moderate potential significance. Impact mitigation through avoidance of protected sites where possible could be expected to reduce impacts to negligible. Much of the benthic habitats within the study area however, remains unknown, and therefore impacts on the majority of the study area remains unknown.

Increased suspended sediment and turbidity: Given that the wave and tidal turbines will be placed in high energy environments, it is likely that surrounding background suspended sediment levels will be high, and the small amounts of sediment released into the water column during turbine and cable installation will have a negligible impact on background suspended sediment and turbidity levels, and therefore a negligible impact on sensitive receptors. This conclusion will of course have to be re-assessed on a case-by-case basis for specific developments.

Disturbance of contaminated sediments is also possible during cable and device installation, which may cause potential effects on species that are sensitive to contamination. Areas of potential contamination risk and the associated implications for water quality are assessed in Chapter C2. Should seabed disturbing activities such as piling, or cable installation disturb such sediments potential major significance effects are present on sensitive species such as tidal rapids and *Modiolus Modiolus*. However this impact can be mitigated through avoidance of areas of contaminated sediment for seabed disturbing works, and residual effects are expected to be negligible.

C6.5.3.2 Operation Effects

During device operation the following impacts are possible:

Substratum loss due to the presence of gravity bases, clump weights and anchors on the seabed, or scouring associated with structures piled into the seabed. The area of seabed lost is impossible to quantify at the strategic level, as it is dependent on many project specific factors.

Maerl beds, tidal rapids, *Modiolus* reef, *Serpula vermicularis* reef and seagrass beds have all been identified as having a high - very high sensitivity to substratum loss, and therefore major significance impacts on these habitats are potentially expected should seabed disturbing works be undertaken where these species occur. Moderate effects are expected on *Sabellaria* reef, sublittoral sands and gravels, sheltered muddy gravel and, mud habitats in deep water which have a low to moderate sensitivity to this impact. Impact mitigation through avoidance of protected sites could be expected to reduce impacts to negligible. Much of the benthic habitats within the study area however, remains unknown, and therefore impacts on the majority of the study area remains unknown.

Decrease in water flow: Based on limited existing projects and modelling studies, it is estimated that the extent of impact on tidal energy can extend up to 0.5 km from the tidal device (for further details see Chapter C3: Metocean Marine Processes). Maerl beds, *Modiolus* beds, *Lophelia pertusa* reefs, tidal rapids are highly sensitive to changes to tidal flows and therefore potential effects of major significance would be expected to occur should devices be placed within 0.5 m of these habitats. *Sabellaria spinulosa* and *alveolata* reefs, *Serpula vermicularis* reefs, sublittoral sands and gravels, seagrass beds, mud habitats in deep water and coastal saltmarsh have a low to moderate sensitivity to this impact, and potential effects of moderate significance could be expected for these habitats. Avoidance of sensitive habitats could be expected to reduce impacts to negligible. Much of the benthic habitats within the study area however, remains unknown, and therefore impacts on the majority of the study area remains unknown.

Decrease in wave exposure: Based on limited existing projects and modelling studies, it is estimated that the extent of impact on wave energy can extend up to 20 km from the wave device. Maerl beds and *Modiolus* beds, and tidal rapids are highly sensitive to decreases in wave energy, and a potential significance rating of major has been assigned to effects on these habitats. *Sabellaria spinulosa* and *alveolata* reefs, *Lophelia pertusa*, *Serpula vermicularis* reefs, sublittoral sands and gravels, seagrass beds, mud habitats in deep water, mudflats and coastal saltmarsh have a low to moderate sensitivity to this impact, and potential effects of moderate significance could be expected for these habitats. Avoidance of sensitive habitats may not be possible if the impact extends 20 m from the device array, and further field studies and modelling is required to understand the footprint of this impact. Much of the benthic habitats within the study area however, remains unknown, and therefore impacts on the majority of the study area remains unknown.

Changes in suspended sediment levels and turbidity: Given that the wave and tidal turbines will be placed in high energy environments, it is likely that surrounding background suspended sediment levels will be high, and the small amounts of sediment released into the water column during turbine and cable installation will have a negligible impact on background suspended sediment and turbidity levels, and therefore a negligible impact on sensitive receptors. This conclusion will of course have to be re-assessed on a case-by-case basis for specific developments.

Contamination from anti-fouling paints and sacrificial anodes: Sensitivity levels for all the UKBAP priority habitats under consideration to heavy metal contamination are either low, moderate or "insufficient information." Should small quantities of toxic materials such as copper be used it is expected that the highly energetic environment in which devices are likely to be located will result in rapid dilution and dispersal. Assuming non-toxic anti-fouling materials are used no measurable impacts, on water or sediment quality from the use of anti-fouling paints, are predicted. With regard to sacrificial anodes, the quantities involved represent concentration below which there is not predicted to be any significant environmental effect. Minor potential effects and negligible residual effects are therefore expected as a result of contamination from anti-fouling paints and sacrificial anodes.

Risk of accidental contamination (hydraulic fluids): Several of the benthic habitats under consideration are known to be sensitive to synthetic chemical contamination that could result from the leaching of hydraulic fluids used for some wave and tidal devices. *Modiolus* beds in particular, are identified as being highly sensitive to synthetic chemical contamination, with very low recoverability rates. The UKBAP for tidal rapids states that species inhabiting tidal rapids may be sensitive to water pollution.

The potential for leakage of hydraulic fluids through accidental storm or collision damage, or vessel fuel and/or cargo through collision damage could potentially present an impact of major significance if it occurred, but it is considered that there is a very low likelihood of such a leakage occurring. It is not possible to make any realistic estimate of the geographical extent of this impact, due to the large numbers of variables involved (quantities leaked, metocean conditions, etc). Assuming the device is designed to minimise this risk (devices which use hydraulic systems will normally be designed such that at least two seal or containment failures are required before a leaking fluid reaches the sea), and avoidance of high traffic density areas of potential collision risk. Residual effects are considered to be negligible.

There is also potential for **colonisation of structures** causing increased biodiversity and leading to increased food availability for fisheries. Whilst this therefore has potential to be a positive impact, species colonising underwater structures may lead to undesirable changes in community structure, giving rise to negative impacts. On balance, recolonisation of underwater structures is generally considered to be of neutral significance.

Table C6.8: Potential Significance of Effects – Benthic Ecology

Potential Effects	Device Characteristics	Development Phase	Receptor	Potential Significance of Effects	Likely Impact Extent	Source	Confidence	Figure Number
Substratum loss (installation)	Seabed disturbing works	CD CC	Maerl beds, tidal rapids, <i>Modiolus</i> reef, <i>serpula vermicularis</i> reef and seagrass beds <i>Sabellaria spinulosa</i> and <i>alveolata</i> reef, sublittoral sands and gravels, sheltered muddy gravel and, mud habitats in deep water, saline lagoons	Major Moderate	Cable and device installation area	Estimate based on expert knowledge	High	C6.2
Smothering	Piled devices and cables	CC CD	Maerl beds, <i>Modiolus</i> beds, Seagrass beds Tidal rapids, Biogenic reefs (exl <i>Modiolus</i>), Saline lagoons, Coastal saltmarsh, Sublittoral sands and gravels Sheltered muddy gravel	Major Moderate	Up to 50m	Estimate based on expert knowledge	High	C6.3
Increased suspended sediment and turbidity (installation)	Seabed disturbing works	CC CD	Maerl beds	Negligible	Negligible	Estimate based on expert knowledge	High	Not mapped
Disturbance of contaminated sediment	Seabed disturbing works	CC CD	Tidal rapids, <i>Modiolus</i> beds	Major	Unknown	N/A	High	Not mapped

Potential Effects	Device Characteristics	Development Phase	Receptor	Potential Significance of Effects	Likely Impact Extent	Source	Confidence	Figure Number
Substratum Loss (operation)	All devices attached to the seabed	OD	Maerl beds, tidal rapids, <i>Modiolus</i> reef, <i>Serpula vermicularis</i> reef and seagrass beds <i>Sabellaria</i> reef, sublittoral sands and gravels, sheltered muddy gravel and, mud habitats in deep water, saline lagoons	Major Moderate	Depends on seabed attachment method and number of devices	N/A	High	C6.2
Decrease in water flow	All tidal	OD	Maerl beds, <i>Modiolus</i> beds, <i>Lophelia pertusa</i> reefs, tidal rapids <i>Sabellaria spinulosa</i> and <i>alveolata</i> reefs, <i>Serpula vermicularis</i> reefs, sublittoral sands and gravels, seagrass beds, mud habitats in deep water and coastal saltmarsh	Major Moderate	Up to 500m	Modelling or MCT Seaflow and Seagen	Low	C6.5
Decrease in wave exposure	All wave	OD	Maerl beds <i>Modiolus</i> beds <i>Sabellaria spinulosa</i> and <i>alveolata</i> reefs, <i>Lophelia pertusa</i> , <i>Serpula vermicularis</i> reefs, sublittoral sands and gravels, seagrass beds, mud habitats in deep water, mudflats and coastal saltmarsh	Major Moderate	Up to 20km	WaveHub (modelling based on highly conservative assumption)	Very low	C6.4
Changes in suspended sediment and turbidity (operation)	Seabed disturbing works	OC OD	All UKBAP priority habitat types	Negligible	Negligible	Estimate based on expert knowledge	High	Not mapped
Contamination from anti-fouling paints and sacrificial anodes	Wave and tidal devices using antifoulants and sacrificial anodes	OD	UKBAP priority habitats	Minor	Negligible	Calculations based on discussions with developers	Mode rate	Not mapped

Potential Effects	Device Characteristics	Development Phase	Receptor	Potential Significance of Effects	Likely Impact Extent	Source	Confidence	Figure Number
Risk of accidental contamination (hydraulic fluids or vessel cargo/fuel)	Wave and tidal	OD CD	UKBAP priority habitats	Major	Impossible to quantify	Discussions with developers	Very low	Not mapped

CD = Construction/decommissioning impact – devices

CC = Construction/decommissioning impact - cables

OD = Operation impact – devices

OC = Operation impact – cables

Note: data on extents of wave and tidal impacts based on work undertaken by WaveHub and MCT has been taken from CCW Policy Research Report 06/7 (ABPmer, 2006)

C6.6

Mitigation Measures

Where potentially significant impacts have been identified for a specific receptor, the following mitigation measures are appropriate for reducing/mitigating impacts.

Table C6.9: Mitigation Measures

Potential effect	Project Phase	Mitigation Measures
Species displacement	CC CD	<ul style="list-style-type: none"> Avoid device placement in sensitive areas / features
Smothering	CC CD	<ul style="list-style-type: none"> Avoid habitats/species sensitive to smothering Avoid installation during sensitive seasons
Increase in suspended sediment and turbidity during construction	CC CD	<ul style="list-style-type: none"> Minimise depth of piling Use cable and device installation methods that minimise sediment re-suspension Release sediment in appropriate tidal conditions to minimise effect Carry out work in appropriate tidal conditions to minimise effect
Decrease in wave exposure Decrease in water flow	OD	<ul style="list-style-type: none"> Careful site selection and assessment of effects
Substratum loss	OD	<ul style="list-style-type: none"> Avoid device placement in sensitive areas / features
Disturbance of contaminated sediments	CC CD	<ul style="list-style-type: none"> Avoid device placement in areas of known sediment contamination Use installation methods that minimise disturbance of sediments Carry out work in appropriate tidal conditions to minimise effect
Contamination from anti-fouling paints and sacrificial anodes	OD	<ul style="list-style-type: none"> Design devices to minimise leakage of pollutants Use of non toxic anti-foulants Minimise use of anti-foulants Minimise use of sacrificial anodes Use low toxicity grout Minimise contact of grout with water Minimise quantity of grout used
Accidental contamination (hydraulic fluids or vessel cargo/fuel)	OD	<ul style="list-style-type: none"> Design devices to minimise risk of leakage of pollutants Risk assessment and contingency planning

C6.7 Likelihood of Occurrence

Within the study area, the wave-exposed shorelines are characteristically steep, rocky and backed by cliffs. Such exposed shorelines are typically poor in terms of species diversity, a trend that continues subtidally where sediments are coarse and mobile. Conversely rocky areas that are exposed to rapid tidal currents, without the extreme rigour of an open oceanic aspect, typically host high biodiversity, unique biological assemblages and are relatively scarce.

The likelihood of tidal devices being placed in areas where they can potentially impact important habitats is therefore significantly higher than the same for wave devices, although the impacts on extraction of energy are likely to extend over a wider area for wave, compared to tidal devices. Figures C6.2 – C6.5 illustrate areas where exploitation for wave and tidal devices could be expected to incur significant impacts, and show where these areas overlap with the likely development areas.

C6.8 Confidence and Knowledge Gaps

Table C6.10 below summarises the current data gaps which will require further research / investigation in order to assign greater confidence to the assessment of potential effect significance. The table has been adapted from ABPmer, 2006.

Table C6.100: Data Gaps – Benthic Ecology

Identified Data Gap	Potential to Fill the Data Gap	Priority
Baseline ecology – most of the seabed within the study area has not been mapped and biologically surveyed using up-to-date acoustic methods supplemented by video ground-truthing.	Broad-scale distribution of benthic biotopes can be surveyed using modern acoustic methods and ground-truthed by underwater video techniques.	Project specific
Certainty in the prediction of potential ecological effects	Collection of baseline data and subsequent monitoring data to confirm prediction regarding potential changes in habitats and species. Such data would assist in understanding the degree of change in wave or tidal energy (if any occur) together with the extent of change.	High
Data currently available defines the known energy requirements of habitats and species, together with intolerance to a change in wave or tidal energy. However the data does not quantify the degree of change in wave or tidal energy that would impact the habitats and species	Investigation of the level of change in wave and tidal energy required for a shift in habitats and species to result. The issue is of particular importance when considering that a small change in success of an individual species such as a sea urchin can have significant consequences for the species present.	Currently low to medium until knowledge of potential extent of change becomes more apparent. Where significant changes are predicted, the priority will rise.
Highly limited data to enable an understanding of the potential geographic footprint of change.	Modelling predicted change, with field survey where feasible, to increase understanding of the potential geographic extent of change.	High

C6.9 Residual Effects

The tables in this section summarise the overall potential and residual significance of the impacts identified for benthic ecology in the study area. The assessment has been undertaken at the habitat level and has focussed on the priority habitats identified in the UKBAP. Protected sites and species are included elsewhere in this report. As previously stated the assessment of significance has been limited by a number of factors which need to be borne in mind when reading the significance tables and accompanying mapping.

The significance assessment applies the precautionary approach to assessment of impacts and therefore, for the most part, presents the maximum potential effect significance for the following reasons:

- Where a site is designated for several habitat types, or a habitat type designated as a cSAC contains several different UKBAP habitats, the determination of potential effect significance has used the habitat type with the highest sensitivity to the impact in question. A more detailed examination of specific sites/habitats as part of site specific projects may therefore determine that impacts are less significant than described here.
- Due to the current level of knowledge on wave and tidal impacts on benthic ecology, maximum impact estimates have been used, which may be reduced once further research and monitoring has been undertaken, and a better level of understanding has been reached.
- Due to the current level of knowledge on the benthic ecological baseline, the SEA has assumed unknown impacts on all areas where benthic ecological importance is unknown. Significance of effects in these areas will need to be determined based on the importance and sensitivity of species found in these areas during more detailed site specific survey.

Table C6.11, below, summarises the potential and residual effect significance, and confidence for the key possible effects identified in the preceding sections, and provides an overview of effects over the entire study area. The table should be read in conjunction with the significance maps (Figures C6.2 – C6.5) which illustrate the estimated extents of potential significant impacts.

Table C6.111: Potential and Residual Significance of Effects – Benthic Ecology

Potential Effect	Device Characteristics	Development Phase	Receptor	Potential Significance of Effects	Industry Good Practice Mitigation	Likelihood of Occurrence	Residual Significance of Effects	Confidence
Substratum loss (installation)	Seabed disturbing works	CD CC	Maerl beds, tidal rapids, <i>Modiolus</i> reef, <i>serpula vermicularis</i> reef and seagrass beds <i>Sabellaria</i> reef, sublittoral sands and gravels, sheltered muddy gravel and, mud habitats in deep water, saline lagoons	Major Moderate	Avoidance of protected habitats	High	Negligible	High
Smothering	Piled devices and cables	CC CD	Maerl beds, <i>Modiolus</i> beds, Seagrass beds Tidal rapids, Biogenic reefs (exl <i>Modiolus</i>), Saline lagoons, Coastal saltmarsh, Sublittoral sands and gravels Sheltered muddy gravel	Major Moderate	Avoidance of protected habitats and sensitive seasons	Moderate	Negligible	High

Potential Effect	Device Characteristics	Development Phase	Receptor	Potential Significance of Effects	Industry Good Practice Mitigation	Likelihood of Occurrence	Residual Significance of Effects	Confidence
Increased suspended sediment and turbidity (construction)	Seabed disturbing works	CC CD	Maerl beds	Negligible	None identified	Low	Negligible	High
Disturbance of contaminated sediment	Seabed disturbing works	CC CD	Tidal rapids, <i>Modiolus</i> beds	Major	Avoid contaminated areas	Low	Minor	High
Substratum Loss (operation)	All devices attached to the seabed	OD	Maerl beds, tidal rapids, <i>Modiolus</i> reef, <i>Serpula vermicularis</i> reef and seagrass beds <i>Sabellaria</i> reef, sublittoral sands and gravels, sheltered muddy gravel and, mud habitats in deep water, saline lagoons	Major Moderate	Avoidance of protected habitats	High	Negligible	High
Decrease in water flow	All tidal	OD	Maerl beds, <i>Modiolus</i> beds, <i>Lophelia pertusa</i> reefs, tidal rapids <i>Sabellaria spinulosa</i> and <i>alveolata</i> reefs, <i>Serpula vermicularis</i> reefs, sublittoral sands and gravels, seagrass beds, mud habitats in deep water and coastal saltmarsh	Major Moderate	Avoidance of protected habitats	High	Moderate	Low
Decrease in wave exposure	All wave	OD	Maerl beds <i>Modiolus</i> beds <i>Sabellaria spinulosa</i> and <i>alveolata</i> reefs, <i>Lophelia pertusa</i> , <i>Serpula vermicularis</i> reefs, sublittoral sands and gravels, seagrass beds, mud habitats in deep water, mudflats and coastal saltmarsh	Major Moderate	None identified	Low	Moderate	Very Low

Potential Effect	Device Characteristics	Development Phase	Receptor	Potential Significance of Effects	Industry Good Practice Mitigation	Likelihood of Occurrence	Residual Significance of Effects	Confidence
Changes in suspended sediment and turbidity (operation)	Seabed disturbing works	OC OD	All UKBAP priority habitat types	Negligible	None identified	Low	Negligible	High
Contamination from anti-fouling paints and sacrificial anodes	Wave and tidal devices using antifoulants and sacrificial anodes	OD	UKBAP priority habitats	Minor	Use of low toxicity antifoulants; minimise use of antifoulants and sacrificial anodes	High	Negligible	High
Risk of accidental contamination (hydraulic fluids or vessel cargo/fuel)	Wave and tidal	OD CD	UKBAP priority habitats	Major	Device design to minimise risk; risk assessment and contingency planning	Very low	Negligible	High

C6.10 Recommendations for Site Specific Survey and Monitoring

C6.10.1 Introduction

Targeted survey and monitoring of benthic ecology associated with a specific development will need to be determined and agreed as part of the EIA and consenting process, but some suggested aspects this would need to take account of are given below. In each case, it is important that the surveying protocols and post-construction monitoring methodologies agreed upon need to be both scientifically and statistically robust.

C6.10.2 Site Survey

In general the benthic ecology baseline, and therefore the potential effects of wave and tidal energy device deployment on the benthic environment are not well studied or understood, and there is therefore a low confidence on several aspects of the risk assessment. Most of the seabed within the study area has not been mapped and biologically surveyed using up-to-date acoustic methods supplemented by video ground-truthing. It is therefore recommended that benthic communities are surveyed prior to device installation, both to provide information on the benthic ecology of the site to allow for any species or habitats considered to be sensitive to significant impacts to be taken into account and avoided during site selection, and to provide a baseline against which monitoring of subsequent impacts can take place. Broad-scale distribution of benthic biotopes can be surveyed using modern acoustic methods and ground-truthed by underwater video techniques.

C6.10.3 Post Installation Monitoring

Monitoring will need to be undertaken to confirm predictions regarding potential effects on, and changes in habitats and species. Such data would assist in understanding the degree of change in wave or tidal energy (if any occur) together with the extent of change. The zones within which benthic monitoring is required will need to be determined based on the project specific modelling to estimate the extent of extraction of energy impacts.

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